R&S®RTE
Digital Oscilloscope
User Manual

1326.1032.02 — 0601

Test & Measurement

User Manual

ROHDE&SCHWARZ

This manual describes the following R&S®RTE models with firmware version 3.35:

- R&S®RTE1022: 200 MHz, 2 channels (1326.2000.22 and 1317.2500.22)
- R&S®RTE1024: 200 MHz, 4 channels (1326.2000.24 and 1317.2500.24)
- R&S®RTE1032: 350 MHz, 2 channels (1326.2000.32 and 1317.2500.32)
- R&S®RTE1034: 350 MHz, 4 channels (1326.2000.34 and 1317.2500.34)
- R&S®RTE1052: 500 MHz, 2 channels (1326.2000.52 and 1317.2500.52)
- R&S®RTE1054: 500 MHz, 4 channels (1326.2000.54 and 1317.2500.54)
- R&S®RTE1102: 1 GHz, 2 channels (1326.2000.62 and 1317.2500.02)
- R&S®RTE1104: 1 GHz, 4 channels (1326.2000.64 and 1317.2500.04)
- R&S®RTE1152: 1,5 GHz, 2 channels (1326.2000.72)
- R&S®RTE1154: 1,5 GHz, 4 channels (1326.2000.74)
- R&S®RTE1202: 2 GHz, 2 channels (1326.2000.82)
- R&S®RTE1204: 2 GHz, 4 channels (1326.2000.84)

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Throughout this manual, products from Rohde & Schwarz are indicated without the ® symbol , e.g. R&S®RTE is indicated as R&S RTE.

Basic Safety Instructions

Always read through and comply with the following safety instructions!

All plants and locations of the Rohde & Schwarz group of companies make every effort to keep the safety standards of our products up to date and to offer our customers the highest possible degree of safety. Our products and the auxiliary equipment they require are designed, built and tested in accordance with the safety standards that apply in each case. Compliance with these standards is continuously monitored by our quality assurance system. The product described here has been designed, built and tested in accordance with the EC Certificate of Conformity and has left the manufacturer’s plant in a condition fully complying with safety standards. To maintain this condition and to ensure safe operation, you must observe all instructions and warnings provided in this manual. If you have any questions regarding these safety instructions, the Rohde & Schwarz group of companies will be happy to answer them.

Furthermore, it is your responsibility to use the product in an appropriate manner. This product is designed for use solely in industrial and laboratory environments or, if expressly permitted, also in the field and must not be used in any way that may cause personal injury or property damage. You are responsible if the product is used for any purpose other than its designated purpose or in disregard of the manufacturer's instructions. The manufacturer shall assume no responsibility for such use of the product.

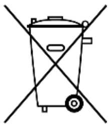
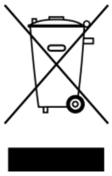
The product is used for its designated purpose if it is used in accordance with its product documentation and within its performance limits (see data sheet, documentation, the following safety instructions). Using the product requires technical skills and, in some cases, a basic knowledge of English. It is therefore essential that only skilled and specialized staff or thoroughly trained personnel with the required skills be allowed to use the product. If personal safety gear is required for using Rohde & Schwarz products, this will be indicated at the appropriate place in the product documentation. Keep the basic safety instructions and the product documentation in a safe place and pass them on to the subsequent users.

Observing the safety instructions will help prevent personal injury or damage of any kind caused by dangerous situations. Therefore, carefully read through and adhere to the following safety instructions before and when using the product. It is also absolutely essential to observe the additional safety instructions on personal safety, for example, that appear in relevant parts of the product documentation. In these safety instructions, the word "product" refers to all merchandise sold and distributed by the Rohde & Schwarz group of companies, including instruments, systems and all accessories. For product-specific information, see the data sheet and the product documentation.

Safety labels on products

The following safety labels are used on products to warn against risks and dangers.

Symbol	Meaning	Symbol	Meaning
	Notice, general danger location Observe product documentation		ON/OFF Power
	Caution when handling heavy equipment		Standby indication
	Danger of electric shock		Direct current (DC)

Symbol	Meaning	Symbol	Meaning
	Caution ! Hot surface		Alternating current (AC)
	Protective conductor terminal To identify any terminal which is intended for connection to an external conductor for protection against electric shock in case of a fault, or the terminal of a protective earth		Direct/alternating current (DC/AC)
	Earth (Ground)		Class II Equipment to identify equipment meeting the safety requirements specified for Class II equipment (device protected by double or reinforced insulation)
	Frame or chassis Ground terminal		EU labeling for batteries and accumulators For additional information, see section "Waste disposal/Environmental protection", item 1.
	Be careful when handling electrostatic sensitive devices		EU labeling for separate collection of electrical and electronic devices For additional information, see section "Waste disposal/Environmental protection", item 2.
	Warning! Laser radiation For additional information, see section "Operation", item 7.		

Signal words and their meaning

The following signal words are used in the product documentation in order to warn the reader about risks and dangers.

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

Indicates information considered important, but not hazard-related, e.g. messages relating to property damage.
In the product documentation, the word ATTENTION is used synonymously.

These signal words are in accordance with the standard definition for civil applications in the European Economic Area. Definitions that deviate from the standard definition may also exist in other economic areas or military applications. It is therefore essential to make sure that the signal words described here are always used only in connection with the related product documentation and the related product. The use of signal words in connection with unrelated products or documentation can result in misinterpretation and in personal injury or material damage.

Operating states and operating positions

The product may be operated only under the operating conditions and in the positions specified by the manufacturer, without the product's ventilation being obstructed. If the manufacturer's specifications are not observed, this can result in electric shock, fire and/or serious personal injury or death. Applicable local or national safety regulations and rules for the prevention of accidents must be observed in all work performed.

1. Unless otherwise specified, the following requirements apply to Rohde & Schwarz products: predefined operating position is always with the housing floor facing down, IP protection 2X, use only indoors, max. operating altitude 2000 m above sea level, max. transport altitude 4500 m above sea level. A tolerance of ±10 % shall apply to the nominal voltage and ±5 % to the nominal frequency, overvoltage category 2, pollution degree 2.
2. Do not place the product on surfaces, vehicles, cabinets or tables that for reasons of weight or stability are unsuitable for this purpose. Always follow the manufacturer's installation instructions when installing the product and fastening it to objects or structures (e.g. walls and shelves). An installation that is not carried out as described in the product documentation could result in personal injury or even death.
3. Do not place the product on heat-generating devices such as radiators or fan heaters. The ambient temperature must not exceed the maximum temperature specified in the product documentation or in the data sheet. Product overheating can cause electric shock, fire and/or serious personal injury or even death.

Electrical safety

If the information on electrical safety is not observed either at all or to the extent necessary, electric shock, fire and/or serious personal injury or death may occur.

1. Prior to switching on the product, always ensure that the nominal voltage setting on the product matches the nominal voltage of the mains-supply network. If a different voltage is to be set, the power fuse of the product may have to be changed accordingly.
2. In the case of products of safety class I with movable power cord and connector, operation is permitted only on sockets with a protective conductor contact and protective conductor.
3. Intentionally breaking the protective conductor either in the feed line or in the product itself is not permitted. Doing so can result in the danger of an electric shock from the product. If extension cords or connector strips are implemented, they must be checked on a regular basis to ensure that they are safe to use.
4. If there is no power switch for disconnecting the product from the mains, or if the power switch is not suitable for this purpose, use the plug of the connecting cable to disconnect the product from the mains. In such cases, always ensure that the power plug is easily reachable and accessible at all times. For example, if the power plug is the disconnecting device, the length of the connecting cable must not exceed 3 m. Functional or electronic switches are not suitable for providing disconnection from the AC supply network. If products without power switches are integrated into racks or systems, the disconnecting device must be provided at the system level.
5. Never use the product if the power cable is damaged. Check the power cables on a regular basis to ensure that they are in proper operating condition. By taking appropriate safety measures and carefully laying the power cable, ensure that the cable cannot be damaged and that no one can be hurt by, for example, tripping over the cable or suffering an electric shock.

6. The product may be operated only from TN/TT supply networks fuse-protected with max. 16 A (higher fuse only after consulting with the Rohde & Schwarz group of companies).
7. Do not insert the plug into sockets that are dusty or dirty. Insert the plug firmly and all the way into the socket provided for this purpose. Otherwise, sparks that result in fire and/or injuries may occur.
8. Do not overload any sockets, extension cords or connector strips; doing so can cause fire or electric shocks.
9. For measurements in circuits with voltages V_{rms} > 30 V, suitable measures (e.g. appropriate measuring equipment, fuse protection, current limiting, electrical separation, insulation) should be taken to avoid any hazards.
10. Ensure that the connections with information technology equipment, e.g. PCs or other industrial computers, comply with the IEC 60950-1 / EN 60950-1 or IEC 61010-1 / EN 61010-1 standards that apply in each case.
11. Unless expressly permitted, never remove the cover or any part of the housing while the product is in operation. Doing so will expose circuits and components and can lead to injuries, fire or damage to the product.
12. If a product is to be permanently installed, the connection between the protective conductor terminal on site and the product's protective conductor must be made first before any other connection is made. The product may be installed and connected only by a licensed electrician.
13. For permanently installed equipment without built-in fuses, circuit breakers or similar protective devices, the supply circuit must be fuse-protected in such a way that anyone who has access to the product, as well as the product itself, is adequately protected from injury or damage.
14. Use suitable overvoltage protection to ensure that no overvoltage (such as that caused by a bolt of lightning) can reach the product. Otherwise, the person operating the product will be exposed to the danger of an electric shock.
15. Any object that is not designed to be placed in the openings of the housing must not be used for this purpose. Doing so can cause short circuits inside the product and/or electric shocks, fire or injuries.
16. Unless specified otherwise, products are not liquid-proof (see also section "Operating states and operating positions", item 1). Therefore, the equipment must be protected against penetration by liquids. If the necessary precautions are not taken, the user may suffer electric shock or the product itself may be damaged, which can also lead to personal injury.
17. Never use the product under conditions in which condensation has formed or can form in or on the product, e.g. if the product has been moved from a cold to a warm environment. Penetration by water increases the risk of electric shock.
18. Prior to cleaning the product, disconnect it completely from the power supply (e.g. AC supply network or battery). Use a soft, non-linting cloth to clean the product. Never use chemical cleaning agents such as alcohol, acetone or diluents for cellulose lacquers.

Operation

1. Operating the products requires special training and intense concentration. Make sure that persons who use the products are physically, mentally and emotionally fit enough to do so; otherwise, injuries or material damage may occur. It is the responsibility of the employer/operator to select suitable personnel for operating the products.

2. Before you move or transport the product, read and observe the section titled "Transport".
3. As with all industrially manufactured goods, the use of substances that induce an allergic reaction (allergens) such as nickel cannot be generally excluded. If you develop an allergic reaction (such as a skin rash, frequent sneezing, red eyes or respiratory difficulties) when using a Rohde & Schwarz product, consult a physician immediately to determine the cause and to prevent health problems or stress.
4. Before you start processing the product mechanically and/or thermally, or before you take it apart, be sure to read and pay special attention to the section titled "Waste disposal/Environmental protection", item 1.
5. Depending on the function, certain products such as RF radio equipment can produce an elevated level of electromagnetic radiation. Considering that unborn babies require increased protection, pregnant women must be protected by appropriate measures. Persons with pacemakers may also be exposed to risks from electromagnetic radiation. The employer/operator must evaluate workplaces where there is a special risk of exposure to radiation and, if necessary, take measures to avert the potential danger.
6. Should a fire occur, the product may release hazardous substances (gases, fluids, etc.) that can cause health problems. Therefore, suitable measures must be taken, e.g. protective masks and protective clothing must be worn.
7. Laser products are given warning labels that are standardized according to their laser class. Lasers can cause biological harm due to the properties of their radiation and due to their extremely concentrated electromagnetic power. If a laser product (e.g. a CD/DVD drive) is integrated into a Rohde & Schwarz product, absolutely no other settings or functions may be used as described in the product documentation. The objective is to prevent personal injury (e.g. due to laser beams).
8. EMC classes (in line with EN 55011/CISPR 11, and analogously with EN 55022/CISPR 22, EN 55032/CISPR 32)
   - Class A equipment:
     Equipment suitable for use in all environments except residential environments and environments that are directly connected to a low-voltage supply network that supplies residential buildings
     Note: Class A equipment is intended for use in an industrial environment. This equipment may cause radio disturbances in residential environments, due to possible conducted as well as radiated disturbances. In this case, the operator may be required to take appropriate measures to eliminate these disturbances.
   - Class B equipment:
     Equipment suitable for use in residential environments and environments that are directly connected to a low-voltage supply network that supplies residential buildings

Repair and service

1. The product may be opened only by authorized, specially trained personnel. Before any work is performed on the product or before the product is opened, it must be disconnected from the AC supply network. Otherwise, personnel will be exposed to the risk of an electric shock.

2. Adjustments, replacement of parts, maintenance and repair may be performed only by electrical experts authorized by Rohde & Schwarz. Only original parts may be used for replacing parts relevant to safety (e.g. power switches, power transformers, fuses). A safety test must always be performed after parts relevant to safety have been replaced (visual inspection, protective conductor test, insulation resistance measurement, leakage current measurement, functional test). This helps ensure the continued safety of the product.

Batteries and rechargeable batteries/cells

If the information regarding batteries and rechargeable batteries/cells is not observed either at all or to the extent necessary, product users may be exposed to the risk of explosions, fire and/or serious personal injury, and, in some cases, death. Batteries and rechargeable batteries with alkaline electrolytes (e.g. lithium cells) must be handled in accordance with the EN 62133 standard.

1. Cells must not be taken apart or crushed.
2. Cells or batteries must not be exposed to heat or fire. Storage in direct sunlight must be avoided. Keep cells and batteries clean and dry. Clean soiled connectors using a dry, clean cloth.
3. Cells or batteries must not be short-circuited. Cells or batteries must not be stored in a box or in a drawer where they can short-circuit each other, or where they can be short-circuited by other conductive materials. Cells and batteries must not be removed from their original packaging until they are ready to be used.
4. Cells and batteries must not be exposed to any mechanical shocks that are stronger than permitted.
5. If a cell develops a leak, the fluid must not be allowed to come into contact with the skin or eyes. If contact occurs, wash the affected area with plenty of water and seek medical aid.
6. Improperly replacing or charging cells or batteries that contain alkaline electrolytes (e.g. lithium cells) can cause explosions. Replace cells or batteries only with the matching Rohde & Schwarz type (see parts list) in order to ensure the safety of the product.
7. Cells and batteries must be recycled and kept separate from residual waste. Rechargeable batteries and normal batteries that contain lead, mercury or cadmium are hazardous waste. Observe the national regulations regarding waste disposal and recycling.

Transport

1. The product may be very heavy. Therefore, the product must be handled with care. In some cases, the user may require a suitable means of lifting or moving the product (e.g. with a lift-truck) to avoid back or other physical injuries.
2. Handles on the products are designed exclusively to enable personnel to transport the product. It is therefore not permissible to use handles to fasten the product to or on transport equipment such as cranes, fork lifts, wagons, etc. The user is responsible for securely fastening the products to or on the means of transport or lifting. Observe the safety regulations of the manufacturer of the means of transport or lifting. Noncompliance can result in personal injury or material damage.
3. If you use the product in a vehicle, it is the sole responsibility of the driver to drive the vehicle safely and properly. The manufacturer assumes no responsibility for accidents or collisions. Never use the product in a moving vehicle if doing so could distract the driver of the vehicle. Adequately secure the product in the vehicle to prevent injuries or other damage in the event of an accident.

Waste disposal/Environmental protection

1. Specially marked equipment has a battery or accumulator that must not be disposed of with unsorted municipal waste, but must be collected separately. It may only be disposed of at a suitable collection point or via a Rohde & Schwarz customer service center.
2. Waste electrical and electronic equipment must not be disposed of with unsorted municipal waste, but must be collected separately.
   Rohde & Schwarz GmbH & Co. KG has developed a disposal concept and takes full responsibility for take-back obligations and disposal obligations for manufacturers within the EU. Contact your Rohde & Schwarz customer service center for environmentally responsible disposal of the product.
3. If products or their components are mechanically and/or thermally processed in a manner that goes beyond their intended use, hazardous substances (heavy-metal dust such as lead, beryllium, nickel) may be released. For this reason, the product may only be disassembled by specially trained personnel. Improper disassembly may be hazardous to your health. National waste disposal regulations must be observed.
4. If handling the product releases hazardous substances or fuels that must be disposed of in a special way, e.g. coolants or engine oils that must be replenished regularly, the safety instructions of the manufacturer of the hazardous substances or fuels and the applicable regional waste disposal regulations must be observed. Also observe the relevant safety instructions in the product documentation. The improper disposal of hazardous substances or fuels can cause health problems and lead to environmental damage.

For additional information about environmental protection, visit the Rohde & Schwarz website.

Instrucciones de seguridad elementales

¡Es imprescindible leer y cumplir las siguientes instrucciones e informaciones de seguridad!

El principio del grupo de empresas Rohde & Schwarz consiste en tener nuestros productos siempre al día con los estándares de seguridad y de ofrecer a nuestros clientes el máximo grado de seguridad. Nuestros productos y todos los equipos adicionales son siempre fabricados y examinados según las normas de seguridad vigentes. Nuestro sistema de garantía de calidad controla constantemente que sean cumplidas estas normas. El presente producto ha sido fabricado y examinado según el certificado de conformidad de la UE y ha salido de nuestra planta en estado impecable según los estándares técnicos de seguridad. Para poder preservar este estado y garantizar un funcionamiento libre de peligros, el usuario deberá atenerse a todas las indicaciones, informaciones de seguridad y notas de alerta. El grupo de empresas Rohde & Schwarz está siempre a su disposición en caso de que tengan preguntas referentes a estas informaciones de seguridad.

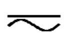
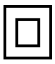
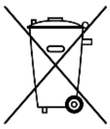
Además queda en la responsabilidad del usuario utilizar el producto en la forma debida. Este producto está destinado exclusivamente al uso en la industria y el laboratorio o, si ha sido expresamente autorizado, para aplicaciones de campo y de ninguna manera deberá ser utilizado de modo que alguna persona/cosa pueda sufrir daño. El uso del producto fuera de sus fines definidos o sin tener en cuenta las instrucciones del fabricante queda en la responsabilidad del usuario. El fabricante no se hace en ninguna forma responsable de consecuencias a causa del mal uso del producto.

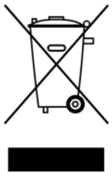
Se parte del uso correcto del producto para los fines definidos si el producto es utilizado conforme a las indicaciones de la correspondiente documentación del producto y dentro del margen de rendimiento definido (ver hoja de datos, documentación, informaciones de seguridad que siguen). El uso del producto hace necesarios conocimientos técnicos y ciertos conocimientos del idioma inglés. Por eso se debe tener en cuenta que el producto solo pueda ser operado por personal especializado o personas instruidas en profundidad con las capacidades correspondientes. Si fuera necesaria indumentaria de seguridad para el uso de productos de Rohde & Schwarz, encontraría la información debida en la documentación del producto en el capítulo correspondiente. Guarde bien las informaciones de seguridad elementales, así como la documentación del producto, y entréguelas a usuarios posteriores.

Tener en cuenta las informaciones de seguridad sirve para evitar en lo posible lesiones o daños por peligros de toda clase. Por eso es imprescindible leer detalladamente y comprender por completo las siguientes informaciones de seguridad antes de usar el producto, y respetarlas durante el uso del producto. Deberán tenerse en cuenta todas las demás informaciones de seguridad, como p. ej. las referentes a la protección de personas, que encontrarán en el capítulo correspondiente de la documentación del producto y que también son de obligado cumplimiento. En las presentes informaciones de seguridad se recogen todos los objetos que distribuye el grupo de empresas Rohde & Schwarz bajo la denominación de "producto", entre ellos también aparatos, instalaciones así como toda clase de accesorios. Los datos específicos del producto figuran en la hoja de datos y en la documentación del producto.

Señalización de seguridad de los productos

Las siguientes señales de seguridad se utilizan en los productos para advertir sobre riesgos y peligros.

Símbolo	Significado	Símbolo	Significado
	Aviso: punto de peligro general Observar la documentación del producto		Tensión de alimentación de PUESTA EN MARCHA / PARADA
	Atención en el manejo de dispositivos de peso elevado		Indicación de estado de espera (standby)
	Peligro de choque eléctrico		Corriente continua (DC)
	Advertencia: superficie caliente		Corriente alterna (AC)
	Conexión a conductor de protección		Corriente continua / Corriente alterna (DC/AC)
	Conexión a tierra		El aparato está protegido en su totalidad por un aislamiento doble (reforzado)
	Conexión a masa		Distintivo de la UE para baterías y acumuladores Más información en la sección "Eliminación/protección del medio ambiente", punto 1.

Símbolo	Significado	Símbolo	Significado
	Aviso: Cuidado en el manejo de dispositivos sensibles a la electrostática (ESD)		Distintivo de la UE para la eliminación por separado de dispositivos eléctricos y electrónicos Más información en la sección "Eliminación/protección del medio ambiente", punto 2.
	Advertencia: rayo láser Más información en la sección "Funcionamiento", punto 7.		

Palabras de señal y su significado

En la documentación del producto se utilizan las siguientes palabras de señal con el fin de advertir contra riesgos y peligros.

PELIGRO	Indica una situación de peligro que, si no se evita, causa lesiones graves o incluso la muerte.
ADVERTENCIA	Indica una situación de peligro que, si no se evita, puede causar lesiones graves o incluso la muerte.
ATENCIÓN	Indica una situación de peligro que, si no se evita, puede causar lesiones leves o moderadas.
AVISO	Indica información que se considera importante, pero no en relación con situaciones de peligro; p. ej., avisos sobre posibles daños materiales. En la documentación del producto se emplea de forma sinónima el término CUIDADO.

Las palabras de señal corresponden a la definición habitual para aplicaciones civiles en el área económica europea. Pueden existir definiciones diferentes a esta definición en otras áreas económicas o en aplicaciones militares. Por eso se deberá tener en cuenta que las palabras de señal aquí descritas sean utilizadas siempre solamente en combinación con la correspondiente documentación del producto y solamente en combinación con el producto correspondiente. La utilización de las palabras de señal en combinación con productos o documentaciones que no les correspondan puede llevar a interpretaciones equivocadas y tener por consecuencia daños en personas u objetos.

Estados operativos y posiciones de funcionamiento

El producto solamente debe ser utilizado según lo indicado por el fabricante respecto a los estados operativos y posiciones de funcionamiento sin que se obstruya la ventilación. Si no se siguen las indicaciones del fabricante, pueden producirse choques eléctricos, incendios y/o lesiones graves con posible consecuencia de muerte. En todos los trabajos deberán ser tenidas en cuenta las normas nacionales y locales de seguridad del trabajo y de prevención de accidentes.

1. Si no se convino de otra manera, es para los productos Rohde & Schwarz válido lo que sigue: como posición de funcionamiento se define por principio la posición con el suelo de la caja para abajo, modo de protección IP 2X, uso solamente en estancias interiores, utilización hasta 2000 m sobre el nivel del mar, transporte hasta 4500 m sobre el nivel del mar. Se aplicará una tolerancia de ±10 % sobre el voltaje nominal y de ±5 % sobre la frecuencia nominal. Categoría de sobrecarga eléctrica 2, índice de suciedad 2.
2. No sitúe el producto encima de superficies, vehículos, estantes o mesas, que por sus características de peso o de estabilidad no sean aptos para él. Siga siempre las instrucciones de instalación del fabricante cuando instale y asegure el producto en objetos o estructuras (p. ej. paredes y estantes). Si se realiza la instalación de modo distinto al indicado en la documentación del producto, se pueden causar lesiones o, en determinadas circunstancias, incluso la muerte.
3. No ponga el producto sobre aparatos que generen calor (p. ej. radiadores o calefactores). La temperatura ambiente no debe superar la temperatura máxima especificada en la documentación del producto o en la hoja de datos. En caso de sobrecalentamiento del producto, pueden producirse choques eléctricos, incendios y/o lesiones graves con posible consecuencia de muerte.

Seguridad eléctrica

Si no se siguen (o se siguen de modo insuficiente) las indicaciones del fabricante en cuanto a seguridad eléctrica, pueden producirse choques eléctricos, incendios y/o lesiones graves con posible consecuencia de muerte.

1. Antes de la puesta en marcha del producto se deberá comprobar siempre que la tensión preseleccionada en el producto coincida con la de la red de alimentación eléctrica. Si es necesario modificar el ajuste de tensión, también se deberán cambiar en caso dado los fusibles correspondientes del producto.
2. Los productos de la clase de protección I con alimentación móvil y enchufe individual solamente podrán enchufarse a tomas de corriente con contacto de seguridad y con conductor de protección conectado.
3. Queda prohibida la interrupción intencionada del conductor de protección, tanto en la toma de corriente como en el mismo producto. La interrupción puede tener como consecuencia el riesgo de que el producto sea fuente de choques eléctricos. Si se utilizan cables alargadores o regletas de enchufe, deberá garantizarse la realización de un examen regular de los mismos en cuanto a su estado técnico de seguridad.
4. Si el producto no está equipado con un interruptor para desconectarlo de la red, o bien si el interruptor existente no resulta apropiado para la desconexión de la red, el enchufe del cable de conexión se deberá considerar como un dispositivo de desconexión.
   El dispositivo de desconexión se debe poder alcanzar fácilmente y debe estar siempre bien accesible. Si, p. ej., el enchufe de conexión a la red es el dispositivo de desconexión, la longitud del cable de conexión no debe superar 3 m).
   Los interruptores selectores o electrónicos no son aptos para el corte de la red eléctrica. Si se integran productos sin interruptor en bastidores o instalaciones, se deberá colocar el interruptor en el nivel de la instalación.
5. No utilice nunca el producto si está dañado el cable de conexión a red. Compruebe regularmente el correcto estado de los cables de conexión a red. Asegúrese, mediante las medidas de protección y de instalación adecuadas, de que el cable de conexión a red no pueda ser dañado o de que nadie pueda ser dañado por él, p. ej. al tropezar o por un choque eléctrico.

6. Solamente está permitido el funcionamiento en redes de alimentación TN/TT aseguradas con fusibles de 16 A como máximo (utilización de fusibles de mayor amperaje solo previa consulta con el grupo de empresas Rohde & Schwarz).
7. Nunca conecte el enchufe en tomas de corriente sucias o llenas de polvo. Introduzca el enchufe por completo y fuertemente en la toma de corriente. La no observación de estas medidas puede provocar chispas, fuego y/o lesiones.
8. No sobrecargue las tomas de corriente, los cables alargadores o las regletas de enchufe ya que esto podría causar fuego o choques eléctricos.
9. En las mediciones en circuitos de corriente con una tensión U_{eff} > 30 V se deberán tomar las medidas apropiadas para impedir cualquier peligro (p. ej. medios de medición adecuados, seguros, limitación de tensión, corte protector, aislamiento etc.).
10. Para la conexión con dispositivos informáticos como un PC o un ordenador industrial, debe comprobarse que éstos cumplan los estándares IEC60950-1/EN60950-1 o IEC61010-1/EN 61010-1 válidos en cada caso.
11. A menos que esté permitido expresamente, no retire nunca la tapa ni componentes de la carcasa mientras el producto esté en servicio. Esto pone a descubierto los cables y componentes eléctricos y puede causar lesiones, fuego o daños en el producto.
12. Si un producto se instala en un lugar fijo, se deberá primero conectar el conductor de protección fijo con el conductor de protección del producto antes de hacer cualquier otra conexión. La instalación y la conexión deberán ser efectuadas por un electricista especializado.
13. En el caso de dispositivos fijos que no estén provistos de fusibles, interruptor automático ni otros mecanismos de seguridad similares, el circuito de alimentación debe estar protegido de modo que todas las personas que puedan acceder al producto, así como el producto mismo, estén a salvo de posibles daños.
14. Todo producto debe estar protegido contra sobretensión (debida p. ej. a una caída del rayo) mediante los correspondientes sistemas de protección. Si no, el personal que lo utilice quedará expuesto al peligro de choque eléctrico.
15. No debe introducirse en los orificios de la caja del aparato ningún objeto que no esté destinado a ello. Esto puede producir cortocircuitos en el producto y/o puede causar choques eléctricos, fuego o lesiones.
16. Salvo indicación contraria, los productos no están impermeabilizados (ver también el capítulo "Estados operativos y posiciones de funcionamiento", punto 1). Por eso es necesario tomar las medidas necesarias para evitar la entrada de líquidos. En caso contrario, existe peligro de choque eléctrico para el usuario o de daños en el producto, que también pueden redundar en peligro para las personas.
17. No utilice el producto en condiciones en las que pueda producirse o ya se hayan producido condensaciones sobre el producto o en el interior de éste, como p. ej. al desplazarlo de un lugar frío a otro caliente. La entrada de agua aumenta el riesgo de choque eléctrico.
18. Antes de la limpieza, desconecte por completo el producto de la alimentación de tensión (p. ej. red de alimentación o batería). Realice la limpieza de los aparatos con un paño suave, que no se deshilache. No utilice bajo ningún concepto productos de limpieza químicos como alcohol, acetona o diluyentes para lacas nitrocelulósicas.

Funcionamiento

1. El uso del producto requiere instrucciones especiales y una alta concentración durante el manejo. Debe asegurarse que las personas que manejen el producto estén a la altura de los requerimientos necesarios en cuanto a aptitudes físicas, psíquicas y emocionales, ya que de otra manera no se pueden excluir lesiones o daños de objetos. El empresario u operador es responsable de seleccionar el personal usuario apto para el manejo del producto.
2. Antes de desplazar o transportar el producto, lea y tenga en cuenta el capítulo "Transporte".
3. Como con todo producto de fabricación industrial no puede quedar excluida en general la posibilidad de que se produzcan alergias provocadas por algunos materiales empleados —los llamados alérgenos (p. ej. el níquel)—. Si durante el manejo de productos Rohde & Schwarz se producen reacciones alérgicas, como p. ej. irritaciones cutáneas, estornudos continuos, enrojecimiento de la conjuntiva o dificultades respiratorias, debe avisarse inmediatamente a un médico para investigar las causas y evitar cualquier molestia o daño a la salud.
4. Antes de la manipulación mecánica y/o térmica o el desmontaje del producto, debe tenerse en cuenta imprescindiblemente el capítulo "Eliminación/protección del medio ambiente", punto 1.
5. Ciertos productos, como p. ej. las instalaciones de radiocomunicación RF, pueden a causa de su función natural, emitir una radiación electromagnética aumentada. Deben tomarse todas las medidas necesarias para la protección de las mujeres embarazadas. También las personas con marcapasos pueden correr peligro a causa de la radiación electromagnética. El empresario/operador tiene la obligación de evaluar y señalizar las áreas de trabajo en las que exista un riesgo elevado de exposición a radiaciones.
6. Tenga en cuenta que en caso de incendio pueden desprenderse del producto sustancias tóxicas (gases, líquidos etc.) que pueden generar daños a la salud. Por eso, en caso de incendio deben usarse medidas adecuadas, como p. ej. máscaras antigás e indumentaria de protección.
7. Los productos con láser están provistos de indicaciones de advertencia normalizadas en función de la clase de láser del que se trate. Los rayos láser pueden provocar daños de tipo biológico a causa de las propiedades de su radiación y debido a su concentración extrema de potencia electromagnética. En caso de que un producto Rohde & Schwarz contenga un producto láser (p. ej. un lector de CD/DVD), no debe usarse ninguna otra configuración o función aparte de las descritas en la documentación del producto, a fin de evitar lesiones (p. ej. debidas a irradiación láser).
8. Clases de compatibilidad electromagnética (conforme a EN 55011 / CISPR 11; y en analogía con EN 55022 / CISPR 22, EN 55032 / CISPR 32)
   - Aparato de clase A:
     Aparato adecuado para su uso en todos los entornos excepto en los residenciales y en aquellos conectados directamente a una red de distribución de baja tensión que suministra corriente a edificios residenciales.
     Nota: Los aparatos de clase A están destinados al uso en entornos industriales. Estos aparatos pueden causar perturbaciones radioeléctricas en entornos residenciales debido a posibles perturbaciones guiadas o radiadas. En este caso, se le podrá solicitar al operador que tome las medidas adecuadas para eliminar estas perturbaciones.
   - Aparato de clase B:
     Aparato adecuado para su uso en entornos residenciales, así como en aquellos conectados directamente a una red de distribución de baja tensión que suministra corriente a edificios residenciales.

Reparación y mantenimiento

1. El producto solamente debe ser abierto por personal especializado con autorización para ello. Antes de manipular el producto o abrirlo, es obligatorio desconectarlo de la tensión de alimentación, para evitar toda posibilidad de choque eléctrico.
2. El ajuste, el cambio de partes, el mantenimiento y la reparación deberán ser efectuadas solamente por electricistas autorizados por Rohde & Schwarz. Si se reponen partes con importancia para los aspectos de seguridad (p. ej. el enchufe, los transformadores o los fusibles), solamente podrán ser sustituidos por partes originales. Después de cada cambio de partes relevantes para la seguridad deberá realizarse un control de seguridad (control a primera vista, control del conductor de protección, medición de resistencia de aislamiento, medición de la corriente de fuga, control de funcionamiento). Con esto queda garantizada la seguridad del producto.

Baterías y acumuladores o celdas

Si no se siguen (o se siguen de modo insuficiente) las indicaciones en cuanto a las baterías y acumuladores o celdas, pueden producirse explosiones, incendios y/o lesiones graves con posible consecuencia de muerte. El manejo de baterías y acumuladores con electrolitos alcalinos (p. ej. celdas de litio) debe seguir el estándar EN 62133.

1. No deben desmontarse, abrirse ni triturarse las celdas.
2. Las celdas o baterías no deben someterse a calor ni fuego. Debe evitarse el almacenamiento a la luz directa del sol. Las celdas y baterías deben mantenerse limpias y secas. Limpiar las conexiones sucias con un paño seco y limpio.
3. Las celdas o baterías no deben cortocircuitarse. Es peligroso almacenar las celdas o baterías en estuches o cajones en cuyo interior puedan cortocircuitarse por contacto recíproco o por contacto con otros materiales conductores. No deben extraerse las celdas o baterías de sus embalajes originales hasta el momento en que vayan a utilizarse.
4. Las celdas o baterías no deben someterse a impactos mecánicos fuertes indebidos.
5. En caso de falta de estanqueidad de una celda, el líquido vertido no debe entrar en contacto con la piel ni los ojos. Si se produce contacto, lavar con agua abundante la zona afectada y avisar a un médico.
6. En caso de cambio o recarga inadecuados, las celdas o baterías que contienen electrolitos alcalinos (p. ej. las celdas de litio) pueden explotar. Para garantizar la seguridad del producto, las celdas o baterías solo deben ser sustituidas por el tipo Rohde & Schwarz correspondiente (ver lista de recambios).
7. Las baterías y celdas deben reciclarse y no deben tirarse a la basura doméstica. Las baterías o acumuladores que contienen plomo, mercurio o cadmio deben tratarse como residuos especiales. Respete en esta relación las normas nacionales de eliminación y reciclaje.

Transporte

1. El producto puede tener un peso elevado. Por eso es necesario desplazarlo o transportarlo con precaución y, si es necesario, usando un sistema de elevación adecuado (p. ej. una carretilla elevadora), a fin de evitar lesiones en la espalda u otros daños personales.

2. Las asas instaladas en los productos sirven solamente de ayuda para el transporte del producto por personas. Por eso no está permitido utilizar las asas para la sujeción en o sobre medios de transporte como p. ej. grúas, carretillas elevadoras de horquilla, carros etc. Es responsabilidad suya fijar los productos de manera segura a los medios de transporte o elevación. Para evitar daños personales o daños en el producto, siga las instrucciones de seguridad del fabricante del medio de transporte o elevación utilizado.
3. Si se utiliza el producto dentro de un vehículo, recae de manera exclusiva en el conductor la responsabilidad de conducir el vehículo de manera segura y adecuada. El fabricante no asumirá ninguna responsabilidad por accidentes o colisiones. No utilice nunca el producto dentro de un vehículo en movimiento si esto pudiera distraer al conductor. Asegure el producto dentro del vehículo debidamente para evitar, en caso de un accidente, lesiones u otra clase de daños.

Eliminación/protección del medio ambiente

1. Los dispositivos marcados contienen una batería o un acumulador que no se debe desechar con los residuos domésticos sin clasificar, sino que debe ser recogido por separado. La eliminación se debe efectuar exclusivamente a través de un punto de recogida apropiado o del servicio de atención al cliente de Rohde & Schwarz.
2. Los dispositivos eléctricos usados no se deben desechar con los residuos domésticos sin clasificar, sino que deben ser recogidos por separado.
   Rohde & Schwarz GmbH & Co.KG ha elaborado un concepto de eliminación de residuos y asume plenamente los deberes de recogida y eliminación para los fabricantes dentro de la UE. Para desechar el producto de manera respetuosa con el medio ambiente, diríjase a su servicio de atención al cliente de Rohde & Schwarz.
3. Si se trabaja de manera mecánica y/o térmica cualquier producto o componente más allá del funcionamiento previsto, pueden liberarse sustancias peligrosas (polvos con contenido de metales pesados como p. ej. plomo, berilio o níquel). Por eso el producto solo debe ser desmontado por personal especializado con formación adecuada. Un desmontaje inadecuado puede ocasionar daños para la salud. Se deben tener en cuenta las directivas nacionales referentes a la eliminación de residuos.
4. En caso de que durante el trato del producto se formen sustancias peligrosas o combustibles que deban tratarse como residuos especiales (p. ej. refrigerantes o aceites de motor con intervalos de cambio definidos), deben tenerse en cuenta las indicaciones de seguridad del fabricante de dichas sustancias y las normas regionales de eliminación de residuos. Tenga en cuenta también en caso necesario las indicaciones de seguridad especiales contenidas en la documentación del producto. La eliminación incorrecta de sustancias peligrosas o combustibles puede causar daños a la salud o daños al medio ambiente.

Se puede encontrar más información sobre la protección del medio ambiente en la página web de Rohde & Schwarz.

Grundlegende Sicherheitshinweise

Lesen und beachten Sie unbedingt die nachfolgenden Anweisungen und Sicherheitshinweise!

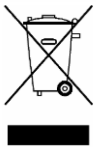
Alle Werke und Standorte der Rohde & Schwarz Firmengruppe sind ständig bemüht, den Sicherheitsstandard unserer Produkte auf dem aktuellsten Stand zu halten und unseren Kunden ein höchstmögliches Maß an Sicherheit zu bieten. Unsere Produkte und die dafür erforderlichen Zusatzgeräte werden entsprechend der jeweils gültigen Sicherheitsvorschriften gebaut und geprüft. Die Einhaltung dieser Bestimmungen wird durch unser Qualitätssicherungssystem laufend überwacht. Das vorliegende Produkt ist gemäß beiliegender EU-Konformitätsbescheinigung gebaut und geprüft und hat das Werk in sicherheitstechnisch einwandfreiem Zustand verlassen. Um diesen Zustand zu erhalten und einen gefahrlosen Betrieb sicherzustellen, muss der Benutzer alle Hinweise, Warnhinweise und Warnvermerke beachten. Bei allen Fragen bezüglich vorliegender Sicherheitshinweise steht Ihnen die Rohde & Schwarz Firmengruppe jederzeit gerne zur Verfügung.

Darüber hinaus liegt es in der Verantwortung des Benutzers, das Produkt in geeigneter Weise zu verwenden. Das Produkt ist ausschließlich für den Betrieb in Industrie und Labor bzw., wenn ausdrücklich zugelassen, auch für den Feldeinsatz bestimmt und darf in keiner Weise so verwendet werden, dass einer Person/Sache Schaden zugefügt werden kann. Die Benutzung des Produkts außerhalb des bestimmungsgemäßen Gebrauchs oder unter Missachtung der Anweisungen des Herstellers liegt in der Verantwortung des Benutzers. Der Hersteller übernimmt keine Verantwortung für die Zweckentfremdung des Produkts.

Die bestimmungsgemäße Verwendung des Produkts wird angenommen, wenn das Produkt nach den Vorgaben der zugehörigen Produktdokumentation innerhalb seiner Leistungsgrenzen verwendet wird (siehe Datenblatt, Dokumentation, nachfolgende Sicherheitshinweise). Die Benutzung des Produkts erfordert Fachkenntnisse und zum Teil englische Sprachkenntnisse. Es ist daher zu beachten, dass das Produkt ausschließlich von Fachkräften oder sorgfältig eingewiesenen Personen mit entsprechenden Fähigkeiten bedient werden darf. Sollte für die Verwendung von Rohde & Schwarz-Produkten persönliche Schutzausrüstung erforderlich sein, wird in der Produktdokumentation an entsprechender Stelle darauf hingewiesen. Bewahren Sie die grundlegenden Sicherheitshinweise und die Produktdokumentation gut auf und geben Sie diese an weitere Benutzer des Produkts weiter.

Die Einhaltung der Sicherheitshinweise dient dazu, Verletzungen oder Schäden durch Gefahren aller Art auszuschließen. Hierzu ist es erforderlich, dass die nachstehenden Sicherheitshinweise vor der Benutzung des Produkts sorgfältig gelesen und verstanden sowie bei der Benutzung des Produkts beachtet werden. Sämtliche weitere Sicherheitshinweise wie z.B. zum Personenschutz, die an entsprechender Stelle der Produktdokumentation stehen, sind ebenfalls unbedingt zu beachten. In den vorliegenden Sicherheitshinweisen sind sämtliche von der Rohde & Schwarz Firmengruppe vertriebenen Waren unter dem Begriff „Produkt“ zusammengefasst, hierzu zählen u. a. Geräte, Anlagen sowie sämtliches Zubehör.

Symbole und Sicherheitskennzeichnungen

Symbol	Bedeutung	Symbol	Bedeutung
	Achtung, allgemeine Gefahrenstelle Produktdokumentation beachten		EIN-/AUS (Versorgung)
	Vorsicht beim Umgang mit Geräten mit hohem Gewicht		Stand-by-Anzeige
	Gefahr vor elektrischem Schlag		Gleichstrom (DC)
	Warnung vor heißer Oberfläche		Wechselstrom (AC)
	Schutzleiteranschluss		Gleichstrom/Wechselstrom (DC/AC)
	Erdungsanschluss		Gerät entspricht den Sicherheits-anforderungen an die Schutzklasse II (Gerät durchgehend durch doppelte / verstärkte Isolierung geschützt.
	Masseanschluss des Gestells oder Gehäuses		EU - Kennzeichnung für Batterien und Akkumulatoren. Das Gerät enthält eine Batterie bzw. einen Akkumulator. Diese dürfen nicht über unsortierten Siedlungsabfall entsorgt werden, sondern sollten getrennt gesammelt werden. Weitere Informationen siehe Seite 7.
	Achtung beim Umgang mit elektrostatisch gefährdeten Bauelementen		EU - Kennzeichnung für die getrennte Sammlung von Elektro- und Elektronikgeräten. Elektroaltgeräte dürfen nicht über unsortierten Siedlungsabfall entsorgt werden, sondern müssen getrennt gesammelt werden. Weitere Informationen siehe Seite 7.
	Warnung vor Laserstrahl Produkte mit Laser sind je nach ihrer Laser-Klasse mit genormten Warnhinweisen versehen. Laser können aufgrund der Eigenschaften ihrer Strahlung und aufgrund ihrer extrem konzentrierten elektromagnetischen Leistung biologische Schäden verursachen. Für zusätzliche Informationen siehe Kapitel „Betrieb“ Punkt 7.		

Signalworte und ihre Bedeutung

Die folgenden Signalworte werden in der Produktdokumentation verwendet, um vor Risiken und Gefahren zu warnen.

GEFAHR kennzeichnet eine unmittelbare Gefährdung mit hohem Risiko, die Tod oder schwere Körperverletzung zur Folge haben wird, wenn sie nicht vermieden wird.

WARNUNG kennzeichnet eine mögliche Gefährdung mit mittlerem Risiko, die Tod oder (schwere) Körperverletzung zur Folge haben kann, wenn sie nicht vermieden wird.

VORSICHT kennzeichnet eine Gefährdung mit geringem Risiko, die leichte oder mittlere Körperverletzungen zur Folge haben könnte, wenn sie nicht vermieden wird.

ACHTUNG weist auf die Möglichkeit einer Fehlbedienung hin, bei der das Produkt Schaden nehmen kann.

Diese Signalworte entsprechen der im europäischen Wirtschaftsraum üblichen Definition für zivile Anwendungen. Neben dieser Definition können in anderen Wirtschaftsräumen oder bei militärischen Anwendungen abweichende Definitionen existieren. Es ist daher darauf zu achten, dass die hier beschriebenen Signalworte stets nur in Verbindung mit der zugehörigen Produktdokumentation und nur in Verbindung mit dem zugehörigen Produkt verwendet werden. Die Verwendung von Signalworten in Zusammenhang mit nicht zugehörigen Produkten oder nicht zugehörigen Dokumentationen kann zu Fehlinterpretationen führen und damit zu Personen- oder Sachschäden führen.

Betriebszustände und Betriebslagen

Das Produkt darf nur in den vom Hersteller angegebenen Betriebszuständen und Betriebslagen ohne Behinderung der Belüftung betrieben werden. Werden die Herstellerangaben nicht eingehalten, kann dies elektrischen Schlag, Brand und/oder schwere Verletzungen von Personen, unter Umständen mit Todesfolge, verursachen. Bei allen Arbeiten sind die örtlichen bzw. landesspezifischen Sicherheits- und Unfallverhütungsvorschriften zu beachten.

1. Sofern nicht anders vereinbart, gilt für R&S-Produkte folgendes:
   als vorgeschriebene Betriebslage grundsätzlich Gehäuseboden unten, IP-Schutzart 2X, Verschmutzungsgrad 2, Überspannungskategorie 2, nur in Innenräumen verwenden, Betrieb bis 2000 m ü. NN, Transport bis 4500 m ü. NN, für die Nennspannung gilt eine Toleranz von ±10%, für die Nennfrequenz eine Toleranz von ±5%.
2. Stellen Sie das Produkt nicht auf Oberflächen, Fahrzeuge, Ablagen oder Tische, die aus Gewichts- oder Stabilitätsgründen nicht dafür geeignet sind. Folgen Sie bei Aufbau und Befestigung des Produkts an Gegenständen oder Strukturen (z.B. Wände und Regale) immer den Installationshinweisen des Herstellers. Bei Installation abweichend von der Produktdokumentation können Personen verletzt, unter Umständen sogar getötet werden.
3. Stellen Sie das Produkt nicht auf hitzeerzeugende Gerätschaften (z.B. Radiatoren und Heizlüfter). Die Umgebungstemperatur darf nicht die in der Produktdokumentation oder im Datenblatt spezifizierte Maximaltemperatur überschreiten. Eine Überhitzung des Produkts kann elektrischen Schlag, Brand und/oder schwere Verletzungen von Personen, unter Umständen mit Todesfolge, verursachen.

Grundlegende Sicherheitshinweise

Elektrische Sicherheit

Werden die Hinweise zur elektrischen Sicherheit nicht oder unzureichend beachtet, kann dies elektrischen Schlag, Brand und/oder schwere Verletzungen von Personen, unter Umständen mit Todesfolge, verursachen.

1. Vor jedem Einschalten des Produkts ist sicherzustellen, dass die am Produkt eingestellte Nennspannung und die Netznennspannung des Versorgungsnetzes übereinstimmen. Ist es erforderlich, die Spannungseinstellung zu ändern, so muss ggf. auch die dazu gehörige Netzsicherung des Produkts geändert werden.
2. Bei Produkten der Schutzklasse I mit beweglicher Netzzuleitung und Gerätesteckvorrichtung ist der Betrieb nur an Steckdosen mit Schutzkontakt und angeschlossenem Schutzleiter zulässig.
3. Jegliche absichtliche Unterbrechung des Schutzleiters, sowohl in der Zuleitung als auch am Produkt selbst, ist unzulässig. Es kann dazu führen, dass von dem Produkt die Gefahr eines elektrischen Schlags ausgeht. Bei Verwendung von Verlängerungsleitungen oder Steckdosenleisten ist sicherzustellen, dass diese regelmäßig auf ihren sicherheitstechnischen Zustand überprüft werden.
4. Sofern das Produkt nicht mit einem Netzschalter zur Netztrennung ausgerüstet ist, beziehungsweise der vorhandene Netzschalter zu Netztrennung nicht geeignet ist, so ist der Stecker des Anschlusskabels als Trennvorrichtung anzusehen.
   Die Trennvorrichtung muss jederzeit leicht erreichbar und gut zugänglich sein. Ist z.B. der Netzstecker die Trennvorrichtung, darf die Länge des Anschlusskabels 3 m nicht überschreiten.
   Funktionsschalter oder elektronische Schalter sind zur Netztrennung nicht geeignet. Werden Produkte ohne Netzschalter in Gestelle oder Anlagen integriert, so ist die Trennvorrichtung auf Anlagenebene zu verlagern.
5. Benutzen Sie das Produkt niemals, wenn das Netzkabel beschädigt ist. Überprüfen Sie regelmäßig den einwandfreien Zustand der Netzkabel. Stellen Sie durch geeignete Schutzmaßnahmen und Verlegearten sicher, dass das Netzkabel nicht beschädigt werden kann und niemand z.B. durch Stolperfallen oder elektrischen Schlag zu Schaden kommen kann.
6. Der Betrieb ist nur an TN/TT Versorgungsnetzen gestattet, die mit höchstens 16 A abgesichert sind (höhere Absicherung nur nach Rücksprache mit der Rohde & Schwarz Firmengruppe).
7. Stecken Sie den Stecker nicht in verstaubte oder verschmutzte Steckdosen/-buchsen. Stecken Sie die Steckverbindung/-vorrichtung fest und vollständig in die dafür vorgesehenen Steckdosen/-buchsen. Missachtung dieser Maßnahmen kann zu Funken, Feuer und/oder Verletzungen führen.
8. Überlasten Sie keine Steckdosen, Verlängerungskabel oder Steckdosenleisten, dies kann Feuer oder elektrische Schläge verursachen.
9. Bei Messungen in Stromkreisen mit Spannungen U_{eff} > 30 V ist mit geeigneten Maßnahmen Vorsorge zu treffen, dass jegliche Gefährdung ausgeschlossen wird (z.B. geeignete Messmittel, Absicherung, Strombegrenzung, Schutztrennung, Isolierung usw.).
10. Bei Verbindungen mit informationstechnischen Geräten, z.B. PC oder Industrierechner, ist darauf zu achten, dass diese der jeweils gültigen IEC 60950-1 / EN 60950-1 oder IEC 61010-1 / EN 61010-1 entsprechen.
11. Sofern nicht ausdrücklich erlaubt, darf der Deckel oder ein Teil des Gehäuses niemals entfernt werden, wenn das Produkt betrieben wird. Dies macht elektrische Leitungen und Komponenten zugänglich und kann zu Verletzungen, Feuer oder Schaden am Produkt führen.

12. Wird ein Produkt ortsfest angeschlossen, ist die Verbindung zwischen dem Schutzleiteranschluss vor Ort und dem Geräteschutzleiter vor jeglicher anderer Verbindung herzustellen. Aufstellung und Anschluss darf nur durch eine Elektrofachkraft erfolgen.
13. Bei ortsfesten Geräten ohne eingebaute Sicherung, Selbstschalter oder ähnliche Schutzeinrichtung muss der Versorgungskreis so abgesichert sein, dass alle Personen, die Zugang zum Produkt haben, sowie das Produkt selbst ausreichend vor Schäden geschützt sind.
14. Jedes Produkt muss durch geeigneten Überspannungsschutz vor Überspannung (z.B. durch Blitzschlag) geschützt werden. Andernfalls ist das bedienende Personal durch elektrischen Schlag gefährdet.
15. Gegenstände, die nicht dafür vorgesehen sind, dürfen nicht in die Öffnungen des Gehäuses eingebracht werden. Dies kann Kurzschlüsse im Produkt und/oder elektrische Schläge, Feuer oder Verletzungen verursachen.
16. Sofern nicht anders spezifiziert, sind Produkte nicht gegen das Eindringen von Flüssigkeiten geschützt, siehe auch Abschnitt "Betriebszustände und Betriebslagen", Punkt 1. Daher müssen die Geräte vor Eindringen von Flüssigkeiten geschützt werden. Wird dies nicht beachtet, besteht Gefahr durch elektrischen Schlag für den Benutzer oder Beschädigung des Produkts, was ebenfalls zur Gefährdung von Personen führen kann.
17. Benutzen Sie das Produkt nicht unter Bedingungen, bei denen Kondensation in oder am Produkt stattfinden könnte oder ggf. bereits stattgefunden hat, z.B. wenn das Produkt von kalter in warme Umgebung bewegt wurde. Das Eindringen von Wasser erhöht das Risiko eines elektrischen Schlages.
18. Trennen Sie das Produkt vor der Reinigung komplett von der Energieversorgung (z.B. speisendes Netz oder Batterie). Nehmen Sie bei Geräten die Reinigung mit einem weichen, nicht fasernden Staublappen vor. Verwenden Sie keinesfalls chemische Reinigungsmittel wie z.B. Alkohol, Aceton, Nitroverdünnung.

Betrieb

1. Die Benutzung des Produkts erfordert spezielle Einweisung und hohe Konzentration während der Benutzung. Es muss sichergestellt sein, dass Personen, die das Produkt bedienen, bezüglich ihrer körperlichen, geistigen und seelischen Verfassung den Anforderungen gewachsen sind, da andernfalls Verletzungen oder Sachschäden nicht auszuschließen sind. Es liegt in der Verantwortung des Arbeitsgebers/Betreibers, geeignetes Personal für die Benutzung des Produkts auszuwählen.
2. Bevor Sie das Produkt bewegen oder transportieren, lesen und beachten Sie den Abschnitt "Transport".
3. Wie bei allen industriell gefertigten Gütern kann die Verwendung von Stoffen, die Allergien hervorrufen - so genannte Allergene (z.B. Nickel) - nicht generell ausgeschlossen werden. Sollten beim Umgang mit R&S-Produkten allergische Reaktionen, z.B. Hautausschlag, häufiges Niesen, Bindehautrötung oder Atembeschwerden auftreten, ist umgehend ein Arzt aufzusuchen, um die Ursachen zu klären und Gesundheitsschäden bzw. -belastungen zu vermeiden.
4. Vor der mechanischen und/oder thermischen Bearbeitung oder Zerlegung des Produkts beachten Sie unbedingt Abschnitt "Entsorgung", Punkt 1.

5. Bei bestimmten Produkten, z.B. HF-Funkanlagen, können funktionsbedingt erhöhte elektromagnetische Strahlungen auftreten. Unter Berücksichtigung der erhöhten Schutzwürdigkeit des ungeborenen Lebens müssen Schwangere durch geeignete Maßnahmen geschützt werden. Auch Träger von Herzschrittmachern können durch elektromagnetische Strahlungen gefährdet sein. Der Arbeitgeber/Betreiber ist verpflichtet, Arbeitsstätten, bei denen ein besonderes Risiko einer Strahlenexposition besteht, zu beurteilen und zu kennzeichnen und mögliche Gefahren abzuwenden.
6. Im Falle eines Brandes entweichen ggf. giftige Stoffe (Gase, Flüssigkeiten etc.) aus dem Produkt, die Gesundheitsschäden verursachen können. Daher sind im Brandfall geeignete Maßnahmen wie z.B. Atemschutzmasken und Schutzkleidung zu verwenden.
7. Falls ein Laser-Produkt in ein R&S-Produkt integriert ist (z.B. CD/DVD-Laufwerk), dürfen keine anderen Einstellungen oder Funktionen verwendet werden, als in der Produktdokumentation beschrieben, um Personenschäden zu vermeiden (z.B. durch Laserstrahl).
8. EMV Klassen (nach EN 55011 / CISPR 11; sinngemäß EN 55022 / CISPR 22, EN 55032 / CISPR 32)

   Gerät der Klasse A:
   Ein Gerät, das sich für den Gebrauch in allen anderen Bereichen außer dem Wohnbereich und solchen Bereichen eignet, die direkt an ein Niederspannungs-Versorgungsnetz angeschlossen sind, das Wohngebäude versorgt.
   Hinweis: Diese Einrichtung kann wegen möglicher auftretender leitungsgebundener als auch gestrahlten Störgrößen im Wohnbereich Funkstörungen verursachen. In diesem Fall kann vom Betreiber verlangt werden, angemessene Maßnahmen durchzuführen.
   Gerät der Klasse B:
   Ein Gerät, das sich für den Betrieb im Wohnbereich sowie in solchen Bereichen eignet, die direkt an ein Niederspannungs-Versorgungsnetz angeschlossen sind, das Wohngebäude versorgt.

Reparatur und Service

1. Das Produkt darf nur von dafür autorisiertem Fachpersonal geöffnet werden. Vor Arbeiten am Produkt oder Öffnen des Produkts ist dieses von der Versorgungsspannung zu trennen, sonst besteht das Risiko eines elektrischen Schlages.
2. Abgleich, Auswechseln von Teilen, Wartung und Reparatur darf nur von R&S-autorisierten Elektrofachkräften ausgeführt werden. Werden sicherheitsrelevante Teile (z.B. Netzschalter, Netztrafos oder Sicherungen) ausgewechselt, so dürfen diese nur durch Originalteile ersetzt werden. Nach jedem Austausch von sicherheitsrelevanten Teilen ist eine Sicherheitsprüfung durchzuführen (Sichtprüfung, Schutzleitertest, Isolationswiderstand-, Ableitstrommessung, Funktionstest). Damit wird sichergestellt, dass die Sicherheit des Produkts erhalten bleibt.

Batterien und Akkumulatoren/Zellen

Werden die Hinweise zu Batterien und Akkumulatoren/Zellen nicht oder unzureichend beachtet, kann dies Explosion, Brand und/oder schwere Verletzungen von Personen, unter Umständen mit Todesfolge, verursachen. Die Handhabung von Batterien und Akkumulatoren mit alkalischen Elektrolyten (z.B. Lithiumzellen) muss der EN 62133 entsprechen.

1. Zellen dürfen nicht zerlegt, geöffnet oder zerkleinert werden.
2. Zellen oder Batterien dürfen weder Hitze noch Feuer ausgesetzt werden. Die Lagerung im direkten Sonnenlicht ist zu vermeiden. Zellen und Batterien sauber und trocken halten. Verschmutzte Anschlüsse mit einem trockenen, sauberen Tuch reinigen.

3. Zellen oder Batterien dürfen nicht kurzgeschlossen werden. Zellen oder Batterien dürfen nicht gefahrbringend in einer Schachtel oder in einem Schubfach gelagert werden, wo sie sich gegenseitig kurzschließen oder durch andere leitende Werkstoffe kurzgeschlossen werden können. Eine Zelle oder Batterie darf erst aus ihrer Originalverpackung entnommen werden, wenn sie verwendet werden soll.
4. Zellen oder Batterien dürfen keinen unzulässig starken, mechanischen Stößen ausgesetzt werden.
5. Bei Undichtheit einer Zelle darf die Flüssigkeit nicht mit der Haut in Berührung kommen oder in die Augen gelangen. Falls es zu einer Berührung gekommen ist, den betroffenen Bereich mit reichlich Wasser waschen und ärztliche Hilfe in Anspruch nehmen.
6. Werden Zellen oder Batterien, die alkalische Elektrolyte enthalten (z.B. Lithiumzellen), unsachgemäß ausgewechselt oder geladen, besteht Explosionsgefahr. Zellen oder Batterien nur durch den entsprechenden R&S-Typ ersetzen (siehe Ersatzteilliste), um die Sicherheit des Produkts zu erhalten.
7. Zellen oder Batterien müssen wiederverwertet werden und dürfen nicht in den Restmüll gelangen. Akkumulatoren oder Batterien, die Blei, Quecksilber oder Cadmium enthalten, sind Sonderabfall. Beachten Sie hierzu die landesspezifischen Entsorgungs- und Recycling-Bestimmungen.

Transport

1. Das Produkt kann ein hohes Gewicht aufweisen. Daher muss es vorsichtig und ggf. unter Verwendung eines geeigneten Hebemittels (z.B. Hubwagen) bewegt bzw. transportiert werden, um Rückenschäden oder Verletzungen zu vermeiden.
2. Griffe an den Produkten sind eine Handhabungshilfe, die ausschließlich für den Transport des Produkts durch Personen vorgesehen ist. Es ist daher nicht zulässig, Griffe zur Befestigung an bzw. auf Transportmitteln, z.B. Kränen, Gabelstaplern, Karren etc. zu verwenden. Es liegt in Ihrer Verantwortung, die Produkte sicher an bzw. auf geeigneten Transport- oder Hebemitteln zu befestigen. Beachten Sie die Sicherheitsvorschriften des jeweiligen Herstellers eingesetzter Transport- oder Hebemittel, um Personenschäden und Schäden am Produkt zu vermeiden.
3. Falls Sie das Produkt in einem Fahrzeug benutzen, liegt es in der alleinigen Verantwortung des Fahrers, das Fahrzeug in sicherer und angemessener Weise zu führen. Der Hersteller übernimmt keine Verantwortung für Unfälle oder Kollisionen. Verwenden Sie das Produkt niemals in einem sich bewegenden Fahrzeug, sofern dies den Fahrzeugführer ablenken könnte. Sichern Sie das Produkt im Fahrzeug ausreichend ab, um im Falle eines Unfalls Verletzungen oder Schäden anderer Art zu verhindern.

Entsorgung

1. Batterien bzw. Akkumulatoren, die nicht mit dem Hausmüll entsorgt werden dürfen, darf nach Ende der Lebensdauer nur über eine geeignete Sammelstelle oder eine Rohde & Schwarz-Kundendienststelle entsorgt werden.
2. Am Ende der Lebensdauer des Produktes darf dieses Produkt nicht über den normalen Hausmüll entsorgt werden, sondern muss getrennt gesammelt werden.
   Rohde & Schwarz GmbH & Co.KG ein Entsorgungskonzept entwickelt und übernimmt die Pflichten der Rücknahme- und Entsorgung für Hersteller innerhalb der EU in vollem Umfang. Wenden Sie sich bitte an Ihre Rohde & Schwarz-Kundendienststelle, um das Produkt umweltgerecht zu entsorgen.

3. Werden Produkte oder ihre Bestandteile über den bestimmungsgemäßen Betrieb hinaus mechanisch und/oder thermisch bearbeitet, können ggf. gefährliche Stoffe (schwermetallhaltiger Staub wie z.B. Blei, Beryllium, Nickel) freigesetzt werden. Die Zerlegung des Produkts darf daher nur von speziell geschultem Fachpersonal erfolgen. Unsachgemäßes Zerlegen kann Gesundheitsschäden hervorrufen. Die nationalen Vorschriften zur Entsorgung sind zu beachten.
4. Falls beim Umgang mit dem Produkt Gefahren- oder Betriebsstoffe entstehen, die speziell zu entsorgen sind, z.B. regelmäßig zu wechselnde Kühlmittel oder Motorenöle, sind die Sicherheitshinweise des Herstellers dieser Gefahren- oder Betriebsstoffe und die regional gültigen Entsorgungsvorschriften einzuhalten. Beachten Sie ggf. auch die zugehörigen speziellen Sicherheitshinweise in der Produktdokumentation. Die unsachgemäße Entsorgung von Gefahren- oder Betriebsstoffen kann zu Gesundheitsschäden von Personen und Umweltschäden führen.

Weitere Informationen zu Umweltschutz finden Sie auf der Rohde & Schwarz Home Page.

Consignes de sécurité fondamentales

Lisez et respectez impérativement les instructions et consignes de sécurité suivantes

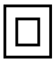
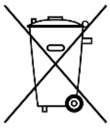
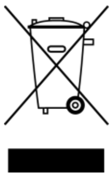
Les usines et sites du groupe Rohde & Schwarz veillent à la conformité des produits du groupe avec les normes de sécurité en vigueur dans un souci constant de garantir aux clients le plus haut niveau de sécurité possible. Nos produits ainsi que les accessoires nécessaires sont fabriqués et testés conformément aux règles de sécurité en vigueur. Le respect de ces règles est vérifié régulièrement par notre système d'assurance qualité. Le présent produit a été fabriqué et contrôlé conformément au certificat de conformité CE ci-joint et a quitté l'usine dans un parfait état de sécurité. Pour le maintenir dans cet état et en garantir une utilisation sans danger, l'utilisateur doit respecter l'ensemble des consignes, remarques de sécurité et avertissements qui se trouvent dans ce manuel. Le groupe Rohde & Schwarz se tient à votre disposition pour toutes questions relatives aux présentes consignes de sécurité.

Il incombe à l'utilisateur d'employer ce produit de manière appropriée. Le produit est exclusivement destiné à l'utilisation en industrie et en laboratoire et/ou, si cela a été expressément autorisé, également aux travaux extérieurs ; il ne peut en aucun cas être utilisé à des fins pouvant causer des dommages corporels ou matériels. L'exploitation du produit en dehors de son utilisation prévue ou le non-respect des consignes du fabricant se font sous la responsabilité de l'utilisateur. Le fabricant décline toute responsabilité en cas d'utilisation non conforme du produit.

Le produit est présumé faire l'objet d'une utilisation conforme lorsqu'il est utilisé conformément aux consignes de la documentation produit correspondante et dans la limite de ses performances (voir fiche technique, documentation, consignes de sécurité ci-après). L'utilisation du produit exige des compétences en la matière et des connaissances de base de l'anglais. Par conséquent, le produit ne devra être utilisé que par un personnel qualifié ou des personnes formées de manière approfondie et possédant les compétences requises. Si, pour l'utilisation des produits Rohde & Schwarz, l'emploi d'un équipement personnel de protection s'avère nécessaire, il en est fait mention dans la documentation produit à l'emplacement correspondant. Conservez les consignes de sécurité fondamentales et la documentation produit dans un lieu sûr et transmettez ces documents aux autres utilisateurs du produit.

La stricte observation des consignes de sécurité a pour but d'exclure des blessures ou dommages causés par des dangers de toutes sortes. A cet effet, il est nécessaire de lire avec soin et de bien comprendre les consignes de sécurité ci-dessous avant l'utilisation du produit et de les respecter lors de l'utilisation du produit. Toutes les autres consignes de sécurité présentées à l'emplacement correspondant de la documentation produit, par exemple, celles concernant la protection des personnes, doivent également être impérativement respectées. Dans les présentes consignes de sécurité, toutes les marchandises commercialisées par le groupe Rohde & Schwarz, notamment les appareils, les systèmes ainsi que les accessoires, sont dénommés « produit ».

Symboles et marquages de sécurité

Symbole	Signification	Symbole	Signification
	Avis, source générale de danger Se référer à la documentation produit		MARCHE / ARRET (tension d'alimentation)
	Attention lors de la manipulation d'appareils ayant un poids élevé		Indicateur de veille
	Risque de choc électrique		Courant continu (CC)
	Avertissement, surface chaude		Courant alternatif (CA)
	Borne de conducteur de protection		Courant continu/alternatif (CC/CA)
	Borne de mise à la terre		L'appareil est conforme aux exigences de sécurité du degré de protection II (appareil entièrement protégé par isolation double/renforcée).
	Borne de mise à la masse du bâti ou du boîtier		Marquage UE pour batteries et accumulateurs. L'appareil contient une batterie ou un accumulateur. Ces pièces ne peuvent pas être éliminées avec les déchets urbains non triés, mais doivent faire l'objet d'une collecte séparée. Pour plus d'informations, voir la page 7.
	Avis : prudence lors de la manipulation de composants sensibles aux décharges électrostatiques		Marquage UE pour la collecte séparée d'équipements électriques et électroniques. Les déchets d'équipements électriques et électroniques ne peuvent pas être éliminés avec les déchets urbains non triés, mais doivent faire l'objet d'une collecte séparée. Pour plus d'informations, voir la page 7.
	Avertissement, rayon laser Les produits laser sont munis d'avertissements normalisés d'après leur catégorie laser. En raison des caractéristiques de leur rayonnement ainsi que de leur puissance électromagnétique extrêmement concentrée, les lasers peuvent causer des dommages biologiques. Pour plus d'informations, voir le chapitre « Fonctionnement »", point 7.		

Mots d'alerte et significations

Les mots d'alerte suivants sont utilisés dans la documentation produit pour avertir des risques et dangers.

⚠ DANGER	Indique une situation dangereuse immédiate qui, si elle n'est pas évitée, comporte un risque élevé de blessures graves ou mortelles.
⚠ AVERTISSEMENT	Indique une situation dangereuse possible qui, si elle n'est pas évitée, comporte un risque modéré de blessures (graves) ou mortelles.
⚠ ATTENTION	Indique une situation dangereuse qui, si elle n'est pas évitée, comporte un risque faible de blessures mineures ou modérées.
AVIS	Indique la possibilité d'une fausse manœuvre susceptible d'endommager le produit.

Ces mots d'alerte correspondent à la définition habituelle utilisée pour des applications civiles dans l'espace économique européen. Des définitions divergentes peuvent cependant exister dans d'autres espaces économiques ou dans le cadre d'applications militaires. Il faut donc veiller à ce que les mots d'alerte décrits ici ne soient utilisés qu'en relation avec la documentation produit correspondante et seulement avec le produit correspondant. L'utilisation des mots d'alerte en relation avec des produits ou des documentations non correspondants peut conduire à des erreurs d'interprétation et par conséquent à des dommages corporels ou matériels.

États et positions de fonctionnement

L'appareil ne doit être utilisé que dans les états et positions de fonctionnement indiqués par le fabricant. Tout obstacle à la ventilation doit être empêché. Le non-respect des indications du fabricant peut provoquer des chocs électriques, des incendies et/ou des blessures graves pouvant éventuellement entraîner la mort. Pour tous les travaux, les règles locales et/ou nationales de sécurité et de prévention des accidents doivent être respectées.

1. Sauf stipulations contraires, les produits Rohde & Schwarz répondent aux exigences ci-après :
   faire fonctionner le produit avec le fond du boîtier toujours en bas, degré de protection IP 2X, degré de pollution 2, catégorie de surtension 2, utilisation uniquement à l'intérieur, fonctionnement à une altitude max. de 2000 m au-dessus du niveau de la mer, transport à une altitude max. de 4500 m au-dessus du niveau de la mer, tolérance de ±10 % pour la tension nominale et de ±5 % pour la fréquence nominale.
2. Ne jamais placer le produit sur des surfaces, véhicules, dépôts ou tables non appropriés pour raisons de stabilité ou de poids. Suivre toujours strictement les indications d'installation du fabricant pour le montage et la fixation du produit sur des objets ou des structures (par exemple parois et étagères). En cas d'installation non conforme à la documentation produit, il y a risque de blessures, voire de mort.
3. Ne jamais placer le produit sur des dispositifs générant de la chaleur (par exemple radiateurs et appareils de chauffage soufflants). La température ambiante ne doit pas dépasser la température maximale spécifiée dans la documentation produit ou dans la fiche technique. Une surchauffe du produit peut provoquer des chocs électriques, des incendies et/ou des blessures graves pouvant éventuellement entraîner la mort.

Sécurité électrique

Si les consignes relatives à la sécurité électrique ne sont pas ou sont insuffisamment respectées, il peut s'ensuivre des chocs électriques, des incendies et/ou des blessures graves pouvant éventuellement entraîner la mort.

1. Avant chaque mise sous tension du produit, il faut s'assurer que la tension nominale réglée sur le produit correspond à la tension nominale du réseau électrique. S'il est nécessaire de modifier le réglage de la tension, il faut remplacer le fusible du produit, le cas échéant.
2. L'utilisation des produits du degré de protection I pourvus d'un câble d'alimentation mobile et d'un connecteur n'est autorisée qu'avec des prises munies d'un contact de protection et d'un conducteur de protection raccordé.
3. Toute déconnexion intentionnelle du conducteur de protection, dans le câble ou dans le produit lui-même, est interdite. Elle entraîne un risque de choc électrique au niveau du produit. En cas d'utilisation de câbles prolongateurs ou de multiprises, ceux-ci doivent être examinés régulièrement quant à leur état de sécurité technique.
4. Si le produit n'est pas doté d'un interrupteur d'alimentation pour le couper du réseau électrique ou si l'interrupteur d'alimentation disponible n'est pas approprié pour couper le produit du réseau électrique, le connecteur mâle du câble de raccordement est à considérer comme dispositif de séparation.
Le dispositif de séparation doit être à tout moment facilement accessible. Si, par exemple, le connecteur d'alimentation sert de dispositif de séparation, la longueur du câble de raccordement ne doit pas dépasser 3 m.
Les commutateurs fonctionnels ou électroniques ne sont pas appropriés pour couper l'appareil du réseau électrique. Si des produits sans interrupteur d'alimentation sont intégrés dans des bâtis ou systèmes, le dispositif de séparation doit être reporté au niveau du système.
5. Ne jamais utiliser le produit si le câble d'alimentation est endommagé. Vérifier régulièrement le parfait état du câble d'alimentation. Prendre les mesures préventives appropriées et opter pour des types de pose tels que le câble d'alimentation ne puisse pas être endommagé et que personne ne puisse subir de préjudice, par exemple en trébuchant sur le câble ou par des chocs électriques.
6. L'utilisation des produits est uniquement autorisée sur des réseaux d'alimentation de type TN/TT protégés par des fusibles d'une intensité max. de 16 A (pour toute intensité supérieure, consulter le groupe Rohde & Schwarz).
7. Ne pas brancher le connecteur dans des prises d'alimentation sales ou poussiéreuses. Enfoncer fermement le connecteur jusqu'au bout de la prise. Le non-respect de cette mesure peut provoquer des étincelles, incendies et/ou blessures.
8. Ne pas surcharger les prises, les câbles prolongateurs ou les multiprises, cela pouvant provoquer des incendies ou chocs électriques.
9. En cas de mesures sur les circuits électriques d'une tension efficace > 30 V, prendre les précautions nécessaires pour éviter tout risque (par exemple équipement de mesure approprié, fusibles, limitation de courant, coupe-circuit, isolation, etc.).
10. En cas d'interconnexion avec des équipements informatiques comme par exemple un PC ou un ordinateur industriel, veiller à ce que ces derniers soient conformes aux normes IEC 60950-1 / EN 60950-1 ou IEC 61010-1 / EN 61010-1 en vigueur.
11. Sauf autorisation expresse, il est interdit de retirer le couvercle ou toute autre pièce du boîtier lorsque le produit est en cours de service. Les câbles et composants électriques seraient ainsi accessibles, ce qui peut entraîner des blessures, des incendies ou des dégâts sur le produit.

12. Si un produit est connecté de façon stationnaire, établir avant toute autre connexion le raccordement du conducteur de protection local et du conducteur de protection du produit. L'installation et le raccordement ne peuvent être effectués que par un électricien ou électronicien qualifié.
13. Sur les appareils stationnaires sans fusible ni disjoncteur automatique ou dispositif de protection similaire intégrés, le circuit d'alimentation doit être sécurisé de sorte que toutes les personnes ayant accès au produit et le produit lui-même soient suffisamment protégés contre tout dommage.
14. Chaque produit doit être protégé de manière appropriée contre les éventuelles surtensions (par exemple dues à un coup de foudre). Sinon, les utilisateurs sont exposés à des risques de choc électrique.
15. Ne jamais introduire d'objets non prévus à cet effet dans les ouvertures du boîtier, étant donné que cela peut entraîner des courts-circuits dans le produit et/ou des chocs électriques, incendies ou blessures.
16. Sauf spécification contraire, les produits ne sont pas protégés contre l'infiltration de liquides, voir aussi la section « États et positions de fonctionnement », point 1. Il faut donc protéger les produits contre l'infiltration de liquides. La non-observation de cette consigne entraîne le risque de choc électrique pour l'utilisateur ou d'endommagement du produit, ce qui peut également mettre les personnes en danger.
17. Ne pas utiliser le produit dans des conditions pouvant occasionner ou ayant déjà occasionné, le cas échéant, des condensations dans ou sur le produit, par exemple lorsque celui-ci est déplacé d'un environnement froid dans un environnement chaud. L'infiltration d'eau augmente le risque de choc électrique.
18. Avant le nettoyage, débrancher le produit de l'alimentation (par exemple réseau électrique ou batterie). Pour le nettoyage des appareils, utiliser un chiffon doux non pelucheux. N'utiliser en aucun cas de produit de nettoyage chimique, tel que de l'alcool, de l'acétone ou un diluant nitrocellulosique.

Fonctionnement

1. L'utilisation du produit exige une formation spécifique ainsi qu'une grande concentration. Il est impératif que les personnes qui utilisent le produit présent les aptitudes physiques, mentales et psychiques requises, vu qu'autrement des dommages corporels ou matériels ne peuvent pas être exclus. Le choix du personnel qualifié pour l'utilisation du produit est sous la responsabilité de l'employeur/l'exploitant.
2. Avant de déplacer ou de transporter le produit, lire et respecter la section « Transport ».
3. Comme pour tous les biens produits de façon industrielle, l'utilisation de matériaux pouvant causer des allergies (allergènes, comme par exemple le nickel) ne peut être totalement exclue. Si, lors de l'utilisation de produits Rohde & Schwarz, des réactions allergiques surviennent, telles qu'éruption cutanée, éternuements fréquents, rougeur de la conjonctive ou difficultés respiratoires, il faut immédiatement consulter un médecin pour en clarifier la cause et éviter toute atteinte à la santé.
4. Avant le traitement mécanique et/ou thermique ou le démontage du produit, il faut impérativement observer la section « Élimination des déchets », point 1.

5. Selon les fonctions, certains produits, tels que des systèmes de radiocommunication RF, peuvent produire des niveaux élevés de rayonnement électromagnétique. Étant donné la vulnérabilité de l'enfant à naître, les femmes enceintes doivent être protégées par des mesures appropriées. Les porteurs de stimulateurs cardiaques peuvent également être menacés par les rayonnements électromagnétiques. L'employeur/l'exploitant est tenu d'évaluer et de repérer les lieux de travail soumis à un risque particulier d'exposition aux rayonnements et de prévenir les dangers éventuels.
6. En cas d'incendie, il se peut que le produit dégage des matières toxiques (gaz, liquides, etc.) susceptibles de nuire à la santé. Il faut donc, en cas d'incendie, prendre des mesures adéquates comme par exemple le port de masques respiratoires et de vêtements de protection.
7. Si un produit laser est intégré dans un produit Rohde & Schwarz (par exemple lecteur CD/DVD), il ne faut pas utiliser de réglages ou fonctions autres que ceux décrits dans la documentation produit pour éviter tout dommage corporel (par exemple causé par rayon laser).
8. Classes CEM (selon EN 55011 / CISPR 11 ; selon EN 55022 / CISPR 22, EN 55032 / CISPR 32 par analogie)
   - Appareil de la classe A :
     Appareil approprié à un usage dans tous les environnements autres que l'environnement résidentiel et les environnements raccordés directement à un réseau d'alimentation basse tension qui alimente des bâtiments résidentiels.
     Remarque : ces appareils peuvent provoquer des perturbations radioélectriques dans l'environnement résidentiel en raison de perturbations conduites ou rayonnées. Dans ce cas, on peut exiger que l'exploitant mette en œuvre de mesures appropriées pour éliminer ces perturbations.
   - Appareil de la classe B :
     Appareil approprié à un usage dans l'environnement résidentiel ainsi que dans les environnements raccordés directement à un réseau d'alimentation basse tension qui alimente des bâtiments résidentiels.

Réparation et service après-vente

1. Le produit ne doit être ouvert que par un personnel qualifié et autorisé. Avant de travailler sur le produit ou de l'ouvrir, il faut le couper de la tension d'alimentation ; sinon il y a risque de choc électrique.
2. Les travaux d'ajustement, le remplacement des pièces, la maintenance et la réparation ne doivent être effectués que par des électroniciens qualifiés et autorisés par Rohde & Schwarz. En cas de remplacement de pièces concernant la sécurité (notamment interrupteur d'alimentation, transformateur d'alimentation réseau ou fusibles), celles-ci ne doivent être remplacées que par des pièces d'origine. Après chaque remplacement de pièces concernant la sécurité, une vérification de sécurité doit être effectuée (contrôle visuel, vérification du conducteur de protection, mesure de la résistance d'isolement et du courant de fuite, essai de fonctionnement). Cela permet d'assurer le maintien de la sécurité du produit.

Batteries et accumulateurs/cellules

Si les instructions concernant les batteries et accumulateurs/cellules ne sont pas ou sont insuffisamment respectées, cela peut provoquer des explosions, des incendies et/ou des blessures graves pouvant entraîner la mort. La manipulation de batteries et accumulateurs contenant des électrolytes alcalins (par exemple cellules de lithium) doit être conforme à la norme EN 62133.

1. Les cellules ne doivent être ni démontées, ni ouvertes, ni réduites en morceaux.
2. Ne jamais exposer les cellules ou batteries à la chaleur ou au feu. Ne pas les stocker dans un endroit où elles sont exposées au rayonnement direct du soleil. Tenir les cellules et batteries au sec. Nettoyer les raccords sales avec un chiffon sec et propre.
3. Ne jamais court-circuiter les cellules ou batteries. Les cellules ou batteries ne doivent pas être gardées dans une boîte ou un tiroir où elles peuvent se court-circuiter mutuellement ou être court-circuitées par d'autres matériaux conducteurs. Une cellule ou batterie ne doit être retirée de son emballage d'origine que lorsqu'on l'utilise.
4. Les cellules ou batteries ne doivent pas être exposées à des chocs mécaniques de force non admissible.
5. En cas de manque d'étanchéité d'une cellule, le liquide ne doit pas entrer en contact avec la peau ou les yeux. S'il y a contact, rincer abondamment à l'eau l'endroit concerné et consulter un médecin.
6. Il y a danger d'explosion en cas de remplacement ou chargement incorrect des cellules ou batteries qui contiennent des électrolytes alcalins (par exemple cellules de lithium). Remplacer les cellules ou batteries uniquement par le type Rohde & Schwarz correspondant (voir la liste des pièces de rechange) pour maintenir la sécurité du produit.
7. Il faut recycler les cellules ou batteries et il est interdit de les éliminer comme déchets normaux. Les accumulateurs ou batteries qui contiennent du plomb, du mercure ou du cadmium sont des déchets spéciaux. Observer les règles nationales d'élimination et de recyclage.

Transport

1. Le produit peut avoir un poids élevé. Il faut donc le déplacer ou le transporter avec précaution et en utilisant le cas échéant un moyen de levage approprié (par exemple, chariot élévateur) pour éviter des dommages au dos ou des blessures.
2. Les poignées des produits sont une aide de manipulation exclusivement réservée au transport du produit par des personnes. Il est donc proscrit d'utiliser ces poignées pour attacher le produit à ou sur des moyens de transport, tels que grues, chariots et chariots élévateurs, etc. Vous êtes responsable de la fixation sûre des produits à ou sur des moyens de transport et de levage appropriés. Observer les consignes de sécurité du fabricant des moyens de transport ou de levage utilisés pour éviter des dommages corporels et des dégâts sur le produit.
3. L'utilisation du produit dans un véhicule se fait sous l'unique responsabilité du conducteur qui doit piloter le véhicule de manière sûre et appropriée. Le fabricant décline toute responsabilité en cas d'accidents ou de collisions. Ne jamais utiliser le produit dans un véhicule en mouvement si cela pouvait détourner l'attention du conducteur. Sécuriser suffisamment le produit dans le véhicule pour empêcher des blessures ou dommages de tout type en cas d'accident.

Élimination des déchets

1. Au terme de leur durée de vie, les batteries ou accumulateurs qui ne peuvent pas être éliminés avec les déchets ménagers peuvent uniquement être éliminés par des points de collecte appropriés ou par un centre de service après-vente Rohde & Schwarz.

2. Au terme de sa durée de vie, un produit ne peut pas être éliminé avec les déchets ménagers normaux, mais doit être collecté séparément.
   Rohde & Schwarz GmbH & Co. KG a développé un concept d'élimination des déchets et assume toutes les obligations en matière de reprise et d'élimination, valables pour les fabricants au sein de l'UE. Veuillez vous adresser à votre centre de service après-vente Rohde & Schwarz pour éliminer le produit de manière écologique.
3. Si les produits ou leurs composants sont travaillés mécaniquement et/ou thermiquement au-delà de l'utilisation prévue, ils peuvent, le cas échéant, libérer des substances dangereuses (poussières contenant des métaux lourds comme par exemple du plomb, du béryllium ou du nickel). Le démontage du produit ne doit donc être effectué que par un personnel qualifié et spécialement formé. Le démontage inadéquat peut nuire à la santé. Les règles nationales concernant l'élimination des déchets doivent être observées.
4. Si, lors de l'utilisation du produit, des substances dangereuses ou combustibles exigeant une élimination spéciale sont dégagées, comme par exemple liquides de refroidissement ou huiles moteurs qui sont à changer régulièrement, les consignes de sécurité du fabricant de ces substances dangereuses ou combustibles ainsi que les règles sur l'élimination en vigueur au niveau régional doivent être respectées. Les consignes de sécurité spéciales correspondantes dans la documentation produit doivent également être respectées, le cas échéant. L'élimination non conforme des substances dangereuses ou combustibles peut provoquer des atteintes à la santé et des dommages écologiques.

Pour plus d'informations concernant la protection de l'environnement, voir la page d'accueil de Rohde & Schwarz.

Customer Support

Technical support – where and when you need it

For quick, expert help with any Rohde & Schwarz equipment, contact one of our Customer Support Centers. A team of highly qualified engineers provides telephone support and will work with you to find a solution to your query on any aspect of the operation, programming or applications of Rohde & Schwarz equipment.

Up-to-date information and upgrades

To keep your instrument up-to-date and to be informed about new application notes related to your instrument, please send an e-mail to the Customer Support Center stating your instrument and your wish. We will take care that you will get the right information.

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Contents

1 Preface

1.1 Key Features

The R&S RTE Digital Oscilloscope provides fast signal acquisition and analysis. Outstanding key features are:

- 1 million waveforms per second waveform acquisition rate
- Bandwidth up to 2 GHz
- Memory depth of 10 MSa per channel, optionally up to 50 MSa per channel
- Highly accurate digital trigger system
- Very low noise floor
- Precise measurements due to single-core A/D converter
- High measurement speed, even for complex analysis functions
- Easy and intuitive to operate
- High-quality line of probes

For a detailed specification refer to the data sheet.

The R&S RTE Digital Oscilloscope brings various benefits in your daily work:

- Find rare signal faults quickly with no trade-offs for measurement and analysis due to highest acquisition rate and shortest blind time.
- Access and analyze prior waveforms in the memory using the history function
- Get fastest results even with maximum data with hardware-accelerated processing: mathematical operations, mask tests, histograms, automatic and cursor measurements, and spectrum display.
- Capture closest successive events with the real-time digital trigger system. It works with high trigger sensitivity at full bandwidth and very low trigger jitter.
- See signal details at your fingertip with fingertip zoom
- Get key measurement results at the push of a button with Quick Measurement
- Easy to use:
  - Smart and straightforward user guidance
  - Color-coded control elements for clear identification
  - Signal icons with drag & drop functionality
  - Toolbar with frequently used functionality
- Verify and debug embedded systems using the options for triggering and decoding of serial protocols such as I²C, SPI, UART, CAN, LIN and FlexRay
- Turn the R&S RTE into a mixed signal oscilloscope using the MSO option and analyze up to 16 additional digital channels

1.2 Documentation Overview

The user documentation for the R&S RTE consists of the following parts:

- Help system on the instrument
- "Getting Started" printed manual in English
- Documentation CD-ROM with:
  - Getting Started
  - User manual
  - Service manual
  - Data sheet
  - Open source acknowledgments
  - Certificates
  - Links to useful sites on the Rohde & Schwarz Internet

Instrument Help

The instrument help is embedded in the instrument's firmware, and it is installed together with the firmware. It offers quick, context-sensitive access to the complete information needed for operation and programming. Firmware updates are available on the Rohde & Schwarz product website in the "Downloads" > "Firmware" section.

Getting Started

The Getting Started manual provides the information needed to set up and start working with the instrument, and describes basic operations and typical measurement examples. The manual also includes safety information. The English edition of this manual is delivered with the instrument in printed form and on the Documentation CD-ROM. The newest English version and translations to other languages (if available) are provided in PDF format on the product website.

User Manual

The user manual describes all instrument functions in detail. It also provides an introduction to remote control and a complete description of the remote control commands with programming examples.

The user manual is available in PDF format on the Documentation CD-ROM. The newest version of the manual is provided on the product website in PDF format for download and as online manual (HTML) for immediate display (no download required).

Service Manual

The Service Manual is available in PDF format on the Documentation CD-ROM. It describes how to check compliance with rated specifications, instrument function, repair, troubleshooting, and fault elimination. It contains all information required for repairing the instrument by replacing modules.

Documentation updates

You can download the newest version of all manuals here: www.rohde-schwarz.com/product/rte.html > "Downloads > Manuals".

1.3 Options Described in this Document

In addition to the base unit, the following options are described in this documentation:

Type	Designation	Order No. for 1326.2000.xx instruments	Order No. for 1317.2500.xx instruments
R&S®RTE-B1	MSO	1317.4961.02	
R&S®RTE-K1	I²C and SPI serial decoding	1326.1178.02	1317.7125.02
R&S®RTE-K2	UART/RS-232/RS-422/RS-485 serial decoding	1326.1184.02	1317.7131.02
R&S®RTE-K3	CAN and LIN serial triggering and decoding	1326.1190.02	1317.7148.02
R&S®RTE-K4	FlexRay™ serial triggering and decoding	1326.1203.02	1317.7154.02
R&S®RTE-K5	I²S (audio) serial triggering and decoding	1326.1210.02	1317.7160.02
R&S®RTE-K6	MIL-STD-1553 serial triggering and decoding	1326.1226.02	1325.9781.02
R&S®RTE-K7	ARINC 429 serial triggering and decoding	1326.1232.02	1325.9798.02
R&S®RTE-K8	Ethernet serial triggering and decoding	1326.1332.02	1317.7402.02
R&S®RTE-K9	CAN-FD serial triggering and decoding	1326.1249.02	1325.9898.02
R&S®RTE-K10	SENT serial triggering and decoding	1326.1603.02	1326.1532.02
R&S®RTE-K17	High definition mode	1326.1261.02	1326.0542.02
R&S®RTE-K18	Spectrum analysis	1326.3006.02	1326.3035.02
R&S®RTE-K31	Power analysis	1326.1278.02	1317.7177.02
R&S®RTE-K50	Custom Manchester and NRZ serial triggering and decoding	1326.1326.02	1326.1310.02
R&S®RTE-K55	MDIO serial triggering and decoding	1326.1255.02	1326.0720.02
R&S®RTE-K60	USB 1.0/1.1/2.0/HSIC serial triggering and decoding	1326.1626.02	1326.1610.02
R&S®RTE-K65	SpaceWire serial triggering and decoding	1326.2845.02	1326.2839.02

1.4 Conventions Used in the Documentation

1.4.1 Typographical Conventions

The following text markers are used throughout this documentation:

Convention	Description
"Graphical user interface elements"	All names of graphical user interface elements on the screen, such as dialog boxes, menus, options, buttons, and softkeys are enclosed by quotation marks.
KEYS	Key names are written in capital letters.
`File names, commands, program code`	File names, commands, coding samples and screen output are distinguished by their font.
Input	Input to be entered by the user is displayed in italics.
Links	Links that you can click are displayed in blue font.
"References"	References to other parts of the documentation are enclosed by quotation marks.

1.4.2 Conventions for Procedure Descriptions

When describing how to operate the instrument, several alternative methods may be available to perform the same task. In this case, the procedure using the touchscreen is described. Any elements that can be activated by touching can also be clicked using an additionally connected mouse. The alternative procedure using the keys on the instrument or the on-screen keyboard is only described if it deviates from the standard operating procedures.

The term "select" may refer to any of the described methods, i.e. using a finger on the touchscreen, a mouse pointer in the display, or a key on the instrument or on a keyboard.

2 Getting Started

Note: the following chapters are identical to those in the R&S RTE Getting Started manual.

2.1 Preparing for Use

This section describes the basic steps to be taken when setting up the R&S RTE for the first time.

NOTICE

Risk of instrument damage

Note that the general safety instructions also contain information on operating conditions that prevent damage to the instrument. The instrument's data sheet can contain additional operating conditions.

2.1.1 Unpacking and Checking the Instrument

To remove the instrument from its packaging and check the equipment for completeness, proceed as follows:

1. Pull off the polyethylene protection pads from the instrument's rear feet.
2. Carefully remove the pads from the instrument handles at the front.
3. Pull off the corrugated cardboard cover that protects the rear of the instrument.
4. Carefully unthread the corrugated cardboard cover at the front that protects the instrument handles and remove it.
5. Check the equipment for completeness using the delivery note and the accessory lists for the various items.
6. Check the instrument for any damage. If there is damage, immediately contact the carrier who delivered the instrument. Make sure not to discard the box and packing material.

Packing material

Retain the original packing material. If the instrument needs to be transported or shipped at a later date, you can use the material to protect the control elements and connectors.

2.1.2 Positioning the Instrument

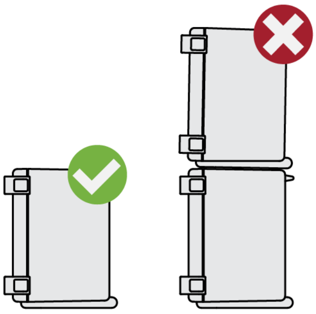
The instrument is designed for use under laboratory conditions. It can be used in standalone operation on a bench top or can be installed in a rack.

CAUTION

Risk of injury and instrument damage if stacking instruments

A stack of instruments may tilt over and cause injury and material damage because the instrument's top surface area is too small.

Never stack instruments on top of each other. If you need to stack instruments, install them in a rack.



2.1.2.1 Standalone Operation

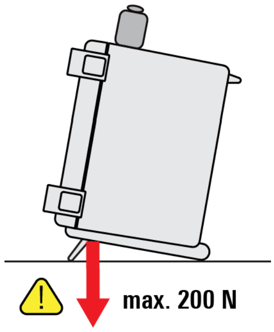
For standalone operation, place the instrument on a horizontal bench with even, flat surface. The instrument can be used in horizontal position, standing on its feet, or with the support feet on the bottom extended.

CAUTION

Risk of injury if feet are folded out

The feet may fold in if they are not folded out completely or if the instrument is shifted. This may cause damage or injury.

- Fold the feet completely in or completely out to ensure stability of the instrument. Never shift the instrument when the feet are folded out.
- When the feet are folded out, do not work under the instrument or place anything underneath.
- The feet can break if they are overloaded. The overall load on the folded-out feet must not exceed 200 N.



2.1.2.2 Rackmounting

The instrument can be installed in a 19" rackmount using a rack adapter kit. The order number is given in the data sheet. The installation instructions are part of the adapter kit.

NOTICE

Risk of instrument damage in a rack

An insufficient airflow can cause the instrument to overheat, which may disturb the operation and even cause damage.

Make sure that all fan openings are unobstructed, that the airflow perforations are unimpeded, and that the minimum distance from the wall is 10 cm.

2.1.3 Starting the Instrument

WARNING

Risk of injury and instrument damage

The instrument must be used in an appropriate manner to prevent electric shock, fire, personal injury, or damage.

- Do not use an isolating transformer to connect the instrument to the AC power supply.
- Do not open the instrument casing.
- Read and observe the "Basic Safety Instructions" delivered as a printed brochure with the instrument.
  In addition, read and observe the safety instructions in the following sections. Notice that the data sheet may specify additional operating conditions.

NOTICE

Risk of instrument damage during operation

An unsuitable operating site or test setup can damage the instrument and connected devices. Ensure the following operating conditions before you switch on the instrument:

- All fan openings are unobstructed and the airflow perforations are unimpeded. The minimum distance from the wall is 10 cm.
- The instrument is dry and shows no sign of condensation.
- The instrument is positioned as described in the following sections.
- The ambient temperature does not exceed the range specified in the data sheet.
- Signal levels at the input connectors are all within the specified ranges.
- Signal outputs are correctly connected and are not overloaded.

2.1.3.1 Powering On

The AC power connector and the main power switch are located on the rear panel of the instrument.

1. Connect the instrument to the AC power supply using the AC power cable delivered with the instrument.
   If grounding is *not* ensured by the mains system, ground the instrument using the protective earth conductor on the front panel and an appropriate cable.
2. Switch the main power switch at the rear of the instrument to position I.

   The power key on the front panel lights up.

When you power up the instrument, be sure to comply with the warm-up phase specified in the data sheet before you start measurements.

You can leave on the AC power permanently. Powering off is only required if the instrument must be disconnected from all power supplies.

2.1.3.2 Starting Up and Shutting Down

The POWER key is located in the bottom left corner of the front panel.

To start up the instrument

1. Make sure that the R&S RTE is connected to the AC power supply and the main power switch on the rear panel is in position I.
2. Press the POWER key on the front panel.

   The instrument performs a system check, boots the Windows operating system, and then starts the R&S RTE firmware.
   The POWER key turns green and the illuminated keys on the front panel light up. If the previous session was terminated regularly, the oscilloscope uses the last settings.

To shut down the instrument

► Press the POWER key on the front panel.

  All current settings are saved, and the software shuts down. The POWER key turns orange. The standby power supplies only the power switch circuits.
  Now it is safe to power off the instrument.

The "Exit" function in the "File" menu shuts down only the firmware application. To shut down the instrument completely, also shut down the operating system in the "Start" menu.

2.1.3.3 Powering Off

Powering off is required only if the instrument must be disconnected from all power supplies.

1. If the instrument is running and the POWER key is green, press the POWER key on the front panel to shut down the instrument.
2. Switch the main power switch at the rear of the instrument to position 0.
3. Disconnect the AC power cable from the AC power supply.

NOTICE

Risk of losing data

If you switch off the running instrument using the rear panel switch or by disconnecting the power cord, the instrument loses its current settings. Furthermore, program data may be lost.

Press the POWER key first to shut down the application properly.

2.1.3.4 EMI Suppression

Electromagnetic Interference (EMI) may affect the measurement results.

To suppress generated Electromagnetic Interference:

- Use suitable shielded cables of high quality. For example use double-shielded RF and LAN cables.
- Always terminate open cable ends.
- Note the EMC classification in the data sheet.

2.1.4 Connecting External Devices

The following interfaces for external devices are provided:

- USB connectors, see also "USB" on page 45
- Monitor connector, see also "MONITOR (DVI-D)" on page 47

2.1.4.1 Connecting USB Devices

The USB interfaces on the front and rear panels of the R&S RTE allow you to connect USB devices directly to the instrument. The number of USB connectors can be increased by using USB hubs. Due to the large number of available USB devices, there is almost no limit to the expansions that are possible with the R&S RTE.

The following list shows various USB devices that can be useful:

- CD-ROM drives for easy installation of firmware applications
- Keyboard and/or mouse to simplify the operation and the entry of data, comments, filenames, etc.
- Printer for printing measurement results

All USB devices can be connected to or disconnected from the instrument during operation.

Installing USB devices on R&S RTE is easy under the Windows operating system, because all USB devices are plug&play. After a device is connected to the USB interface, Windows automatically searches for a suitable device driver.

If the operating system does not find a suitable driver, it prompts you to specify a directory that contains the driver software. If the driver software is on a CD, connect a USB CD-ROM drive to the instrument before proceeding.

When a USB device is disconnected from the R&S RTE, Windows immediately detects the change in hardware configuration and deactivates the corresponding driver.

The properties of external USB devices are configured in the operating system, not in the R&S RTE software. It is recommended that you use mouse and keyboard to access and modify the settings of the Windows operating system. To access Windows, press the Windows key on the external keyboard, or select "File" > "Minimize" on the R&S RTE menu.

Connecting a USB flash drive or CD-ROM drive

If installation of a USB flash driver or CD-ROM drive is successful, Windows informs you that the device is ready to use. The device is made available as a new drive ("D:") and is displayed under Windows Explorer. The name of the drive depends on the manufacturer.

Connecting a keyboard

The keyboard is detected automatically when it is connected. The default input language is English – US.

Use the Windows "Start" menu > "Control Panel" > "Change keyboards or other input methods" to configure the keyboard properties.

Connecting a mouse

The mouse is detected automatically when it is connected.

Use the Windows "Start" menu > "Devices and Printers" > "Mouse" to configure the mouse properties.

Connecting a printer

When printing a file, the instrument checks whether a printer is connected and turned on and whether the appropriate printer driver is installed. If necessary, printer driver installation is initiated using the Windows' "Add a Printer" wizard. A printer driver needs to be installed only once.

You can load updated and improved driver versions or new drivers from a USB flash drive, or another external storage medium. If the instrument is integrated in a network, you can also install driver data stored in a network directory.

Use the Windows "Start" menu > "Devices and Printers" > "Add a printer" to install the driver.

2.1.4.2 Connecting an External Monitor

You can connect an external monitor or projector to the MONITOR (DVI-D) connector on the instrument's rear panel. See also: "MONITOR (DVI-D)" on page 47.

Before connecting an external monitor, ensure that the monitor and the R&S RTE are connected to a ground contact. Otherwise the instrument may be damaged.

After connecting an additional monitor or projector to the instrument, configure it for usage. The relevant settings are Windows settings but you can configure the displays directly in the instrument setup.

1. Check the input type of the monitor or projector. Make sure to select the correct cable. To use a VGA monitor, an active DVI-D to VGA adapter is required.
2. Press the SETUP key.
3. Select the "System" tab.
4. Tap "Display / Monitors".
5. To show the instrument's display content only on the external monitor, select "Projector only".
   To show the instrument's display content on both the oscilloscope and the external monitor, select "Duplicate".

The touchscreen of the R&S RTE has a screen resolution of 1024 x 768 pixel. Most external monitors have a higher screen resolution. If the screen resolution of the monitor is set higher than the instrument's resolution, the application window uses a 1024 x 768 area of the monitor display. For full screen display, adjust the monitor's screen resolution using "Additional display settings".

2.2 Instrument Tour

This chapter describes the front and rear panels of the instrument including all function keys and connectors, and also the touchscreen with its control elements.

2.2.1 Front Panel

The front panel of the R&S RTE is shown in Figure 2-1. The function keys are grouped in functional blocks to the left and the right of the touchscreen. Below the screen, various connectors are located.

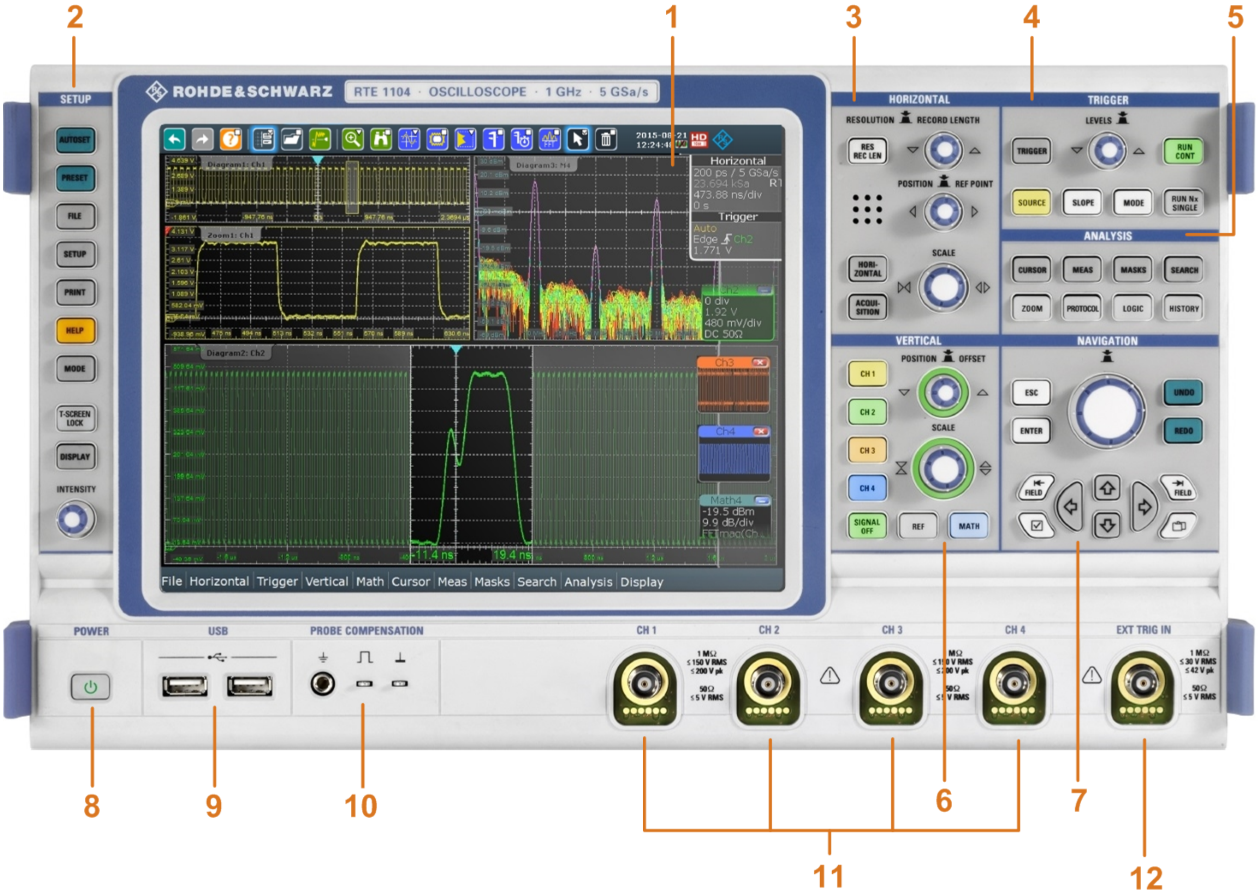


Figure 2-1: Front panel of R&S RTE1104 with 4 input channels

1 = Touchscreen
2 = SETUP controls
3 = HORIZONTAL controls
4 = TRIGGER controls
5 = ANALYSIS controls
6 = VERTICAL controls
7 = NAVIGATION controls
8 = POWER key
9 = USB 2.0 connectors
10 = Connectors for probe compensation
11 = Input channels
12 = External trigger input

NOTICE

Instrument damage caused by cleaning agents

Cleaning agents contain substances that may damage the instrument. For example, cleaning agents that contain a solvent may damage the front panel labeling, plastic parts, or the display.

Never use cleaning agents such as solvents (thinners, acetone, etc), acids, bases, or other substances.

The outside of the instrument can be cleaned sufficiently using a soft, lint-free dust cloth.

2.2.1.1 SETUP Controls

SETUP keys set the instrument to a defined state, change basic settings, and provide print and help functions. The intensity rotary knob adjusts the display contrast for several display elements.

AUTOSET
The instrument analyzes the enabled channel signals, and adjusts appropriate horizontal, vertical, and trigger settings to display stable waveforms.

PRESET
Resets the instrument to a default state. All measurements, mask tests, zoom, and most individual settings are deleted, and all channels except for channel 1 are disabled. You can define preset configurations and save them to a file. The PRESET key can be configured to set either factory defaults or a user-defined preset configuration.

FILE
Opens and closes the "File" dialog box, where you can:
- Save instrument settings
- Load instrument settings which were saved before
- Save waveform data and measurement results
- Define a naming pattern for autonaming of files

SETUP
Opens and closes the "Setup" dialog box, where you can:
- Access Windows configuration and install firmware updates
- Configure the touchscreen
- Check and install option keys for software options
- Check availability of hardware options
- Configure LXI and GPIB (if installed)

PRINT
Performs the action that is assigned to the key in "File" menu > "Frontpanel Setup" > "Hardkeys". By default, the key saves a screenshot of the waveform display.

See also: Chapter 3.3.2, "Hardkeys: Function Assignment", on page 113

HELP
Opens the appropriate help topic for the active tab. If no dialog box is open, the contents page of the help appears.

MODE
Opens and closes a dialog box where you can change the instrument mode:
- Enable High Definition mode (requires option R&S RTE-K17).
- Enable functionality in beta state.

T-SCREEN LOCK
Locks the touchscreen to prevent unintended use. When the touchscreen is off, the key is illuminated. Press again to unlock the touchscreen.

DISPLAY
Opens and closes the "Display" dialog box to configure the appearance of the waveforms, the diagram layout, color tables, and also the XY-diagram.

INTENSITY
Adjusts the intensity of the waveforms on the screen, or the background transparency of dialog boxes, or the transparency of result boxes. If a dialog box is open, turning the knob changes the transparency of dialog boxes. If a result box is open, the transparency of result boxes is changed. Otherwise the waveform intensity is adjusted. Press the knob to toggle between the three settings. The controlled parameter and its value are shown in the input box in the upper left corner of the screen.

2.2.1.2 HORIZONTAL Controls

The keys and rotary knobs in theHORIZONTAL functional block adjust the acquisition basic settings and the horizontal parameters. These settings are effective for all channel waveforms.

RES REC LEN
Opens and closes the "Setup" tab in the "Horizontal" dialog box, where you can set the resolution and the record length.

HORIZONTAL
Opens and closes the "Setup" tab in the "Horizontal" dialog box, where you can:
- Adjust the time scale, and acquisition time

- Adjust the horizontal position, and reference point

ACQUISITION
Opens and closes the "Acquisition" tab in the "Horizontal" dialog box, where you can define the acquisition processing (decimation and arithmetic).

RESOLUTION / RECORD LENGTH
The rotary knob changes the resolution or the record length. Press the knob to toggle the setting. The controlled parameter and its value are shown in the input box in the upper left corner of the screen.

For resolution, turn clockwise to increase the resolution: the time between two acquisition points gets shorter. Record length and sample rate increase while the acquisition time remains constant.

For record length, turn clockwise to increase the record length, and the resolution increases too - the time between to acquisition points gets shorter.

POSITION / REF POINT
The rotary knob changes the horizontal position of the waveform or the position of the reference point on the screen.

Press the knob to toggle the setting. The controlled parameter and its value are shown in the input box in the upper left corner of the screen.

"Horizontal position" defines the time distance of the reference point from the zero point of the diagram. Turn clockwise to move the waveform to the right.

"Reference point" defines the position of the reference point on the screen. Turn clockwise to move it to the right. The reference point marks the rescaling center of the time scale. It is indicated by a gray triangle outline at the top of the diagram. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.

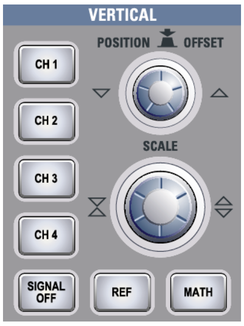
SCALE
The rotary knob adjusts the time scale for all signals. The time scale is also known as timebase.

Turn clockwise to stretch the waveforms. Doing so, the scale value *time/div* decreases.

Press the knob to toggle between coarse and fine scale adjustment.

2.2.1.3 VERTICAL Controls

The keys and knobs in the VERTICAL functional block select a signal and adjust the vertical scale and position of the selected signal.



CH ×
Turns on, selects, and configures a channel. If the channel is selected, the key lights up in the corresponding channel color .

The effect of the keypress depends on state of the channel:
- If channel is off: Pressing the key turns on the channel and selects it.
- If the channel is on, but not selected: Pressing the key selects the channel waveform.
- If the waveform is selected: Pressing the key opens the "Vertical" dialog box for the appropriate channel.

The vertical rotary knobs are focused on the selected waveform and they are illuminated in the color of the selected waveform.

REF
Opens the "Reference" dialog box, where you can configure and display reference waveforms. Press the key repeatedly to switch to the reference waveform to be configured.

The vertical rotary knobs are focused on the selected reference waveform, and they are illuminated in the color of the selected waveform.

MATH
Opens the "Math" dialog box, where you can configure the calculation of new waveforms using various mathematic operations on other waveforms. Press the key repeatedly to switch to the math waveform to be configured.

The vertical rotary knobs are focused on the selected math waveform, and they are illuminated in the color of the selected waveform.

POSITION / OFFSET (upper knob)
The upper rotary knob changes the vertical position or the offset of the selected waveform. The horizontal axis and the selected waveform are moved vertically. Turn clockwise to move up the waveform.

Press the knob to toggle the setting. The controlled parameter and its value are shown in the input box in the upper left corner of the screen.

- Position indicates the vertical location in divisions.
- Offset moves the vertical center of the selected channel to the offset value.

The knob lights up in the color of the selected waveform.

SCALE

This rotary knob adjusts the vertical scale for the selected waveform. The knob lights up in the color of the selected waveform.

Turn clockwise to stretch the waveform. Doing so, the scale value V/div decreases.

Press the knob to toggle between coarse and fine scale adjustment.

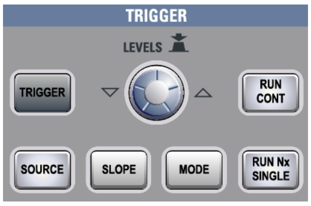
SIGNAL OFF

Turns off the selected signal and selects the next channel, math, or reference waveform.

The key is illuminated in the color of the selected signal and changes the color according to the new selection.

2.2.1.4 TRIGGER Controls

The keys and knob in the TRIGGER functional block adjust the trigger and start or stop acquisition.



TRIGGER

Opens and closes the "Trigger" dialog box, where you can:
- Select a trigger type and configure it.
- Set general trigger parameters and control the acquisition run.
- Configure a sequence of subsequent trigger events.

LEVELS

The rotary knob sets the trigger level for all trigger types. Turn clockwise to move up the trigger level. If the selected trigger type requires two trigger levels - upper and lower level - press the knob to toggle between the two levels.

SOURCE

Opens a dialog box where you can select the trigger source. Press the key again to switch the source. The key lights up in the color of the selected trigger source.

SLOPE

Toggles the trigger slope or trigger polarity, dependent on the trigger type. The current setting is shown on the trigger label, which is in the upper part of the signal bar on the touchscreen.

MODE

Toggles the trigger mode between Auto and Normal. The current setting is shown on the trigger label.

RUN CONT
Starts and stops the continuous acquisition. A green light indicates a running acquisition. A red light shows that acquisition is stopped.

RUN N× SINGLE
Starts a defined number of acquisition cycles. A green light indicates running acquisition. A red light shows that acquisition is stopped. To set the number of acquisitions, press the TRIGGER key, select the "Ctrl/Action" tab, and set "Average count (N-single count)". Press the key again to stop running acquisitions.

2.2.1.5 ANALYSIS Keys

The keys in the ANALYSIS functional block provide direct access to measurement and analyzing functions. If you press CURSOR, ZOOM or MEAS, the operation starts on first keypress, and a second keypress opens the corresponding dialog box. If you press another function key, the dialog box opens.

CURSOR
Displays vertical and horizontal cursors in the active diagram and displays the "Cursor Results" box.

Cursors are markers which are placed at points of interest on a waveform. The instrument measures the cursor positions and delta values between parallel cursors.

If you press the key while a cursor measurement is enabled, the "Cursors" dialog box opens.

In "Cursors" dialog box, you can:
- Configure up to 2 cursor sets
- Define style and labels of the cursors
- Connect the cursor to the waveform and couple the cursors

MEAS
Starts the default automatic measurement for the active waveform and displays the "Measurement" result box.

If you press the MEAS key while a measurement is enabled, the "Measurements" dialog box is displayed, where you can:
- Configure amplitude and time measurements, eye, spectrum, and histogram measurements
- Configure gated measurement
- Configure long term and statistic measurements
- Configure actions to be executed if specified limits are exceeded

ZOOM
Displays a zoom diagram for the active diagram. The key is illuminated if at least one zoom is active. If you press the key while the zoom function is on, the "Zoom" dialog box opens, where you can configure several zoom areas for detailed signal observation.

PROTOCOL
Opens the "Protocol" dialog box which contains the configuration of serial buses and the settings for decoding the signals.

The key lights up if the decoding of a serial bus is active. You can switch off the decoded bus using the SIGNAL OFF key.

MASKS
Opens and closes the "Masks" dialog box. Masks are used for error detection and compliance tests of digital signals.

You can:
- Configure masks and masks segments
- Define mask test parameters
- Configure actions triggered by mask violation
- Configure the mask display

SEARCH
Opens and closes the "Search" dialog box, where you can:
- Configure trigger or measurement events to be searched for
- Limit the search by gating
- Configure the presentation of search results

LOGIC
Opens the dialog box for configuration of parallel buses and digital channels. The key lights up if you enable at least one parallel bus. You can switch off the selected bus using the SIGNAL OFF key.

HISTORY
The sample memory contains a number of stored acquisitions before the current one which is shown in the display. Press the key to open the quick access "History" dialog box, where you can view the stored acquisitions and use them for further analysis. Press the key again to open the main "History" dialog box with more settings and information.

The key is illuminated as long as a history acquisition or replay is displayed.

2.2.1.6 NAVIGATION Controls

The rotary knob and the navigation keys provide an alternative way to navigate in dialog boxes and to enter numeric data.

See also: Chapter 2.4.7, "Using Dialog Boxes", on page 99

Navigation rotary knob
The navigation knob has various functions:
- In numeric entry fields: turn to increase or decrease the value.
- In tables: press to activate the edit mode, turn clockwise to increase the value or turn counterclockwise to decrease it, and press to enter the value and move to the next cell.
- To set cursor positions, histogram areas, and mask points in input boxes: press to toggle the parameter, turn clockwise to increase the value or turn counterclockwise to decrease it.
- To move zoom area, cursor line, or gate in diagrams: Turn to move the element that has the focus, and press to toggle the focus.

UNDO
Reverses the last setting actions step by step. Undo is not possible after load and recall actions, and after creating a reference waveform.

REDO
Recovers the undo steps in reverse order.

ESC
Closes a dialog box or input box.

ENTER
The ENTER key has various functions:
- In usual dialog box, in an opened selection list: the key applies the selected value.
- In tables: the key activates the edit mode. If the table cell is in edit mode, the key confirms the value, quits the edit mode and moves to the next cell.

Field left, Field right
In dialog boxes and tables, the keys move the focus.

In diagrams, the keys switch the focus between zoom areas, cursor lines, and gates.

Checkmark ☑
The checkmark key ☑ has different functions depending on the focus:
- In usual dialog box: if the focus is on a selection list, the key opens the list and applies the selected value.

- In tables: activates the edit mode.

Tab
The tab key has various functions:

- In a dialog box that has only horizontal tabs, the key switches the horizontal tabs.
- In a dialog box that has horizontal and vertical tabs, the key switches the vertical tabs preferably. If the focus is on a horizontal tab, it switches the horizontal tabs.
- In a table or diagram, the key moves the focus in the same way as the ⇨ key.

Up arrow ⇧ , Down arrow ⇩
The up and down arrow keys have the following effects:
- In numeric edit fields: increase or decrease the parameter value.
- In tables: scroll vertically through the rows.
- In dialog boxes, for option buttons in a column: select an option. In an open selection list, the keys scroll the list.

Left arrow ⇦ , Right arrow ⇨
The left and right arrow keys have the following effects:
- In edit fields: move the cursor.
- In tables: scroll horizontally through the columns.
- In dialog boxes, for option buttons in a row: select an option.

2.2.1.7 POWER Key

The POWER key is located on the lower left corner of the front panel. It starts up and shuts down the instrument's software.

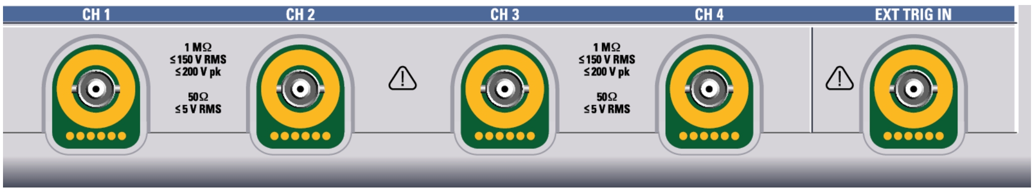
The light of the key shows the instrument state:

- Orange: Standby, the main power switch is on, the software is shut down.
- Green: The instrument is ready for operation.

See also: Chapter 2.1.3, "Starting the Instrument", on page 30.

2.2.1.8 Input Connectors

The R&S RTE has two or four channel inputs to connect the input signals, and an external trigger input to control the measurement by an external signal.



The input connectors are provided with a special Rohde & Schwarz active probe interface, and they are BNC compatible. Thus, the instrument can automatically detect passive probes with standard BNC connector and active Rohde & Schwarz probes having the Rohde & Schwarz probe interface.

The input impedance is selectable, the values are 50 Ω and 1 MΩ.

WARNING

Risk of electrical shock or fire

Voltages higher than 30 V RMS or 42 V peak or 60 V DC are regarded as hazardous contact voltages. When working with hazardous contact voltages, use appropriate protective measures to preclude direct contact with the measurement setup:

- Use only insulated voltage probes, test leads and adapters.
- Do not touch voltages higher than 30 V RMS or 42 V peak or 60 V DC.

CAUTION

Risk of injury and instrument damage

The instrument is not rated for any measurement category.

Make sure that the input voltage on *channel inputs* does not exceed 200 V peak, 150 V RMS at 1 MΩ input impedance and 5 V RMS at 50 Ω input impedance.

Transient overvoltages must not exceed 200 V peak.

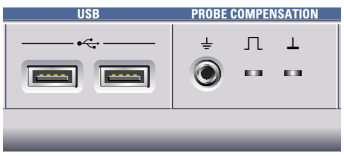
When performing measurements in circuits with transient overvoltages of category II, III or IV circuits, make sure that no such overvoltages reach the R&S RTE input. Therefore, use only probes that comply with DIN EN 61010-031. When performing measurements in category II, III or IV circuits, it is mandatory to insert a probe that appropriately reduces the voltage so that no transient overvoltages higher than 200 V peak are applied to the instrument. For detailed information, refer to the documentation and safety information of the probe manufacturer.

For the *external trigger input*, the maximum input voltage is 30 V RMS at 1 MΩ input impedance and 5 V RMS at 50 Ω input impedance. For further specifications, refer to the data sheet.

Explanation: According to section AA.2.4 of EN 61010-2-030, measuring circuits without any measurement category are intended for measurements on circuits which are not connected to the mains system.

2.2.1.9 Other Front Panel Connectors

Besides the input connectors, the instrument has USB connectors and probe compensation connectors at the front panel.



USB

Two USB type A connectors that comply with standard USB 2.0. They are used to connect devices like keyboard, mouse, printer and USB flash drive.

Note: Electromagnetic interference (EMI) can affect the measurement results. To avoid any impact, do not use USB connecting cables exceeding 1 m.

PROBE COMPENSATION
Probe compensation terminal to support adjustment of passive probes to the oscilloscope channel.

⏚	Protective earth conductor for grounding the instrument.
⎍	Square wave signal for probe compensation with 1 kHz and 1 V_{pp}.
⊥	Ground connector for probes.

2.2.2 Rear Panel

Figure 2-2 shows the rear panel of the R&S RTE with its connectors.

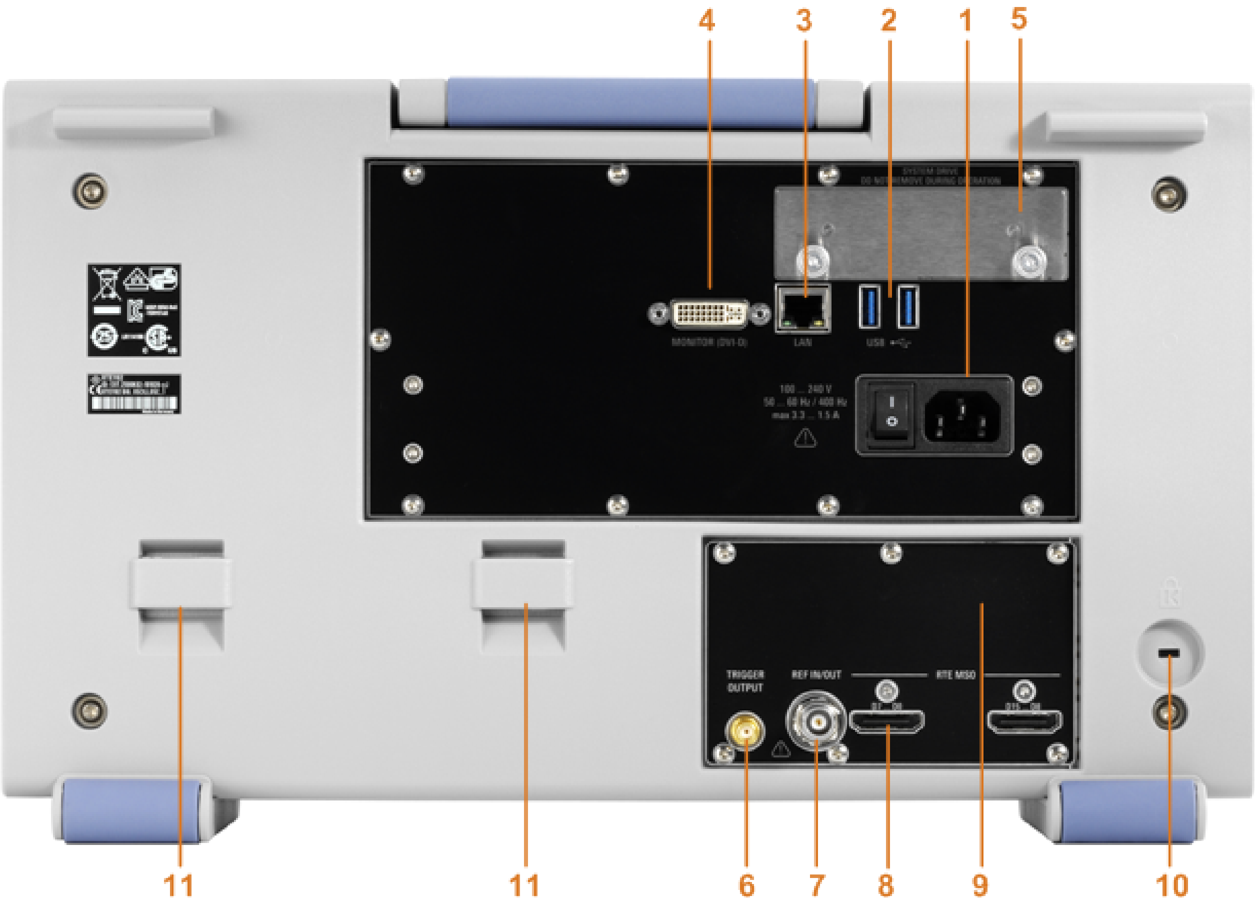


Figure 2-2: Rear panel view of R&S RTE

1 = AC power supply connector and main power switch
2 = USB connectors
3 = LAN connector
4 = DVI-D connector for external monitor
5 = Optional exchangeable hard disk: solid state disk, option R&S RTE-B18 or standard hard disk drive, option R&S RTE-B19

6 = External trigger output
7 = Reference input/output
8 = Optional connectors for digital probes (Mixed Signal Option R&S RTE-B1)
9 = Optional GPIB connector (option R&S RTE-B10, not shown in figure)
10 = Kensington lock slot to secure the instrument against theft
11 = Lugs to attach the accessory bag

AC power supply connector and main power switch

Connection to the AC power line. The R&S RTE can be used with different AC power voltages and adapts itself automatically to it. The nominal voltage and frequency ranges are displayed on the rear panel and quoted in the data sheet.

If grounding is *not* ensured by the mains system, ground the instrument using the protective earth conductor on the front panel and an appropriate cable.

When you power up the instrument, be sure to comply with the warm-up phase specified in the data sheet before you start measurements.

See also: Chapter 2.1.3, "Starting the Instrument", on page 30

USB

Two USB type A connectors that comply with standard USB 3.0. They are used to connect devices like keyboard, mouse, printer, and flash drive to store and reload instrument settings and measurement data.

Note: Electromagnetic interference (EMI) can affect the measurement results. To avoid any impact, do not use USB connecting cables exceeding 1 m..

LAN

8-pin RJ-45 connector used to connect the instrument to a Local Area Network (LAN). It supports up to 1000 Mbit/s (10/100/1000BASE-T Ethernet).

MONITOR (DVI-D)

Digital connector for an external monitor or projector. The monitor shows the complete content of the instrument's screen.

See also: Chapter 2.1.4.2, "Connecting an External Monitor", on page 33.

TRIGGER OUTPUT

The SMA connector for external trigger output is used to provide the internal trigger signal of the oscilloscope to trigger other instruments for synchronized measurements.

When a trigger occurs, the R&S RTE creates a pulse of 5 V with a source impedance of 50 Ω and delivers it to the external trigger output. The instrument can also send the pulse on mask test violation or violation of measurement limits and margins.

If the connector is terminated with 50 Ω, the signal level is 2.5 V (50 mA). With 1 MΩ termination, the level is 5 V. A short-circuit of the connector to ground creates current of 100 mA.

To enable the trigger out signal, select "Trigger" menu > "Ctrl/Action". Here you also adjust polarity, delay, and length of the pulse. The default is a positive pulse of 100 ns. The minimum delay is 800 ns.

REF IN/OUT
BNC female connector for input or output of reference signals. The input or output direction is set in "Horizontal" menu > "Reference clock".

The input frequency range is 10 MHz. The input impedance is 50 Ω.

The nominal output frequency is 10 MHz, the impedance is 50 Ω. For detailed specifications, refer to the data sheet.

RTE MSO
Mixed Signal Option, input for digital signals (parallel buses). The hardware module and logic probe come with option R&S RTE-B1. The module provides connectors for two logical probes with 8 digital channels each (D0 to D7 and D8 to D15).

The maximum input voltage is 40 V peak at 100 kΩ input impedance. The maximum input frequency for a signal with the minimum input voltage swing of 500 mV (V_{pp}) is 400 MHz. For detailed specifications, refer to the data sheet.

RTO-B10
Optional GBIP connector coming with option R&S RTE-B10 GBIP interface. For detailed specifications, refer to the data sheet.

2.3 Trying Out the Instrument

This chapter introduces the most important functions and settings of the R&S RTE step by step. The complete description of the functionality and its usage is given in the "User Manual". Basic instrument operation is described in Chapter 2.4, "Operating the Instrument", on page 79.

Prerequisites

- The instrument is set up, connected to the mains system, and started up as described in Chapter 2.1, "Preparing for Use", on page 27.
- A probe is available.

For these first measurements, you use the internal calibration signal, so you do not need any additional signal source or instruments. Try out the following:

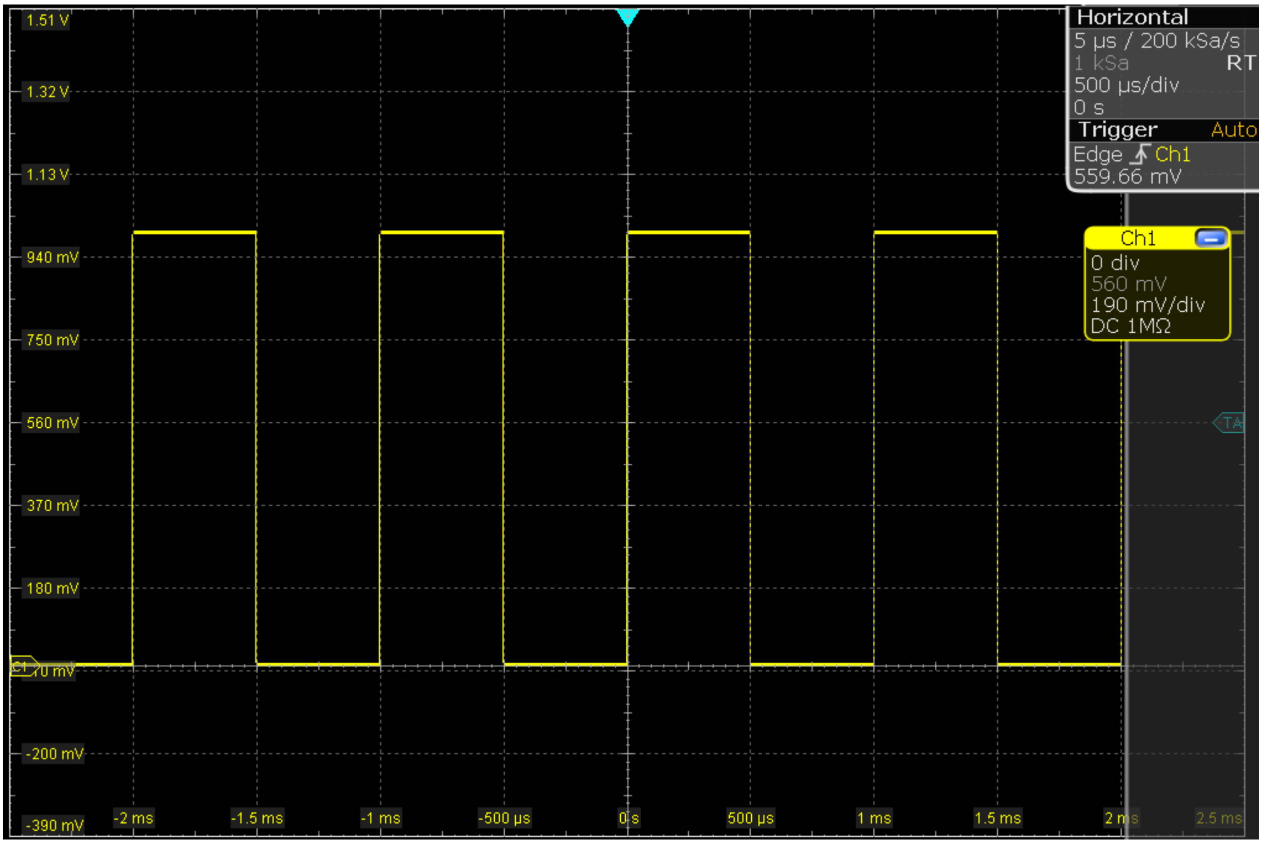
2.3.1 Displaying a Basic Signal

Displaying the input from a signal channel is simple and straightforward. Furthermore, you get to know some basic trigger functions. The R&S RTE provides wide-ranging trigger functions to find various signal anomalies, which are described in the instrument help and in the "User Manual".

1. Press the PRESET key on the front panel (in the SETUP area on the left).
2. Connect the probe to the input connector CH 1.
   Connect the probe's ground connector to the right compensation pin ⊥, and the tip to the left pin ⎍.

   The instrument recognizes the probe, and a signal is displayed in the diagram.
3. Press the AUTOSET key on the front panel (in the SETUP area on the left).

   Autoset finds appropriate horizontal and vertical scales and trigger conditions to present a stable square waveform. The trigger is set to edge trigger on rising edge with auto trigger mode.



4. If necessary, compensate the passive probe as described in Chapter 4.8.1, "Adjusting Passive Probes", on page 183.
5. In the TRIGGER area of the front panel, press the SOURCE key. Press the key again to switch the trigger source to "C2".

An unstable waveform is displayed. In auto mode, the instrument triggers repeatedly after a time interval if no real trigger occurs.

6. In the TRIGGER area, press the MODE key.
7. Check the "Trigger" settings in the upper right corner of the screen.

   The trigger mode has changed to "Normal". The waveform is no longer refreshed, and the "Trigger state" message box appears. The instrument cannot find a real trigger event because there is no signal on channel 2.
8. Tap the "Undo" icon on the toolbar repeatedly until the trigger mode is "Auto" and the trigger source is "CH1".

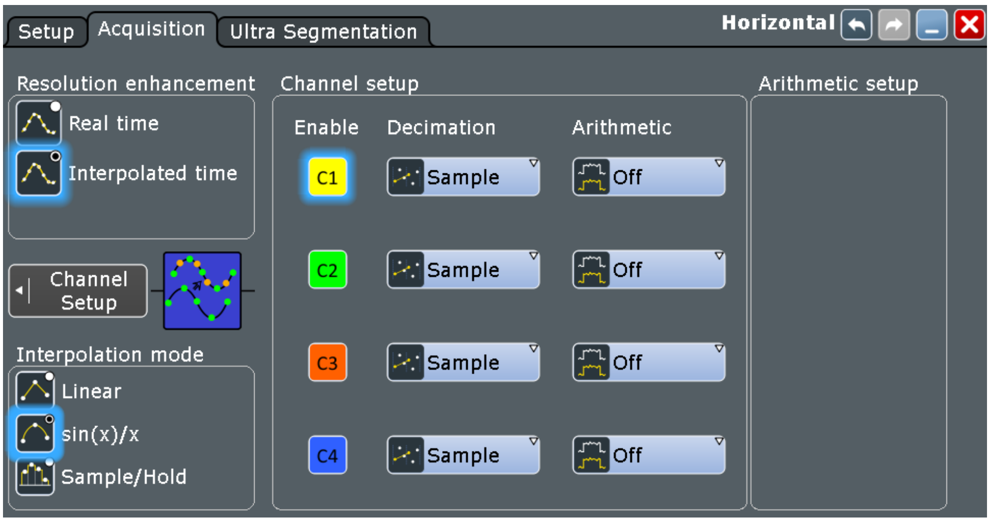
   
9. Press the SLOPE key to toggle the trigger slope.
   Watch the waveform and the "Trigger" settings.

2.3.2 Acquiring Data

You can acquire data using different arithmetic methods to get envelope or average waveforms.

If you need to change only one setting during analysis, and you need to change it often, you can reduce the dialog box to a small box that only contains the required setting. Thus you can change the setting and see the result immediately.

1. Press the ACQUISITION key on the front panel, in the HORIZONTAL area.
2. In the "Acquisition" tab of the "Horizontal" dialog box, select the "Decimation" type *Sample*.

3. Tap the "Arithmetic" button for C1 to set the focus on this setting.
4. Tap the  "Minimize" icon in the upper right corner of the dialog box.

The dialog box turns into a mini box that contains only the "Wfm Arithmetic" setting.

5. Select *Envelope* and check the waveform.

   The instrument sets the "Decimation" type automatically to *Peak detect* to display the correct envelope waveform.

6. Select *Average* and check the waveform.

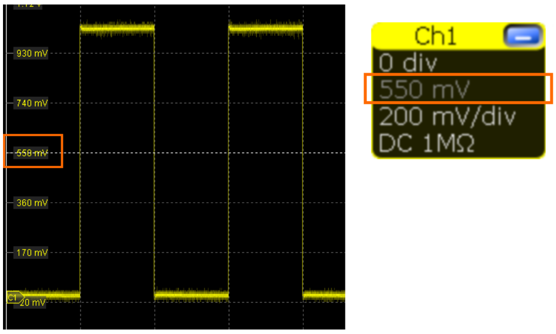
7. Tap the "Maximize" icon in the mini dialog box.

   The complete "Acquisition" dialog box is restored.

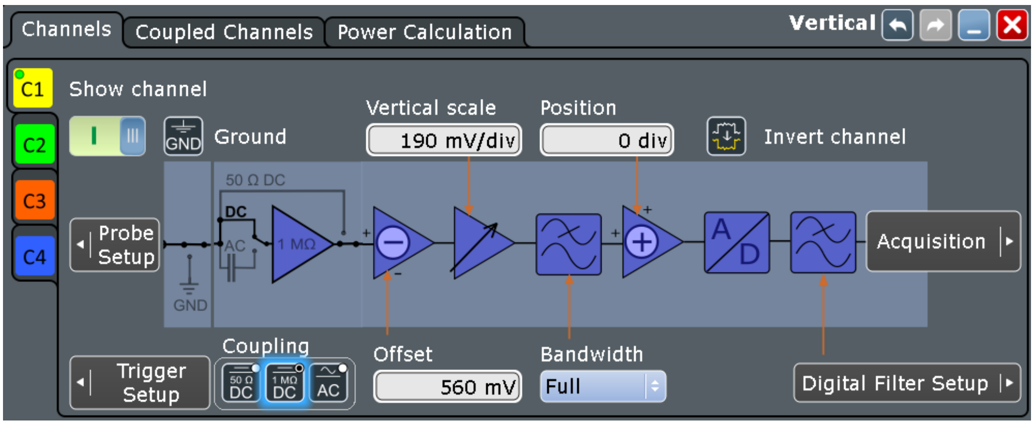
8. Close the dialog box by tapping .

2.3.3 Changing the Waveform Scaling and Position

As you can see on the y-axis of the display, the calibration signal has a vertical offset of about 550 mV. The value can differ.



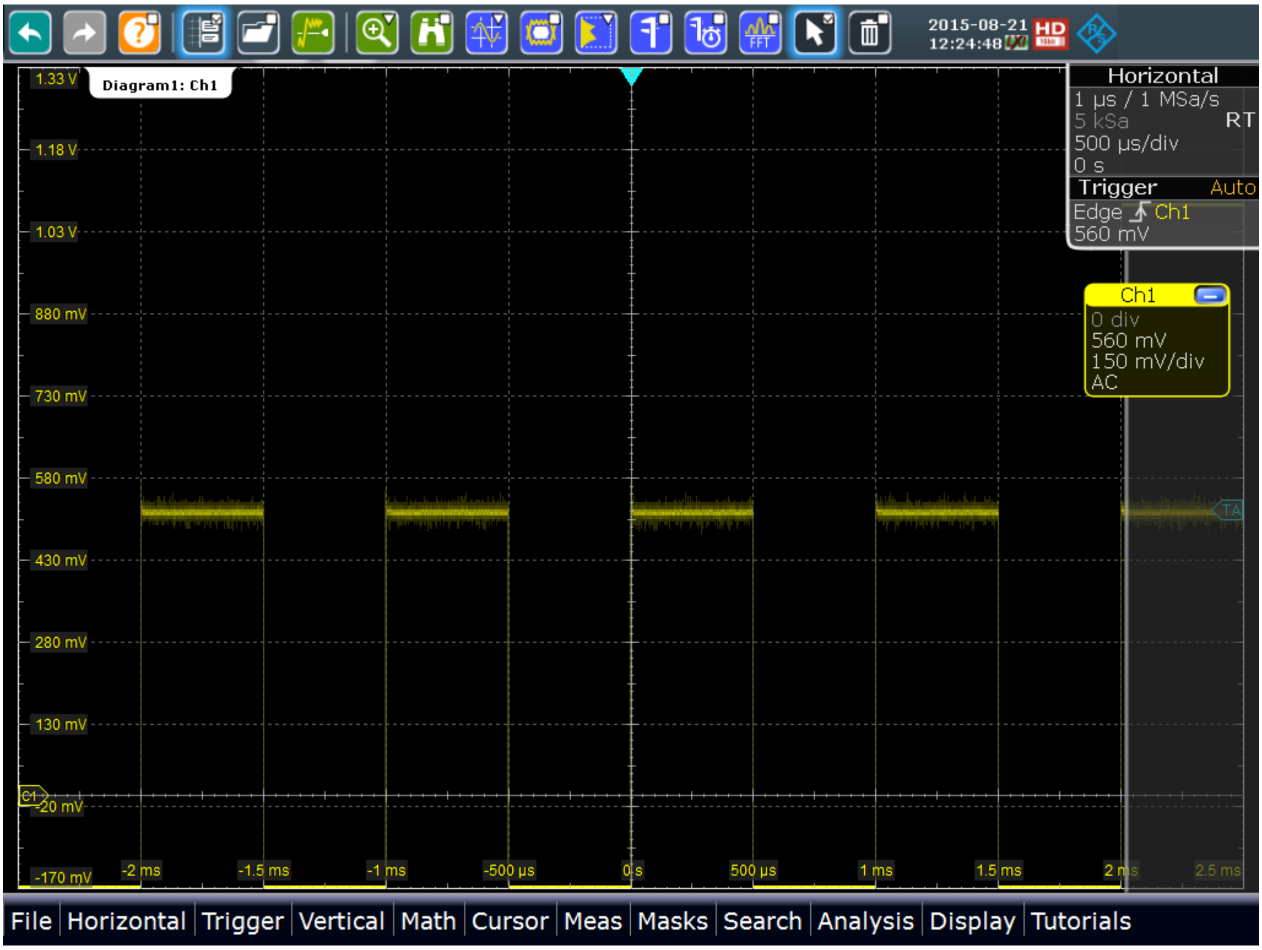
This value is also indicated in the signal icon for channel1 (2nd row). If you press the CH1 key, the "Vertical" settings dialog box also displays the "Offset" value. The offset is the DC component of the signal.



If you use a passive probe, you can filter the DC component by using the AC coupling function. Then you quickly find the new trigger level, and try out the scaling functions:

1. Press the CH1 key on the front panel (in the VERTICAL area) to display the "Vertical" dialog box.
2. Change the "Coupling" to "AC". Close the dialog box.

   The DC component of the signal is eliminated; the waveform position moves down vertically and is now centered around 0 V.

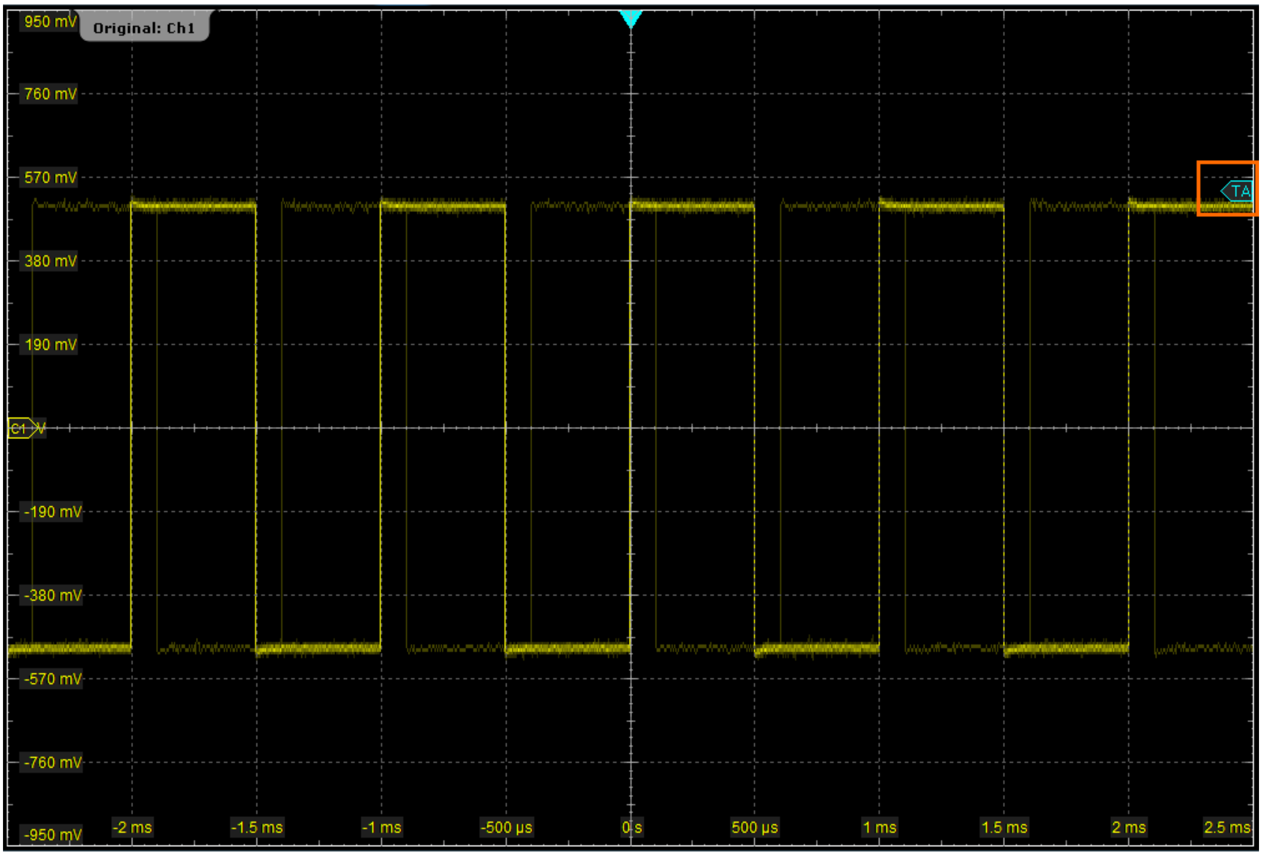


3. To move the waveform back to the center of the screen, eliminate the offset in the vertical settings:
   a) Press the CH1 key again.
   b) Enter *0 V* in the "Offset" field.

   The waveform is now displayed in the center of the display, with the x-axis crossing at 0 V. The waveform might be unstable if the trigger level is above.
4. Tap the "Show signal bar" icon on the toolbar.

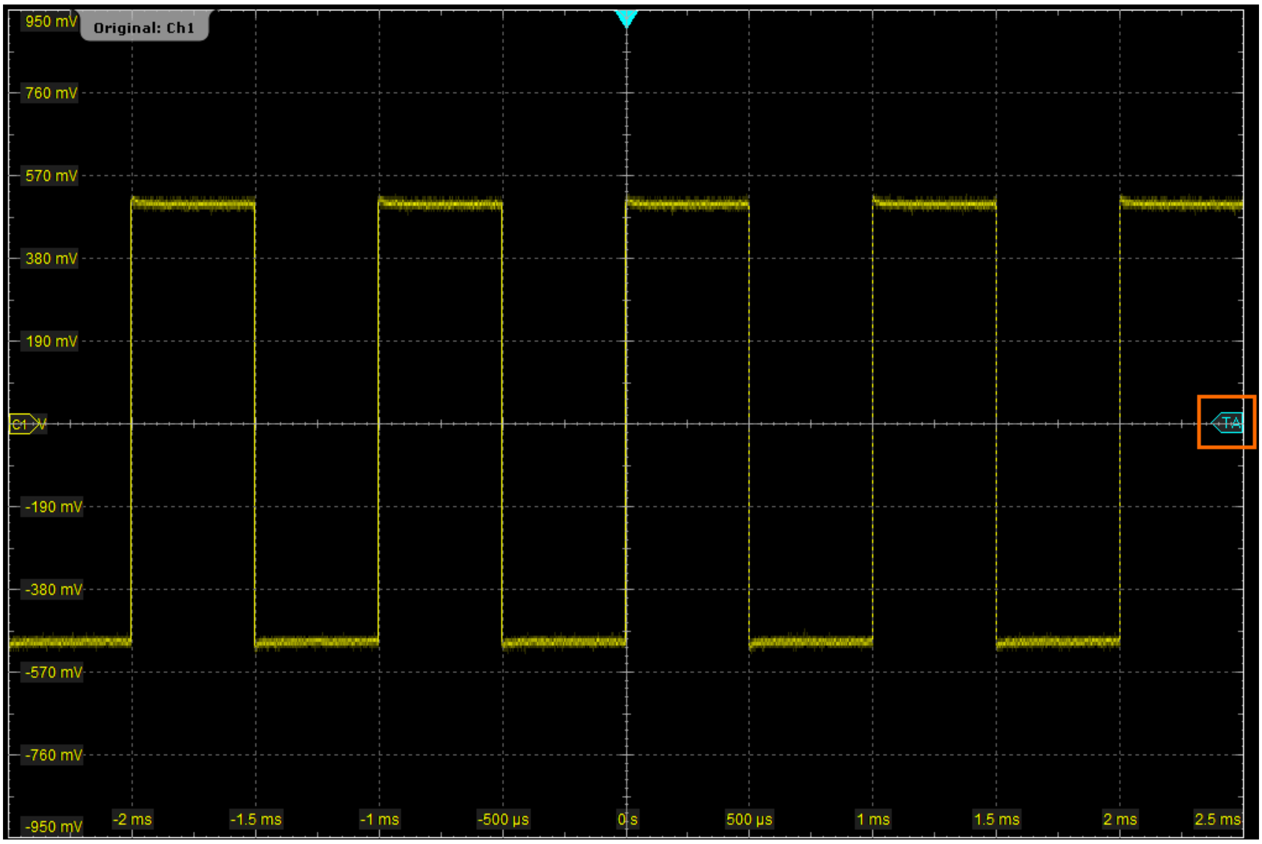
   

The signal bar disappears, and you can see the trigger level marker on the right.

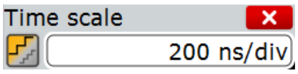


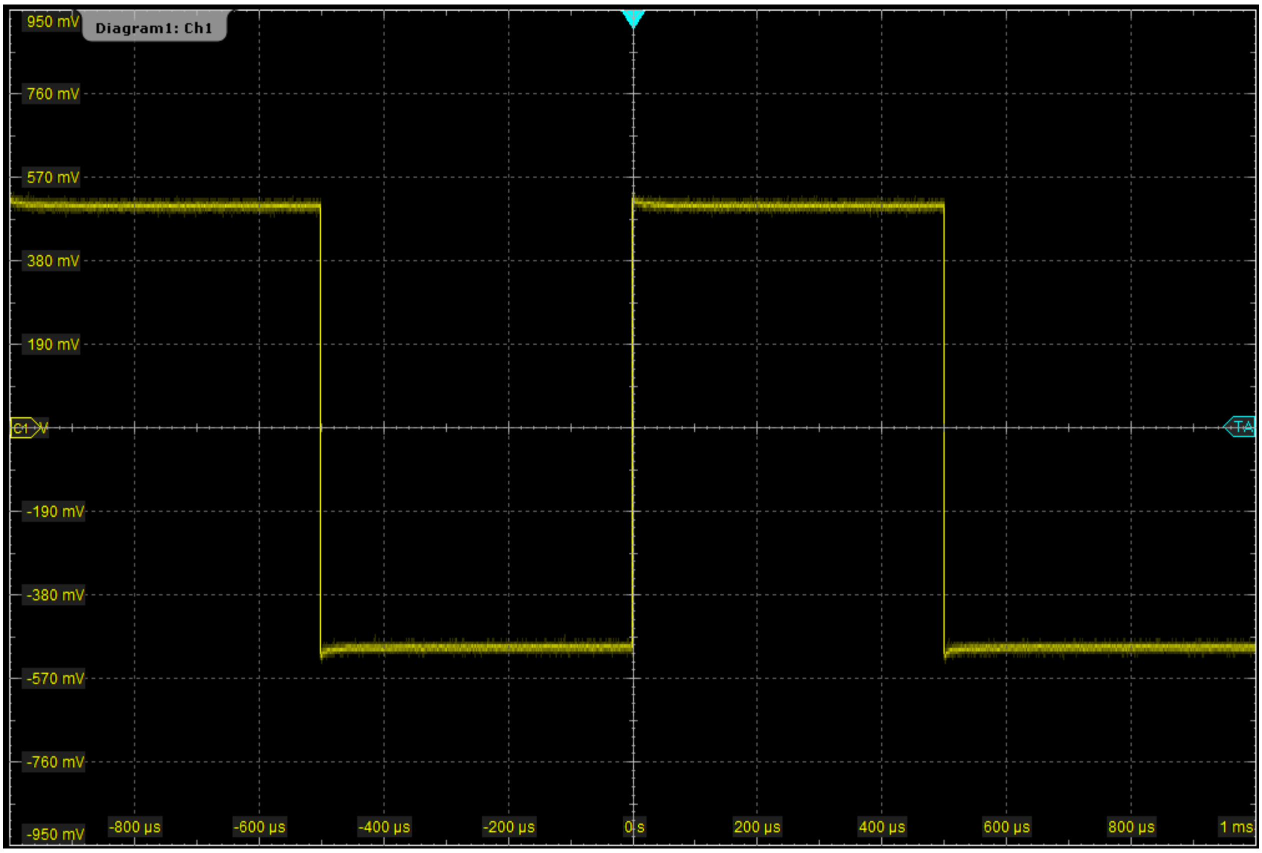
5. Tap the "Find level" icon on the toolbar.

The instrument adjusts the trigger level, and a stable waveform is displayed.



6. To examine one pulse in the signal in more detail, turn the horizontal "Scale" rotary knob.
   The current scale factor per division is displayed in the upper left-hand corner of the display while you turn the knob. You can switch between a small and large step size in the scaling factor by tapping the step icon.



7. To return to the original scaling, try the UNDO key in the NAVIGATION area:
   a) Press the UNDO key repeatedly until the original scaling is displayed.
   b) Press the REDO key to retrace the undone steps. Thus, you can toggle between the two displays using the undo and redo keys until you perform a different action.

   Tip: Instead of using the UNDO and REDO keys, you can tap the corresponding icons on the toolbar.

If you use an active single-ended probe, you can measure the DC component of the signal directly at the probe tip by means of the integrated R&S ProbeMeter:

1. On the "Vertical" menu, tap "Probe Setup".
2. Make sure that the correct channel is selected on the left tab.
3. In the "Additional" section, tap "ProbeMeter".

   A result box shows the DC voltage measured by the R&S ProbeMeter.

2.3.4 Zooming into the Display

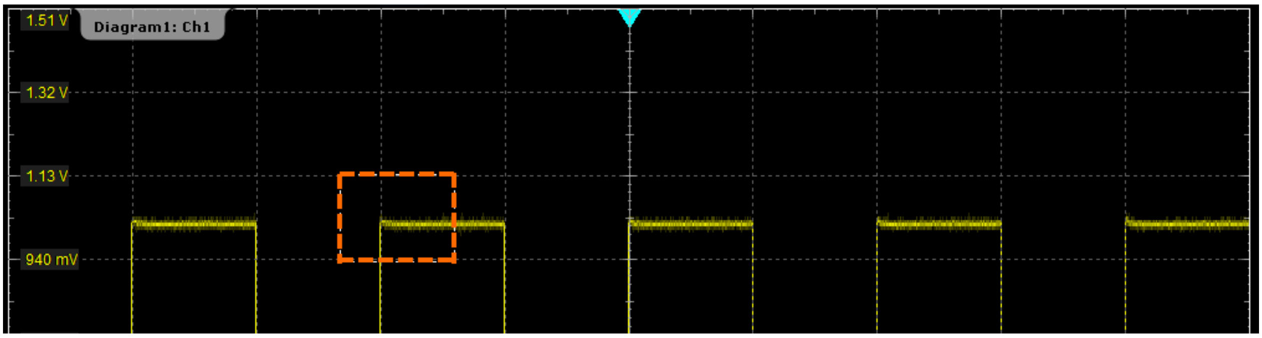
Using the SCALE rotary knobs, you can change the scaling of the time base and signal amplitudes in order to enlarge the waveform. If you need to see more details, use one of the zoom functions. The instrument has 4 zoom types, 2 of them you try out in this chapter.

The usage of zooms is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Zoom".

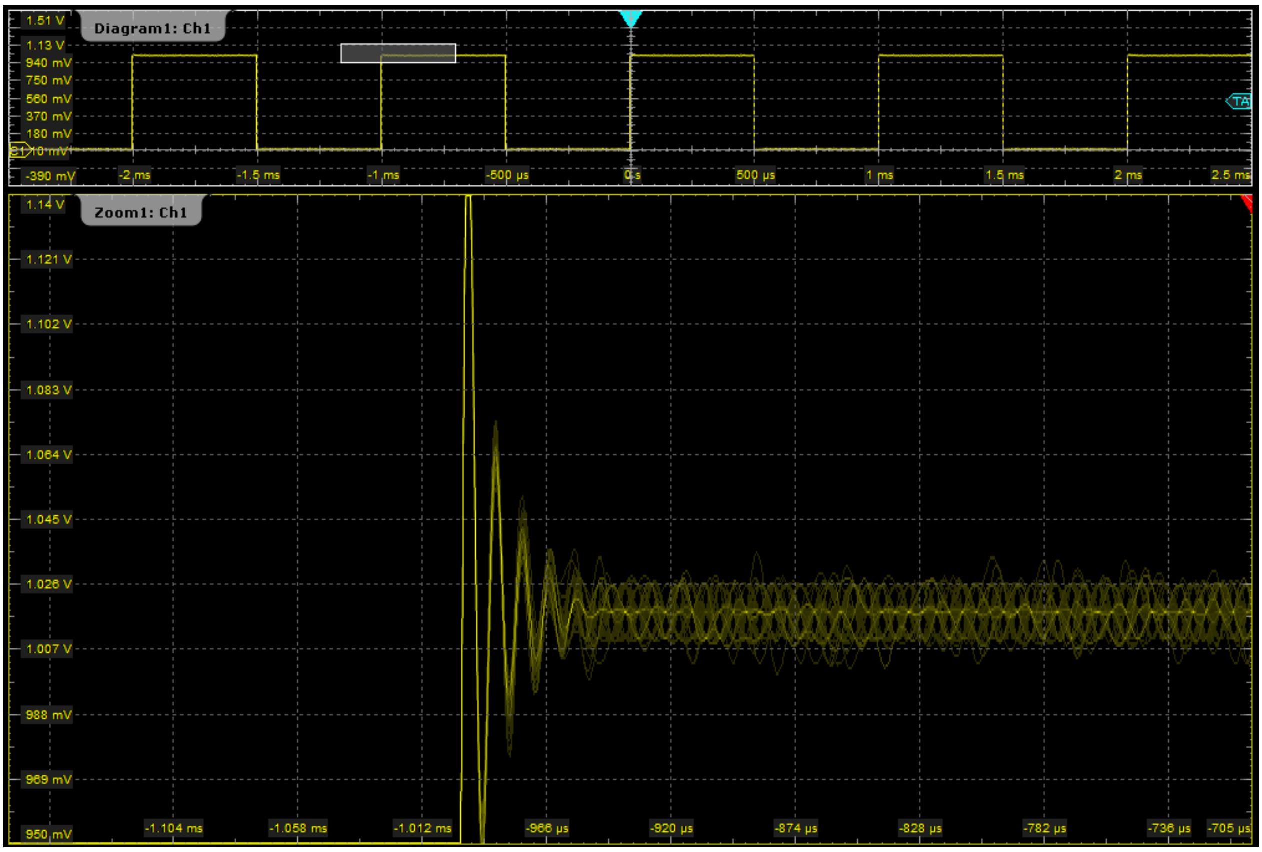
2.3.4.1 Using the Standard Zoom

1. Restore the default signal channel settings by pressing the PRESET and AUTOSET keys.
2. On the toolbar, tap the "Zoom" icon.

3. Tap the position in the diagram that you want to define as one corner of the zoom area. Then drag your finger to the opposite corner of the zoom area.
While you drag your finger on the touchscreen, a dotted rectangle is displayed to indicate the current zoom area. When the rectangle covers the required zoom area, remove your finger.



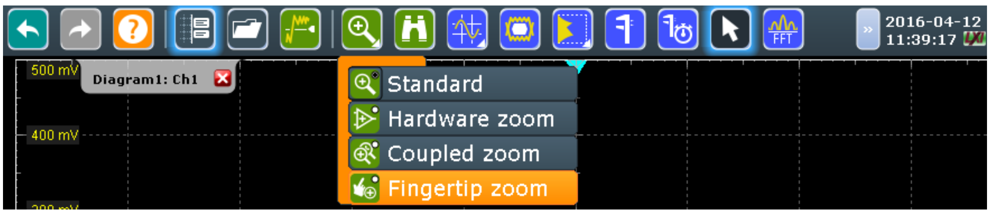
The indicated area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle.



4. To remove the zoom window and make room on the display for other results, tap the "Delete" icon and then the zoom window.

2.3.4.2 Using the Fingertip Zoom

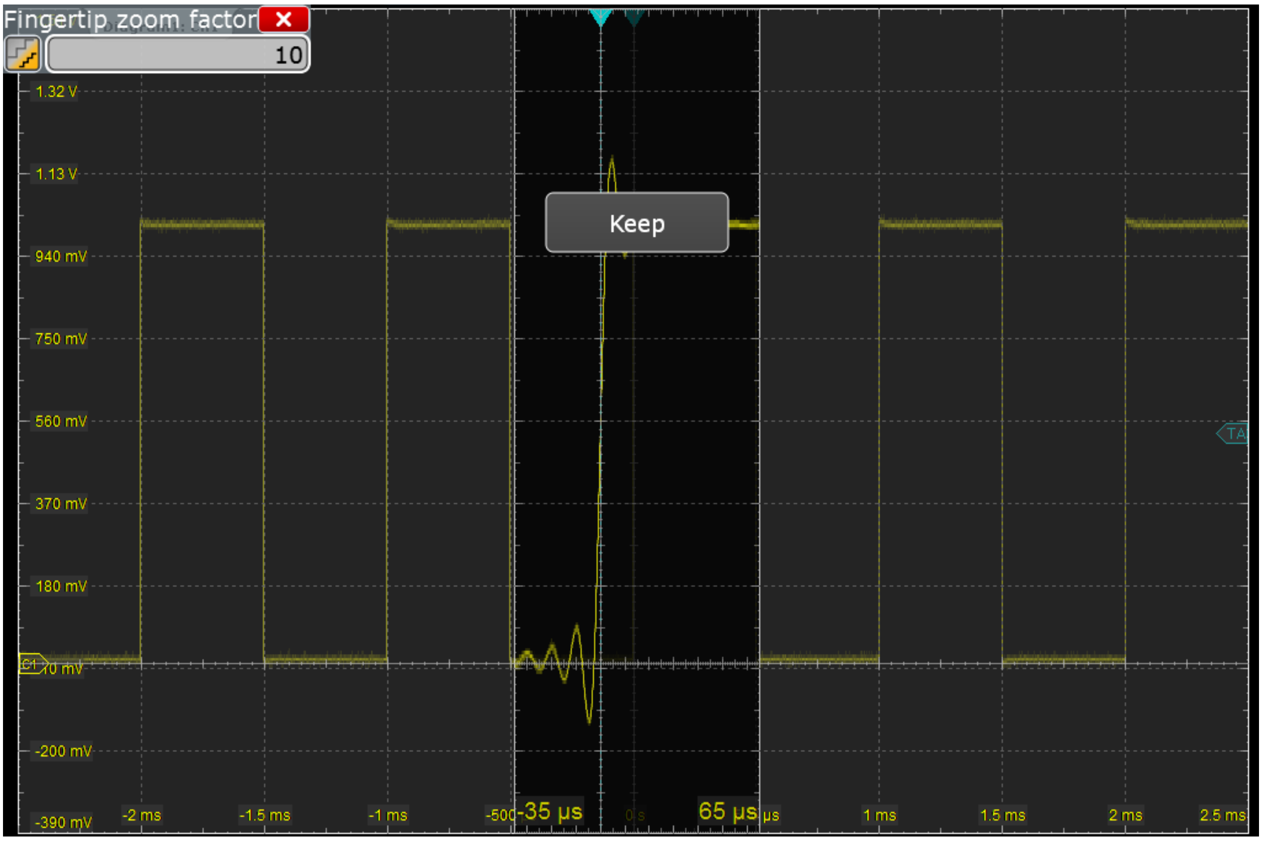
1. Touch the "Zoom" icon on the toolbar and drag it down until the "Zoom" toolbar menu opens. Release the finger.
2. Tap "Fingertip zoom".



3. Touch and hold the waveform and move your finger slowly in horizontal direction.

   Tip: You can turn the NAVIGATION knob to change the zoom factor while holding the waveform.

4. Release the finger when the waveform segment of interest is visible in the zoom.
5. Tap "Keep" to convert the fingertip zoom into a standard zoom diagram.



2.3.5 Displaying the Waveform History

During a continuous acquisition, the instrument stores the acquired data in the memory and shows the current acquisition on the display. When the acquisition was stopped and a new acquisition is started with RUN CONT or RUN N× SINGLE, the memory is cleared and written anew. The history accesses and displays the samples that were saved before the current acquisition.

In the following example, you acquire 10 waveforms, and display the 3 most recent waveforms.

1. In the HORIZONTAL area, press the ACQUISITION key.

   The "Horizontal" settings dialog box opens.
2. Set the "Average count" to *10* to perform 10 waveform acquisitions.
3. Close the "Horizontal" dialog box.
4. In the TRIGGER area, press the RUN N× SINGLE key.

   Ten waveform acquisitions are performed. The most recent acquisition is displayed in the diagram.

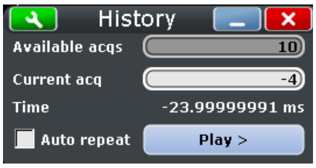
5. In the ANALYSIS area, press the HISTORY key.

   The quick access "History" dialog box appears, and the history mode is enabled.

6. Tap "Play".

   The ten stored waveforms are displayed one after the other, but very fast.

7. In the "Current acq." field, enter *-4* to display the sixth waveform, counted from acquisition start. The latest acquisition has the number 0, the oldest has -9.

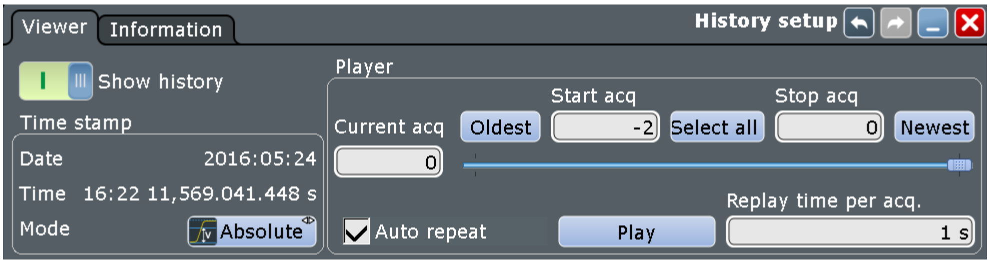
8. Tap  to open the "History" setup dialog box.

9. Enter *-2* in the "Start acq" field. Tap "Newest" to enter *0* in the "Stop acq" field.

   Thus the three latest acquisitions are displayed.

10. In the "Replay time per acq." field, enter *1 s* to display each waveform for one second.

11. Enable the "Auto repeat" option to see the three waveforms repeatedly.

12. Tap "Play".
    The currently displayed waveform is indicated in the "Current acq." field.

13. Close the "History" dialog box so you can see the waveform better.

14. Tap "Running" to stop the display.
    During running display, the "Play" is labeled "Running".

15. Close the quick access "History" dialog box.

    The history mode is disabled. The HISTORY key is no longer illuminated.

2.3.6 Showing Basic Measurement Results

Using the R&S RTE you can perform and display different measurements simultaneously. The color of the results in the result table corresponds with the source waveform color.

2.3.6.1 Performing a Cursor Measurement

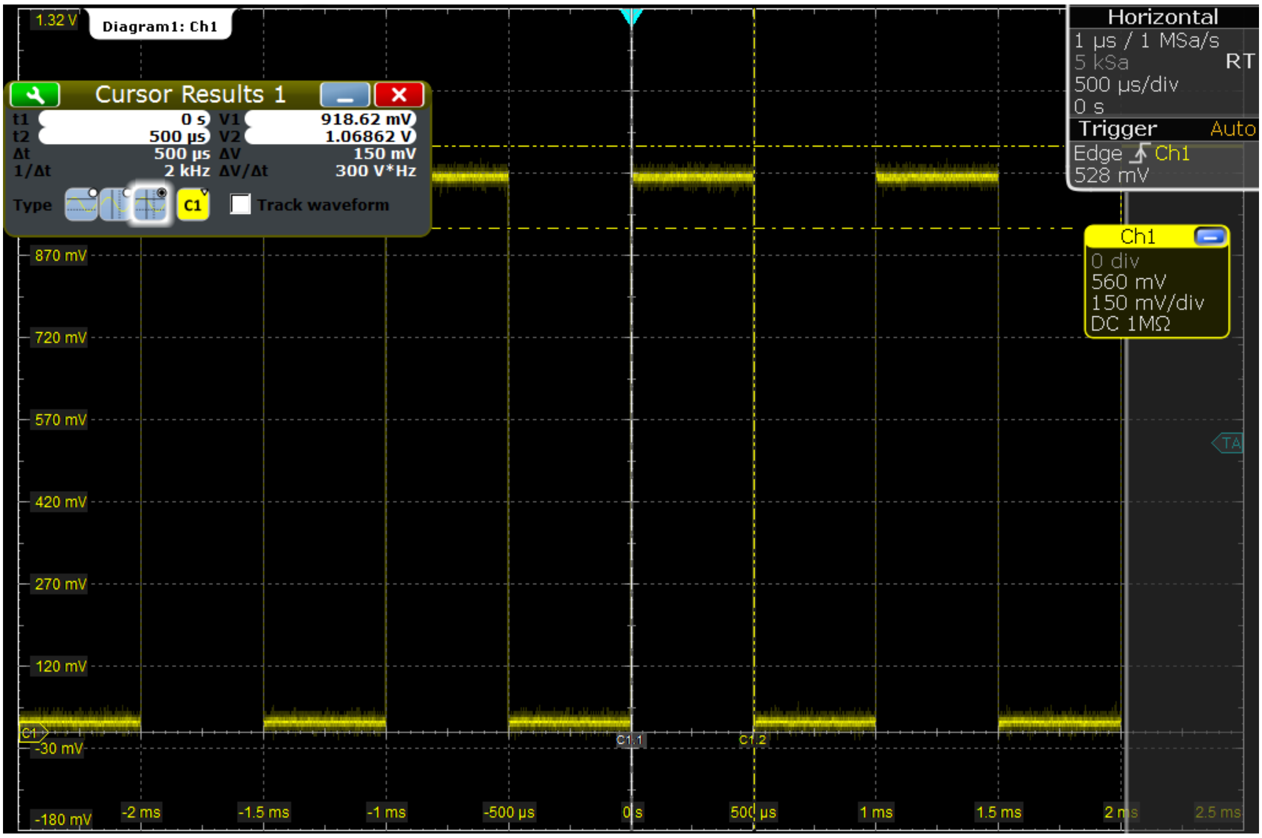
1. Restore the default signal channel settings: Press the PRESET and AUTOSET keys.
2. Tap the "Cursor" icon on the toolbar.

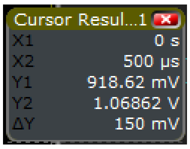
3. Tap the diagram in which you want to set the cursors.
   Alternatively, draw a rectangle on the screen to position the cursor lines.

   The cursor lines appear in the diagram and the "Cursor Results" box opens. The measured values of the waveform at the cursor positions are displayed.

4. You can move the cursor lines in different ways:
   - Touch a cursor line and drag it on the screen.
   - Tap a cursor line to activate it. Turn the NAVIGATION knob to adjust the position.
   - Enter the position values in the result box.



5. To save space in the display, minimize the result box. The most important results are displayed and updated in the result icon, as well.



6. To remove the result icon and make room on the display for other results, tap the red cross on the icon label.

2.3.6.2 Performing Automatic Amplitude Measurements

You can start up to 8 automatic measurements to run in parallel. The "Automatic measurment" icon starts the measurements one after the other.

In the following example you start and configure 3 automatic measurements: amplitude, rise time, and fall time measurement, and you display the statistical evaluation.

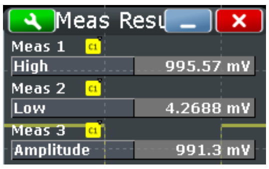
1. Restore the default signal channel settings by pressing the PRESET and AUTOSET keys.
2. Tap the "Automatic measurment" icon. Then tap the waveform.

   By default, the measurement of the high signal level is started.
3. Tap the "Automatic measurment" icon again. Then tap the waveform.

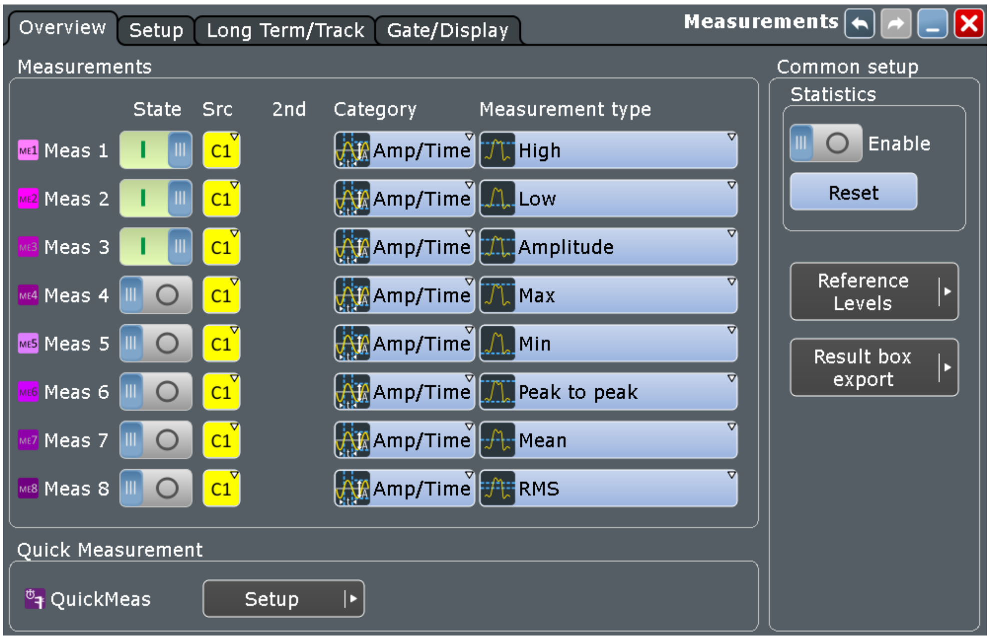
   By default, the measurement of the low signal level is started.
4. Tap the "Automatic measurment" icon again. Then tap the waveform.

   By default, the amplitude measurement is started.

5. Tap the icon in the result box to open the "Measurements" dialog box.

   In the "Setup" tab, you see the activated measurements and the assigned measurement types.
6. In the "Meas1" line, tap the measurement type button labeled "High".



7. Select "Rise time".
8. In the "Meas2" line, tap the measurement type button labeled "Low".
9. Select "Fall time".
10. Under "Statistics", tap "Enable".

11. Close the "Measurements" dialog box and check the results.
12. Close the "Measurement Results" box.

2.3.6.3 Performing and Configuring the Quick Measurement

A set of up to eight different measurements on one source can be performed at once, simply by tapping the "Quick measurement" toolbar icon. The results are displayed in a result box. You can configure the measurement types to be included in quick measurement. This way, repeating measurements are performed very quickly.

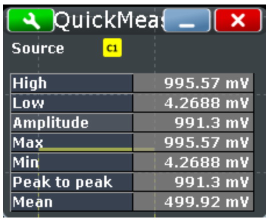
In the following example, you start a quick measurement and change the QuickMeas configuration.

1. Press AUTOSET.
2. Tap the "Quick measurement" icon on the toolbar.

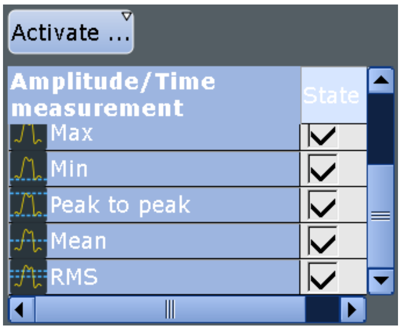
   

3. Tap the diagram.

   The result box shows the results of the default quick measurement.

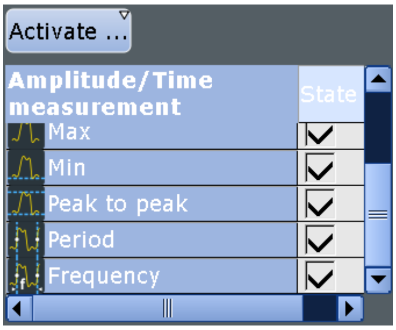
4. Tap the  icon to open the "Measurements" dialog box.
5. If necessary, select the "Quick Meas" tab.
6. Scroll down in the table and disable the Mean and RMS measurements.

7. Tap "Activate" and select *Period*.

   Now the result box also shows the result of the period measurement.

8. Tap "Activate" and select *Frequency*.



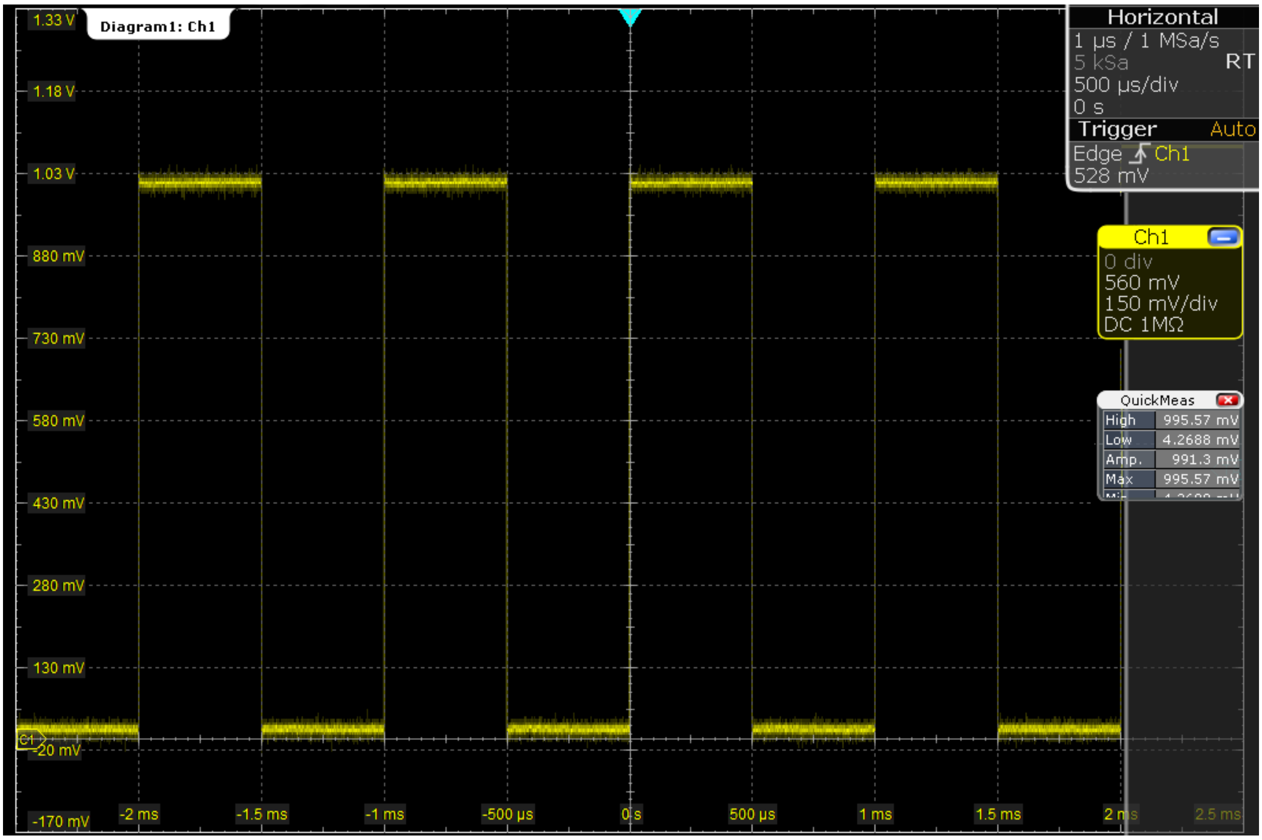
Now the result box also shows the result of the time measurements.

9. Tap "Set as QuickMeas".

   The current configuration is set as default quick measurement and can be repeated until you save another configuration.

10. Close the dialog box.

11. To save space in the display, minimize the result box:
    The most important results are displayed and updated in the result icon, as well. Do not close the result icon, as you need the results for the Search example (see Chapter 2.3.9, "Performing a Search", on page 70).

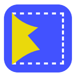


2.3.6.4 Displaying a Histogram

Histograms are useful to analyze the occurrence of measurement values statistically.

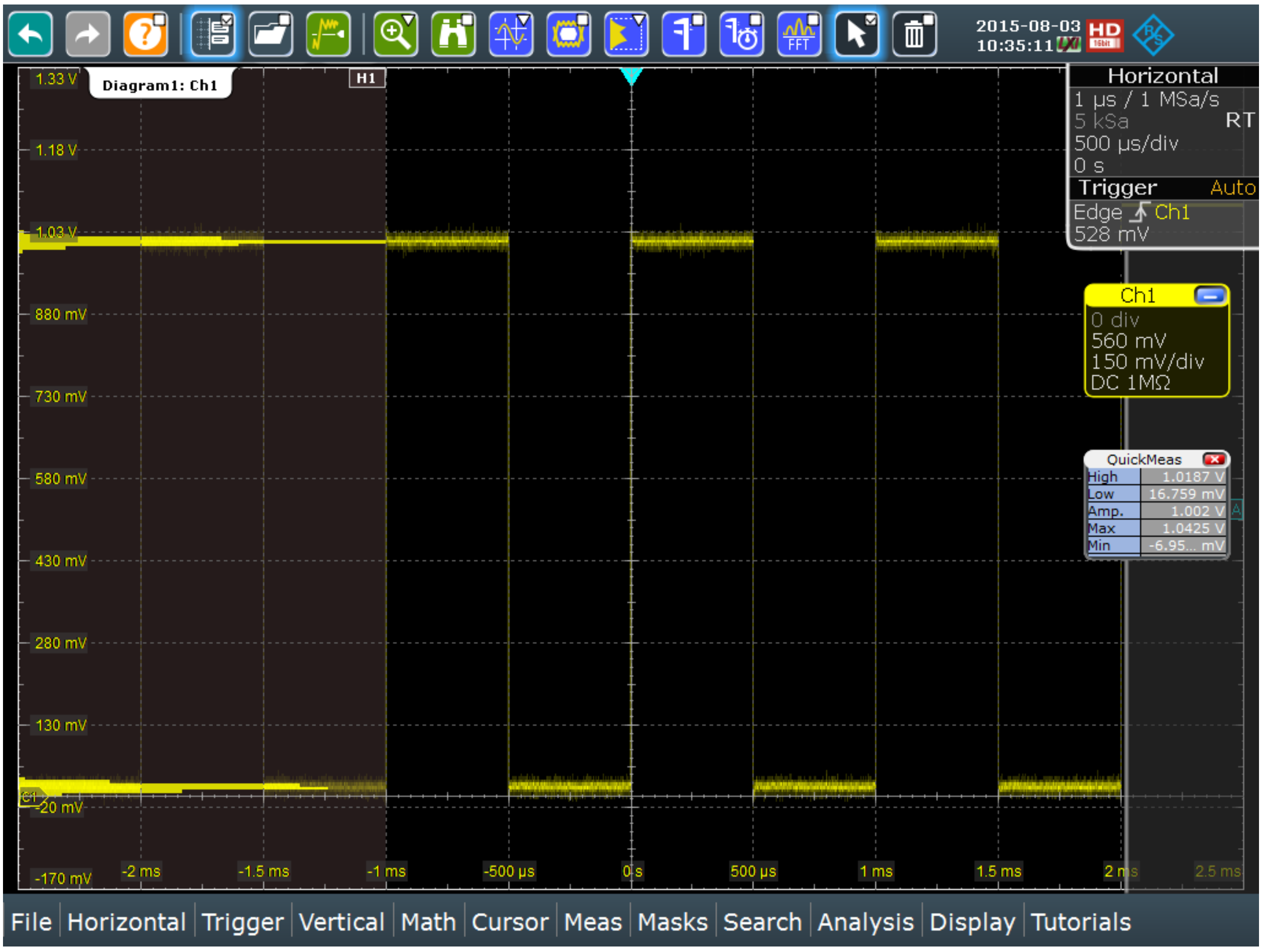
The usage of histograms is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Histogram".

1. Tap the "Histogram" icon on the toolbar.



2. Tap the diagram in which you want to generate the histogram.

   You can also draw a rectangle on the screen to define the area on which the histogram is based. The histogram range is indicated in the diagram and a vertical histogram is defined and displayed.



3. To display the measurement results for the histogram, tap the "Measurement" icon on the toolbar.

4. Tap the histogram.

   The waveform count for the histogram is displayed.

5. To display further measurement results for the histogram, tap the icon in the result box.
   Alternatively, you can press the MEAS key on the front panel.

6. For "Meas 2", select "Category = Hist" and the required measurement type.

7. To finish the measurement, tap the "Close" icon in the result box.

8. To remove the histogram, tap the "Delete" icon on the toolbar and then the histogram. Both the histogram and any measurements based on that histogram are deactivated.

2.3.7 Performing a Basic FFT Analysis

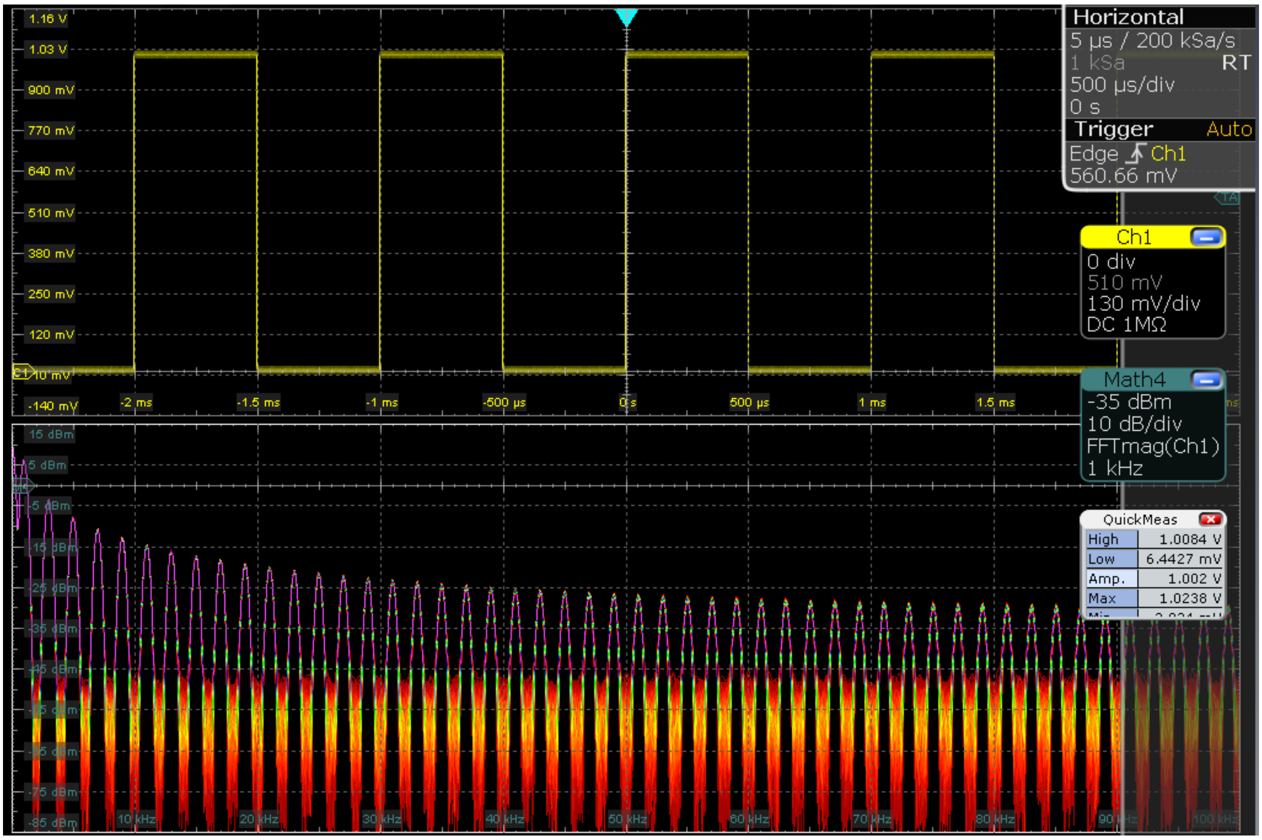
During FFT analysis, a signal in the time domain is converted to a spectrum of frequencies. A basic spectrum waveform can be displayed quickly.

The usage of FFT is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > FFT".

1. Restore the default signal channel settings by pressing the AUTOSET key.

2. Tap the "FFT" icon on the toolbar. Then tap the diagram.

   A math waveform is configured that uses the "Mag(FFT(x))" operator with "Ch1" as source. The spectrum waveform is displayed in a new diagram.

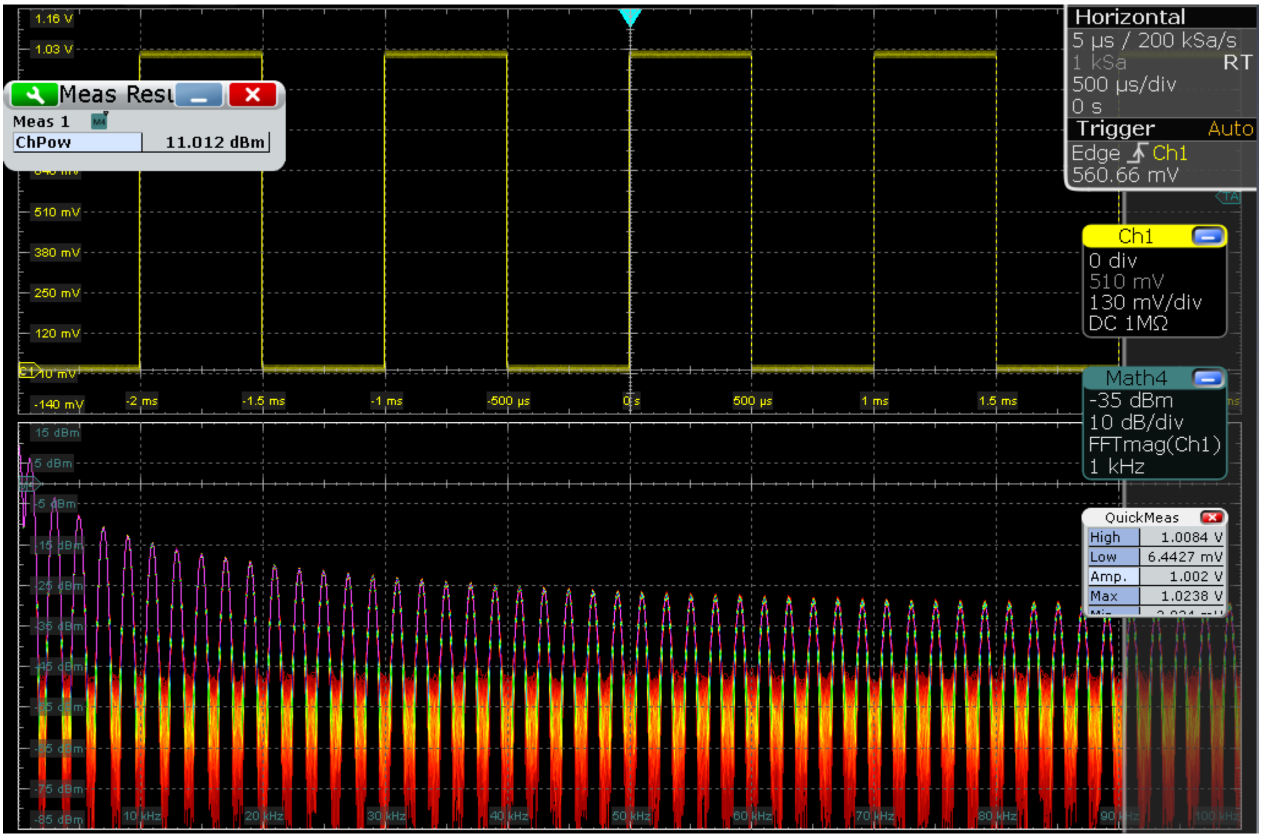


3. To measure the spectrum on the math channel, tap the "Measurement" icon on the toolbar.

4. Tap the spectrum waveform.

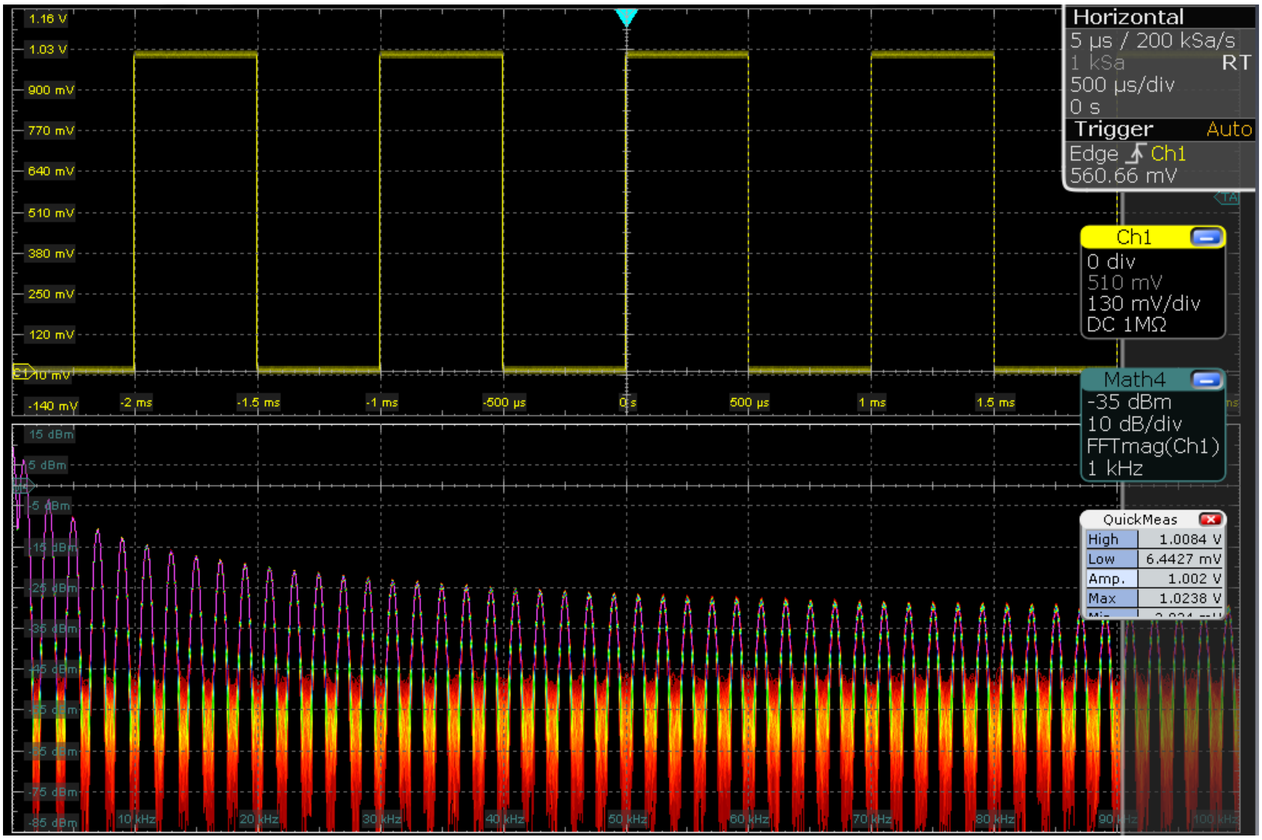
   The spectrum measurement results are displayed in a result box.



5. Double-tap the spectrum waveform.

   The "FFT Setup" dialog box opens.

6. Set the "Center frequency" to *10 kHz*.
   The instrument adjusts the frequency span automatically.
   Close the dialog box.



7. If the spectrum analysis option R&S RTE-K18 is installed on your instrument, double-tap the spectrum waveform again.
8. Enable the spectrogram. Close the dialog box.
9. To remove the FFT results, tap the "Delete" icon and then the spectrum waveform.

10. Close the "Measurement" result box.

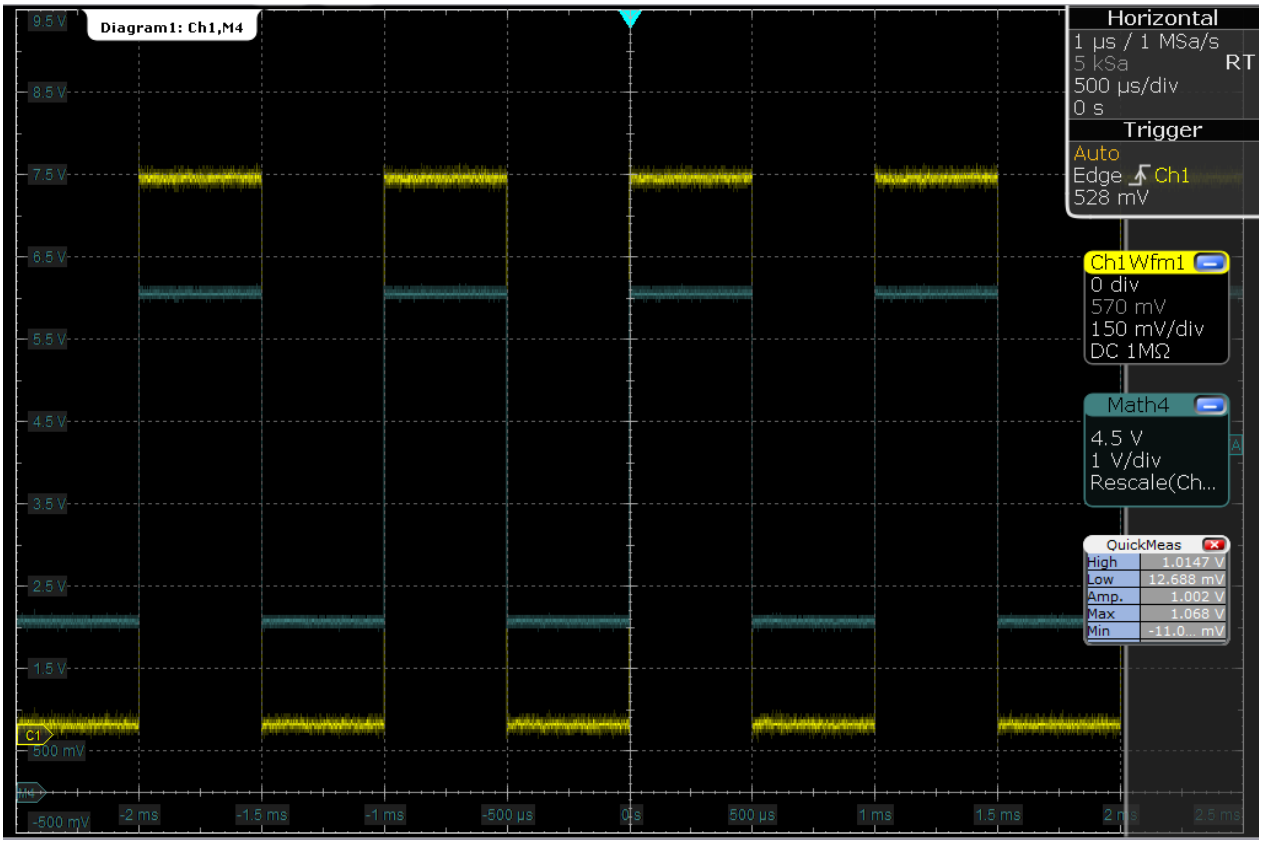
2.3.8 Performing Mathematical Calculations

In addition to the measured waveforms, you can display calculated data to compare the current measurement result with.

For example, you can rescale the waveform and display it in the same diagram as the original waveform.

1. Press AUTOSET.
2. Press the MATH key.
3. In the "Setup" tab, select the "Basic" subtab.
4. Tap the "Source1" icon and select *Ch1*.

5. Tap the "Operator" icon and select *Rescale*.
6. For "a", enter the vertical scaling factor, e.g. *4*.
7. Under "b", enter the vertical position offset, e.g. *2*.
   Look at the lower part of the dialog box and note that the instrument adjusts the "Vertical scale" and "Vertical offset" of the math waveform automatically.
8. Tap "Enable" to display the first math waveform.
   The original and the rescaled waveforms are displayed.
9. Close the "Math" dialog box.



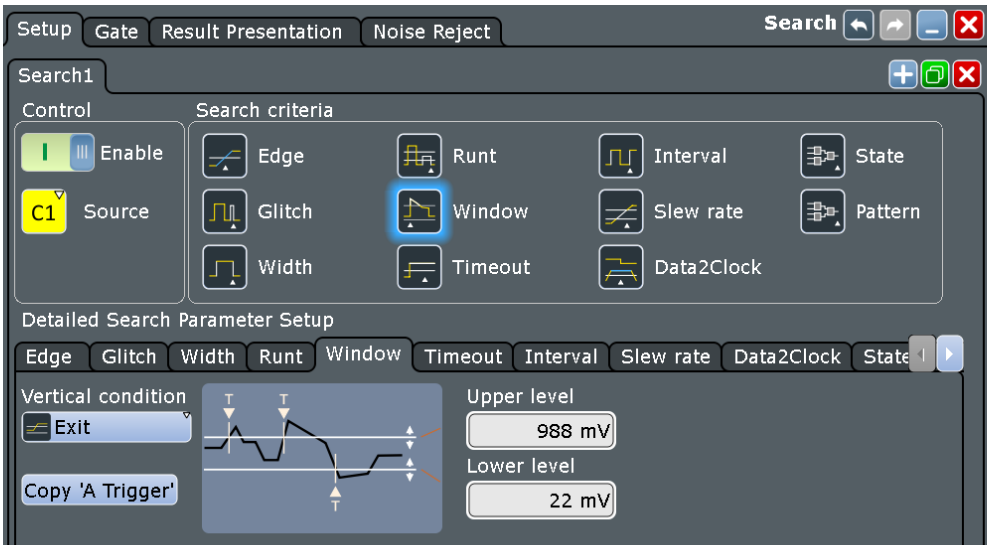
10. To remove the math waveform, do one of the following:
    - Tap the "Delete" icon and then the math waveform.
      
    - Minimize the math waveform by tapping the signal icon. Then close the signal icon

2.3.9 Performing a Search

In the following search, you detect positive and negative overshoots, i.e. values that exceed the high or low levels. To find these events, you can use the windows search.

To determine the search conditions, we use the results of the measurement example described in Chapter 2.3.6.3, "Performing and Configuring the Quick Measurement", on page 63.

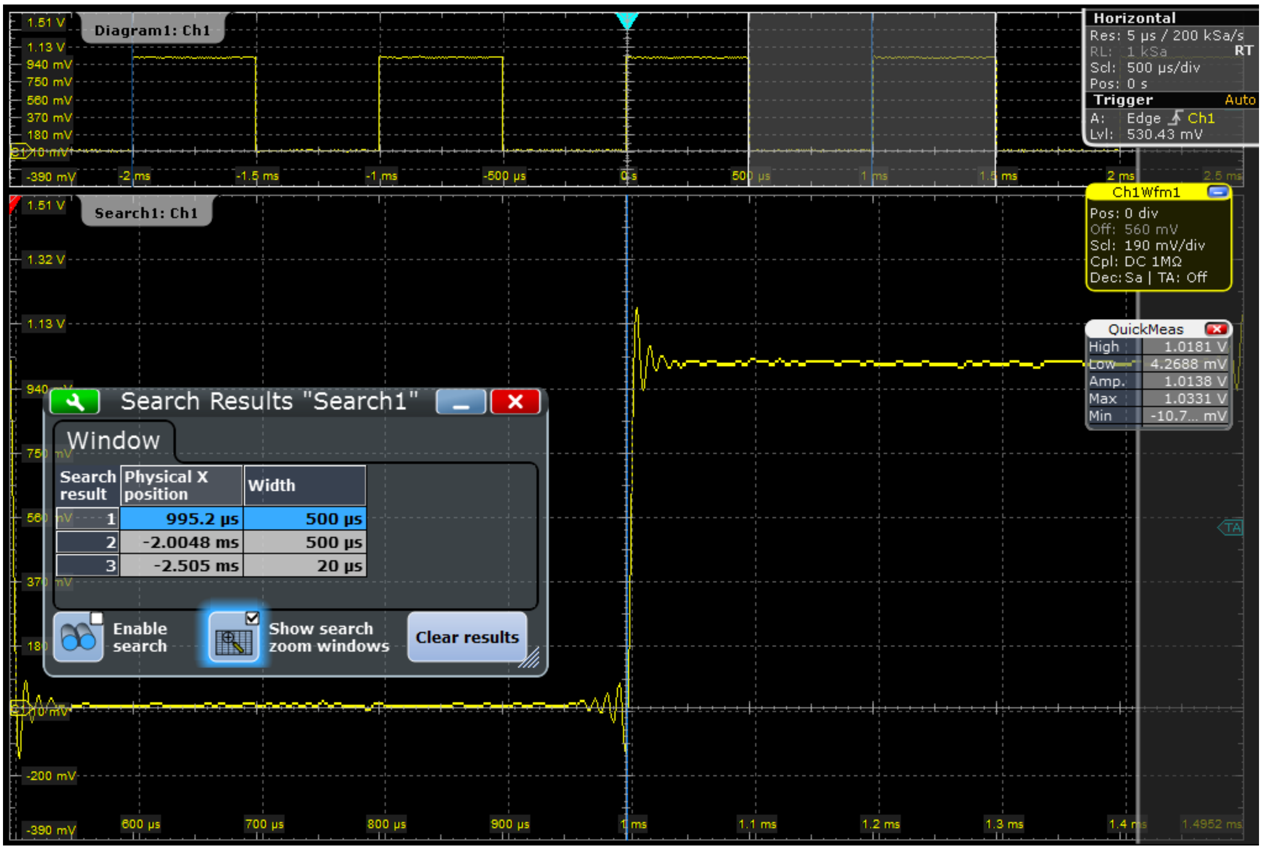
1. Press the SEARCH key on the front panel (ANALYSIS area).
2. Select "C1" as "Source".
3. Select the search criteria: Enable "Window".
4. In the "Window" tab below, define the search conditions:
   a) In the "Upper level" field, enter the result of the "High" level measurement.
   b) In the "Lower level" field, enter the result of the "Low" level measurement.
   c) As "Vertical condition", select "Exit" to find values that are outside the range defined by the high and low levels.



5. Select "Enable" to start the continuous search on the acquired data.
6. Close the "Search" dialog box.
7. In the "Search Results" box, select "Show search zoom windows".

   The acquisition stops, and the detected overshoots of the last acquisition are listed in the search result table. The search zoom window shows the last result that was found. Vertical lines indicate the time values for which a result was found.

8. In the results table, tap the row of the search result that you want to display in the search zoom diagram.



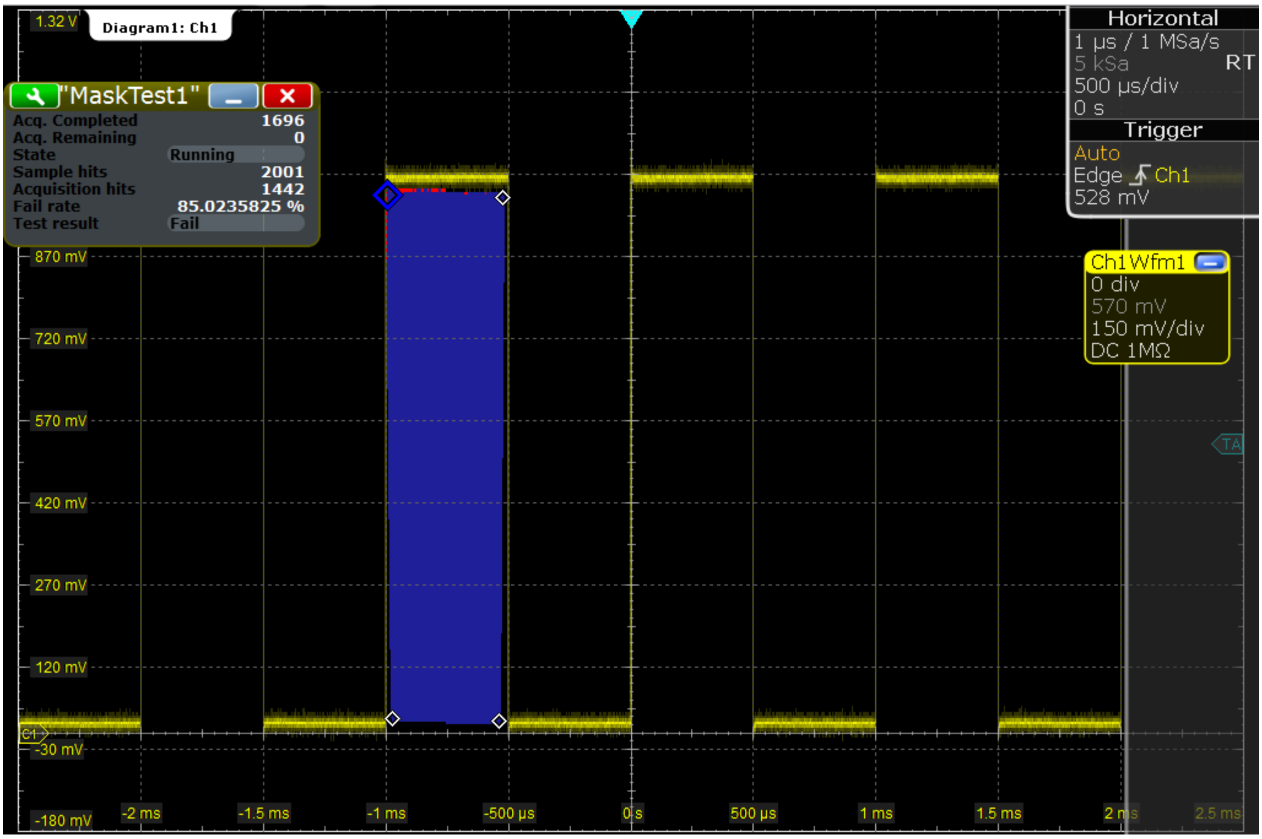
2.3.10 Performing a Mask Test

In the following example, you perform a mask test to determine whether the signal exceeds a rectangular area.

The usage of masks tests is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Mask Test".

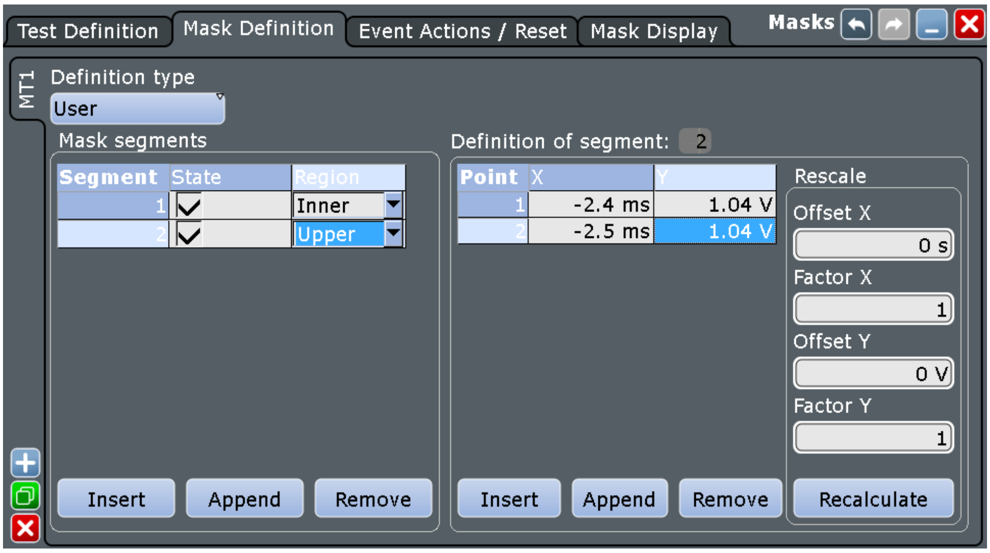
1. To restore the default signal channel settings, press PRESET and AUTOSET.
2. Tap the "Masks" icon on the toolbar.

3. Tap the corner points of the first mask segment on the touchscreen. Select the corner points of one complete pulse, with a minor offset to the inside. To finish the mask definition, double-tap the last point.



Tip: To create an exact rectangle, draw the diagonal of the rectangle on the screen.

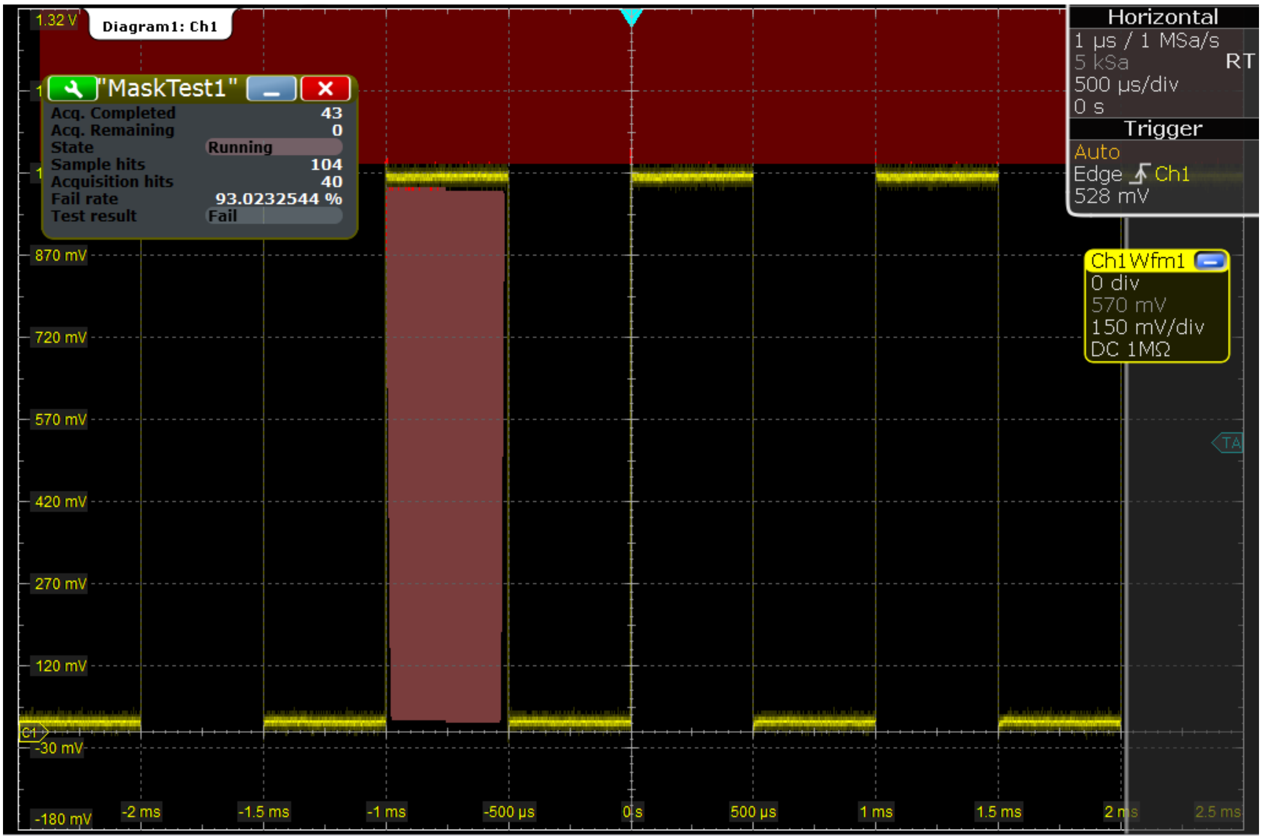
4. To define the further mask test settings, press the MASKS key on the front panel (in the ANALYSIS area), and select the "Mask Definition" tab.
5. If necessary, correct the mask segment points you defined graphically in the "Mask Definition" tab. In the "Region" column of the mask segment, "Inner" is selected. That means, a mask hit is detected if the signal is inside the segment.
6. Insert another mask segment above the positive pulse:
   a) Tap the "Append" button under "Mask segments".
   b) In the "Region" column of the new mask segment, select "Upper". In this case, a mask hit is detected if the signal is above the mask limit line.
   c) Under "Definition of segment", tap "Insert" twice to insert two points.
   d) Enter the x and y-values to define a line beneath which the values of the positive pulse should remain.



7. Tap the  icon in the result box, and select the "Test Definition" tab.
8. Select channel 1 as the "Source".
9. Define the number of tolerable sample hits in the "Tolerance" field.

   A test has failed if the number of sample hits exceeds the limit of "Violation tolerance" hits.
10. Select the "Event Action / Reset" tab.
11. For the "Stop acquisition" action, select *On violation*. If the violation tolerance is exceeded, acquisition stops.

    The results of the mask test are shown in the "MaskTest" results box. Mask hits are also indicated as red points in the mask segment in the diagram.



12. Press RUN CONT to start the next acquisition and watch the screen.

13. Close the "MaskTest" results box by tapping the red cross in the label.

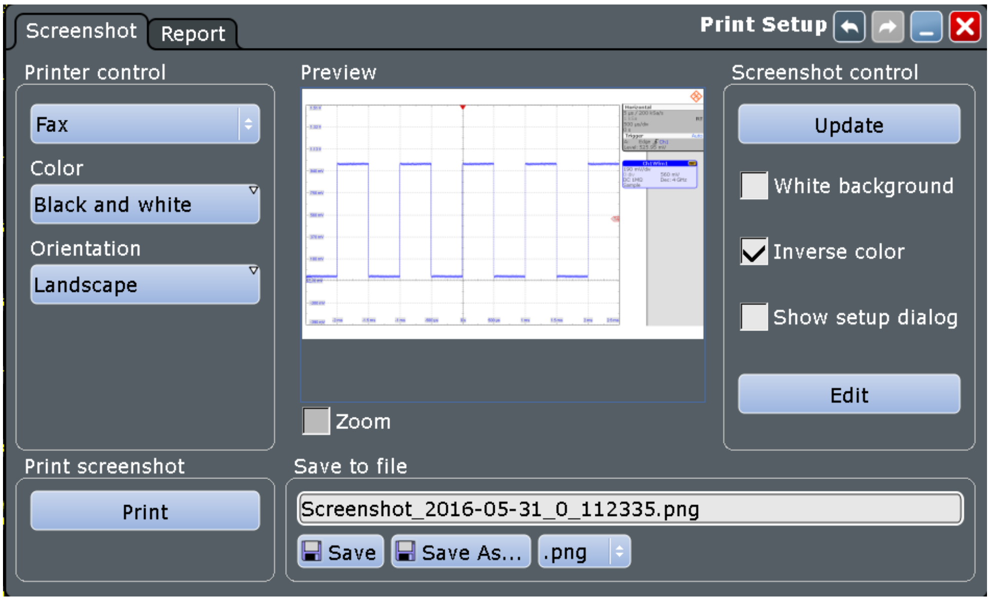
2.3.11 Printing and Saving Screenshots

You can print and save screenshots of the current display to document your results. In the following examples, you print the current display as a black and white graphic with inverted colors, i.e. a black waveform is printed on a white background. Then you save some screenshots using the PRINT key.

To print a screenshot

You need a printer that is connected to the instrument. If the instrument is connected to the network, you can also use a network printer.

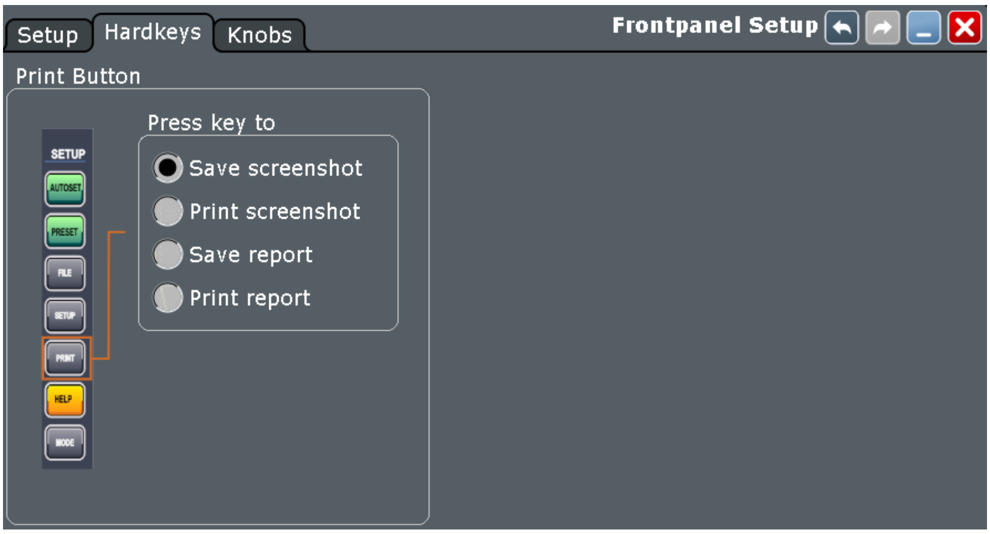
1. Open the "File" menu and tap "Print Setup".
2. Tap "Color" and select "Black and white".
3. Enable "Inverse color".



4. Tap the upper left button and select the printer.
5. Tap "Print". The result is a monochrome image.
6. Close the dialog box.

To configure the PRINT key

1. Open the "File" menu and tap "Frontpanel Setup".
2. Select the "Hardkeys" tab.
3. Select "Save screenshot".



4. Close the dialog box.

To save screenshots

1. Press the PRINT key.
2. Change the horizontal scale.
3. Press the PRINT key.
   The files are saved to the following directory:
   `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\ScreenShots`
   The default file name is `Screenshot_<date>_<index>_<time>.png`.
4. To access the saved files, open the "File" menu and tap "Minimize Application".
5. Double-tap the "User" folder icon on the desktop.
6. Open the `ScreenShots` folder.

2.3.12 Saving Data

After a measurement with the R&S RTE, you can save the resulting waveform data for further evaluation or comparison. You can also save measurement results, and device settings in order to repeat or restore previous measurements.

- "Saving waveform data" on page 77
- "Saving data of an acquisition series" on page 78
- "Saving measurement results" on page 79
- "Saving and restoring device settings" on page 79

Saving waveform data

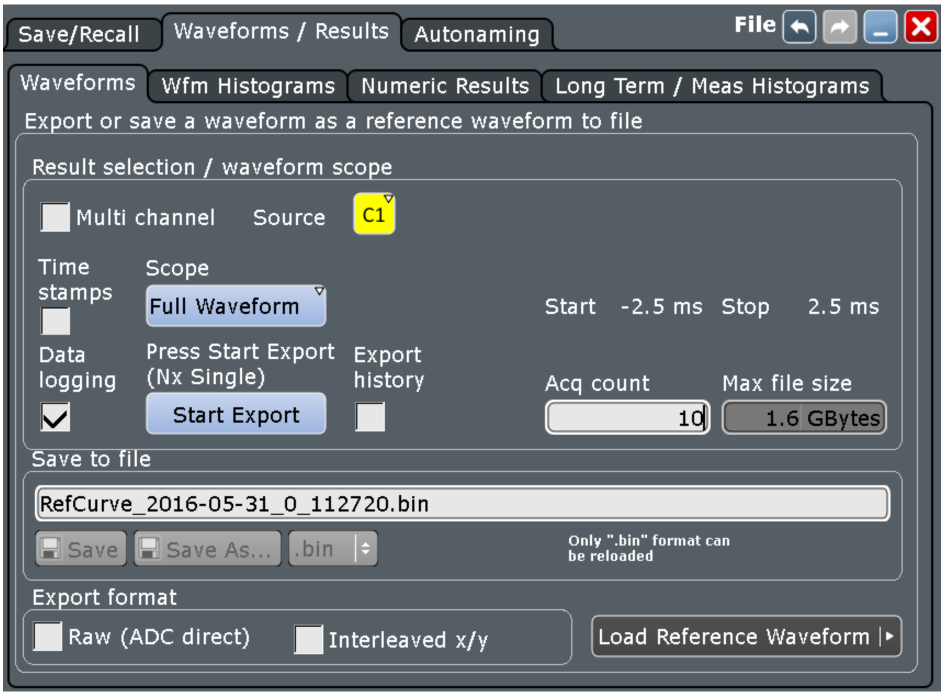
1. Press the FILE key on the front panel (in the SETUP area on the left).
2. Select the "Waveforms/Results" tab.
3. Select the "Waveforms" tab.
4. Check the "Source".
5. Set "Scope" to "Full Waveform".
   Tip: If a cursor, zoom or measurement gate is defined, you can use these settings to export only a part of the waveform.
6. Under "Save to file", tap "Save As".
7. The file selection dialog box shows the default storage directory:
   `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\RefWaveforms`
8. Tap the keyboard icon on the right of the "File Name" field.

9. Enter *Waveform1* on the online keyboard
10. Tap "ENTER" to close the online keyboard.
11. Select the file type: "*.bin".
12. Tap "Save".

    The waveform data is saved to the files `Waveform1.Wfm.bin` and `Waveform1.bin` in the selected directory.

Saving data of an acquisition series

1. Press the FILE key on the front panel.
2. Select the "Waveforms /Results" tab.
3. Set the export scope of the waveform:
    a) Check the "Source".
    b) Set "Scope" to "Full Waveform".
    c) Tap "Data logging" to enable export all waveforms of a running acquisition.
    d) Enter "Acq count" = *10*, the number of subsequent waveforms that the instrument acquires and saves.



4. Tap "Start Export" to save the waveforms to file. You can change the file name in "Save to file".

Saving measurement results

1. Perform a measurement as described in Chapter 2.3.6.2, "Performing Automatic Amplitude Measurements", on page 61.
2. Tap in the result box.
3. Tap "Result box export" in the "Setup" tab.
4. Select the "Numeric Results" tab.
5. Select the results that you want to save.
6. For further usage of the results, select the "CSV-Delimiter" that is used to convert the values in columns. For MS Excel, the semicolon is recommended.
7. Tap "Save".

   The results are saved to the following folder:
   `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\ResultBoxExport`
   The file name is created according to the autonaming settings.

Saving and restoring device settings

1. Press the FILE key on the front panel.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.
4. Tap "Save As". Enter the path and file name.
   `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\SaveSets\Settings_Meas1.dfl`
5. Tap "Save".
6. To restore the default instrument settings, press the PRESET key.
7. To repeat the initial measurement, tap the "Load saveset" icon on the toolbar.

   
8. Use the buttons on the left and the right to scroll the stored savesets. The file name and a screenshot help identify the correct saveset.
9. Tap "Load".

   The device and measurement settings are restored and you can repeat the measurement.

2.4 Operating the Instrument

There are three ways to operate the R&S RTE.

Manual operation

Use the touchscreen, keys and rotary knobs, or an optional mouse and/or keyboard. The principles of manual operation are explained in this section.

Remote control

Create programs to automatize repeating settings, tests, and measurements. The instrument is connected to a computer running the program.

This way of operation is described in: Chapter 16, "Remote Control Commands", on page 863

Remote operation

The remote desktop connection of Windows Embedded Standard 7 can be used for instrument control and file transfer. Even on computers with non-Windows operating systems, a remote desktop connection is possible using RDP applications.

See also: User Manual, chapter "Remote Desktop Connection".

Remote monitoring and control of the instrument from a connected computer is also possible with a standard web browser and the common cross-platform technology Virtual Network Computing (VNC). To use VNC, install the VNC server on the R&S RTE. Installation and configuration are described in the Application Note "Remote Monitoring and Control of the R&S RTE with a Web Browser", available on the Rohde & Schwarz Internet.

2.4.1 Means of Manual Interaction

The R&S RTE provides the following means of manual interaction, which you can use alternatively or complementary:

- Touchscreen:
  Using the touchscreen is the most direct interaction way. Use your finger to place waveforms on the screen, mark areas for zoom and histograms, set parameters in dialog boxes, enter data, and much more. Most of the control elements and actions on the screen are based on common concepts, and you will easily become familiar with the user interface.

  Tapping the screen works like clicking mouse buttons:
  - Tap = click: Selects a parameter or provokes an action.
  - Double-tap = double-click has the same effect as touch and hold = right-click: Opens the on-screen keyboard or keypad, or a specific editor if available
- Function keys and rotary knobs:
  The front panel provides nearly all functions and controls to operate the instrument in the classic ways, without touchscreen. As an exception, the signal bar cannot be used with front panel controls.
- Optional mouse and/or keyboard:
  These devices work conform to Windows standards. The navigation keys on the front panel correspond to the keys on the keyboard.

The usage of the touchscreen and navigation keys is described in detail in the following sections.

2.4.2 Touchscreen Display

2.4.2.1 Information on the Display

The touchscreen display of the instrument shows not only waveforms and measurement results, but also information and everything that you need to control the instrument. All waveform-related display elements are shown in Figure 2-3. An overview of control elements - like dialog box, toolbar - is given in Figure 2-6 .

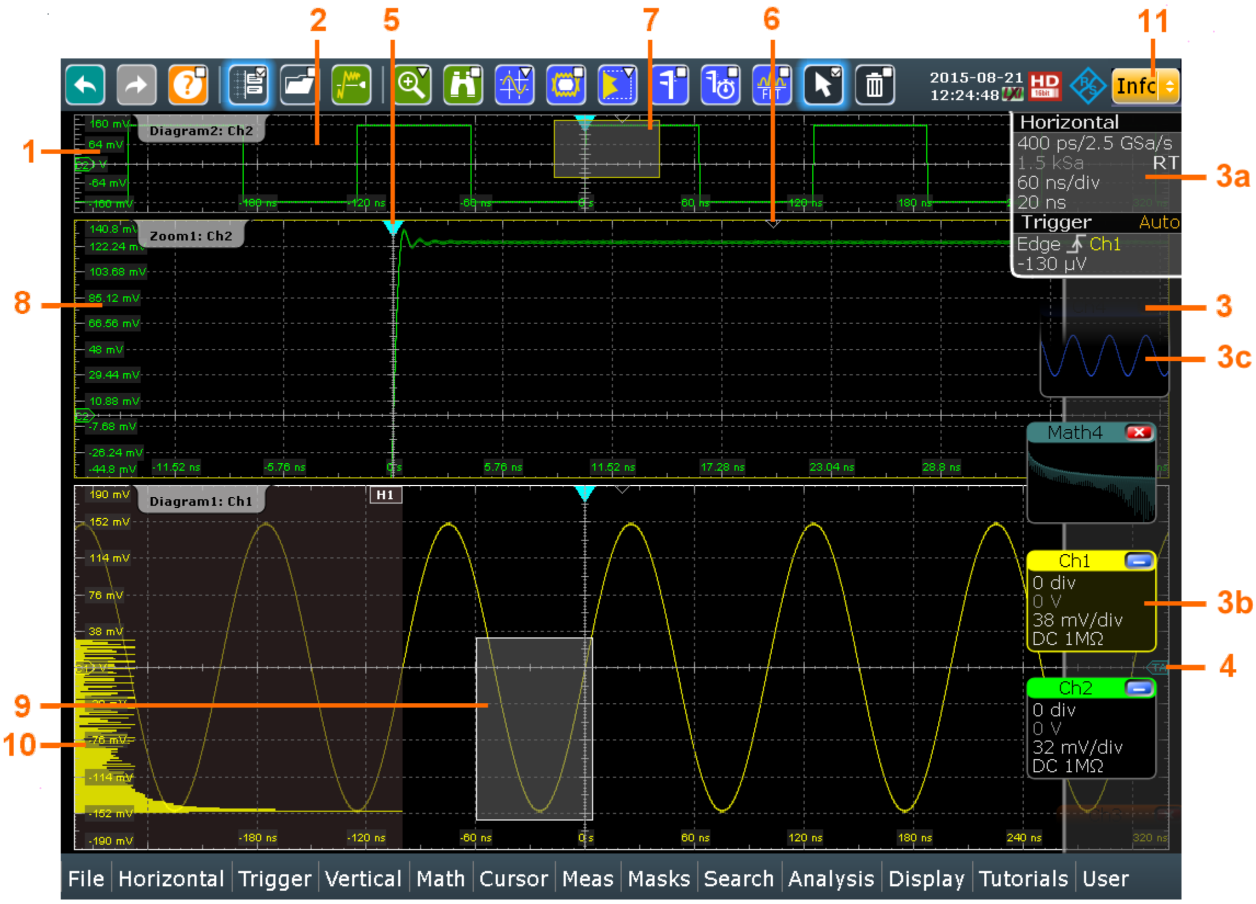


Figure 2-3: Display information

1 = Diagram
2 = Grid
3 = Signal bar with horizontal and trigger label (3a), signal icon with signal label (3b) and signal icon with minimized live waveform (3c)
4 = Trigger level
5 = Trigger position
6 = Reference point (distance from trigger position to reference point = horizontal position)
7 = Zoom area
8 = Zoom diagram

9 = Histogram area
10 = Histogram
11 = Messages

Diagram (1)
A diagram shows one or more waveforms: channel, reference, and math waveforms together with histograms, masks etc. Zoom details appear in separate zoom diagrams, also XY-waveforms appear in separate diagrams.

By default, the diagram name contains the diagram number and the short names of the waveforms shown inside. To change the diagram name, touch and hold the tab name. The on-screen keyboard opens to enter the new name. Names must be unique.

To arrange the diagrams on the screen, the Rohde & Schwarz SmartGrid function helps you to find the target place simply and quickly. A tabbed view is also possible, and you can adjust the diagram size.

For details, see "To arrange a waveform using the SmartGrid" on page 88.

Grid (2)
The grid shows the vertical and horizontal divisions. The division lines are labeled with the correspondent values. The grid labels have the color of the waveform to which they belong. If several waveforms are shown in one diagram, the grid has the color of the selected waveform.

Signal bar (3)
The signal bar is the control center for all enabled waveforms. On the top, the horizontal and trigger labels show the main timebase and trigger settings. If you tap a label, the relevant dialog box opens with the tab used at last.

Figure 2-4: Horizontal and trigger label on top of the signal bar

1 = Resolution
2 = Record length
3 = Timebase, horizontal scale
4 = Horizontal position
5 = Sample rate
6 = RT - real time, IT - interpolated time
7 = Trigger mode
8 = Trigger type, slope, and source
9 = Trigger level

Below, each waveform is represented by a signal icon. For each waveform that is shown in a diagram, a signal icon displays the signal label with its main vertical and acquisition settings. If you tap the "Minimize" icon on the signal label, the waveform switches from the diagram area to the signal icon: the icon shows the real-time preview of the waveform. If you tap a label, the dialog box with vertical settings for this waveform opens. See Chapter 2.4.3, "Working with Waveforms", on page 86 for a detailed description.

In Figure 2-3, the signal icons Ch1 and Ch2 show the signal label, and the waveforms are displayed in diagrams. All other waveforms are minimized and shown in the signal view.

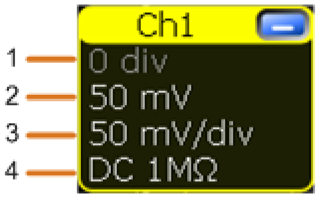


Figure 2-5: Signal label on the signal bar

1 = Vertical position
2 = Offset
3 = Vertical scale
4 = Coupling

You can also adjust the behavior of the signal bar in various ways, see Chapter 2.4.4, "Using the Signal bar", on page 90.

Trigger position and trigger level (4, 5)
The blue markers show the horizontal position of the trigger and the vertical trigger level. You can touch and move the trigger markers in the diagram to set the positions. The trigger point is the zero point of the diagram.

The trigger position can be moved outside the diagram. A red trigger position marker indicates that the trigger position is not visible.

Reference point (6)
The reference point marks the rescaling center. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.

You can define the position of the reference point (HORIZONTAL), and its time distance from the trigger point of the diagram (POSITION / REF POINT).

Zoom diagram and zoom area (7, 8)
Zoomed waveforms are shown in separate zoom diagrams, in addition to the waveform diagrams. On the original waveform diagram, a rectangle indicates the zoomed section of the waveform - this is the zoom area. You can modify the zoom area by dragging the rectangle as a whole, and by dragging its edges. To toggle between these modes, tap the zoom area. You can also set exact positions.

The frames of the zoom area and of the associated zoom diagram have the same color, different zooms are marked with different colors. So it is easy to assign zoom area and zoom diagram.

As for waveform diagrams, you can change the name of the zoom diagram. A zoom in a zoom and coupled zooms are also possible.

All zooming possibilities are described in detail in the "User Manual", chapter "Zoom".

Histogram and histogram area (9, 10)
A histogram shows the frequency of occurrence of voltage or time values in a bar chart directly in the diagram. The rectangular histogram area indicates the part of the waveform that is considered in the histogram. The vertical histogram counts the voltage values, and the horizontal histogram counts time values. You can switch between vertical and horizontal mode, and modify the histogram area by dragging the rectangle as a whole, by dragging its edges, or by setting exact positions.

Messages (11)
A yellow or red button on the toolbar points to the status messages of the instrument. To open the message box, tap the button. See also: Chapter 2.4.9, "Messages", on page 102.

2.4.2.2 Control Elements on the Touchscreen

The touchscreen provides everything you need to control the instrument, to analyze waveforms, and to get measurement results. Figure 2-6 shows the control elements on a glance.

Figure 2-6: Control elements on the touchscreen

1 = Toolbar
2 = Signal bar, see "Signal bar (3)" on page 82
3 = Menu bar
4 = Dialog box
5 = Tab in a dialog box
6 = Result box
7 = Input box

Toolbar (1)

The icons on the toolbar provide quick and easy access to the most important functionality. For a detailed description, refer to Chapter 2.4.5, "Toolbar", on page 91.

Menu bar (3)

The menus provide access to the complete functionality of R&S RTE.

Dialog box (4, 5)

The tabs of the dialog boxes contain all task-oriented settings and operations, and black buttons for calling related tabs. The usage of dialog boxes is described in Chapter 2.4.7, "Using Dialog Boxes", on page 99.

Result box (6)
If you perform manual or automatic measurements, mask testing, or a search, the result box shows the results of the action. Similar to waveform diagrams, you can minimize the result box to a result icon on the signal bar, and display results in a separate diagram on the screen. The  icon opens the corresponding dialog box to adjust the settings.

For details, see Chapter 2.4.6, "Displaying Results", on page 98.

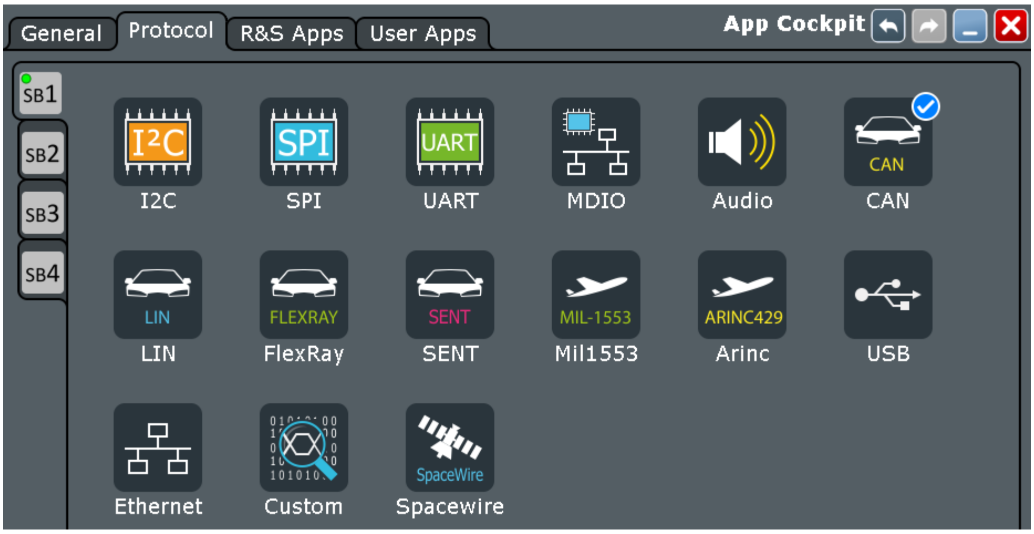
Input box (7)
The input box appears if you adjust a value using one of the rotary knobs, or if you drag an element on the screen, for example, a cursor line. The input box shows the current value of the modified parameter. You can enter the exact numerical value, change the step size, and - if available - autoset the value directly in the input box. The box title shows the name of the currently adjusted parameter. The input box is helpful when using the multi-function rotary knobs, for example, INTENSITY, and RESOLUTION / RECORD LENGTH.

See also: Chapter 2.4.8, "Entering Data", on page 100.

2.4.2.3 App Cockpit

The app cockpit provides fast access to all available applications.

► To open the app cockpit, tap  in the menu.



2.4.3 Working with Waveforms

The R&S RTE can create and display several types of waveforms:

- Channel waveforms:

For each input channel, one channel waveform is shown.

- Reference waveforms:
  Four waveforms can be used as reference for comparison and analysis.
- Math waveforms:
  Four mathematic waveforms can be created with mathematic operations performed on channel, reference, and other math waveforms.
- Zoom waveforms:
  Show the details of waveforms.
- XY-waveforms:
  Four XY-waveforms can be created. Each XY-waveform is built from the voltage values of two source waveforms.
- Digital waveforms:
  The Mixed Signal Option R&S RTE-B1 provides 16 digital channels grouped in two logic probes (pods) with 8 channels each.

Waveform handling

The R&S RTE can show and analyze many waveforms. To handle this multitude while keeping track of it, the R&S RTE provides intelligent support:

- The color system helps to distinguish the waveforms. The color of the vertical rotary knobs indicates the signal that is focused (selected). The color of each waveform can be changed, the color of its signal icon and of the illuminated keys is adjusted to the new color. Alternatively, a color table can be assigned to a waveform. Settings: DISPLAY > "Signal Colors / Persistence" tab.
- Waveforms can be minimized to signal icons showing a small real-time signal view. Thus, more space in the diagram area is available without switching off waveforms.
- Diagrams are displayed on tabs – you can arrange them side by side or one above the other. To change the diagram name, double-tap the tab name.
- The Rohde & Schwarz SmartGrid function helps to arrange the diagrams.

Waveform states

Depending on its place on the screen and the effect of settings, a waveform has one of the following states:

- Off
- Active:
  The waveform is shown in a diagram
- Selected:
  One of the active waveforms that has the focus. In each diagram, one of the assigned waveforms is selected – it appears "on top" in the diagram, and the grid labels have the color of the selected waveform. Some of the toolbar functions, like cursor and histogram measurements are performed on the selected waveform. All waveform-specific settings are applied to the selected waveform of the selected diagram. The vertical POSITION / OFFSET and SCALE knobs, and the SIGNAL OFF key are illuminated with the color of the selected waveform.
  In Figure 2-3, "Ch1" is the selected waveform: The frame of the diagram and the signal icon are highlighted.

- Minimized:
  The waveform is shown as real-time signal view in its signal icon.

To switch a waveform on

A channel waveform is activated as soon as you connect the probe. You can switch it on and off according to your needs.

► Choose one of the following ways:
  - Press the channel key.
  - In the "Vertical" dialog box, select the channel and tap the "Show channel" button.

The waveform is now active, selected, and is shown in the diagram.

To select a waveform

► Choose one of the following ways:
  - Tap the waveform in the waveform diagram.
  - To select a channel, reference, or math waveform, press the corresponding key.
  - Tap the signal icon.

Note: Zoom waveforms in zoom diagrams cannot be selected.

To minimize a waveform

► Choose on of the following ways:
  - Tap the "Minimize" icon in the upper right corner of the waveform's signal label in the signal bar.
  - Drag the waveform from the diagram to the signal bar.

The waveform disappears from the diagram and the minimized signal view is shown in the signal icon.

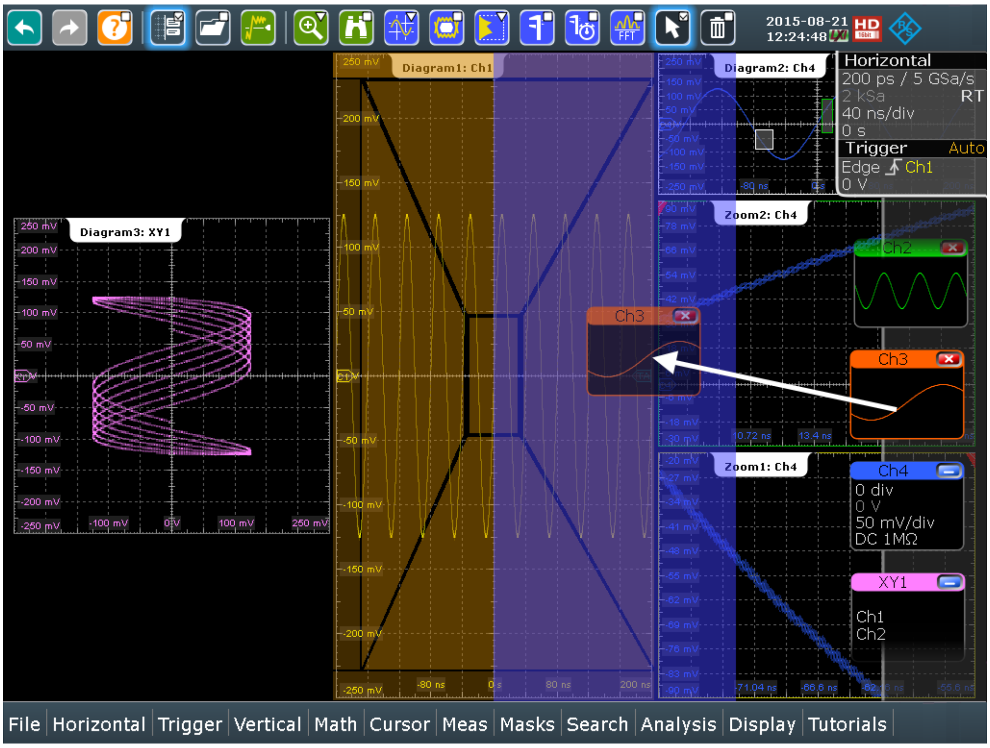
Tip: To set the waveform back to its previous diagram immediately, use "Undo".

To arrange a waveform using the SmartGrid

You can arrange waveforms in one of the existing diagrams, or in a new diagram.

The usage of the SmartGrid is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > SmartGrid".

1. Drag the signal icon to the diagram area, and move it around.
   The Rohde & Schwarz SmartGrid appears and a blue area shows where the waveform will be placed.
2. Drop the waveform in the target area.
   The waveform appears in an existing or in a new diagram, and it is selected for further actions.



3. To change the size of the new diagram, drag its edge to the required position.

The diagram layout depends on the position where you drop the signal view, in relation to an existing diagram.

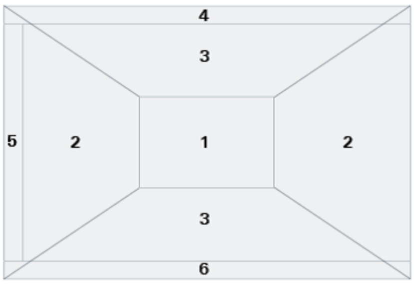


Figure 2-7: SmartGrid positions

1 = In the existing diagram, overlay of signal
2 = New diagram on the left or right
3 = New diagram above or below
4 = New diagram on top of the existing diagram
5 = XY-diagram
6 = YX-diagram

To switch off a waveform

► Do one of the following:

- Select the waveform, and then press the SIGNAL OFF key.

- To switch off a minimized waveform, tap the "Close" icon in the upper right corner of the minimized signal view.
- Disable "Show channel" in the "Vertical" > "Channels" tab.
- Tap the "Delete" icon (Recycle bin) in the toolbar, and then the waveform. If several waveforms overlap or lie close together, the upper (selected) waveform is switched off.

2.4.4 Using the Signal bar

The signal bar can hold a large number of signal and result icons. Signal icons represent the waveforms, serial buses and parallel buses, while result icons are minimized result boxes showing measurement and search results.

To scroll the signal bar

If the signal bar contains more than four icons, not all icons are visible on the display.

► Touch one of the signal icons and move it up or down until the required icon appears.

To switch on and off the signal bar

If you need the complete screen to see the diagrams and results, you can switch off the signal bar completely.

► Tap the "Show signal bar" icon on the toolbar.

Alternatively, tap "Signal Bar" on the "Display" menu.

To change the position of the signal bar

► Touch the "Horizontal" label on the top of the signal bar and drag it to the opposite side of the screen.

To configure auto-hide

The signal bar can be hidden if the displayed information has not changed for a defined time, and is displayed again automatically when a setting in the signal bar changes. The signal bar does not hide entirely, it simply fades and becomes less visible in the display.

1. Press the DISPLAY key on the front panel.
2. In the "Display" dialog box, select the "Diagram Layout" tab.
3. Select "Auto-hide".
4. Define the hiding properties:
   - "Hide bar after": the time after which the bar is hidden if no changes occur

- "Hiding transparency": Transparency of the hidden signal bar on a scale from 20% (low transparency) to 70% (high transparency)
- Hide head also: the horizontal and trigger labels are also faded

To change the colors

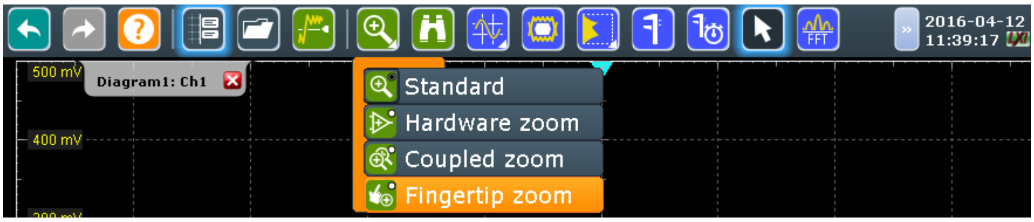
If you want to highlight the signal bar, you can change the "Fill color" and "Border color" of the bar.

1. Press the DISPLAY key on the front panel.
2. In the "Display" dialog box, select the "Diagram Layout" tab.
3. Tap "Border color" to change the color of the signal bar frame, or "Fill color" to change the fill color of the bar.
4. In the "Adjust Colors" dialog box, select the color.
5. To use a color that is not yet defined, tap "Userdefined Colors". Define the new color settings.
   To see the effect of a setting change in the "Preview" area, enter the value and press the ENTER key.
6. Tap "OK."

   The signal bar is displayed in the new colors.

2.4.5 Toolbar

The toolbar provides direct access to important control and measurement functions. It shows current date and time, and a message button. The selected function is highlighted.



A little triangle in the lower right corner of the icon means, that a menu is available where you can select the required function.

By default, the toolbar shows the most frequently used functions. You can configure the content of the toolbar and hide the date/time display, see Chapter 2.4.5.2, "Configuring the Toolbar", on page 92.

2.4.5.1 Using the Toolbar

Using the toolbar is easy and straightforward.

Some of the toolbar functions are one-click actions. These actions are performed immediately when you tap the icon.

Other toolbar functions are analyzing functions. These actions are interactive actions.

To use analyzing functions (interactive actions)

1. If several waveforms are shown in the diagram, select the waveform that you want to analyze.
   See: "To select a waveform" on page 88
2. Tap the icon of the function in the toolbar.

3. To define the analyzed area, do one of the following:
   - Tap the required diagram.
   - Drag a rectangle on the diagram.

To select a function on a toolbar menu

Icons with a little triangle in the lower right corner show the last selected function. A short tap on the icon activates the displayed function. To change the function, proceed as follows:

1. Touch the icon and drag your finger down.
2. When the menu has opened, remove the finger.
3. Tap the required function on the menu.

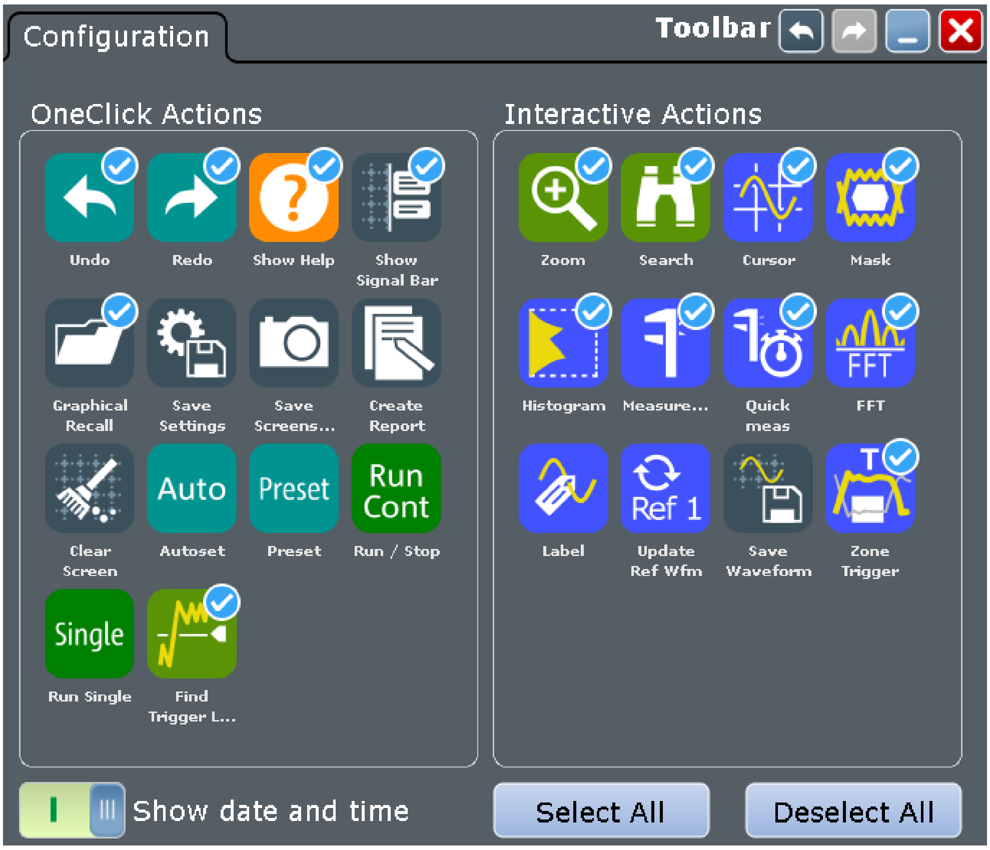
   The function is selected, and its icon is shown in the toolbar.

The toolbar handling is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Toolbar".

2.4.5.2 Configuring the Toolbar

You can configure the contents of the toolbar so that only the required functions are displayed. Furthermore, date and time can be hidden. The toolbar configuration is part of the user preferences. It is retained when you switch off and on the instrument, and you can save it in the user preferences and user-defined preset.

1. On the "Display" menu, select "Toolbar".
2. Select the functions to be displayed:
   - To select specific functions, enable the "Visible" option for each function. Disable the functions that you do not need.
   - To display all available toolbar icons, tap "Show All".
   - To hide all toolbar icons, tap "Hide All".
3. To hide the current date and time on the toolbar, disable "Show date and time".



A detailed description of the toolbar functions is given in Chapter 2.4.5.3, "Toolbar Functions", on page 93.

2.4.5.3 Toolbar Functions

This chapter describes all toolbar functions in detail.

One-click actions	Interactive actions
Undo	Zoom
Redo	Search
Show Help	Cursor
Graphical Recall (load saveset)	Mask
Find Trigger Level	Histogram
Save Settings	Measurement
Save Screenshot	Quick meas
Create Report	FFT
Show Signal Bar	Select
Clear Screen	Delete

One-click actions	Interactive actions
Autoset and Preset	Label
Run / Stop and Run Single	Update Ref Waveform
	Save Waveform
	Spectrogram (option R&S RTE-K18)

You can configure the content of the toolbar and hide the date/time display, see Chapter 2.4.5.2, "Configuring the Toolbar", on page 92.

The following list describes at first the default toolbar functions and then the additional functions.

Undo
Undoes the last setting actions step by step. Some actions cannot be revoked: locking the touchscreen with T-SCREEN LOCK, and saving data. The undo stack is deleted during the following actions: Reloading settings from file, and reference waveform actions (save, load and preset with active reference waveform).

Redo
Recovers the undo steps in reverse order.

Show Help
Enables the tooltip display. A short description appears when you tap a parameter in a dialog or result box. To open the corresponding help topic, tap the "Show Help" button in the lower right corner of the tooltip. See also: Chapter 2.4.10, "Getting Information and Help", on page 103.

Show Signal Bar
Shows and hides the signal bar.

The look and the behavior of the signal bar can be configured, see Chapter 2.4.4, "Using the Signal bar", on page 90.

Graphical Recall (load saveset)
Opens a window to select and load instrument settings that were previously stored in a saveset. A graphical preview helps you to find the required settings.

Find Trigger Level
Analyses the signal and sets the trigger level to the middle of the signal peaks.

Zoom
The zoom icon on the toolbar shows the last selected zoom type. A short tap on the icon activates the selected zoom.

If you touch the icon and drag your finger down, a menu opens where you can select another zoom type.

Standard zoom ← Zoom
Displays a magnified section of the diagram in an additional zoom diagram. It is a display zoom, instrument settings are not changed.

Touch and hold the zoom area to open the "Zoom" dialog box.

Remote command:
`LAYout:ZOOM:ADD` on page 986

Hardware zoom ← Zoom
Changes the instrument settings - horizontal and vertical scales as well as trigger level and offset - to display a part of the diagram in greater detail.

Coupled zoom ← Zoom
Creates a coupled zoom area and its related zoom diagram. If you change the size of one zoom area, the size of all coupled zoom areas is changed as well.

Remote command:
`LAYout:ZOOM:ADDCoupled` on page 987

Fingertip zoom ← Zoom
Magnifies the waveforms around your fingertip.

Tap the icon and put your finger on the waveform. The touched part of the waveform is displayed in a magnifier. Drag your finger on the screen to move the magnifier. You can change the zoom factor using the Navigation knob.

Search
Performs a search according to the settings in the "Search Setup" dialog box. Tap the icon and then tap the diagram with the waveform to be searched, or drag a rectangle to define a search gate. The search is performed on the selected waveform.

Cursor
The cursor icon shows the last selected cursor type. A short tap on the icon activates the selected cursor.

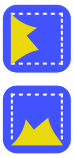
If you touch the icon and drag your finger down, a menu opens where you can select another cursor type: horizontal cursors, vertical cursors, or both.

Tap the diagram where you want to set the cursors, or draw a rectangle in the diagram to position the cursor lines. The resulting cursor lines measure the selected waveform. The results appear in the "Cursor Results" box. You can adjust the cursor source, type and position in the result box. Move the cursor lines by dragging them in the diagram, or by turning the navigation knob. Pressing the knob switches the parameter to be changed.

Mask
Starts the on-screen mask definition and the testing against the defined mask.

Tap the icon and then tap the points that build the mask. Double-tap the last point to finish mask definition. To create a rectangular mask, draw a rectangle on the screen. You can move the mask on the screen.

To configure the mask test settings, tap the icon in the "Mask" result box.



Histogram
The histogram icon on the toolbar shows the last selected histogram type. A short tap on the icon activates the selected histogram.

If you touch the icon and drag your finger down, a menu opens where you can select another histogram type: horizontal histogram, or vertical histogram.

Tap the icon and then drag a rectangle on the diagram to mark the histogram area. The histogram for the selected waveform appears.

Touch and hold the histogram area to open the "Histogram" dialog box.

Measurement
Starts an automatic measurement.

You can start up to 8 automatic measurements to run in parallel. The "Automatic measurment" icon starts the measurements one after the other.

Tap the icon and then tap the diagram with the waveform to be measured. To define a measurement gate, draw a rectangle on the screen.

To configure the measurement or select a different measurement type, tap the  icon in the "Measurement" result box.

Quick meas
Performs a set of measurements on the selected waveform. You can configure up to 8 measurement types to be included in quick measurement.

Tap the icon and then tap the diagram with the waveform to be measured.

FFT
Transforms a waveform to the frequency spectrum by fast Fourier transform (FFT). The FFT trace is shown in a new diagram.

Tap the icon and then tap diagram with the waveform to be transformed. The FFT diagram is created from the selected waveform.

To adjust FFT settings, double-tap the FFT diagram.

Select
Enables the select mode to move and modify objects on the touchscreen. The select mode is activated automatically when an analyzing function is completed.

Delete
Removes zoom and histogram areas and their diagrams; measurement areas and their associated results; and mask segments. The icon also switches off a waveform.

Tap the icon and then tap the area or diagram to be deleted, or the waveform to be switched off.

Save Settings
Saves the current instrument settings in a saveset. The filename is created according to the autonaming pattern. You can reload the saveset using the "Load saveset (Graphical recall)" toolbar icon, or using FILE > "Save/Recall" > "Settings".

Save Screenshot
Saves a screenshot of the current display using the settings defined in "File" menu > "Print Setup".

Create Report
Creates a report of the current measurement settings and results using the settings defined in "File" menu > "Report Setup".

Clear Screen
Deletes all measurement results including long term measurement and statistic results. Also deletes the current measurement and channel waveforms.

Autoset and Preset
Performs an autoset, or a preset to a default state. The icons have the same functionality as the corresponding keys on the front panel. They are useful when you control the instrument remotely.

Run / Stop and Run Single
Starts and stops the continuous acquisition, or starts a defined number of acquisition cycles. The icons have the same functionality as the corresponding keys on the front panel. They are useful when you control the instrument remotely.

Label
Defines a waveform label that names or explains the waveform. Tap the icon and then tap the waveform to be labeled. If you tap the display background, the label is assigned to the selected waveform. Enter the label text using the onscreen keyboard. The text is shown in the same color as the waveform. You can drag the label to another position.

Update Ref Waveform
Copies the selected source waveform with all its settings to the reference waveform. If the acquisition is running, the reference waveform is a snapshot. You can configure up to four reference waveforms.

Select the required reference waveform (R1 to R4) in the toolbar menu of the icon.

Save Waveform
Exports the waveform data to file using the settings defined in FILE > "Waveforms / Results" > "Waveforms". The filename is created according to the autonaming pattern.

Tap the icon and then tap the waveform to be exported. If you tap the display background, the selected waveform is exported, or a multichannel export is performed if configured.

Spectrogram (option R&S RTE-K18)
Starts an FFT and the spectrogram. The FFT trace and the spectrogram are shown in separate diagrams.

Tap the icon and then tap diagram with the waveform to be transformed. The diagrams are created from the selected waveform.

2.4.6 Displaying Results

The results of automatic and cursor measurements, mask tests, and searches are displayed immediately in a result box.

There are three ways to display the results:

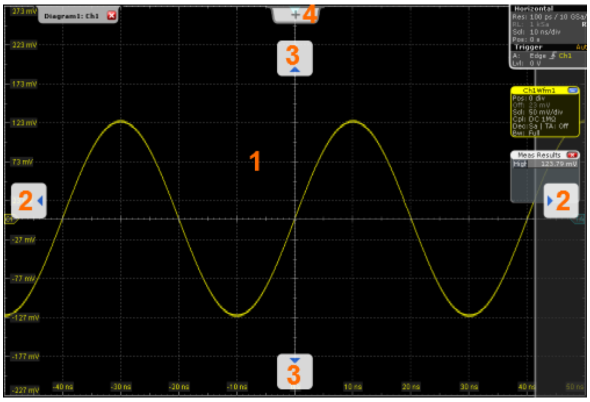
- In a floating result box in front of the diagrams, which you can move on the display
- In a minimized view (result icon) on the signal bar
- In a diagram

The default position and the font size can be adjusted.

To arrange a result box on the display

► Touch the title of the result box and drag the box on the screen. The SmartGrid indicates where the result box will be placed.

- If you drop the box on one of the buttons, the results are shown in a diagram.
- If you drop the box on the signal bar, a result icon is created.
- If you drop the box somewhere else, a floating result box is created.



1 = Floating result box
2 = Table in a diagram on the left or right
3 = Table in a diagram above or below
4 = New tab

To open the corresponding setup dialog box

► In the result box, tap the icon.

The dialog box with corresponding settings opens.

To define the default position of results

1. Press the DISPLAY key on the front panel.
2. In the "Display" dialog box, select the "Diagram Layout" tab.
3. Under "Result box", select the "Default position":
   - "Preview": result icon on the signal bar
   - "Floating": floating result box in front of the diagrams

To adjust the font size in result boxes

1. Press the SETUP key.
2. Select the "Screen" tab.
3. Set the "Result dialog font size".

2.4.7 Using Dialog Boxes

All functionality is provided in dialog boxes as known from computer programs. You can control the instrument intuitively with the touchscreen. This section provides an overview of the accessing methods and describes how to use the dialog boxes.

Each dialog box has four icons in the upper right corner:

	Go back: opens the previously opened dialog box.
	Go forward: opens the next dialog box.
	Minimizes the dialog box to a small box that only contains the last selected function.
	Closes the dialog box.

For direct access to important control and measurement functions use the toolbar, see Chapter 2.4.5, "Toolbar", on page 91.

To open a dialog box

► Perform one of the following actions:

- Tap the required menu, and then the menu entry.
- Press the function key on the front panel.
- If a results box is open, tap the icon to open the corresponding dialog box.
- To open the "Vertical" dialog box of a waveform, tap its signal icon. For XY-waveforms, the "XY Diagram" tab opens.
- Tap the horizontal or trigger label to open the "Horizontal" or "Trigger" dialog box, respectively.

To minimize a dialog box

If you want to change only one setting during analysis, and you need to change it often, you can display a small box that only contains the required setting.

1. Tap the function that you need to modify.

2. Tap the "Minimize" icon in the upper right corner of the dialog box.

   The dialog box turns into a small box that contains only the "Wfm Arithmetic" setting.

3. To restore the complete dialog box, tap the "Maximize" icon in the small box.

To close a dialog box

► Tap the "Close" icon in the upper right corner.
Or:
Press the ESC key on the front panel.

To select an option in a dialog box

► Tap the required option.
Or:
Press the ⇤ FIELD and ⇥ FIELD keys to navigate to the required option. Then press the ☑ key.

To select an option in a list

If many options are available - for example, for the trigger type - the options are provided in a list. The current selection is shown on the list button.

► Tap the list button. Then tap the required option.
Or:
Use the front panel keys:

a) Press the ⇤ FIELD and ⇥ FIELD keys to navigate to the list button.
b) Press the ☑ key to open the list.
c) Press the ⇧ and ⇩ keys to navigate to the required option in the list.
d) Press the ☑ key to select the marked option.

2.4.8 Entering Data

Most important parameters have their own rotary knobs on the front panel. When you turn a knob, the input box appears the upper left corner of the screen, showing the parameter name and current value.

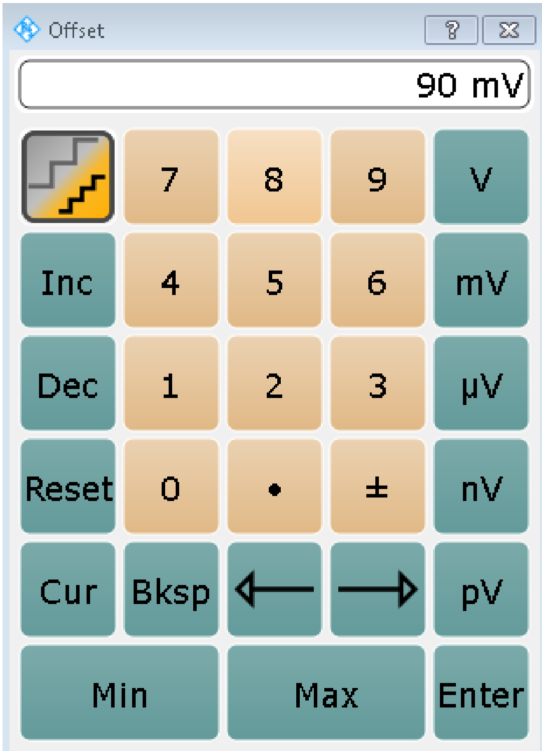
Using rotary knobs

1. Turn the knob to change the value.
2. To toggle the increment, tap the "Steps" icon in the input box.
3. To set the parameter to the autoset value (if available), tap the "RESET" icon.

For data input in dialog boxes, the touchscreen provides an on-screen keypad to enter numeric values and units. For text input, the on-screen keyboard with English key layout is used.

To enter values with the on-screen keypad

1. Double-tap the entry field.
   The on-screen keypad opens.



2. Enter the numeric value using the following methods:
   - To use the default value, tap "Reset" (if available).
   - To use the minimum or maximum value, tap "Min" or "Max", respectively.
   - To increase the displayed value in fixed steps, tap "Inc".
     To decrease the value in fixed steps, tap "Dec".
     To toggle between small steps and large steps, tap the "Steps" icon.

   - To get the value that was used before the keypad was displayed, tap "Cur".
   - To enter a user-defined value, tap the numbers and complete the entry by tapping the unit button.
     – The arrow buttons move the cursor left or right.
     – "Bksp" deletes the last character before the cursor.

– ± changes the sign of the value.

To enter data with the on-screen keyboard

1. Double-tap the entry field to open the on-screen keyboard.
   If available, you can also tap the keyboard icon on the right of the entry field.

2. Enter the text as you would on a normal keyboard.
   - To enter a series of capital characters, tap "Caps".
     To enter one capital character, tap "Shift".
   - To use the currently defined value, tap "Cur". This is the value that was used before the keyboard was displayed.
   - The arrow buttons move the cursor left or right.
   - "Bksp" deletes the last character before the cursor.
3. Tap "Enter" to complete the entry.

To enter numeric data in a dialog box with navigation controls

1. To navigate to the entry field, press the ⇤ FIELD and ⇥ FIELD keys.
2. To change the value with a small step size, turn the rotary knob.
   Alternatively, press the ⇧ and ⇩ keys for a larger step size.

If you edit numeric data in tables, the entry field must be in edit mode. To activate the edit mode, press ENTER, or the ☑ key, or the navigation rotary knob.

2.4.9 Messages

Status messages of the instrument are displayed for a few seconds. Then they are saved in a message box in the upper right corner of the screen. By default, the message box is closed. You can open it to read the messages and to delete them.

► To open and close the message box, tap the "Info" button.

If no messages are available, the "Info" button is hidden.

Important messages are indicated by a red "Info" button. These messages cannot be deleted, they remain until the problem is solved.

2.4.10 Getting Information and Help

In many dialog boxes, graphics are included to explain the way a setting works. For further information, you can use the following sources:

- Tutorials demonstrate the general usage of the R&S RTE, for example, how to use the SmartGrid.
- Tooltips give a short description of the parameter.
- The context help provides functional description on a setting, and the corresponding remote command.
- The general help explains a dialog box, provides instructions, and general information.

2.4.10.1 Displaying Tutorials

Tutorials are silent movies, which are available directly on the instrument, on the Documentation CD-ROM on the "Movies" tab, and on the Internet. They show basic usage aspects.

To see a tutorial on the instrument

1. On the menu, tap "Tutorials".
2. Tap "Getting Started".
3. Tap the tutorial that you want to see.

2.4.10.2 Displaying Help

To display tooltips and context help

1. Enable the "Tooltip" icon on the toolbar.

2. Tap the parameter for which you need information.

   The tooltip opens.

3. To open the corresponding help topic, tap the "Show Help" button in the lower right corner of the tooltip.

   The "Help" window opens and displays the comprehensive description and the corresponding remote command. You can browse the help for further information.

   Note: The tooltip icon disables automatically when you tap a parameter. To show another tooltip, tap the tooltip icon again.

To open general help

► Press the yellow HELP button on the left side of the screen.

   If a dialog box is open, the help topic for the current tab is shown. Otherwise the "Contents" page appears.

2.4.10.3 Using the Help Window

The Help window contains several tabs:

- "View" - shows the selected help topic
- "Contents" - contains a table of help contents
- "Index" - contains index entries to search for help topics
- "Search" - provides text search

The Help toolbar provides some buttons:

- To browse the topics in the order of the table of contents: Up arrow = previous topic, Down arrow = next topic
- To browse the topics visited before: Left arrow = back, Right arrow = forward
- To increase or decrease the font

To navigate the Help, use the touchscreen. Alternatively, you can also use the navigation keys on the front panel.

To search for a topic in the index

The index is sorted alphabetically. You can browse the list, or search for entries in the list.

1. Switch to the "Index" tab.
2. Select the "Keyboard" icon besides the entry field.
3. Enter the first characters of the keyword you are interested in.

   The entries containing these characters are displayed.
4. Double-tap the suitable index entry.

   The "View" tab with the corresponding help topic is displayed.

To search topics for a text string

1. Switch to the "Search" tab.
2. Select the "Keyboard" icon besides the entry field.
3. Enter the string you want to find.
   If you enter several strings with blanks between, topics containing all words are found (same as AND operator).

   For advanced search, consider the following:
   - To find a defined string of several words, enclose it in quotation marks. For example, a search for *"trigger qualification"* finds all topics with exactly *"trigger qualification"*. A search for *trigger qualification* finds all topics that contain the words *trigger* and *qualification*.
   - Use "Match whole word" and "Match case" to refine the search.
   - Use operators AND, OR, and NOT.

To close the Help window

► Select the "Close" icon in the upper right corner of the help window.
Or: Press the ESC key.

3 Instrument Setup

You can adapt various instrument settings to your requirements, such as language, display appearance, and assign functions to some keys.

The chapter describes also the handling of software options.

The following setup procedures are described in other chapters of the documentation:

- Chapter 2.1.4, "Connecting External Devices", on page 32
- Chapter 15.2.3, "LXI Configuration", on page 852
- Chapter 15.4, "Remote Settings", on page 860
- The firmware update is described in the release notes.

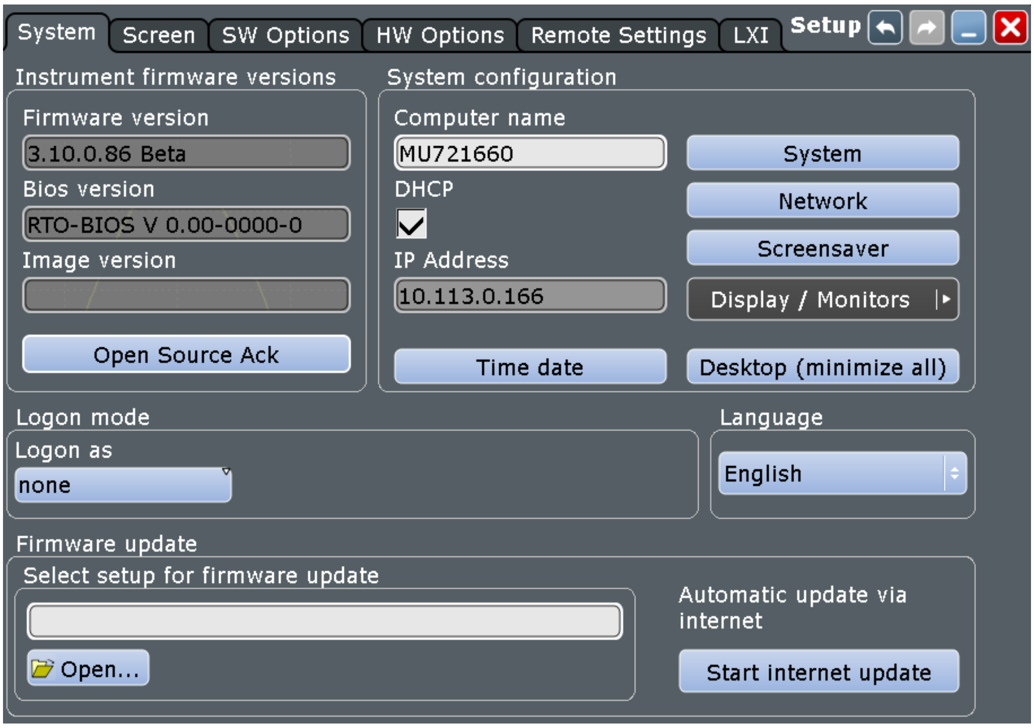
The following settings and procedures are described in the current chapter:

3.1 System Setup

3.1.1 System Settings

Access: SETUP > "System" tab

The settings on this tab are related to the basic instrument and system configuration.



Firmware version

Indicates the firmware version currently installed on the instrument.

Remote command:

`DIAGnostic:SERVice:FWVersion?` on page 892

Bios version

Indicates the BIOS version currently installed on the instrument.

Image version

Indicates the image version currently installed on the instrument.

Desktop (minimize all)
Minimizes all displayed application windows on the instrument, so that the desktop becomes visible on the screen to access the Windows functionality.

This function is also available from the "File" menu.

Computer name, IP Address, DHCP
Indicates the currently defined computer name, the defined IP address and DHCP address enabling. These values are required to configure the instrument for work in a network.

NOTICE! Risk of network problems. All parameters can be edited here; however, beware that changing the computer name has major effects in a network. For details, see Chapter 15.2.1, "Setting Up a Network (LAN) Connection", on page 847.

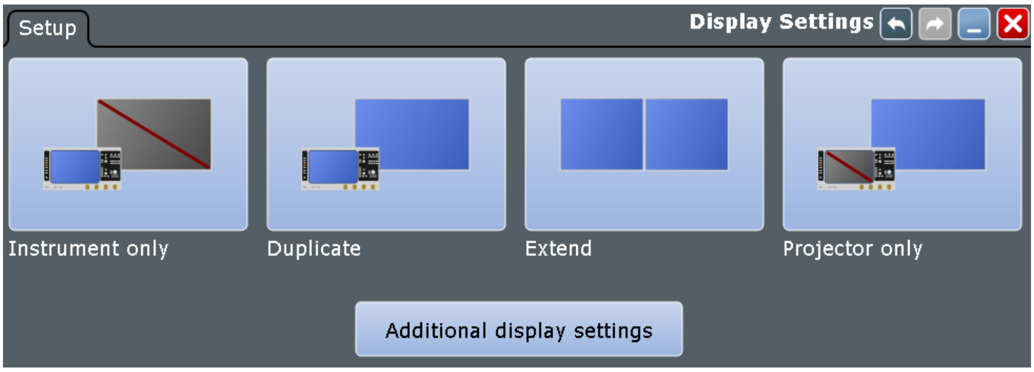
Remote command:
`DIAGnostic:SERVice:COMPutername` on page 892

System
Opens the standard Windows "System Properties" dialog box to configure system settings.

Network
Opens the standard Windows "Network Connections" dialog box to configure a network.

Screensaver
Opens the standard Windows "Display Properties" dialog box to configure a screen saver.

Display / Monitors: Display Settings
The "Display / Monitors" button opens the "Display Settings" dialog box, where you can extend or duplicate the instrument display to a second monitor or projector (external display).



"Instrument only"	The instrument display is on, the external display is off.
"Duplicate"	The external display shows the same content as the instrument display.

"Extend"	The instrument display and the external display show different content.
"Projector only"	The instrument's user interface is only shown on the external display, the instrument display is off.
"Additional display settings"	Opens the Windows configuration for display settings.

Time, date

Opens the standard Windows "Date and Time Properties" dialog box to set the correct date and time.

Note: Usually date and time are set correctly. To adjust your regional time, select the correct time zone rather than changing the time.

Remote command:
`SYSTem:DATE` on page 891
`SYSTem:TIME?` on page 892

Log on as

Sets the user that is automatically logged on during the startup process of the instrument. The change of this setting takes effect at the next instrument startup

"User autologon"	Auto-logon as standard user with limited access. Enter the "User name" and "Password" of the user who will log on at the next instrument startup.
"Admin autologon"	Auto-logon with unrestricted access to the instrument and network. The setting is only available for administrators. Enter the administrator "Password" to enable the auto-logon.
"None"	No auto-logon, user name and password are requested at instrument startup.

Language

Selects the language in which the dialog boxes, result boxes and other screen information is displayed.

Select setup for firmware update

Your instrument is delivered with the latest firmware version.

Firmware updates and the "Release Notes" describing the improvements and modifications are provided on the Internet at www.rohde-schwarz.com/ product/rte.html > "Downloads" > "Firmware".

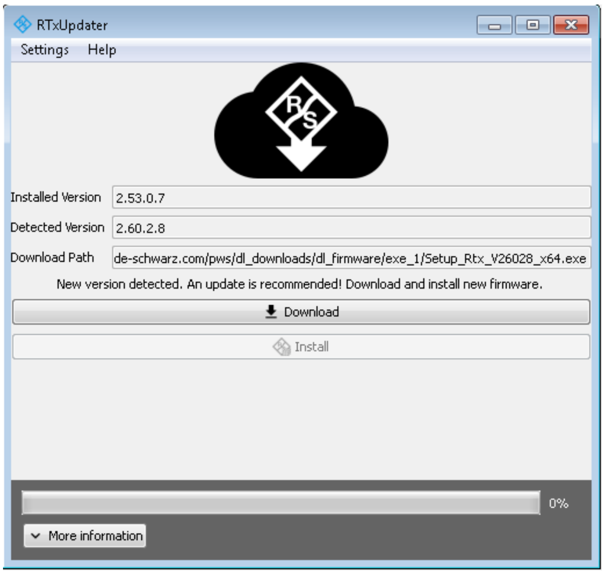
How to update the firmware is described in the "Release Notes" of the R&S RTE.

"Load"	Loads the specified file.
"Open"	Opens a file selection dialog box and loads the selected file.
"Explore"	Opens the Windows file explorer where you can navigate and search for files and folders by means of the operating system.

Start internet update

Starts the "RTxUpdater", which connects to the internet, checks for newer versions, downloads the firmware file, and installs the firmware.

Make sure that your device is connected to the Internet. If your corporate network uses a proxy server, enter the proxy settings in "Settings" menu > "Proxy Settings". Ask your administrator for correct proxy settings.



A short instruction is available under "Help" > "Help".

3.1.2 Setting the Display Language

You can change the language in which the dialog boxes, result boxes and other screen information is displayed. A reboot of the instrument is not necessary.

1. Press the SETUP key.
2. Select the "System" tab.
3. Tap the "Language" button. The button shows the current language.
4. Select the required language.

   The instrument changes the language after a few seconds.

3.2 Screen Setup

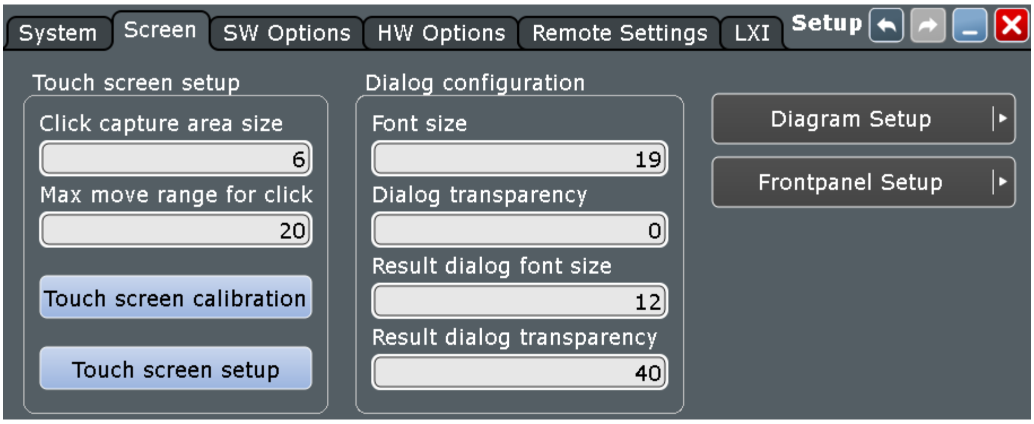
3.2.1 Screen Settings

Access: SETUP > "Screen" tab

The settings on this tab are related to the screen display.

Note for "Dialog configuration", "Front panel setup" and "Navigation rotary knob" settings:

These settings are user-specific, they are *not* reset by PRESET and `*RST`. You can reset them to default values using FILE > "Save/Recall > User defined preset > Factory defaults" or using the `SYSTem:PRESet` command.



Click capture area size
Defines the number of pixels around each element (e.g. button, icon, data point) that create a capture area. If you tap your finger or click the mouse pointer within this capture area, this element is considered to be selected. If you tap or click outside this area, a different or no element is selected.

The larger the area, the easier is it to select an element. However, when selecting data points, for example, a large frame does not allow you to select precisely.

Max move range for click
Defines the maximum number of pixels around an element (e.g. data point) within which your pointing device must stay in order to "click" the element. When you tap or click a specific element and move your finger or the mouse outside this range, it is considered to be a "moving" or "dragging") operation.

Touchscreen calibration
Opens the touchscreen calibration application, see Chapter 3.2.2, "Aligning the Touchscreen", on page 112.

Touchscreen setup
Opens the touchscreen configuration application for advanced touchscreen setup and more sophisticated calibration.

Font size
Defines the font size of the text in dialog boxes.

Dialog transparency
Defines the transparency of the dialog box background. For high transparency values, you can see the waveform display in the background, and possibly check the effect of the changed setting. For lower transparency values, readability in the dialog box improves.

Result dialog font size
Defines the font size of the text in result boxes. The size of the result box is adapted to the font size.

Result dialog transparency
Defines the transparency of the measurement result boxes in the same way as Dialog transparency.

3.2.2 Aligning the Touchscreen

When the device is delivered, the touchscreen is initially calibrated. However, to ensure that the touchscreen responds to the finger contact correctly, a touchscreen alignment is required.

Alignment of the touchscreen is useful:

- At first use
- If the position of the instrument has been changed and you cannot look straight on the screen
- If another person operates the instrument
- If you notice that touching a specific point on the screen does not achieve the correct response

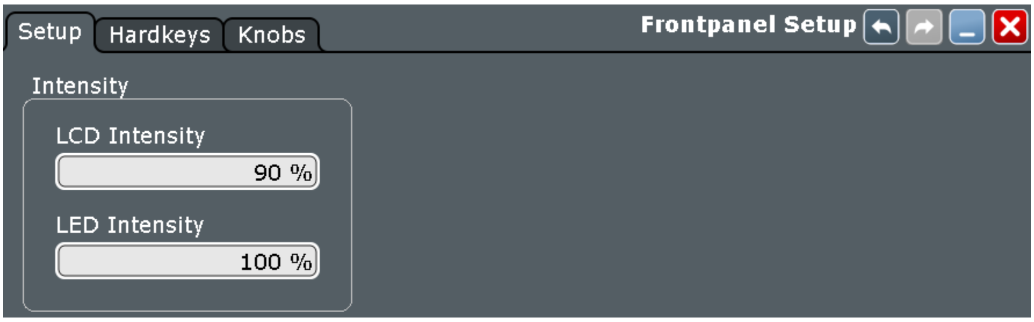
1. Press the SETUP key.
2. Select the "Screen" tab.
3. Tap "Touchscreen Calibration".
   A blinking cross appears in the lower left corner of the screen.
4. Touch and hold the cross until "OK" is shown.
5. Repeat this action for the crosses in the other corners.
6. Tap the R&S logo button in the task bar to display the instrument's user interface.

3.3 Frontpanel Setup

In the "Frontpanel Setup" dialog box, you can adjust the luminosity of the screen and luminous keys, assign functions to keys and knobs, and adjust the NAVIGATION knob.

3.3.1 Setup: Luminosity Settings

Access: "File" menu > "Frontpanel Setup" > "Setup"



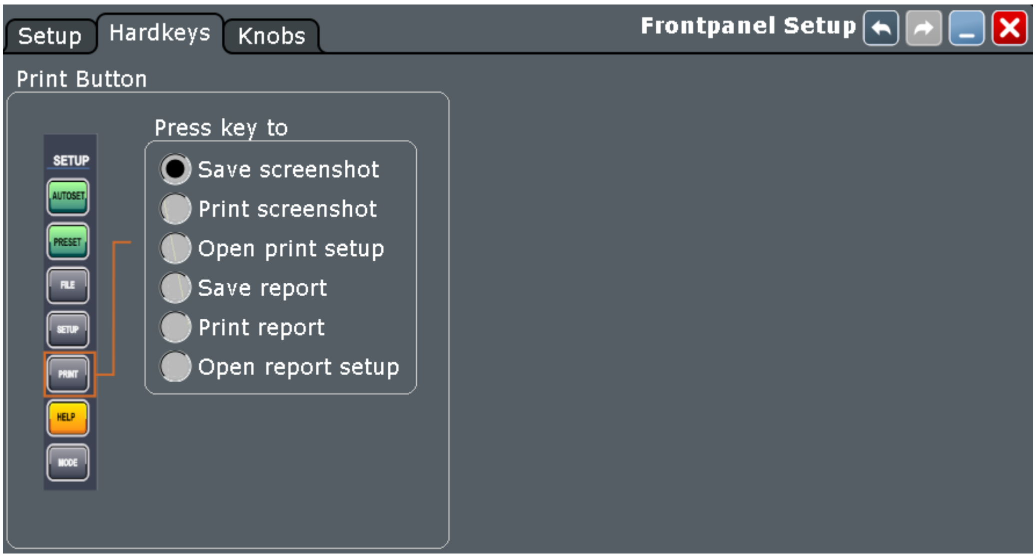
LCD Intensity
Changes the background luminosity of the touchscreen.

LED Intensity
Defines the luminosity of illuminated front panel keys and rotary knobs.

3.3.2 Hardkeys: Function Assignment

Access: "File" menu > "Frontpanel Setup" > "Hardkeys"

You can configure the function of some controls on the front panel to your needs.



Print Button

The PRINT key on the left side of the display is a shortcut key that initiates an associated action.

You can assign one of the following actions to the PRINT key:

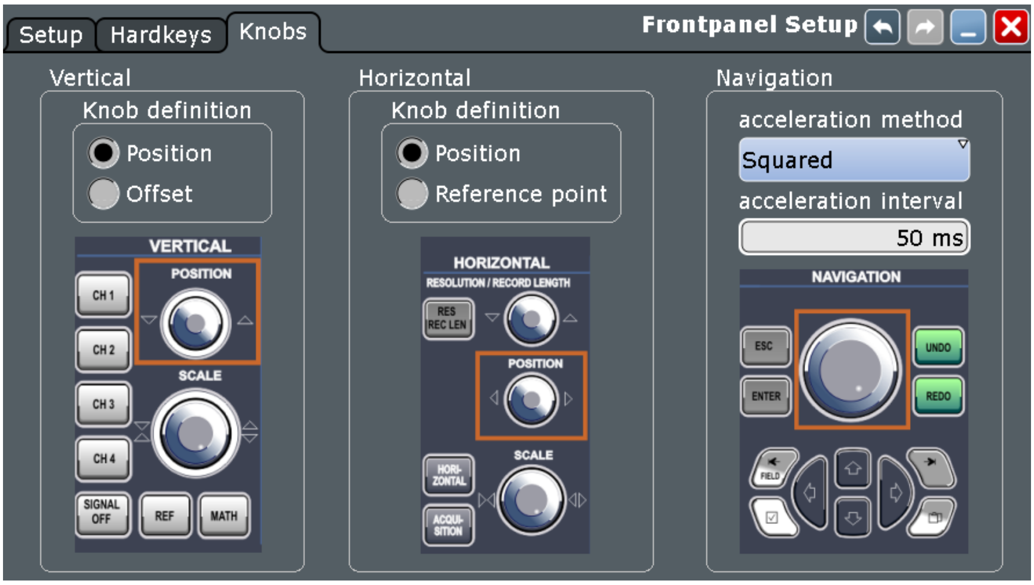
- Save a screenshot
- Print a screenshot
- Open print setup
- Save a report
- Print a report
- Open report setup

Configure the settings for the selected action.

- Screenshots: "File" menu > "Print Setup", see Chapter 11.3.1, "Screenshot Settings", on page 430.
- Report: "File" menu > "Report Setup", see Chapter 11.4.1, "Report Settings", on page 435.

3.3.3 Knobs

Access: "File" menu > "Frontpanel Setup" > "Knobs"



Vertical

The vertical POSITION / OFFSET knob can change the waveform position or the offset of the selected waveform. Select the action that you want to perform.

See also: "POSITION / OFFSET (upper knob)" on page 39.

Horizontal

The horizontalPOSITION / REF POINT knob can change the horizontal position or the reference point. Select the action that you want to perform.

See also: "POSITION / REF POINT" on page 38.

Rotary knob acceleration method

Selects a method to accelerate the movement of the element on the screen compared to the actual movement of the rotary knob. Acceleration is useful if you need to move from one end of the screen to the other, for example. Without acceleration, you have to turn the knob quite a while to reach the other end. On the other hand, acceleration can make precise selection difficult, since a small movement of the knob causes a relatively large movement on the screen.

"None"	No acceleration method used.
"Squared"	Moderate acceleration method used.
"Exponential"	Strong acceleration method used.

Rotary knob acceleration interval

Defines the delay time during which the movement of the rotary knob is analyzed before acceleration is applied. For short intervals, acceleration sets in quickly, but is not as effective. For long intervals, acceleration is more effective. However, it takes longer until the instrument reacts on the knob's input. Furthermore, when you turn the knob slowly during fine-tuning, subsequent movements that occur during the same interval are accelerated, making precise selection difficult.

3.4 Display Configuration

3.4.1 Adjustable Display Elements

You can customize the various elements on the screen according to your needs:

Signal bar

The signal bar contains signal icons (mini windows) that display either real-time views of minimized waveforms, or labels with setting information for displayed waveforms. On the top of the bar, the timebase label and trigger label provide general information for all displayed channels.

The signal bar can be manually switched on and off, it can be automatically hided, and you can adjust color and transparency of the bar.

Toolbar

The toolbar contains icons that start frequently used functions. You can define which tools are displayed on the toolbar.

Diagrams

The basic diagram elements can be shown or hidden: grid, crosshair, label, and tab titles. You can also enter user-defined diagram names.

Waveforms

For waveforms, you can adjust the persistence, the waveform style, and color. You can also annotate the waveforms by adding screen texts.

To set the color, you can select it from a color palette or assign color tables defining the color of waveform pixels depending on the cumulative occurrence of the associated values. You can assign a different color or color table to each waveform.

The following default color tables are provided:

- "False colors"
- "M-Hot"
- "M-Hsv"
- "M-Jet"
- "Spectrum"
- "Single Event"
- "Temperature"

Dialog boxes and result boxes

You can configure the font size, contrast and transparency in dialog and result boxes. Thus, you can optimize readability or keep track of the waveforms while changing settings in dialog boxes.

Clear screen results

To delete all results and waveforms, select "Display" menu > "Clear screen results".

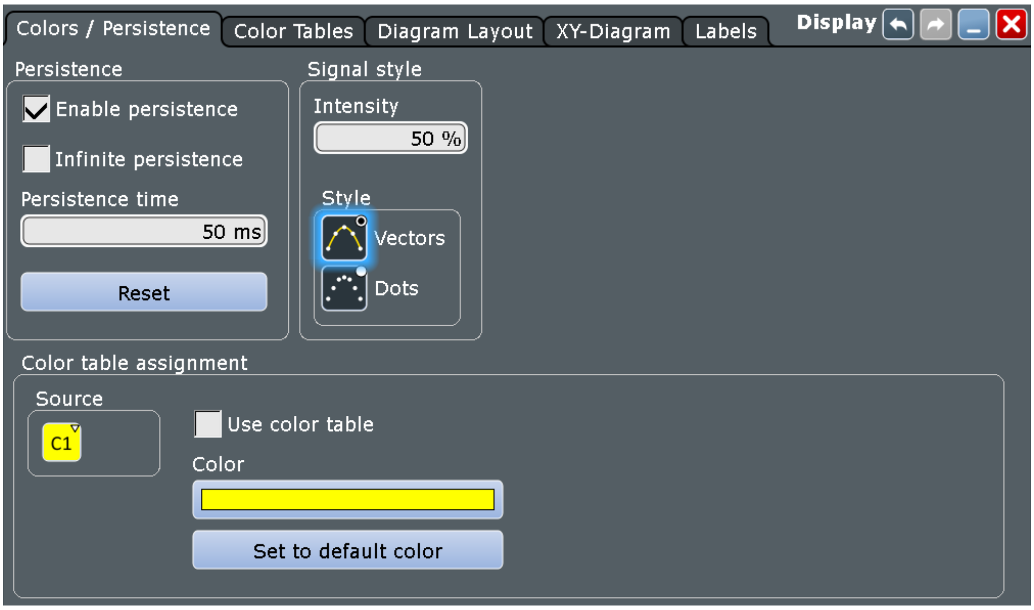
3.4.2 Display Settings

Display settings are configured in the "Display" dialog box, which is opened when you press the DISPLAY key or select an item from the "Display" menu.

3.4.2.1 Colors / Persistence

Access: DISPLAY > "Colors / Persistence" tab

The "Colors / Persistence" tab contains settings for the general display of waveform data.



Enable persistence

If enabled, each new data point in the diagram area remains on the screen for the duration defined under Persistence time, or as long as Infinite persistence is selected.

If disabled, the signal value is only displayed as long as it actually occurs.

Remote command:
`DISPlay:PERSistence[:STATe]` on page 895

Infinite persistence

If persistence is enabled, each new data point in the diagram area remains on the screen infinitely until this option is disabled.

Remote command:
`DISPlay:PERSistence:INFinite` on page 895

Persistence time

If persistence is enabled, each new data point in the diagram area remains on the screen for the duration defined here.

Remote command:
`DISPlay:PERSistence:TIME` on page 896

Reset
Resets the display, removing persistent values.

Remote command:
DISPlay:PERSistence:RESet on page 896

Intensity
This value determines the strength of the waveform line in the diagram. Enter a percentage between 0 (not visible) and 100% (very strong). The default value is 50%.

You can also use the INTENSITY knob on the left side of the screen to adjust the waveform intensity directly.

Note: Use of color tables. The exact mapping of the cumulative value occurrences according to the assigned color table is guaranteed only if the intensity is set to 50%. All other intensity values falsify the mapping but may improve the visibility of the signal. See also: Chapter 3.4.3.1, "Editing Waveform Colors", on page 127.

Remote command:
DISPlay:INTensity on page 896


Style
Select the style in which the waveform is displayed:

"Vectors" The individual waveform points are connected by a line.
Define the strength of the line using the INTENSITY knob on the left side of the screen.

"Dots" Only the individual waveform points are displayed. Waveform sample points are the ADC sample points and additional interpolated points if "Interpolated time" is used for resolution enhancement. To see the dots of one waveform, perform one acquisition with RUN N× SINGLE and N=1 ("Average count" = 1). During continuous acquisition, or a RUN N× SINGLE acquisition with N > 1, the dots of multiple subsequent waveforms are displayed on the screen. Thus, the waveform on the screen might look like a line.
Consider also the "Interpolation" on page 156.

Remote command:
DISPlay:DIAGram:STYLe on page 896

Color
Shows the current color of the selected waveform. To change the color, tap the button and select a color. The color of the waveform, its signal icon, channel icon, and of the illuminated keys is adjusted to the new color.

Set to default color
Resets the color of the selected waveform to the factory default.

Use color table
If enabled, the selected waveform is displayed according to its assigned color table.

If this option is disabled, the selected color is displayed, and the intensity of the specific signal color varies according to the cumulative occurrence of the values.

Remote command:
`DISPlay:COLor:SIGNal<m>:USE` on page 897

Source
Selects the waveform to which the color table and the labels are assigned.

Option R&S RTE-K18: A spectrogram always has the same color as the math (spectrum) waveform from which it is created.

Assigned color table
Adjust the waveform colors to suit your preferences. For each of the following waveform types you can assign a suitable color table:
- Analog and digital channels
- Reference waveforms
- Results of a mathematical function, also for FFT and derived spectrogram.
- Measurements and tracks
- XY-traces
- Serial buses if a protototocol option is activated
- Parallel buses if MSO option is installed

See also: Chapter 3.4.2.2, "Color Tables", on page 119.

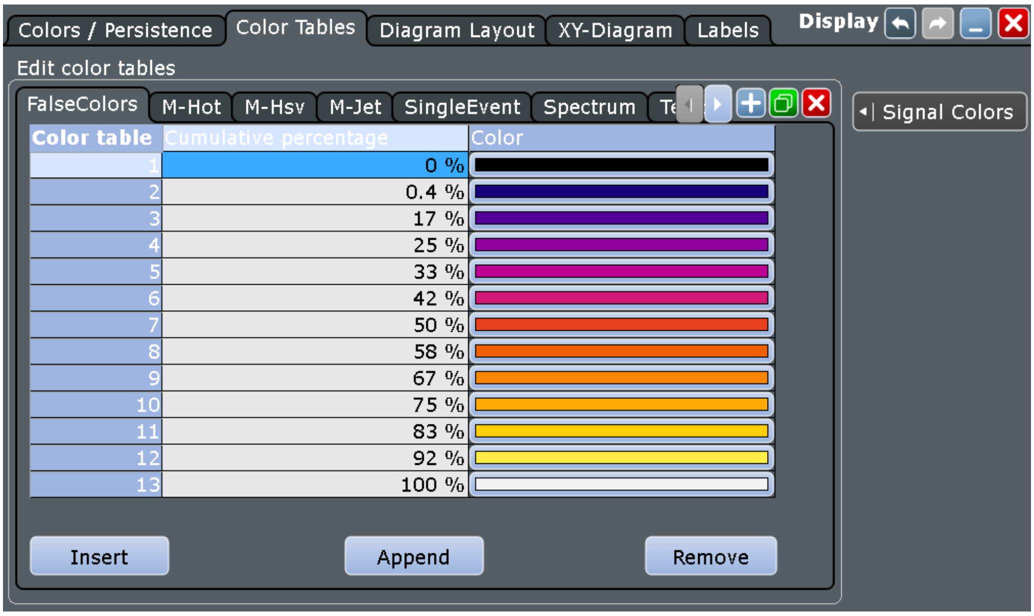
Remote command:
`DISPlay:COLor:SIGNal<m>:ASSign` on page 897

3.4.2.2 Color Tables

Access: DISPLAY > "Color Tables" tab

Color tables define the color of the waveform pixels depending on the cumulative occurrence of the associated values. By default, the intensity of the specific waveform color varies according to the cumulative occurrence of the values. The more often a value occurs, the darker the color of the data point is displayed.

The following default color tables are provided:
- "False colors"
- "M-Hot"
- "M-Hsv"
- "M-Jet"
- "Spectrum"
- "Single Event"
- "Temperature"



The editing table allows you to edit existing color tables or add new ones that can then be assigned to the waveforms. To assign a color table to a waveform, use the "Signal colors / Persistence" tab.

See also:

- Chapter 3.4.3.1, "Editing Waveform Colors", on page 127
- Assigned color table

Remote commands

The following remote commands are used to configure color tables:

`DISPlay:COLor:PALette:COUNt?` on page 898

`DISPlay:COLor:PALette:ADD` on page 897

`DISPlay:COLor:PALette:REMove` on page 897

`DISPlay:COLor:PALette:POINt:INSert` on page 898

`DISPlay:COLor:PALette:POINt:ADD` on page 898

`DISPlay:COLor:PALette:POINt[:VALue]` on page 898

`DISPlay:COLor:PALette:POINt:COUNt?` on page 899

`DISPlay:COLor:PALette:POINt:REMove` on page 898

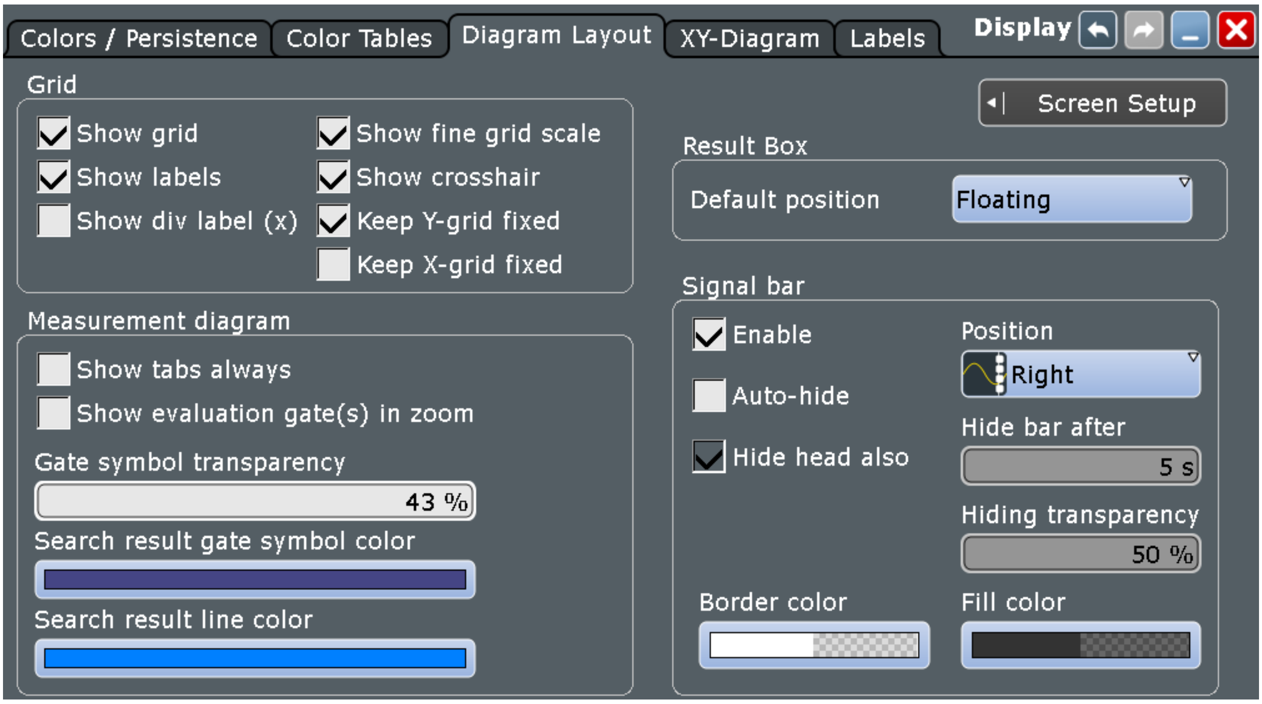
`DISPlay:COLor:PALette:COUNt?` on page 898

3.4.2.3 Diagram Layout

Access: DISPLAY > "Diagram Layout" tab

On the "Diagram Layout" tab, you define the basic diagram layout and the appearance and behavior of the signal bar.

These settings are user-specific, they are *not* reset by PRESET and `*RST`. You can reset them to default values using FILE > "Save/Recall > User defined preset > Factory defaults" or using the `SYSTem:PRESet` command.



Show grid
If selected, a grid is displayed in the diagram area. A grid helps you associate a specific data point to its exact value on the x- or y-axis.

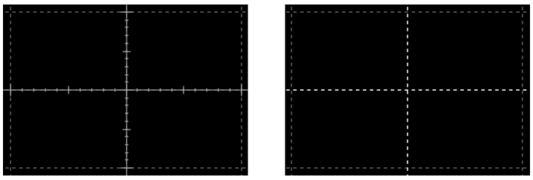
Remote command:
DISPlay:DIAGram:GRID on page 900

Show labels
If selected, labels mark values on the x- and y-axes in specified intervals in the diagram.

Remote command:
DISPlay:DIAGram:LABels on page 900

Show div label (x)
If selected, the time scale value is shown at the diagram bottom instead of the horizontal grid labels. For example, 10 ns/div is shown instead of the values 0, 10, 20, 30... ns.

Show fine grid scale
If selected, the crosshair is displayed as a ruler with scale markers. If disabled, the crosshair is shown as dashed lines.



Remote command:
DISPlay:DIAGram:FINegrid on page 900

Show crosshair
If selected, a crosshair is displayed in the diagram area. A crosshair allows you to select a specific data point by its co-ordinates.

Remote command:
DISPlay:DIAGram:CROSshair on page 900

Keep Y-grid fixed
If enabled, the horizontal grid lines remain in their position when the position of the curve is changed. Only the values at the grid lines are adapted. Fixed horizontal grid lines correspond to the behavior of traditional oscilloscopes.

Remote command:
DISPlay:DIAGram:YFIXed on page 901

Keep X-grid fixed
If enabled, the vertical grid lines remain in their position when the horizontal position is changed. Only the values at the grid lines are adapted.

Show tabs always
If selected, the tab titles of all diagrams are displayed: "Diagram1", "Diagram2" ...

If cleared, the tab titles are not shown except for titles in a tabbed diagram. In tabbed diagrams, the tab titles are required to change the tabs.

Remote command:
`DISPlay:DIAGram:TITLe` on page 900

Show evaluation gate(s) in zoom
If enabled, the available histogram areas, masks, and measurement gates are shown in the zoom diagrams. If the evaluation gate is within the zoom area, the display helps to move or modify the evaluation gates in the zoom window.

Make sure that the option is disabled if the zoom area and the evaluation gate are of nearly the same size to avoid conflicts in mouse operation.

Gate symbol transparency
Sets the transparency of the area that is defined as measurement or search gate. The setting only takes effect if "Show gate" is enabled.

Remote command:
`DISPlay:GATE:TRANsparency` on page 901

Search result gate symbol color
Sets the color of the search zoom area. The search zoom area is displayed if "Show search zoom windows" is enabled. See also: "Search zoom window" on page 395.

Search result line color
Sets the color of the search result markers. The markers are displayed if "Show search zoom windows" is enabled.

Result Box: Default position
Defines where a new result box opens.

"Floating" The result box opens as a box similar to a dialog box in front of the diagrams. It can be moved and shows all results.

"Preview" The result box opens as a minimized result icon on the signal bar. It shows only two columns and a few rows of the results.

Remote command:
`DISPlay:RESultboxes:DEFaultpos` on page 901

Signal bar
You can adjust the position and appearence of the signal bar in various ways.

Enable ← Signal bar
If enabled, the signal bar is displayed in the diagram area.

The signal bar contains signal icons (mini windows) that display either real-time views of minimized waveforms, or labels with setting information for displayed waveforms. On the top of the bar, the timebase label and trigger label provide general information for all displayed channels.

Remote command:
`DISPlay:SIGBar[:STATe]` on page 901

Position ← Signal bar
The signal bar can be placed vertically at the right (default position), or at the left to ensure best visibility of the waveforms.

Remote command:
`DISPlay:SIGBar:POSition` on page 903

Auto-hide ← Signal bar
If selected, the signal bar disappears automatically after some time, similar to the Windows task bar. With the settings below "Auto hide", you can define when and how the signal bar hides.

The signal bar reappears if you tap it, or if an action changes the content of the bar.

Remote command:
`DISPlay:SIGBar:HIDE[:AUTO]` on page 904

Hide head also ← Signal bar
If selected, the "Auto hide" function hides also the horizontal and trigger label at the top of the signal bar.

Remote command:
`DISPlay:SIGBar:HIDE:HEAD` on page 904

Hide bar after ← Signal bar
Sets the time when the signal bar is faded out with "Auto-hide".

Remote command:
`DISPlay:SIGBar:HIDE:TIME` on page 904

Hiding transparency ← Signal bar
Sets the transparency of the signal bar when the signal bar is faded out with "Auto-hide". The maximum value is 70%, the signal bar is always slightly visible. The minimum value 20% applies the best visibility of the signal bar.

Remote command:
`DISPlay:SIGBar:HIDE:TRANsparency` on page 904

Border color ← Signal bar
Opens a color selection dialog box to define the color of the signal bar border.

For details, see "To change the colors" on page 91.

Remote command:
`DISPlay:SIGBar:COLor:BORDer` on page 904

Fill color ← Signal bar
Opens a color selection dialog box to define the fill color of the signal bar.

For details, see "To change the colors" on page 91.

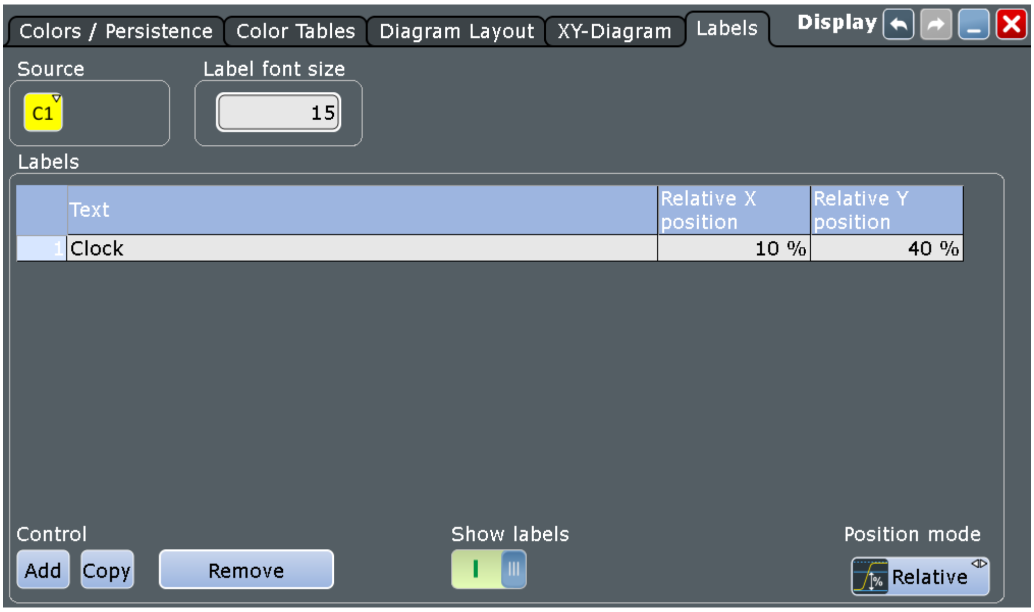
Remote command:
`DISPlay:SIGBar:COLor:FILL` on page 905

3.4.2.4 Waveform Labels

Access: DISPLAY > "Labels" tab

Using labels, you can annotate the waveforms to name or explain each waveform. The text is shown in the same color as the assigned waveform. Each label has its individual position. You can enter exact positions in the dialog box, or drag the labels on the screen to the required position. The position can be a fixed one (relative to the screen), or a flexible position (absolute, assigned to the axes).

To add labels quickly, you can add the "Label" icon to the toolbar and use it.



Make sure that the correct waveform tab is selected before you enter the labels.

Labels

For each waveform, the "Labels" table shows the assigned texts and their positions. Enter the label text and the horizontal and vertical positions for each label.

"Add" Adds a line at the end of the list.

"Copy" Copies the selected line in a new line.

"Remove" Deletes the selected line. Only single lines can be removed.
You can also delete a label by using the toolbar: Tap the "Delete" icon and then the label.

Remote command:
`DISPlay:SIGNal:LABel:ADD` on page 905
`DISPlay:SIGNal:LABel:REMove` on page 906
`DISPlay:SIGNal:LABel:TEXT` on page 906
`DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition` on page 907

DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition on page 907
DISPlay:SIGNal:LABel:HORizontal:RELative:POSition on page 908
DISPlay:SIGNal:LABel:VERTical:RELative:POSition on page 908

Show labels
Enables or disables the label display.

Position mode
Defines the label position either relative to the diagram or with absolute values according to the units of the waveform. Relative positions are fixed, whereas absolute positions move with the waveform display when the scales, the vertical position or offset, or the reference point are changed.

The position mode applies to all labels of the selected waveform. For different waveforms, different position modes can be selected.

"Relative" Sets a fixed position in percent of the screen counting from the upper left corner.

"Absolute" Sets the position in time and voltage values, or in other units depending on the waveform character.

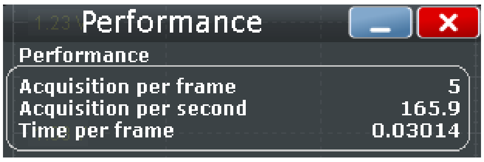
Remote command:
DISPlay:SIGNal:LABel:POSMode on page 907

Label font size
Defines the size of the labels in the diagram.

3.4.2.5 Performance

Access: "Display" menu > "Show Performance"

The "Performance" result box shows information on the current acquisition performance values of the R&S RTE.



The instrument groups acquired waveforms together in a frame, and displays the frame content. The maximum number of frames displayed per second is about 30. The current number of frames per second is indicated as reciprocal "Time per frame". If the time scale decreases, and thus the number of acquisitions per second also decreases, the number of acquisitions per frame can drop to 1.

3.4.2.6 Clear Screen Results

"Display" menu > "Clear screen results"

"Clear screen results" resets all results in all measurement result boxes including long term measurement and statistic results and deletes the current measurement waveforms. If you need this function frequently, you can add the correspondent icon to the toolbar, see Chapter 2.4.5.2, "Configuring the Toolbar", on page 92.

3.4.3 Adjusting the Display

To change the diagram name

► Double-tap the diagram tab name. The on-screen keyboard opens to enter the new name.

3.4.3.1 Editing Waveform Colors

For each waveform, you can set a waveform color, or you define a color table that specifies which waveform points are displayed in which color. You can use one of the default color tables, or define your own table according to your needs. You can also edit the default color tables.

After you define a color table, you must assign it to the waveform it is to be used for, and enable its use.

The exact mapping of the cumulative value occurrences according to the assigned color table is guaranteed only if the intensity is set to 50%. All other intensity values falsify the mapping but may improve the visibility of the signal.

See also: "Intensity" on page 118.

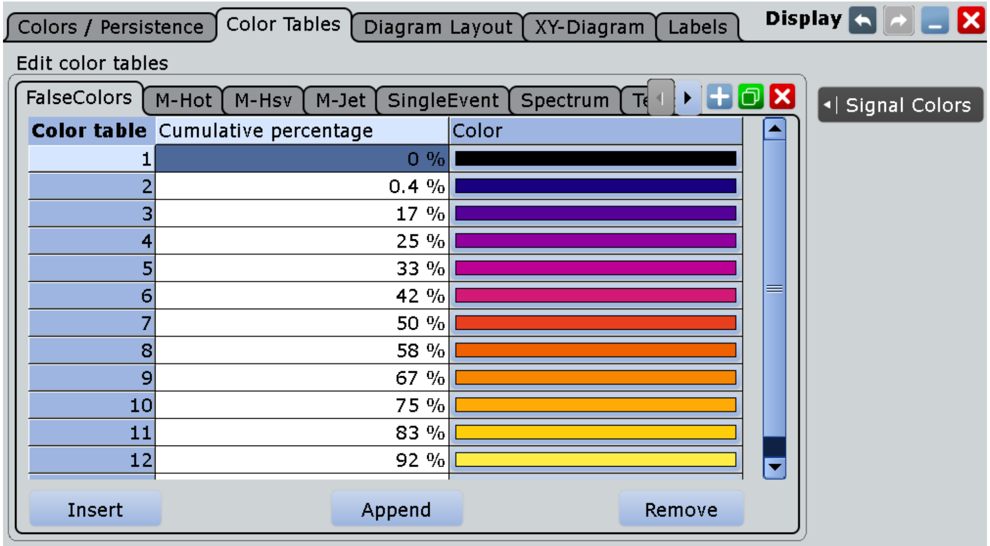
For details on signal color settings, see Chapter 3.4.2.2, "Color Tables", on page 119.

To change a waveform color

1. On the "Display" menu, tap "Signal Colors / Persistence".
2. Under "Color table assignment", select the waveform for which you want to change the color.
3. Tap the "Color" button.
4. In the "Adjust Colors" dialog box, select a predefined color, or define any other RGB color with "User defined Colors".

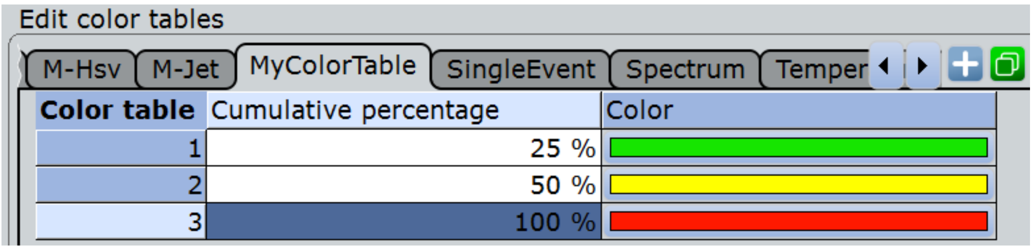
To edit a color table

1. On the "Display" menu, tap "Color Tables".
2. Under "Edit Color Tables", select the color table you want to edit.



3. For each range of cumulative occurrence of the values, insert an entry in the color table:
   - To insert an entry at the end of the color table, tap "Append".
   - To insert an entry before an existing entry, tap the existing row. Then tap "Insert".
   - To remove an entry, tap the entry. Then tap "Remove".
4. Assign a color to each entry: Tap the "Color" cell.
   Select a predefined color, or define your own color.

Example:



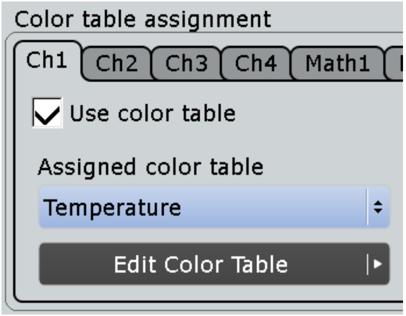
In this example, values with a cumulative occurrence under 25% (very short or rare display) are displayed green. Values with an occurrence of 40% are yellow-green. Values with an occurrence of 90% (displayed almost for the entire duration of the signal) are a deep shade of orange.

To create a color table

1. On the "Display" menu, tap "Signal Colors".
2. **To create an empty color table:** tap the "Add" button and enter a name for the new color table using the on-screen keyboard.
   To copy an existing color table: select the color table you want to copy, and tap the "Copy" button. Enter a name for the new color table using the on-screen keyboard.

To assign the color table and enable its use

1. Open the "Signal Colors/ Persistence" tab of the "Display" dialog box.
2. Under "Color Table Assignment", select the tab for the waveform.
3. Enable "Use Color table".



4. Under "Assign color table", select the color table you want to assign to the wave-form.

   The waveform colors are displayed according to the definition in the color table.

3.4.3.2 Using the Signal bar

The signal bar can hold a large number of signal and result icons. Signal icons represent the waveforms, serial buses and parallel buses, while result icons are minimized result boxes showing measurement and search results.

To scroll the signal bar

If the signal bar contains more than four icons, not all icons are visible on the display.

► Touch one of the signal icons and move it up or down until the required icon appears.

To switch on and off the signal bar

If you need the complete screen to see the diagrams and results, you can switch off the signal bar completely.

► Tap the "Show signal bar" icon on the toolbar.

Alternatively, tap "Signal Bar" on the "Display" menu.

To change the position of the signal bar

► Touch the "Horizontal" label on the top of the signal bar and drag it to the opposite side of the screen.

To configure auto-hide

The signal bar can be hidden if the displayed information has not changed for a defined time, and is displayed again automatically when a setting in the signal bar changes. The signal bar does not hide entirely, it simply fades and becomes less visible in the display.

1. Press the DISPLAY key on the front panel.
2. In the "Display" dialog box, select the "Diagram Layout" tab.
3. Select "Auto-hide".
4. Define the hiding properties:
   - "Hide bar after": the time after which the bar is hidden if no changes occur
   - "Hiding transparency": Transparency of the hidden signal bar on a scale from 20% (low transparency) to 70% (high transparency)
   - Hide head also: the horizontal and trigger labels are also faded

To change the colors

If you want to highlight the signal bar, you can change the "Fill color" and "Border color" of the bar.

1. Press the DISPLAY key on the front panel.
2. In the "Display" dialog box, select the "Diagram Layout" tab.
3. Tap "Border color" to change the color of the signal bar frame, or "Fill color" to change the fill color of the bar.
4. In the "Adjust Colors" dialog box, select the color.
5. To use a color that is not yet defined, tap "Userdefined Colors". Define the new color settings.
   To see the effect of a setting change in the "Preview" area, enter the value and press the ENTER key.
6. Tap "OK."

   The signal bar is displayed in the new colors.

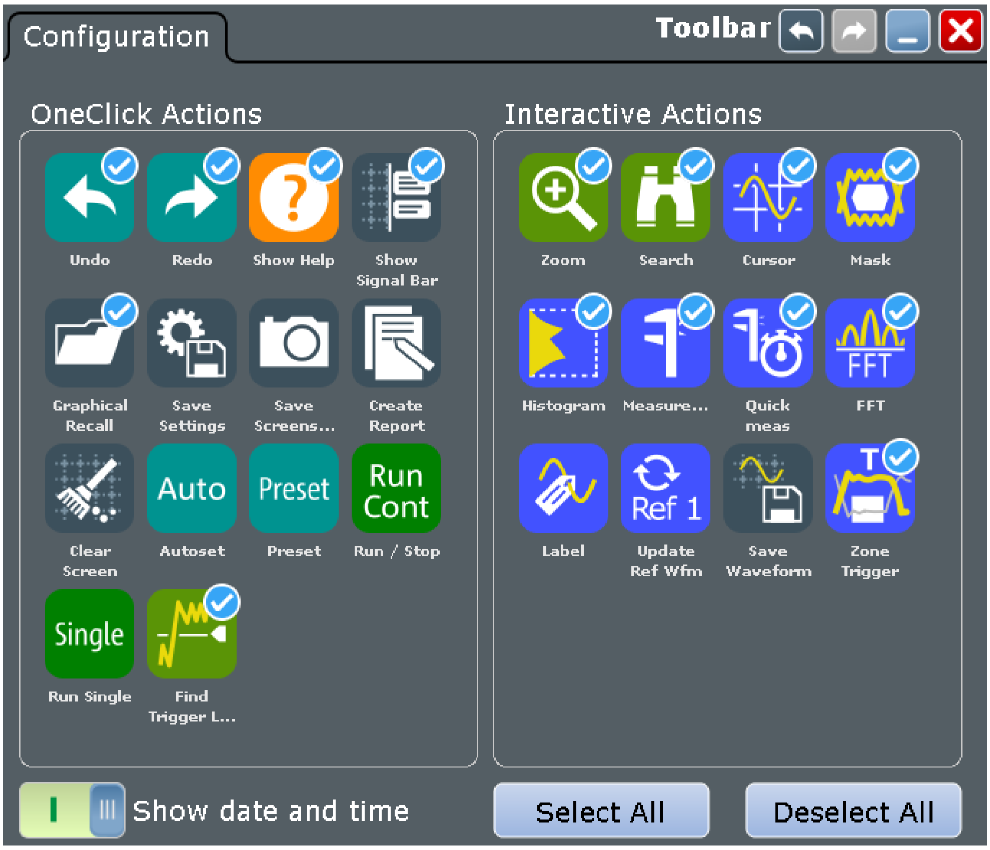
3.4.3.3 Configuring the Toolbar

You can configure the contents of the toolbar so that only the required functions are displayed. Furthermore, date and time can be hidden. The toolbar configuration is part of the user preferences. It is retained when you switch off and on the instrument, and you can save it in the user preferences and user-defined preset.

1. On the "Display" menu, select "Toolbar".
2. Select the functions to be displayed:
   - To select specific functions, enable the "Visible" option for each function. Disable the functions that you do not need.

- To display all available toolbar icons, tap "Show All".
- To hide all toolbar icons, tap "Hide All".

3. To hide the current date and time on the toolbar, disable "Show date and time".



A detailed description of the toolbar functions is given in Chapter 2.4.5.3, "Toolbar Functions", on page 93.

3.4.3.4 Configuring Dialog Boxes and Result Boxes

You can optimize the display of dialog and result boxes so they do not interfere with the waveform display and you can still analyze the results and settings.

To change the font size in dialog and result boxes

1. Press SETUP.
2. Select the "Screen" tab.
3. To set the font size in points for text in all dialog boxes, change "Font size". Most dialog boxes are optimized for a font size of 19 pt.
4. To set the font size in points for result boxes, change "Result dialog font size". The default is 12 pt.

To change the transparency of dialog boxes and result boxes

The transparency of the dialog box background lets you see the waveforms behind the box. You can configure the transparency separately for dialog boxes and result boxes.

1. Press SETUP.
2. In the "Screen" tab, in the "Dialog box transparency" field, enter the transparency value for dialog boxes.
   For high transparency values, you can see the waveform display in the background, and possibly check the effect of the changed setting. For lower transparency values, readability in the dialog box improves.
3. In the "Result box transparency" field, enter the transparency value for result boxes.

Alternatively, you can press the INTENSITY knob until the required parameter is shown in the data input box, and then turn the knob to set the transparency.

To change the color theme and contrast for dialog boxes

When you print a screenshot of the display, it is helpful to use dark-colored text on a light-colored background. For improved readability, different settings are required, depending on the transparency value.

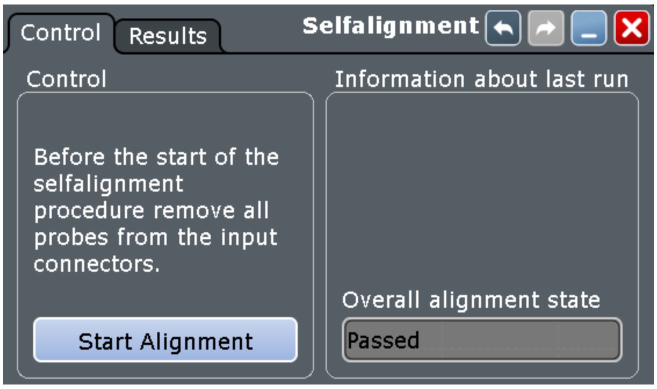
1. Press SETUP.
2. In the "Screen" tab, select the color theme suitable for the current operating situation.

3.5 Self-Alignment

When data from several input channels is displayed at the same time, it may be necessary to align the data vertically or horizontally in order to synchronize the time bases or amplitudes and positions. This is the case, for example, when strong temperature changes occur (> 5°).

3.5.1 Control

Access: "File" menu > "Selfalignment"



Start Alignment

Starts the self-alignment procedure for all channels.

Remote command:

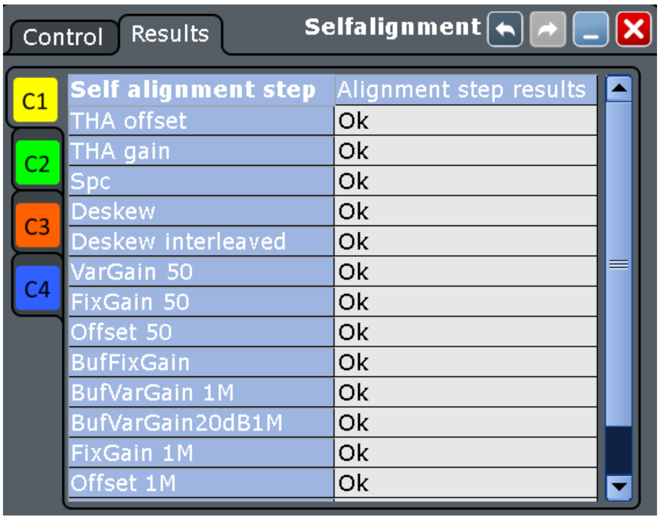
*CAL? on page 882

Date / Time / Overall alignment state

Show the date and the summary result of the self-alignment process: Passed or Failed. Detailed results are provided on the "Results" tab.

3.5.2 Results

For each channel, the results of the individual aligment steps are shown for all technical channel component. In case you require support, you may be asked to provide this information.



3.5.3 Performing a Self-alignment

The self-alignment aligns the data from several input channels vertically and horizontally to synchronize the timebases, amplitudes and positions. The self-alignment process includes a basic hardware check.

Recommendation on performing the self-alignment:

- When putting the instrument into operation for the first time
- After a firmware update
- Once a week
- When major temperature changes occur (> 5°)

NOTICE

Warm-up and prepare the instrument

Make sure that the instrument has been running and warming up before you start the self-alignment. The minimum warm-up time is indicated in the data sheet.

Remove the probes from the input connectors.

1. On the "File" menu, select "Selfalignment".
2. On the "Control" tab, tap "Start Alignment".

   The alignment is performed, the process might take several minutes. A message box informs you about the running process, wait until this message box closes. The overall pass/fail result is shown in the "Overall alignment state" field. The results of the individual alignment steps for each input channel are indicated in the "Results" tab. This information is required if problems arise.

3.6 Options

Additional options for the R&S RTE can be enabled using a license key. To obtain the license key, consult your sales representative.

The license type defines the duration of applicability and the portability of a license. The following license types are provided: evaluation, permanent, portable, quantified, timed with duration of 1, 3, 6 or 12 months. A license can also be in the states deactivated and expired.

Unregistered licenses
Unregistered licenses are not assigned to a particular instrument. The instrument accepts only registered licenses. If your license is delivered unregistered, use the online tool R&S License Manager to register the license for your instrument. The registration of a permanent license is irreversible, so ensure that you register it for the correct instrument. The address of the tool is https://extranet.rohde-schwarz.com/service.

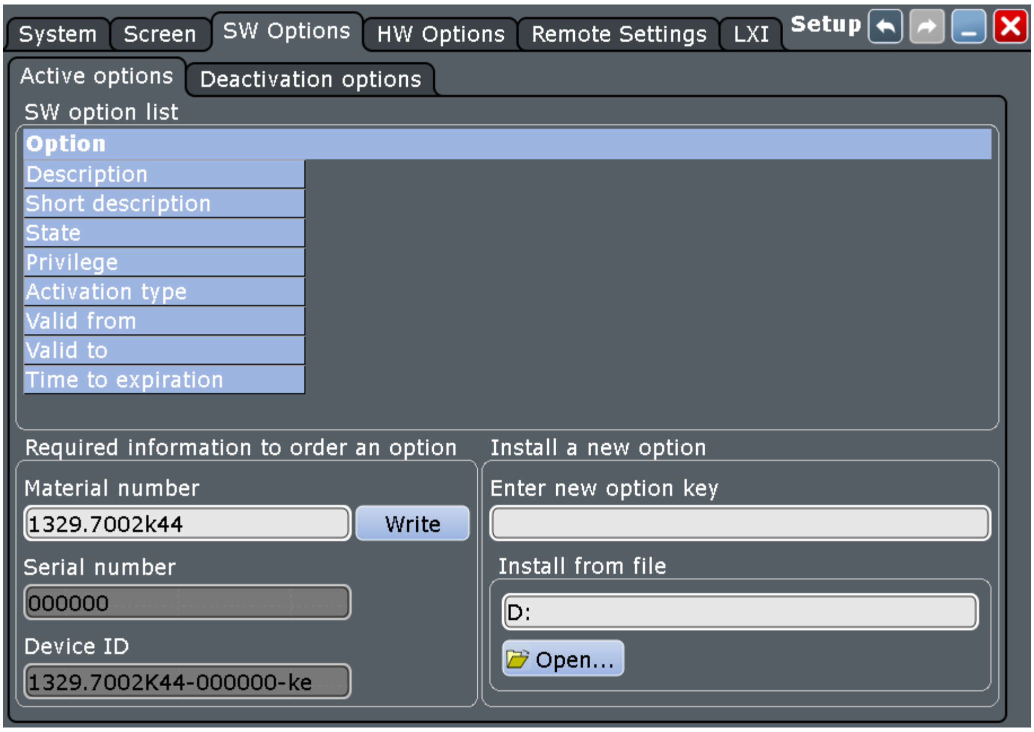
The R&S License Manager also allows you to move a portable license to another instrument.

3.6.1 SW Options

3.6.1.1 Active Options Settings

Access: SETUP > "SW Options" tab > "Active options" subtab

The "Active options" tab provides information on installed software options. Here you can install new options or deactivate existing options using license keys.



SW option list
Shows the activated options. This information provided for administration and troubleshooting purposes. If you need support for an option, provide this information to the service representative.

The "State" of the option indicates whether the installed option is a normal or a beta-release version. Beta-release versions must be activated explicitly in the "Mode" dialog box (see Chapter 3.6.5, "Options in Beta State", on page 139).

Material number, Serial number, Device ID
Indicates the material number, serial number and the device identification string (device ID) of your instrument. These numbers, in particular the device ID, are required to order a new option, or to move a portable option.

Remote command:
`DIAGnostic:SERVice:PARTnumber` on page 892
`DIAGnostic:SERVice:SERialnumber?` on page 893
`SYSTem:DEVice:ID?` on page 892

Enter new option key
Enter the license key here to activate the option. For license keys delivered as a file, use Install from file.

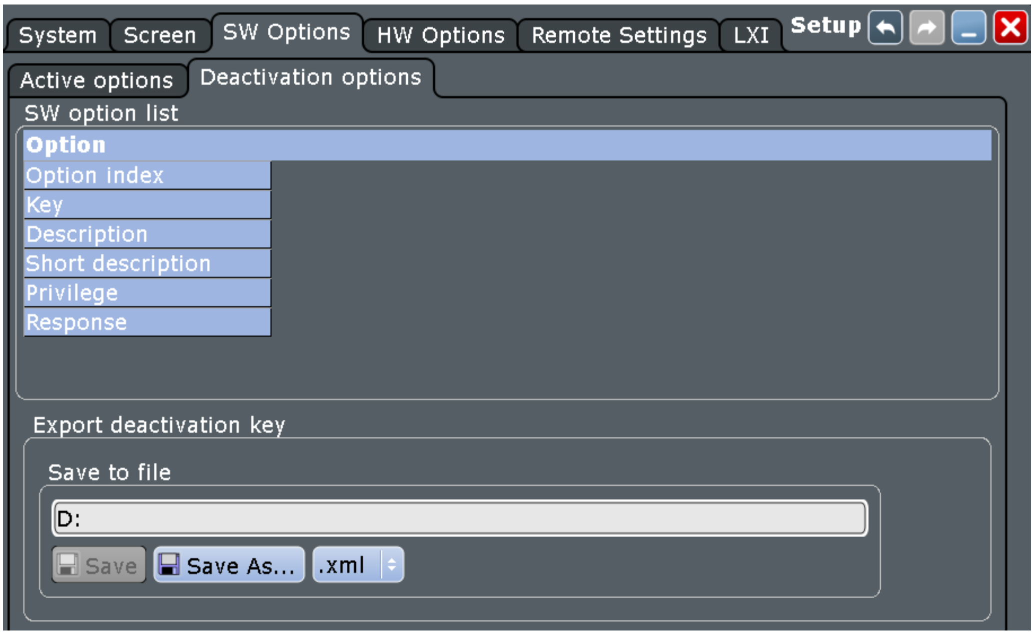
Install from file
If you got a license file, install the license here. Tap "Open" to open the file selection dialog, or enter the complete path and filename. For details, see Chapter 11.1.7, "File Selection Dialog", on page 408.

When you move a portable license, use this function to import the deactivation key that is generated by the "R&S License Manager". See also Chapter 3.6.4, "Moving a Portable License", on page 138.

3.6.1.2 Deactivation Options

Access: SETUP > "SW Options" tab > "Deactivation options" subtab

The "Deactivation options" tab shows all deactivated options and provides a function to export the deactivation response.



Export deactivation key
When you move a portable license, or deactivate an option, you have to note the response key, or to save the response to a file. The "R&S License Manager" needs the response key.

See also Chapter 3.6.4, "Moving a Portable License", on page 138.

3.6.2 HW Options

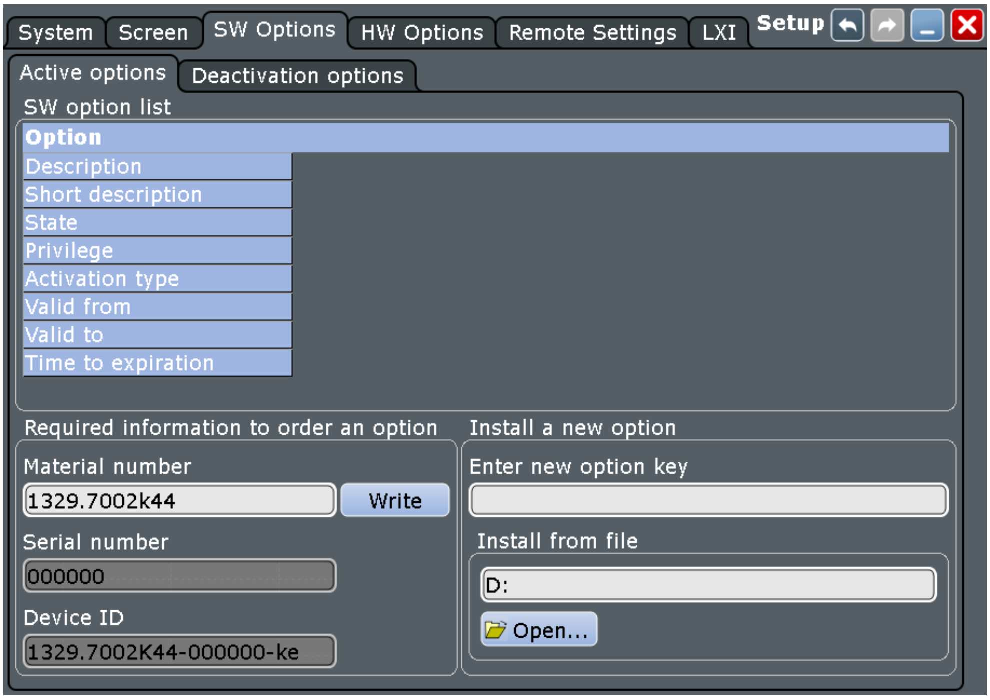
This tab informs about the availability of hardware options.

3.6.3 Activating Options

Options are activated by license keys. No additional installation is required. Consult your sales representative and provide the material number and serial number (or the device ID) of your instrument to get a license key. The license key is provided in written form or in a file. Unregistered licenses must be registered in the R&S License Manager before they can be activated on the instrument.

If the option has a portable license, keep the license file or option key at a save place. You will need the license to move it to another instrument.

1. Press the SETUP key and select the "SW options" tab.



2. If you received a key in written form, enter the key in the "Enter new option key" field.
   If you received a key in digital form as a file, Tap "Open" to open the file selection dialog box, navigate to the directory that contains the file, and select the option key file.
3. If you want to activate several options, repeat step 3 for each option.
4. Restart the instrument or restart the firmware.

See also: Chapter 3.6.1, "SW Options", on page 135

3.6.4 Moving a Portable License

The following procedure describes how to move an active portable license to another instrument. Each instrument is identified by its individual device ID.

The procedure involves the transfer of files between the R&S License Manager web tool and the instruments (source and target). For file transfer, you can use a USB flash drive, or store the files in a LAN directory that can be accessed by both instruments and by the device that runs the R&S License Manager.

1. Make sure that the license file or written option key that is installed on the source instrument is available.
2. On the source and target instruments:
   Select SETUP > "SW Options" tab > "Active options" subtab and note the device IDs of both instruments.

3. In the R&S License Manager:
   a) Open the R&S License Manager: https://extranet.rohde-schwarz.com/service.
   b) Select "Move Portable License".
   c) Enter the device identifications of the source and target instruments.
4. In the R&S License Manager:
   a) Open the portable license file of the source instrument, or enter the license key (option key).
   b) Generate the deactivation key and store it to a file.
5. On the source instrument:
   a) On the "Active options" subtab, use "Install from file" to install the deactivation key file generated in the previous step.
   b) Select the "Deactivation options" subtab and note the "Response" key.
6. In the R&S License Manager:
   a) Enter the deactivation response key generated in the previous step.
      As a result, a portable license file registered for the target is generated.
   b) Store the new license file.
7. On the target instrument:
   On the "Active options" subtab, use "Install from file" to install the license generated in the previous step.
8. Reboot the source and the target instruments.

   The portable license is now active on the target instrument, and it is not any more available an the source instrument.

3.6.5 Options in Beta State

Options may be released in beta state. These options require a license key and an additional activation.

To activate a beta option:

1. On the "File" menu, select "Mode".
2. Select the "Operating Mode" tab.
3. Enable "Enable options in beta state".

The activation is effective immediately until the next shut-down of the firmware.

4 Acquisition and Waveform Setup

This chapter describes the horizontal and vertical settings as well as the acquisition and probe setup.

4.1 Basics

This chapter provides background information on the essential settings in the vertical and horizontal systems, on acquisition setup and probing.

4.1.1 Vertical System

The controls and parameters of the vertical system are used to scale and position the waveform vertically.

4.1.1.1 Input Coupling

The input coupling influences the signal path between input connector and the following internal signal stage. The coupling can be set to DC, AC, or ground.

- DC coupling shows all of an input signal. DC coupling is available with 1 MΩ input impedance to connect standard passive probes. DC coupling is the default for 50 Ω input impedance.
- AC coupling is useful if the DC component of a signal is of no interest. AC coupling blocks the DC component of the signal so that the waveform is centered around zero volts.
- Ground coupling disconnects the input signal from the vertical system to see the ground level (zero volts) on the screen. Ground coupling is useful for reference purposes.

4.1.1.2 Vertical Scale and Position

Vertical scale and vertical position directly affect the resolution of the waveform amplitude. The vertical scale corresponds to the ADC input range. To get the full resolution of the ADC, set up the waveforms to cover most of the height of the diagram.

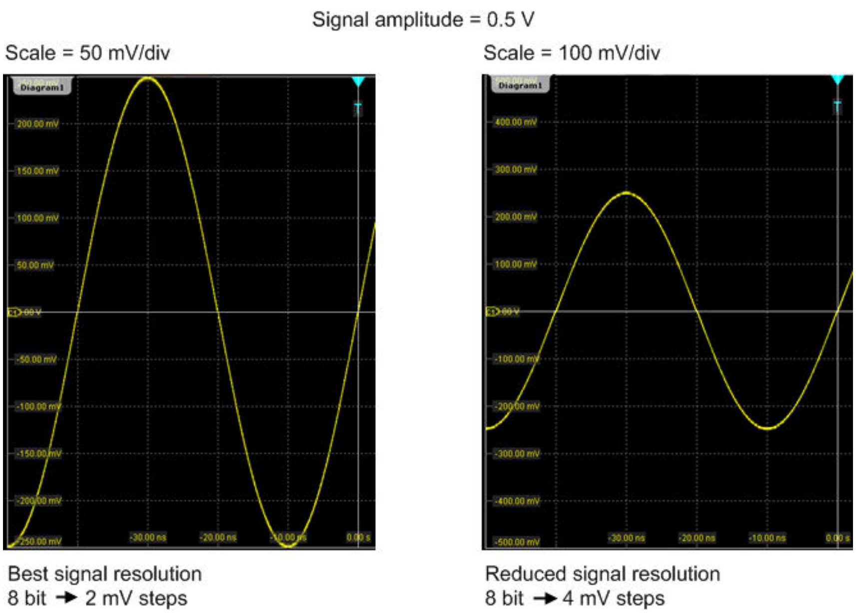


Figure 4-1: Input range and resolution of the ADC

With R&S RTE, you can work with multiple diagrams, and each diagram obtains the full vertical resolution, no matter where the diagram is placed. Therefore, use a separate diagram for each waveform instead of the traditional setup that arranges the waveforms side by side in one diagram.

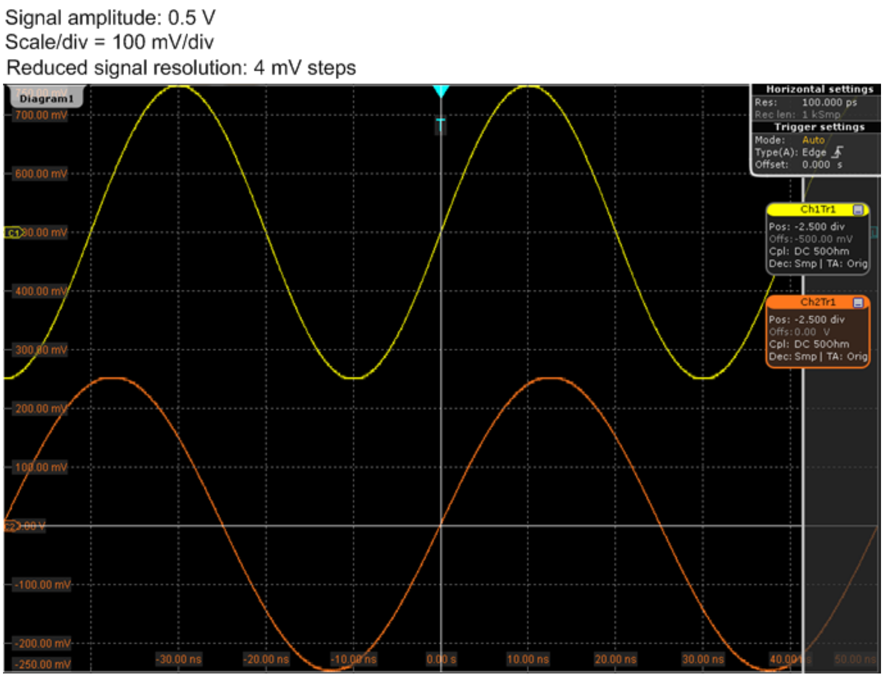


Figure 4-2: Traditional setup of multiple waveforms in one diagram: reduced resolution

Signal amplitude: 0.5 V
Scale = 50 mV/div
Best signal resolution: 2 mV steps

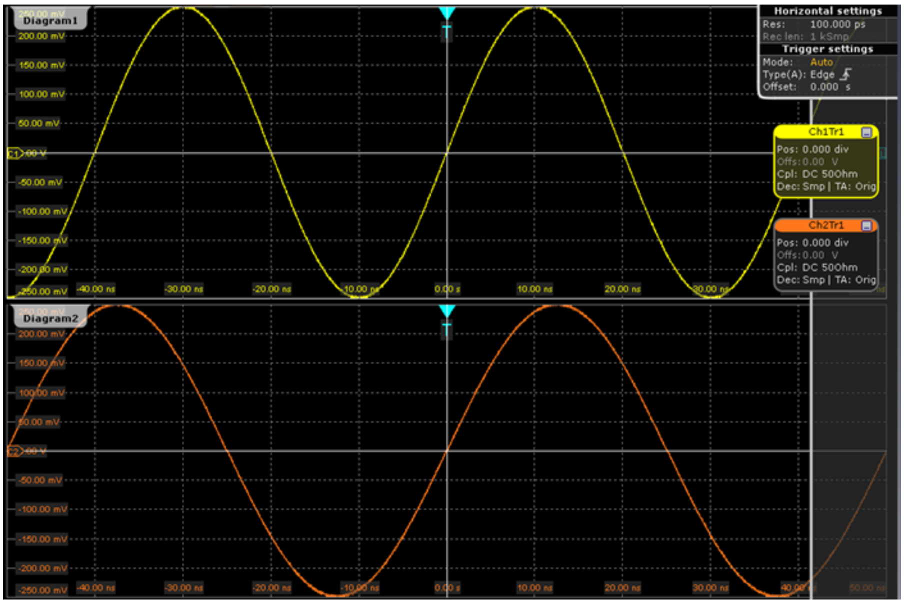


Figure 4-3: R&S RTE setup of multiple waveforms in separate diagrams: best resolution

4.1.1.3 Bandwidth

For analog applications, the highest signal frequency determines the required oscilloscope bandwidth. The oscilloscope bandwidth should be slightly higher than the maximum frequency included in the analog test signal to measure the amplitude with very little measurement error.

Most test signals are more complex than a simple sine wave and include several spectral components. A digital signal, for example, is built up of several odd harmonics. As a general rule, for digital signals the oscilloscope bandwidth should be 5 times higher than the clock frequency to be measured.

The oscilloscope is not a stand-alone system. You need a probe to measure the signal of interest, and the probe has a limited bandwidth, too. The combination of oscilloscope and probe creates a *system bandwidth*. To reduce the effect of the probe on the system bandwidth, the probe bandwidth must exceed the bandwidth of the oscilloscope, the recommended factor is 1.5 x oscilloscope bandwidth.

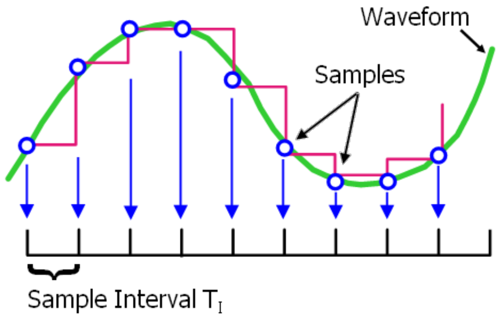
See also: Chapter 4.1.4.1, "Voltage Probes", on page 147

4.1.2 Sampling and Acquisition

The vertical system of a digital oscilloscope conditions the test signal in a way that the following A/D Converter (ADC) can transform the measured voltage into digital data.

4.1.2.1 Sampling and Processing

The A/D converter samples the continuous signal under test at specific points in time and delivers digital values called **ADC samples**. The rate at which the converter is working is the **ADC sample rate**, a constant value specified in GHz: $f_{ADC} = 1 / T_I$



The digital ADC samples are processed according to the acquisition settings. The result is a waveform record that contains **waveform samples** and is stored in the **waveform memory**. The waveform samples are displayed on the screen and build up the waveform.

The number of waveform samples in one waveform record is called **record length**. The rate of recording waveform samples - the number of waveform samples per second - is the **sample rate**. The higher the sample rate, the better is the resolution and the more details of the waveform are visible.

A sufficient resolution is essential for correct reconstruction of the waveform. If the signal is undersampled, aliasing occurs - a false waveform is displayed. To avoid aliasing and accurately reconstruct a signal, Nyquist theorem postulates that the sample rate must be at least twice as fast as the highest frequency component of the signal. However, the theorem assumes ideal conditions, so the Nyquist sample rate is usually not sufficient.

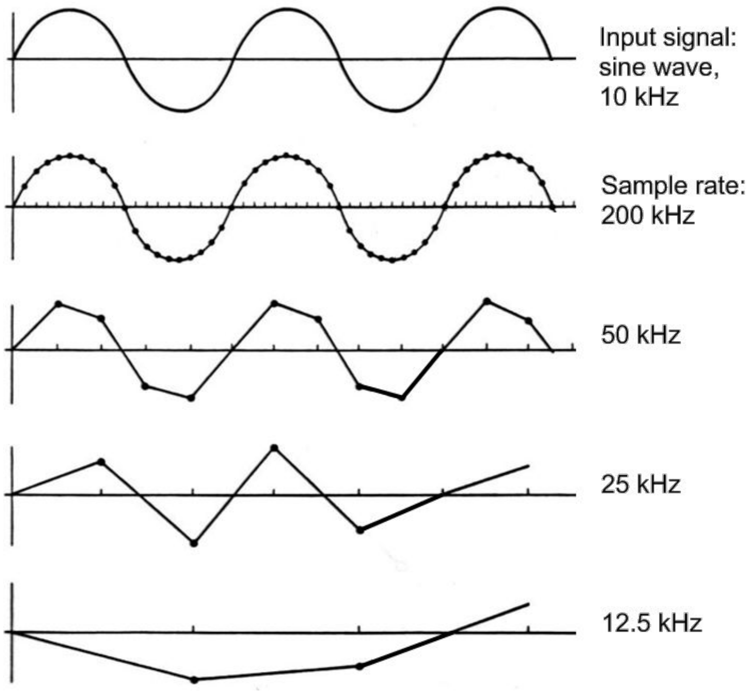


Figure 4-4: Waveforms acquired with different sample rates

To avoid aliasing, the sample rate must be set to a value 3 to 5 times the fastest frequency component of the signal. A higher sample rate increases signal fidelity, increases the chance to capture glitches and other signal anomalies, and improves the zoom-in capabilities.

4.1.2.2 Acquisition Settings

The sample rate can be the same as the constant ADC sample rate, or higher, or lower. To get a higher sample rate, interpolation as method of **resolution enhancement** is used. To reduce the sample rate, **decimation** methods help: sample, peak detect, high resolution and RMS.

As digital waveform data is stored in the memory, and the memory can save many waveform records, further **waveform arithmetic** processing is possible: average and envelope waveforms are resulting waveforms, created from a composite of sample points taken from multiple acquisitions.

You can combine interpolation and waveform decimation modes with waveform arithmetic.

4.1.2.3 Acquisition Control

You can run the R&S RTE in two ways:

- RUN CONT: the instrument acquires data until you stop it manually.
- RUN N× SINGLE: the instrument samples and processes a specified number of acquisitions.

The determining point of an acquisition is the trigger. The instrument acquires continuously and keeps the sample points to fill the pre-trigger part of the waveform record. When the trigger occurs, the instrument continues acquisition until the post-trigger part of the waveform record is filled. Then it stops acquiring and waits for the next trigger. When a trigger is recognized, the instrument does not accept another trigger until the acquisition is complete.

The trigger modes define how the instrument triggers:

- Normal: The instrument acquires a waveform only if a real trigger occurs, that is, if all trigger conditions are fulfilled.
- Auto: The instrument triggers repeatedly after a fixed time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. If the real trigger is faster than the auto trigger, both modes are virtually the same.

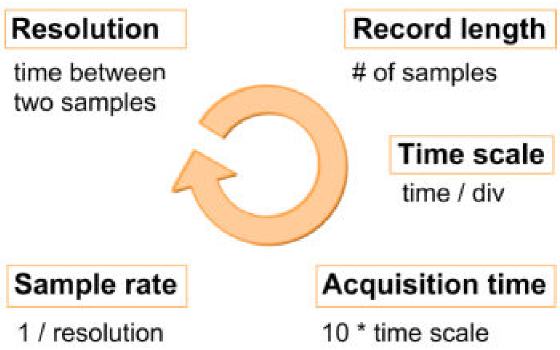
In practice, both trigger modes are useful: The auto mode lets you see the signal with little adjustment, while the normal mode selects the interesting part of the waveform. If you want to acquire a specified number of waveforms, make sure to select the normal trigger mode. Thus you get only the required number of interesting acquisitions.

See also: Chapter 5, "Triggers", on page 188

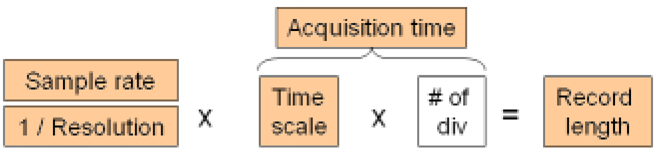
4.1.3 Horizontal System

4.1.3.1 Parameters of the Horizontal System

The control parameters of the horizontal system are tightly connected. Thus, changing one parameter affects the other parameters as well.



The mathematical dependencies can be summarized as follows:



The number of divisions is 10, this is the only constant parameter.

When you set up horizontal parameters, you can choose whether the record length or the resolution remains constant.

- With constant resolution, increasing the time scale also increases the record length, and vice versa. You can limit the record length to a maximum value.
- With constant record length, increasing the time scale coarsens the resolution, that is, the time between two waveform samples gets longer.

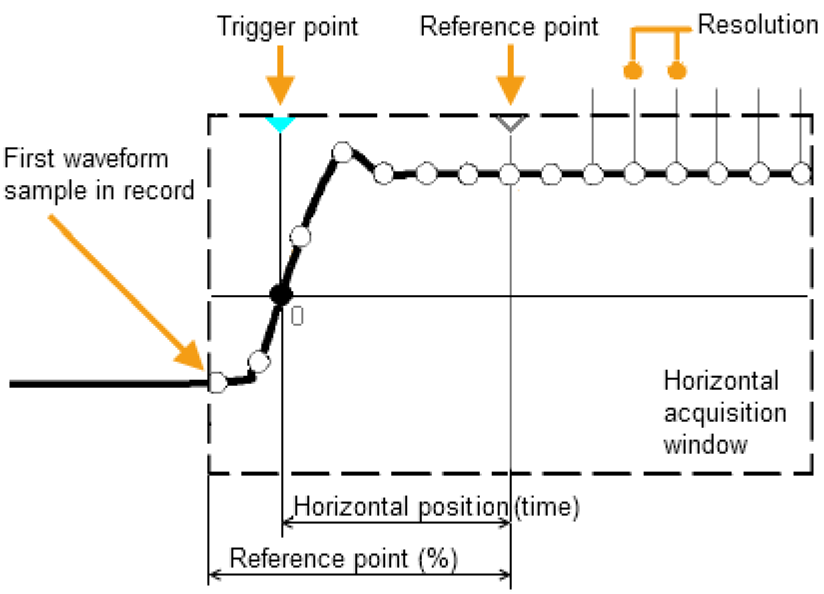
For both settings, the "Auto adjustment" ensures a sufficient resolution to prevent undersampling.

4.1.3.2 Horizontal Position

As described before in Chapter 4.1.2.3, "Acquisition Control", on page 144, the trigger is the determining point of the waveform record.

In many scenarios, you might want to analyze the waveform some time before or after the trigger. To adjust the horizontal acquisition window to the waveform section of interest, you can use the following parameters:

- The **horizontal position** defines the time distance from the trigger point (the zero point of the diagram) to the reference point. Changing the horizontal position, you can move the trigger point, even outside the screen.
- The **reference point** is the rescaling center of the time scale.on the screen. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.



4.1.4 Probes

A probe connects the signal source (DUT) to the oscilloscope, and delivers the signal to be measured. It is the essential first link in the measurement chain.

An ideal probe fulfills the following requirements:

- Safe and reliable contacts
- Infinite bandwidth
- The probe should not load the signal source and thus impact the circuit operation.
- The connection should not introduce or suppress signal components (hum, noise, filter) and thus degrade or distort the transferred signal.

In reality, the probe can never be an ideal one, it always affects the signal transmission and the signal source, and thus the measured signal. It depends on the frequency to be measured and on the signal source to determine the acceptable loading, and to determine which kind of probe delivers good results.

The solution depends on the quantity to be measured with respect to:

- Signal type: voltage, current, power, pressure, optical, etc.
- Signal amplitude: The oscilloscope itself can only display voltages in a limited range. Most probes can adjust the dynamic range to amplitudes from a few mV to 10 V. Smaller or much larger signals require specialized equipment.
- Signal frequency: High frequencies require advanced equipment in order to get correct results.
- Source characteristic: The source impedance is the decisive factor when choosing the suitable connection.

4.1.4.1 Voltage Probes

The following table provides an overview on common voltage probes and their usage.

Table 4-1: Voltage probes overview

Probe type	Attenuation	Typical bandwidth range	Oscilloscope input	Usage
Passive, high impedance	1:1	10 MHz	1 MΩ	Low speed, low level signals
Passive, high impedance	10:1	500 MHz	1 MΩ	General purpose
Passive, low impedance	10:1	up to 10 GHz	50 Ω	High frequency
Active, single-ended	10:1	up to 10 GHz	50 Ω	High speed
Active, differential	10:1		50 Ω	Floating

For a list of recommended probes refer to the R&S RTE product brochure.

Besides the possible input voltage range, two factors are important when selecting a voltage probe: Bandwidth and impedance over frequency.

- **Bandwidth:**
  The combination of probe and oscilloscope builds up a system. The resulting system bandwidth is approximately determined with:

$$\frac{1}{BW_{system}} = \sqrt{\left(\frac{1}{BW_{probe}}\right)^2 + \left(\frac{1}{BW_{scope}}\right)^2}$$

To measure the signal with low measurement error, the system bandwidth should be higher than the highest frequency component of the signal. The probe bandwidth must be even higher than the system bandwidth.

- **Impedance:**
  A minimum impedance is required to keep the circuit loading low. Over frequency, the impedance decreases, in particular with passive probes. The probe impedance should be approximately 10 times the impedance of the circuit test point at the highest signal frequency.

Passive voltage probes

Passive probes have the following qualities:

- No active components inside
- BNC connector for universal use
- Compensate the probe when it is connected to a scope input: LF compensation matches the probe (mainly cable) capacitance to the oscilloscope input capacitance.
- With high impedance probes, the impedance varies significantly over frequency.
- With low impedance probes, the impedance variation over frequency is low, but the load on the source is high.

If you use passive probes, remember some recommendations:

- Use a probe recommended for your oscilloscope model.
- Use a ground lead as short as possible to minimize the effect of ground lead inductance. The resonance frequency can be much lower than the system bandwidth and thus can affect the measurement results, in particular, if you measure steep edge rise times.
- Select a probe that has a bandwidth of 5 to 10 times the highest frequency being measured. This preserves the harmonics and thus the waveform integrity.

Active voltage probes - General

Active probes require operating power from the instrument and have a proprietary interface to the instrument. Their main qualities are:

- Low loading on signal source
- The probe is automatically recognized by the instrument, no adjustment is required.
- Adjustable DC offset at probe tip allows for high resolution on small AC signals which are superimposed on DC levels.
- Connections should be as short as possible to keep the usable bandwidth high.
- Observe the operating voltage range.
- The probe impedance depends on the signal frequency.

RT-ZS single-ended active probes and RT-ZD differential active probes provide special features for easier use and precise measurements. These special features are not available on RT-ZSxxE probes.

- The micro button on the probe head remotely controls important functions on the instrument, like running and stopping the acquisition, autoset, AutoZero and setting the offset to mean value.
- The R&S ProbeMeter measures DC voltages between the probe tip and the ground connection with very high precision. The result is displayed on the instrument's screen. So you can check DC voltages with different levels without having to adjust the measurement range of the oscilloscope. The R&S ProbeMeter also measures the zero error of the probe to optimize measurement results at small signal levels.

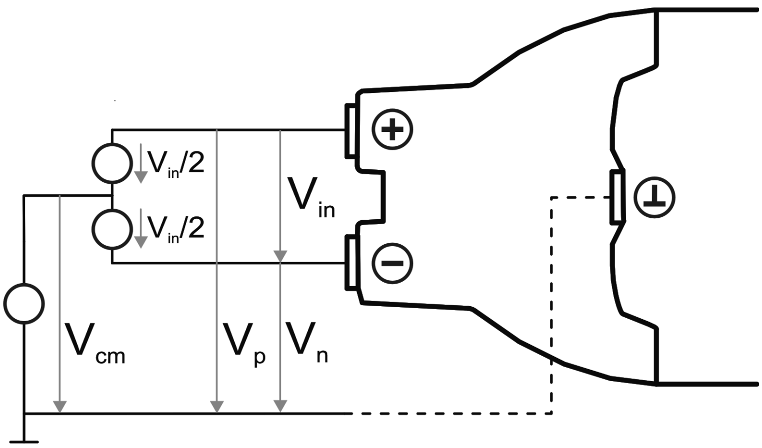
When you connect an R&S RT-ZSxx active probe to a channel input of the R&S RTE, the oscilloscope recognizes the probe. It reads the identification and calibration data from the probe box and shows the result in the "Setup" and "Probe Attributes" tabs. This data together with the deskew time for a given channel is stored and processed by the R&S RTE. If you connect the probe the next time to the same channel, the information is fetched and used.

Differential Active Probes

Differential active probes are designed to measure signals that are referenced against each other, and voltages that are not references to ground, for example twisted-pair signal lines. The R&S RT-ZD probes are differential probes with high input impedance, they can be used to measure voltages between any two test points.

Compared with two-channel measurement setup with single-ended probes, the measurement with differential probes is symmetric due to the same amplification and cable length on both paths. It is also immune to interference and noise and occupies only one input channel.

A differential probe has three sockets: the positive signal socket (+), the negative signal socket (-), and the ground socket.



Multiple input voltages can be defined for a differential probe:

- Differential mode input voltage (V_{in}, V_{dm})
  Voltage between the positive and negative signal sockets

- Positive single-ended input voltage (V_p)
  Voltage between the positive signal socket and the ground socket
- Negative single-ended input voltage (V_n)
  Voltage between the negative signal socket and the ground socket
- Common mode input voltage (V_{cm})
  Mean voltage of positive and negative signal sockets referred to the ground socket, respectively

Two of these voltages are independent values, the other two can be calculated:

$$V_{in} = V_p - V_n$$

$$V_{cm} = \frac{V_p + V_n}{2}$$

R&S RT-ZD probes detect only differential input voltages and provide it to the oscilloscope. Common mode signals are suppressed by the probe. This characteristic is described by the Common Mode Rejection Ratio (CMRR):

$$CMRR = \frac{DifferentialGain}{CommonMode\,Gain}$$

In addition, the R&S ProbeMeter of R&S RT-ZD differential probes can measure differential and common mode DC voltages. The measurement result is displayed on the oscilloscope's screen. The common mode measurement of the R&S ProbeMeter allows you to check the input voltage relative to ground. Thus, the CM measurement is a convenient way to detect breaches of the operating voltage window, and the reason of unwanted clippings.

4.2 Horizontal Settings

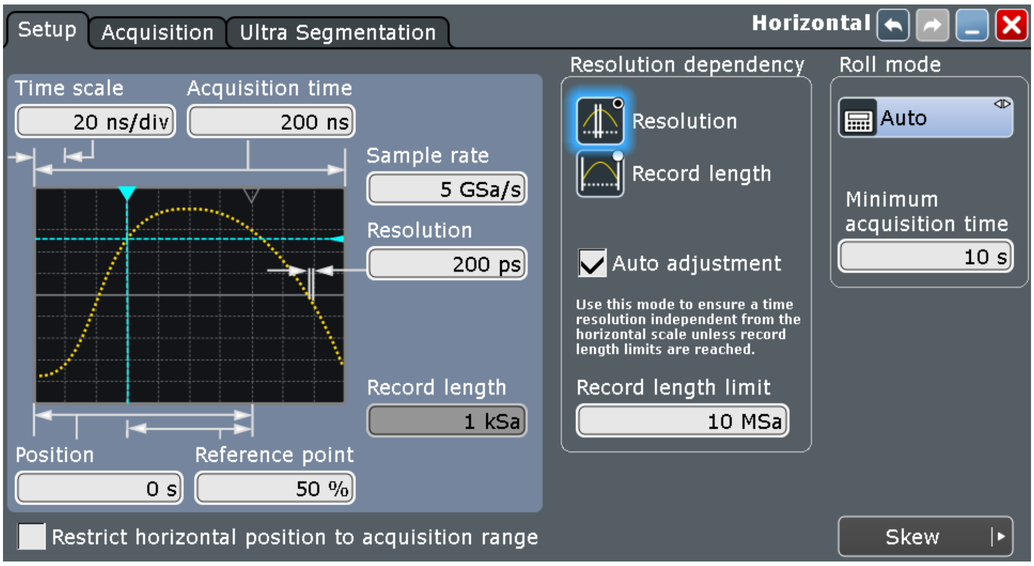
The "Horizontal" menu provides the time base and acquisition configuration for channel and spectrum waveforms:

4.2.1 Setup

Access: HORIZONTAL key

The "Setup" tab in the "Horizontal" dialog box provides the settings for the time axis and the roll mode.

For background information, see Chapter 4.1.3, "Horizontal System", on page 145.



Time scale

Sets the horizontal scale for all channel and math waveforms in seconds per division. Increase the scale to see a longer time interval of the waveform. Decrease the scale to see it in more detail. The scale has a point that remains fixed on the screen when the scale value is changing - the reference point.

Remote command:

`TIMebase:SCALe` on page 910

Acquisition time

Shows the time of one acquisition, that is the time across the 10 divisions of the diagram:

Acquisition time = Time scale * 10 divisions

Changing the acquisition time changes the time scale too.

Remote command:

`TIMebase:RANGe` on page 910

Position
Defines the time distance between the reference point and the trigger point (the zero point of the diagram). If you want to see a section of the waveform some time before or after the trigger, enter this time as horizontal position. The requested waveform section is shown around the reference point. Use positive values to see waveform sections after the trigger - the waveform and the diagram origin move to the left.

See also "Reference point" on page 152.

Remote command:
`TIMebase:HORizontal:POSition` on page 911

Reference point
Sets the position of the reference point in % of the screen. The reference point marks the rescaling center of the time scale. It is indicated by a grey triangle outline at the top of the diagram. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.

Remote command:
`TIMebase:REFerence` on page 911

Restrict horizontal position to acquisition range
If enabled, the horizontal position cannot be set outside the visible waveform diagram.

Remote command:
`TRIGger<m>:OFFSet:LIMited` on page 911

Sample rate
Sets the number of recorded waveform points per second. The sample rate is the reciprocal value of the resolution and thus also depends on the acquisition time and the record length. It considers the samples of the ADC, the additional waveforms points resulting from interpolation, and the reduction of waveform points by decimation.

See also:
- Chapter 4.1.2, "Sampling and Acquisition", on page 142
- Chapter 4.1.3, "Horizontal System", on page 145

Remote command:
`ACQuire:SRATe` on page 913

Resolution
Sets the time between two waveform samples. A fine resolution with low values produces a more precise waveform record.

Remote command:
`ACQuire:RESolution` on page 913

Record length
Indicates the number of waveform samples that build the waveform across the acquisition time.

Remote command:
`ACQuire:POINts[:VALue]` on page 913


Resolution / Record length (Resolution dependency)
You can choose to keep constant either the resolution or the record length when you adjust the time scale or acquisition time.

- With constant resolution, increasing the time scale also increases the record length, and vice versa. You can limit the record length to a maximum value.
- With constant record length, increasing the time scale coarsens the resolution, that is, the time between two waveform samples gets longer.

Remote command:
`ACQuire:POINts:AUTO` on page 912

Auto adjustment (Resolution dependency)
Prevents undersampling and ensures a sufficient resolution to acquire the correct waveform if the time scale is changed. The setting takes effect if the changed parameter - resolution or record length - reaches a limit. The instrument automatically keeps this parameter constant at its limit, and changes the other parameter regardless of the "Resolution / Record length" setting.

See also: Resolution / Record length (Resolution dependency)

Remote command:
`ACQuire:POINts:AADJust` on page 912

Record length limit (Resolution dependency)
Sets a limit for the record length to prevent very large records. This value is only available if "Auto adjustment" is on and a constant resolution is selected. If you increase the time scale, the resolution remains constant and the record length increases until the limit is reached. Further increase of the time scale changes the resolution and keeps the record length limit.

See also:

- Resolution / Record length (Resolution dependency)
- Auto adjustment (Resolution dependency)

Remote command:
`ACQuire:POINts:MAXimum` on page 912

Roll mode
In roll mode, the instrument shows the waveforms immediately, without waiting for the complete acquisition of the waveform record. If the time base is slow - at long time scale values - the roll mode saves waiting for the waveform display. The instrument displays newly acquired waveform points at the right edge of the display and moves the waveform to the left.

The roll mode has following restrictions:

- Roll mode disables persistence
- History is not available
- If more than one waveform for an active channel is enabled, the instrument disables the roll mode.

If set to "Auto", the instrument activates the roll mode automatically if the following conditions are fulfilled:

- Acquisition time exceeds the defined "Minimum acquisition time"

- Record length is below a limit that depends on the acquisition time. If the record length exceeds the limit, the instrument switches back to normal mode.
  If the acquisition time is >50 s, the record length limit is 50 MSa. The limit is equivalent to a sample rate of 1 MSa/s at 50 s acquisition time, and to lower sample rates at higher acquisition times according to
  Sample rate = 50 MSa / Acquisition time.
  If the acquisition time is ≤50 s, the instrument defines a lower record length limit, and the corresponding sample rate limit is
  Sample rate = 2 MSa/s / Number of active wfms.
- Waveform arithmetic is disabled ("Off")
- All channel waveforms are set to the same decimation mode, and to one of these values: "Sample", "Peak detect", or "High res"
- All mask tests are disabled
- Ultra segmentation is disabled
- FFT is disabled
- All serial buses are disabled
- All parallel buses are disabled (MSO option R&S RTE-B1)

Remote command:
`TIMebase:ROLL:ENABle` on page 913
`TIMebase:ROLL:STATe?` on page 914

Minimum acquisition time ← Roll mode
The instrument can activate the roll mode automatically if the Acquisition time exceeds the value given here.

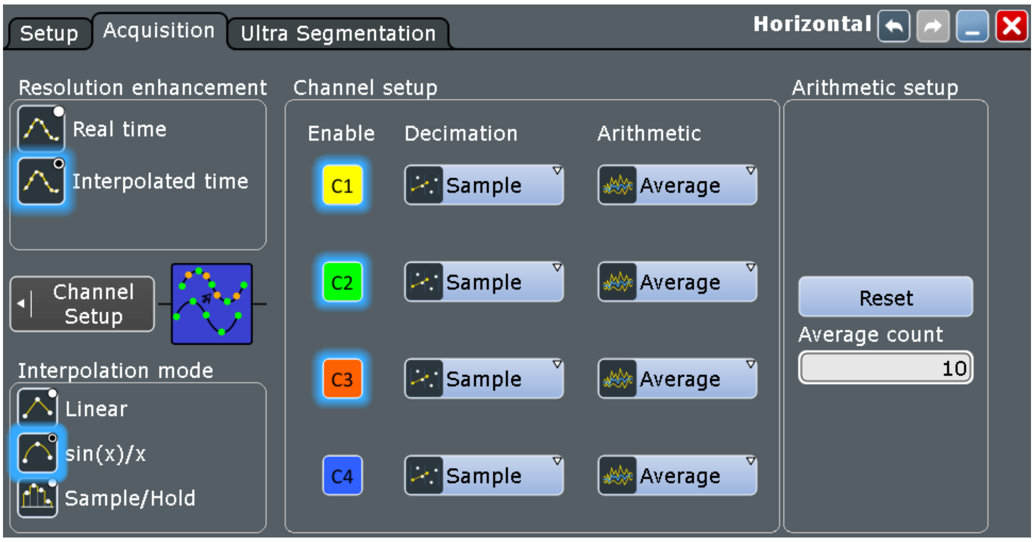
Remote command:
`TIMebase:ROLL:MTIMe` on page 914

4.2.2 Acquisition

Access: ACQUISITION key

Acquisition settings control how the waveform is built from the acquired samples.

For background information, see Chapter 4.1.2, "Sampling and Acquisition", on page 142.



The "Decimation" and "Arithmetic" settings are the same for all active channels.


Resolution enhancement

If the ADC sample rate is too slow to capture sufficient samples to achieve the required resolution, the sample rate can be increased by adding calculated points to the waveform record. The enhancement method is the same for all channel waveforms. As long as the waveform sample rate is not higher than the ADC sample rate, the instrument works automatically in real time mode, enhancement settings are ignored. Otherwise - for resolutions faster than 200 ps - the instrument changes to interpolated time mode. If enhancement is done, the instrument ignores the decimation settings.

The methods are:

"Real time"	The sampled points of the input signal are used directly to build the waveform. Actually, the real time mode is not an enhancement mode. The maximum "Sample rate" is the "ADC sample rate". In this mode, decimation can be set to reduce the amount of data. The real time mode is used to acquire non-repetitive and transient signals.
"Interpolated time"	If the "Sample rate" is higher than the "ADC sample rate", interpolation adds points between the ADC samples of the waveform by various mathematic methods, see Interpolation.

Remote command:
`ACQuire:MODE` on page 914

Interpolation

Selects the interpolation method. If the defined "Sample rate" is higher than the ADC sample rate, interpolation adds points between the captured samples of the waveform by various mathematic methods.

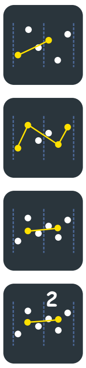
"Linear"	Two adjacent ADC sample points are connected by a straight line, the interpolated points are located on the line. You see a polygonal waveform similar to the real signal, and also the ADC sample points as vertexes.
"sin (x)/x"	Two adjacent ADC sample points are connected by a sin(x)/x curve, and also the adjoining sample points are considered by this curve. The interpolated points are located on the resulting curve. This interpolation method is very precise and shows the best signal curve.
"Sample/Hold"	The ADC sample points are displayed like a histogram. For each sample interval, the voltage is taken from the sample point and considered as constant, and the intervals are connected with vertical lines. Thus, you see the discrete values of the ADC - the measured samples.

Remote command:
`ACQuire:INTerpolate` on page 915

Enable

Activates or deactivates the selected channel.

Remote command:
`CHANnel<m>[:WAVeform<n>][:STATe]` on page 915



Decimation

Selects the decimation mode. Decimation reduces the data stream of the ADC to a stream of waveform points with lower sample rate and a less precise time resolution. The R&S RTE uses decimation, if the waveform "Sample rate" is less than the ADC sample rate. In this case, interpolation is not possible.

There are different methods to define the recorded waveform point out of a number of n sample points:

"Sample"	One of n samples in a sample interval of the ADC is recorded as waveform point, the other samples are discarded. The time between the two adjacent waveform points is exactly the resolution. Very short glitches might remain undiscovered by this method.
"Peak detect"	The minimum and the maximum of n samples in a sample interval are recorded as waveform points, the other samples are discarded.
"High res"	The average of n sample points is recorded as one waveform sample. Averaging reduces the noise, the result is a more precise waveform with higher vertical resolution.
"RMS"	The waveform point is the root mean square of n sample values. Thus, the RMS value reflects the instantaneous power. This arithmetic mode is used to average a measured power waveform. Linear averaging of power signals causes an error dependent on the noise of the signal to be averaged.

Remote command:
CHANNel<m>[:WAVeform<n>]:TYPE on page 915



Arithmetic

Waveform arithmetic builds the resulting waveform from several consecutive acquisitions of the signal. The arithmetic works with interpolated and decimated waveforms.

The methods are:

"Off" The data of only one acquisition is recorded according to the decimation settings. In effect, no waveform arithmetic is processed.

"Envelope" Detects the minimum and maximum values in a sample interval over a number of acquisitions. Each acquisition is done in the "Peak detect" decimation mode, and the most extreme values for all acquisitions build the envelope. The resulting diagram shows two envelope waveforms: the minimums (floor) and maximums (roof).

Note: If you change from "Envelope" to "Off", make sure to set also the "Decimation" to the required value.

"Average" The average is calculated from the data of the current acquisition and a number of acquisitions before. The method reduces random noise and other heterodyne signals. It requires a stable, triggered and periodic signal for correct function.
The number of acquisitions for average calculation is defined with "Average count"

Remote command:
CHANNel<m>[:WAVeform<n>]:ARIThmetics on page 916

Acquisition/average count

Access:
- TRIGGER > "Control" tab > "Average count (N-single count)"
- ACQUISITION > "Average count"
- HORIZONTAL > "Ultra Segmentation" tab > disable "Acquire maximum" > "Required"
- MATH > "Setup" tab > "Average count"

The acquisition and average count has several effects:
- It sets the number of waveforms acquired with RUN N× SINGLE
- It defines the number of waveforms used to calculate the average waveform. Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the value is, the better the noise is reduced.
- It sets the number of acquisitions to be acquired in an ultra segmentation acquisition series. Thus, you can acquire exactly one ultra segmentation acquisition series with RUN N× SINGLE.
If ultra segmentation is enabled and configured to acquire the maximum number of acquisitions, the acquisition count is set to that maximum number and cannot be changed. See also: "Number of acquisitions" on page 159.
- It is the "Finished" criteria for the state of a mask test.

Remote command:
ACQuire:COUNt on page 917

Reset

Forces the immediate restart of the envelope and average calculation for all waveforms.

Remote command:
`ACQuire:ARESet:IMMediate` on page 917

4.2.3 Ultra Segmentation

In normal acquisition mode, only a short time is used for sampling; processing and display take most of the time. The processing and display time is blind time causing a gap in the recorded signal. The normal acquisition mode may miss very short time and infrequent events occurring during the dead time.

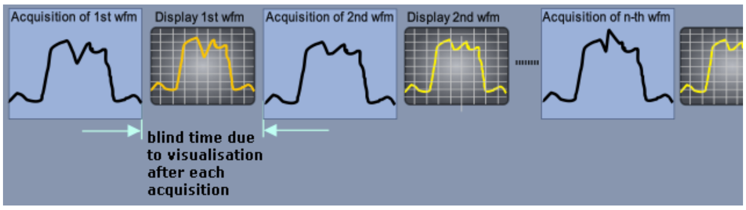


Figure 4-5: Normal acquisition with blind time

With ultra segmentation, a number of triggered acquisitions are captured very fast, with hardly any dead time between the acquisitions. The data is processed and the waveforms are displayed when the acquisition of the series has been completed.

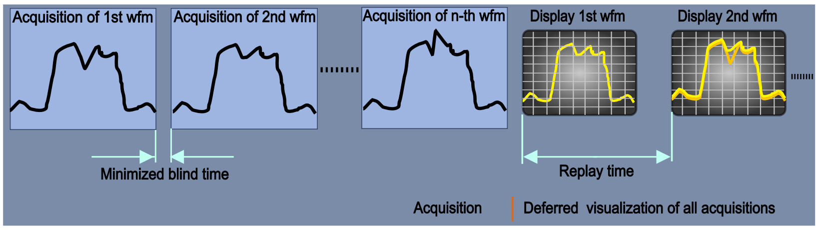


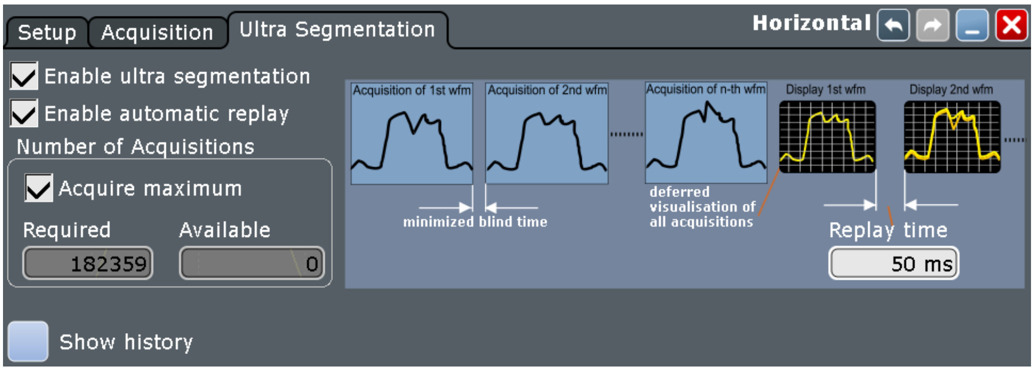
Figure 4-6: Ultra segmentation with deferred processing and display

Ultra segmentation and history

The acquisition series is written in the sample memory, thus the memory size limits the number of acquisitions in a series. This memory is the memory that is accessed by the history, thus the history function is used to read out the contents of the sample memory.

To use the history functionality, enable "Show history" in the "Ultra Segmentation" tab. The history viewer settings are displayed directly in the "Ultra Segmentation" tab.

See also: Chapter 6.4, "History", on page 258.



Enable ultra segmentation

Switches the ultra segmentation mode on and off.

Remote command:

`ACQuire:SEGMented:STATe` on page 917

Enable automatic replay

If enabled, the instrument starts processing and displaying the data as soon as the acquisition series is captured completely. Depending on the number of acquisitions, it may take some time until the acquisition series is displayed. If the setting is disabled, the instrument only captures the data and stores it in the sample memory.

Remote command:

`ACQuire:SEGMented:AUToreplay` on page 918

Number of acquisitions

You can define the number of acquisitions to be stored in an ultra segmentation acquisition series:

- Acquire the maximum number of acquisitions that can be stored in the sample memory.
  To acquire the maximum number, enable "Acquire maximum". The maximum number of acquisitions is shown in the "Required" field.
- Acquire a given number of acquisitions.
  Enter the number in the "Required" field.

The acquisition count (Acquisition/average count) is always set to the required number of acquisitions. Thus you can acquire exactly one ultra segmentation acquisition series with RUN N× SINGLE. The RUN CONT key works in the same way as RUN N× SINGLE, it stops acquisition when the series is completed.

You can stop the running acquisition before the series is completed.

The number of acquired waveforms is shown in "Available" and can be displayed with "Show history".

Remote command:

`ACQuire:SEGMented:MAX` on page 918

Replay time

Defines the display speed of the ultra segmentation acquisition series. Display starts after the series has been captured completely.

See also: "Replay time per acq." on page 261

Show history

Enables the history mode and displays the history viewing functions in the "Ultra Segmentation" tab.

See also: Chapter 6.4.2.1, "Viewer", on page 259.

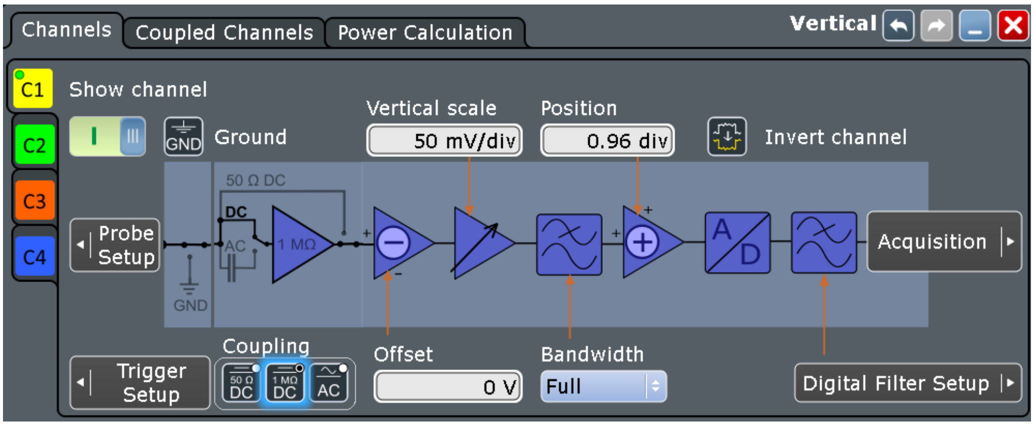
4.3 Vertical Settings

The "Vertical" menu contains all channel-dependent settings and information.

4.3.1 Channels

Access: "Vertical" menu > "Channels"

The "Channels" tab provides all basic vertical settings. The channels are listed in vertical tabs at the left side of the dialog box.



Make sure that the correct channel tab is selected. The vertical rotary knobs are illuminated in the color of the selected channel.

Show channel
Switches the channel signal on or off. The signal icon appears on the signal bar. The waveform of the last acquisition is displayed in the diagram.

Remote command:
`CHANnel<m>:STATe` on page 918

Ground
Connects the input to the ground.

Remote command:
`CHANnel<m>:GND` on page 919

Vertical scale
Defines the vertical scale in Volts per division. Increasing the scale compresses the display of the signal.

Remote command:
`CHANnel<m>:SCALe` on page 919

Position
Moves the selected signal up or down in the diagram. The visual effect is the same as for Offset but the waveform is adjusted at a later time in the signal flow. While the offset sets a voltage, position is a graphical setting given in divisions.

By default, the horizontal grid axis remains in the center when the offset is changed. To shift the axis together with the waveform, disable Keep Y-grid fixed in "Display > Diagram Layout".

Remote command:
`CHANnel<m>:POSition` on page 920

Invert channel
Turns the inversion of the signal amplitude on or off. To invert means to reflect the voltage values of all signal components against the ground level. If the inverted channel is the trigger source, the instrument triggers on the inverted signal.

You can use inversion, for example, to switch the polarity of a differential signal without changing the probe connections.

Remote command:
`CHANnel<m>:INVert` on page 921

Coupling
Selects the connection of the channel signal determining what part of the signal is used for waveform analysis and triggering.

In addition to coupling, the signal can be filtered for high frequency rejection, see .Chapter 4.6, "Digital Filter Setup", on page 180

"DC 50 Ω"	Connection with 50 Ω termination, passes both DC and AC components of the signal.
"DC 1 MΩ"	Connection with 1 MΩ termination, passes both DC and AC components of the signal.

"AC" Connection through DC capacitor, removes DC and very low-frequency components.

Remote command:
`CHANnel<m>:COUPling` on page 919

Offset

The offset voltage is subtracted to correct an offset-affected signal. The vertical center of the selected channel is shifted by the offset value and the signal is repositioned within the diagram area. Negative offset values move up the waveform, positive values move it down.

The offset of a signal is determined and set by the autoset procedure. The current value is shown in the waveform label.

By default, the horizontal grid axis remains in the center when the offset is changed. To shift the axis together with the waveform, disable Keep Y-grid fixed in "Display > Diagram Layout".

Remote command:
`CHANnel<m>:OFFSet` on page 921

Bandwith

Selects the bandwidth limit.

The specified full bandwidth indicates the range of frequencies that the instrument can acquire and display accurately with less than 3dB attenuation. The probe has also a limited bandwidth and thus affects the resulting system bandwidth.

See also: Chapter 4.1.1.3, "Bandwidth", on page 142

"Full" At full bandwidth, all frequencies in the specified range are acquired and displayed. Full bandwidth is used for most applications.

"20 MHz, 200 MHz" Frequencies above the selected limit are removed to reduce noise at different levels.

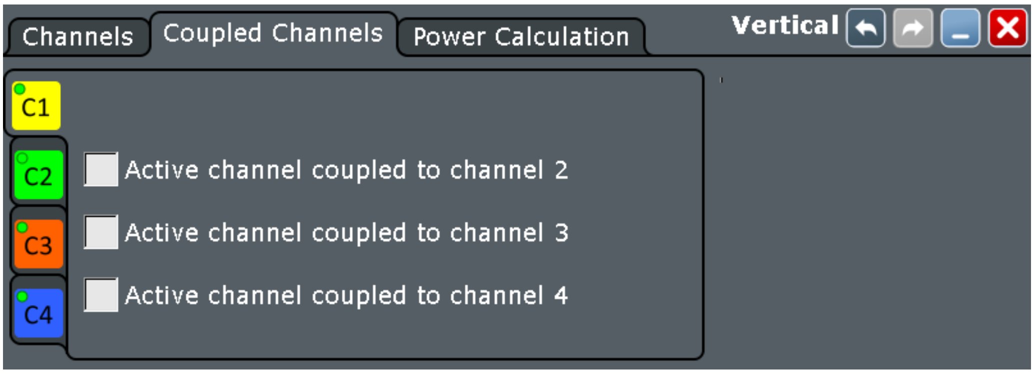
Remote command:
`CHANnel<m>:BANDwidth` on page 921

4.3.2 Coupled Channels

Access: "Vertical" menu > "Coupled Channels"

Channel coupling sets the vertical settings of the coupled channels to the values of the active channel. If you want to have the same vertical settings for two or more channels , you can set them at once by coupling these channels.

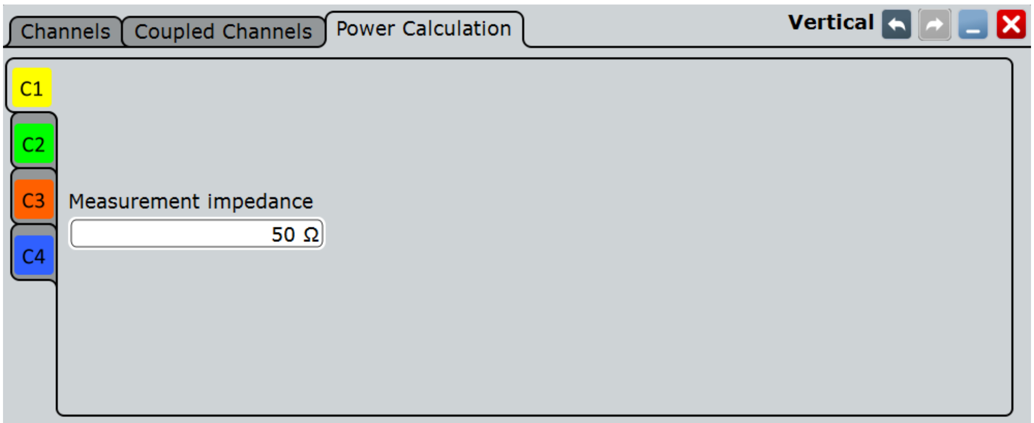
Channel coupling affects all vertical settings that are adjusted in the "Channels" tab: vertical scale, position, offset, bandwidth, coupling, and ground.



4.3.3 Power Calculation

Access: "Vertical" menu > "Power Calculation"

Make sure that the correct channel tab is selected.



Show channel
Switches the channel signal on or off. The signal icon appears on the signal bar. The waveform of the last acquisition is displayed in the diagram.

Remote command:
`CHANnel<m>:STATe` on page 918

Measurement impedance
Sets the impedance of the channel for power calculations and measurements.

Remote command:
`CHANnel<m>:IMPedance` on page 922

4.4 High Definition (Option R&S RTE-K17)

The high definition mode offers up to 16 bits of vertical resolution. Higher vertical resolution reduces quantization noise and acquires waveforms of higher accuracy with finer details of the signal to be seen.

The number of vertical resolution bits defines the number of vertical levels that the acquisition samples are mapped to (quantization). 16 bits of resolution represent 65536 voltage quantization levels, while 8 bits of resolution represent only 256 voltage levels. The waveform values are recorded with 16 bit word length, except for peak detect decimation.

The higher vertical resolution is achieved by applying a digital low pass filter (DSP filter) to the output of the ADC, which reduces the bandwidth of the signal. Increasing the bandwidth reduces the resulting digital resolution. The high definition is also applied to the digital trigger, thus the R&S RTE can trigger with the same high resolution with which they can display signals.

High definition can be used, for example, to measure slow pulses with high accuracy, or to analyze AM signals with very low modilation index, as used in radar.

See also:

- Chapter 4.1.1, "Vertical System", on page 140
- Chapter 4.1.2, "Sampling and Acquisition", on page 142

4.4.1 High Definition Settings

Access: MODE > "Acquisition"

High definition is a special acquisition mode of the oscilloscope. This mode has only one setting - the filter bandwidth.

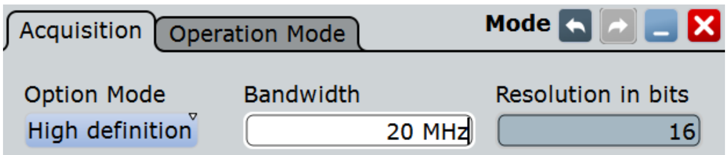


Figure 4-7: Setting the instrument into high definition mode

Option mode
Sets the operation mode of the instrument.

"Normal"	Usual oscilloscope mode
"High definition"	Mode with higher digital resolution, up to 16 bit. Requires option R&S RTE-K17.

Remote command:
`HDEFinition:STATe` on page 939

Bandwidth
Sets the filter bandwidth for the high definition mode.

The maximum filter bandwidth depends on the instrument bandwidth.

Instrument bandwidth	Maximum filter bandwidth
200 MHz	200 MHz
350 MHz	300 MHz
≥ 500 MHz	500 MHz

Remote command:
HDEFinition:BWIDth on page 940

Resolution in bits
Shows the resulting vertical resolution in high definition mode. The higher the filter bandwith, the lower the resolution. For details, refer to the R&S RTE Specifications.

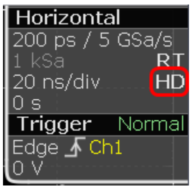
Remote command:
HDEFinition:RESolution? on page 940

4.4.2 Effects of the High Definition Mode

The high definition mode has several effects:

Acquisition

The active high definition mode is indicated by "HD" in the horizontal label.



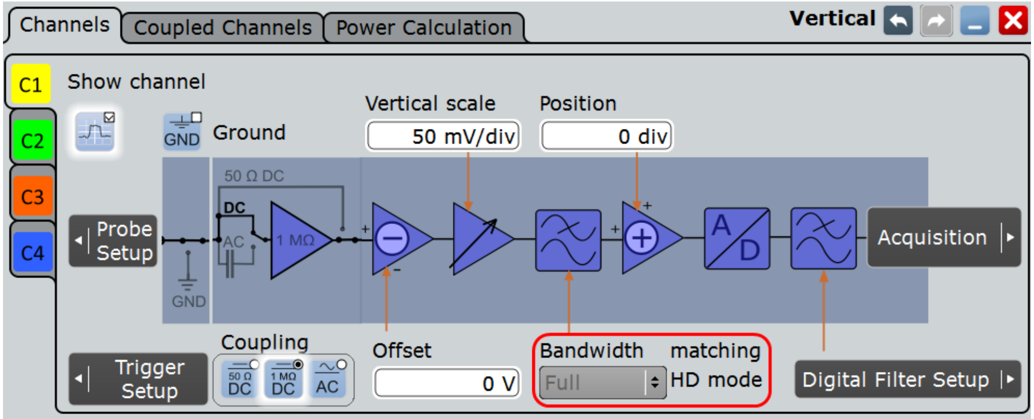
The high definition mode works with half the realtime sample rate. For FFT, the instrument halves this sample rate again.

The waveform values are recorded with 16 bit word length, except for peak detect decimation (2 values with 8 bit).

Vertical system

The current bandwidth is shown in the channel label.

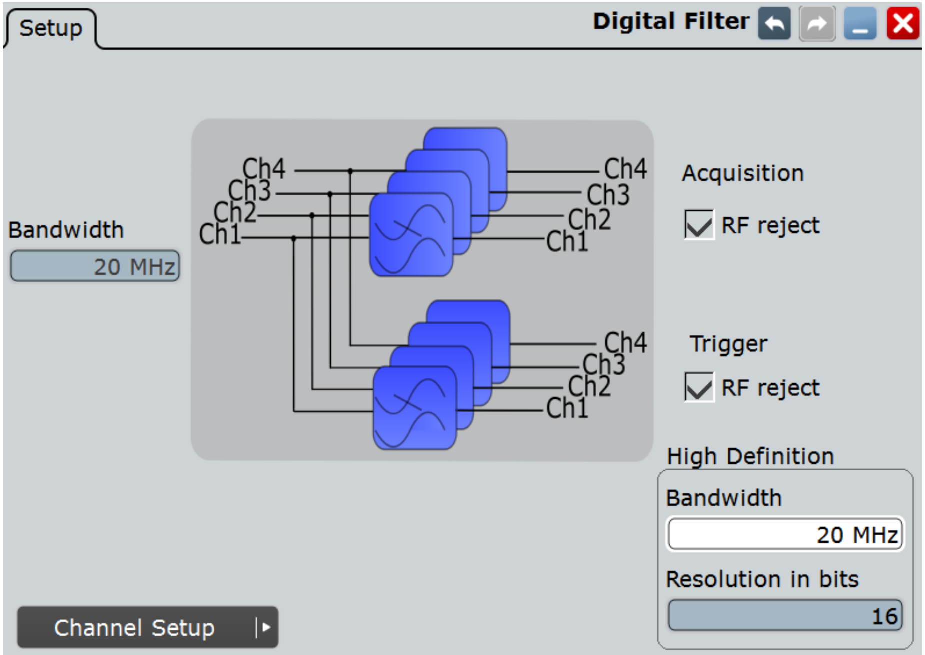
In the "Channels" dialog box (CH<x>), the "Bandwidth" setting is not available because the bandwidth is set by the high definition filter.



R&S RTE of the 1317.2500.Kxx series only: The minimum vertical scale is 500 µV/div instead of 1 mV in normal mode.

Digital filter

The digital filter settings are set automatically. You can change the high definition "Bandwidth" in the "Digital Filter Setup".



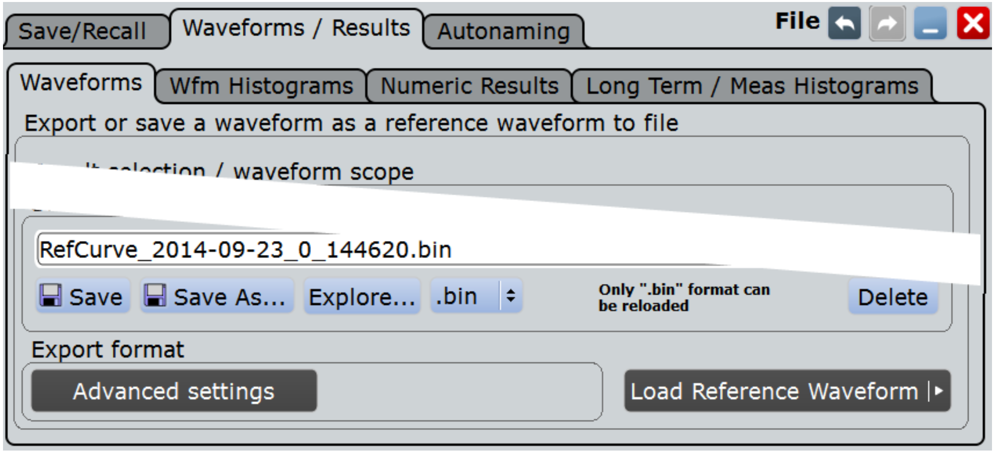
History

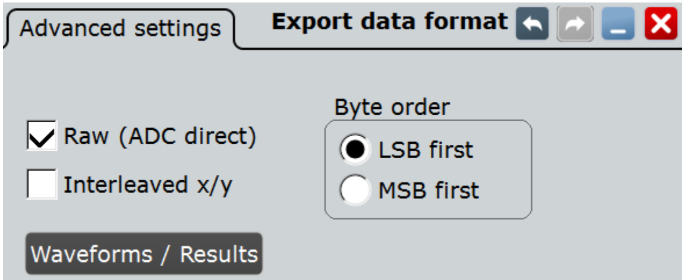
Due to the 16 bit word length, the history depth is reduced, less waveforms are saved than in normal mode

Export

In high definition mode, waveform data in raw format is exported to file with 16 bit word length, except for peak detect decimation (2 values with 8 bit). In addition, you can define the byte order of the data words.

To define additional export settings, tap "Advanced Settings" in the FILE > "Wave-forms" tab.





See:

- "Raw (ADC direct)" on page 420
- "Interleaved x/y" on page 420
- "Byte order" on page 421

If you use remote control commands to transfer data to a controlling computer, set the data format to `INT,16` to transfer the complete data words (see `FORMat[:DATA]` on page 887).

Further restrictions

The IQ mode (option R&S RTE-K11) is not available if high definition mode is active.

4.5 Probes

With R&S RTE digital oscilloscopes you can use various probe types, mostly these are passive and active voltage probes. The "Probes" dialog box provides all probe-relevant information. The instrument can detect the R&S RT-ZP10 as well as R&S RT-ZS and R&S RT-ZD probes and read out the probe-specific parameters, for example, band-width and attenuation. Other probes cannot be detected, but their characteristics are known to the R&S RTE. These known probes are called "Predefined probes".

In the "Setup" tab, you find all settings that are relevant for the connected probe. Additional information is given in the "Probe Attributes" and "Calibration Results" tabs.

For background information, see Chapter 4.1.4, "Probes", on page 146.

4.5.1 Setup for Passive Probes and External Attenuation

If a passive probe is connected, the probe attenuation is read out and shown in the "Setup" tab. Passive probes require compensation.

If you need to change the unit or attenuation, change the "Mode" to "Manual" and enter the correct values.

In addition, an external attenuation can be defined for all probe types, and AutoZero can be used.

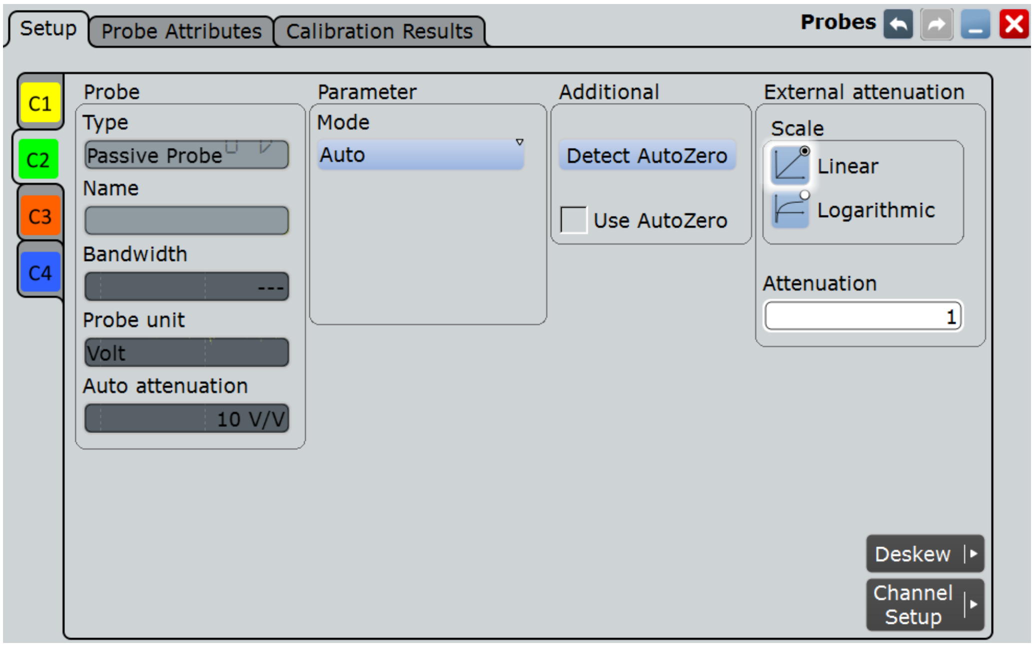


Figure 4-8: Probe setup for passive probe R&S RT-ZP10

Type, Name, Bandwidth

Many probes are recognized by the instrument. The fields show the characteristics of a recognized probe for information. If the instrument cannot recognize the probe, the "Type" is "None".

Remote command:
PROBe<m>:SETup:TYPE? on page 925
PROBe<m>:SETup:NAME? on page 925
PROBe<m>:SETup:BANDwidth? on page 926
TRPRobe:SETup:TYPE? on page 925 (trigger input)
TRPRobe:SETup:NAME? on page 925 (trigger input)
TRPRobe:SETup:BANDwidth? on page 926 (trigger input)

Probe unit, Auto attenuation
If the probe is recognized by the R&S RTE, the instrument reads the attenuation unit and value from the probe an displays them.

Remote command:
PROBe<m>:SETup:ATTenuation[:AUTO]? on page 926
TRPRobe:SETup:ATTenuation[:AUTO]? on page 926 (trigger input)

Mode
Defines how the attenuation of a passive probe is set.

"Auto"	The instrument uses the values that are given by the probe.
"Manual"	You can define the attenuation unit and value. See: "Vertical unit, Attenuation, Gain" on page 169

Remote command:
PROBe<m>:SETup:ATTenuation:MODE on page 926
TRPRobe:SETup:ATTenuation:MODE on page 926 (trigger input)

Vertical unit, Attenuation, Gain
Show the attenuation or gain values for predefined probes.

If no probe is defined, you can set user-defined values for unit, gain and attenuation.

Remote command:
PROBe<m>:SETup:ATTenuation:UNIT on page 926
PROBe<m>:SETup:ATTenuation:MANual on page 927
PROBe<m>:SETup:GAIN:MANual on page 927
TRPRobe:SETup:ATTenuation:UNIT on page 926 (trigger input)
TRPRobe:SETup:ATTenuation:MANual on page 927 (trigger input)
TRPRobe:SETup:GAIN:MANual on page 927

Detect AutoZero, Use AutoZero
Differences in DUT and oscilloscope ground levels may cause larger zero errors affecting the waveform. If the DUT is ground-referenced, the AutoZero function corrects the zero error of the probe to optimize measurement results at small signal levels.The validation limit depends on the probe attenuation because probes with high attenation often have to compensate high offsets. AutoZero detects offset values even when the signal is out of the current measurement range.

To correct the zero error of voltage probes, short the signal pin and the ground pin together and connect them to the ground of the DUT. Then tap "Detect AutoZero". While the alignment is running, the instrument switches to DC coupling to display the waveform correctly.

To include this additional offset in measurement results, enable "Use AutoZero".

If a current probe is connected, the function demagnetizes the probe's sensor head and sets the waveform to zero position. See "Detect AutoZero" on page 178.

Remote command:
`PROBe<m>:SETup:OFFSet:AZERo` on page 927
`PROBe<m>:SETup:OFFSet:USEautozero` on page 927
`TRPRobe:SETup:OFFSet:AZERo` on page 927 (trigger input)

External attenuation: Scale, Attenuation
Considers a voltage divider that is part of the DUT before the measuring point. The external attenuation is included in the measurement, and the instrument shows the results that would be measured before the divider. External attenuation can be used with all probes.

"Scale" Select linear or logarithmic attenuation scale.

"Attenuation" Enter the attenuation of the voltage divider according to the selected scale. The conversion from linear to logarithmic values depends on the "Vertical unit" of the probe:
For power-based unit (W):
*attenuation (dB) = 10 * log_{10}(attenuation factor)*
For voltage-based unit (V and A):
*attenuation (dB) = 20 * log_{10}(attenuation factor)*

Remote command:
`CHANnel<m>:EATScale` on page 928
`CHANnel<m>:EATTenuation` on page 928

4.5.2 Setup for Active Voltage Probes

Active single-ended probes R&S RT-ZS and active differential probes R&S RT-ZD (except for R&S RT-ZD01) have an integrated data memory that contains identification data and individual probe correction parameters. The R&S RTE can detect these active single-ended and differential probes and read out the data.

The Rohde & Schwarz active single-ended and differential probes have special features for easier use and precise measurements. The features and their settings appear on the tab if one of these probes is attached:

- Configuration of the micro button action
- DC measurement with R&S ProbeMeter

Additionally, you can use AutoZero and set an external attenuation.

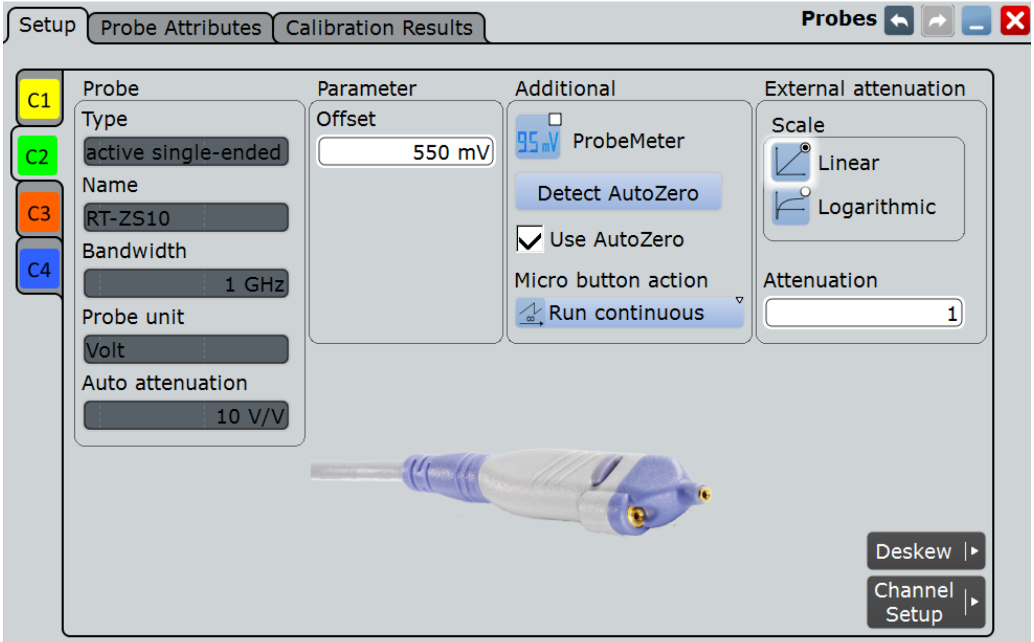


Figure 4-9: Probe setup for active single-ended probes

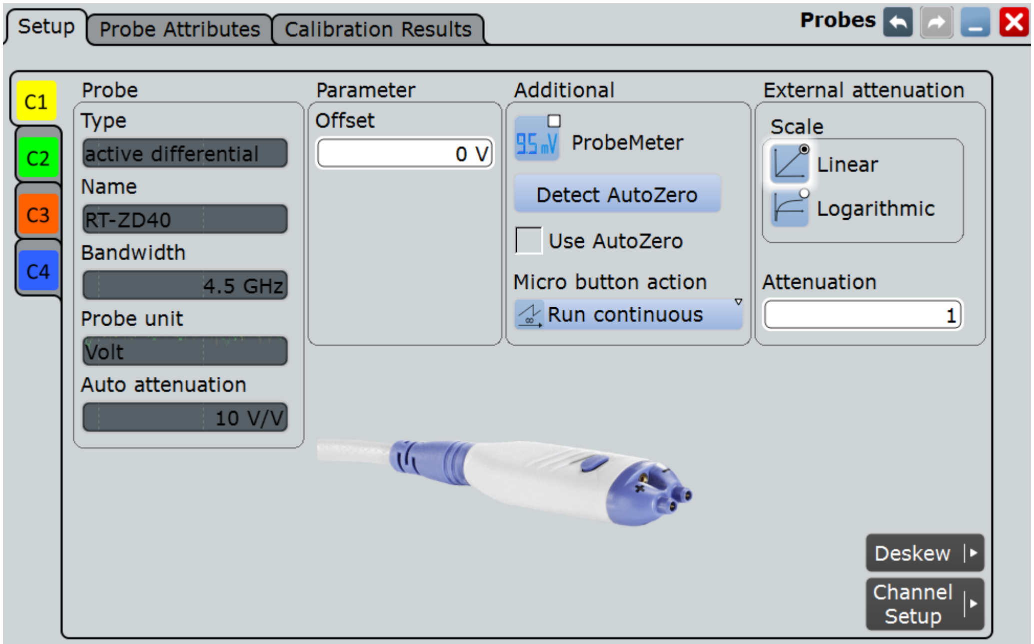


Figure 4-10: Probe setup for active differential probes

The information on the probe is shown under "Probe", see "Type, Name, Bandwidth" on page 168 and "Probe unit, Auto attenuation" on page 169.

The settings for external attenution are the same as for passive probes, see "External attenuation: Scale, Attenuation" on page 170.

Auto Zero settings are also general, see "Detect AutoZero, Use AutoZero" on page 169

Specific settings for active single-ended and differential probes are:

Offset

See "Offset" on page 162.

For differential probes, this offset is the differential offset.

CM offset

Sets the common-mode offset to compensate for a common DC voltage applied to both input sockets (referenced to the ground socket). This is particularly helpful for measurements on differential signals with high common mode levels, for example, current measurements using a shunt resistor. You can measure the common mode input voltage using the R&S ProbeMeter.

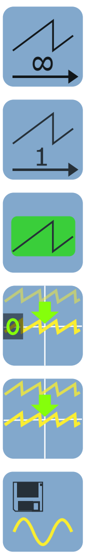
The setting is only available for Rohde & Schwarz differential probes.

Remote command:
`PROBe<m>:SETup:CMOFfset` on page 929
`TRPRobe:SETup:CMOFfset` on page 929 (trigger input)

Probe attenuator RT-ZA15

If you use the external attenuator R&S RT-ZA15 together with one of the differential active probes R&S RT-ZD10/20/30, enable RT-ZA15 to include the external attenuation in the measurements.

Remote command:
`PROBe<m>:SETup:ZAXV` on page 930
`TRPRobe:SETup:ZAXV` on page 930



Micro button action

Active R&S probes (except for RT-ZS10E) have a configurable Micro Button on the probe head. Pressing this button, you can perform an action on the instrument directly from the probe. During internal automatic processes the button is disabled, for example, during self alignment, autoset, and find level.

Select the action that you want to start from the probe:

"Run Continuous"
is the default assignment. The acquisition is running as long as you press the micro button again.

"Run single" Starts one acquisition.

"Auto set" Starts the autoset procedure.

"AutoZero" See: "Detect AutoZero, Use AutoZero" on page 169.

"Set offset to mean"
Performs an automatic compensation for a DC component of the input signal using the result of a background mean measurement. See: "Set offset to mean" on page 176.

"Print" Prints the current display according to the "Printer control" settings in the "Print" dialog box, see Chapter 11.3, "Screenshots", on page 429. Depending on the selected printer. you can print to a local or network driver, or save to a file.

"Save image to file" Saves the current display as image according to the image settings in the "Print" dialog box, see Chapter 11.3, "Screenshots", on page 429.

"Find trigger level" Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*. The function is not available for an external trigger source and the TV trigger.

"Create report" Creates and saves a report using the settings defined in "File" menu > "Report Setup".

"No action" Select this option to prevent unwanted actions due to unintended usage of the micro button.

Remote command:
`PROBe<m>:SETup:MODE` on page 928
`TRPRobe:SETup:MODE` on page 928 (trigger input)

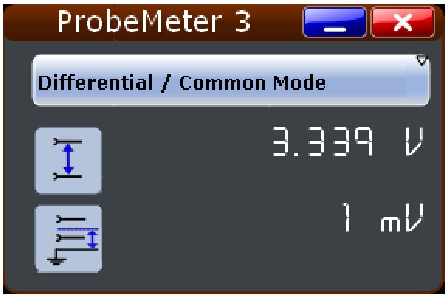
ProbeMeter

The integrated R&S ProbeMeter of active R&S probes (except for RT-ZS10E) is a voltmeter that measures DC voltages between the probe tip and ground connection or between the probe tips with very high precision. The R&S ProbeMeter enables ground-referenced measurements of voltages. The measurement is performed continuously and in parallel to the measurements of the oscilloscope.

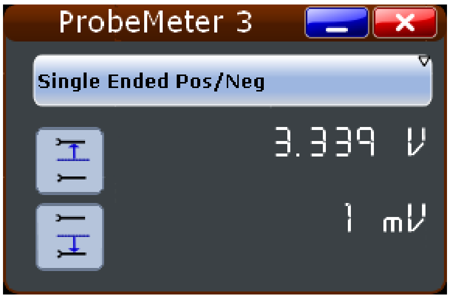
- **"Probemeter"**
  Select "Probemeter" to activate the integrated R&S ProbeMeter of active R&S probes. The measured voltages are displayed in the "ProbeMeter" result box on the screen.
- **ProbeMeter measurement results of single-ended active R&S probes**
  Measures the voltage between the probe tip and the ground.

- **ProbeMeter measurement results of differential active R&S probes**
  You can select the voltage to be measured by the differential active probe:
  – "Differential / Common Mode":
    Differential voltage is the voltage between the positive and negative signal sockets.
    Common mode voltage is the mean voltage between the signal sockets and the ground socket. It measures the voltage level relative to ground, for example, to check the operating voltage window.
    See also: "Differential Active Probes" on page 149.



– "Single Ended Pos/Neg": Measures the voltage between the positive/negative signal socket and the ground.



The ProbeMeter always measures the common mode and differential voltages. Single-ended voltages are calculated values:
$V_p = V_{cm} + 0,5 * V_{in}$ and $V_n = V_{cm} - 0,5 * V_{in}$

Remote command:
Channel probes:
`PROBe<m>:PMETer:VISibility` on page 931
`PROBe<m>:SETup:DISPlaydiff` on page 930
`PROBe<m>:PMETer:RESults:SINGle?` on page 931
`PROBe<m>:PMETer:RESults:POSitive?` on page 933
`PROBe<m>:PMETer:RESults:NEGative?` on page 932
`PROBe<m>:PMETer:RESults:DIFFerential?` on page 932
`PROBe<m>:PMETer:RESults:COMMon?` on page 931
Probe on trigger input:
`TRPRobe:SETup:DISPlaydiff` on page 930
`TRPRobe:PMETer:VISibility` on page 931
`TRPRobe:PMETer:RESults:SINGle?` on page 931
`TRPRobe:PMETer:RESults:POSitive?` on page 933
`TRPRobe:PMETer:RESults:NEGative?` on page 932
`TRPRobe:PMETer:RESults:DIFFerential?` on page 932
`TRPRobe:PMETer:RESults:COMMon?` on page 931

4.5.3 Setup for Predefined and Unknown Probes

Some probes cannot be detected, but their characteristics are known to the R&S RTE. These probes are called "Predefined probes".

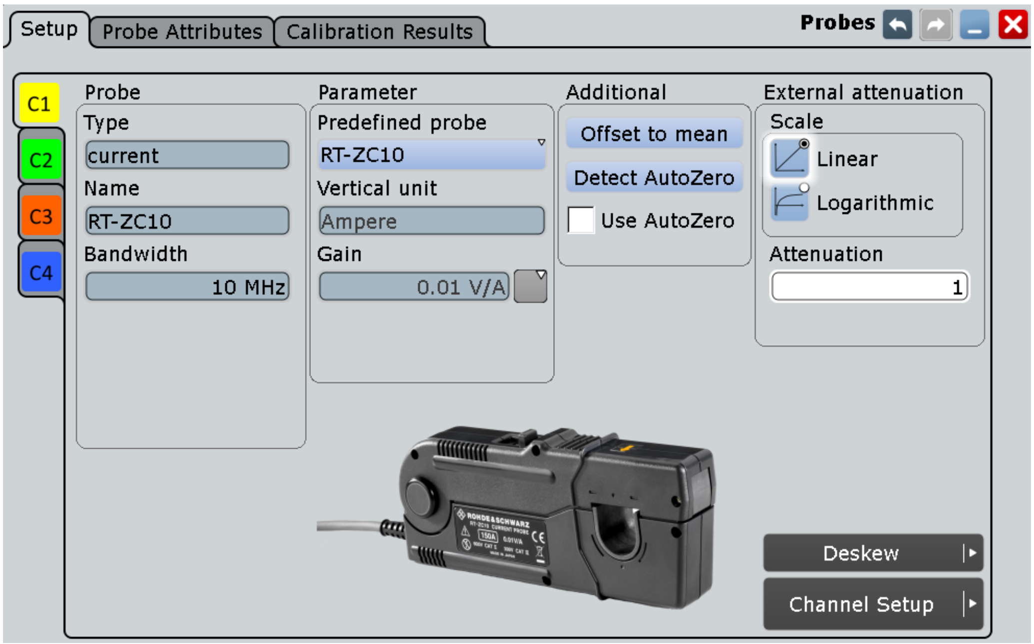


Figure 4-11: Probe setup for current probes R&S RT-ZCxx

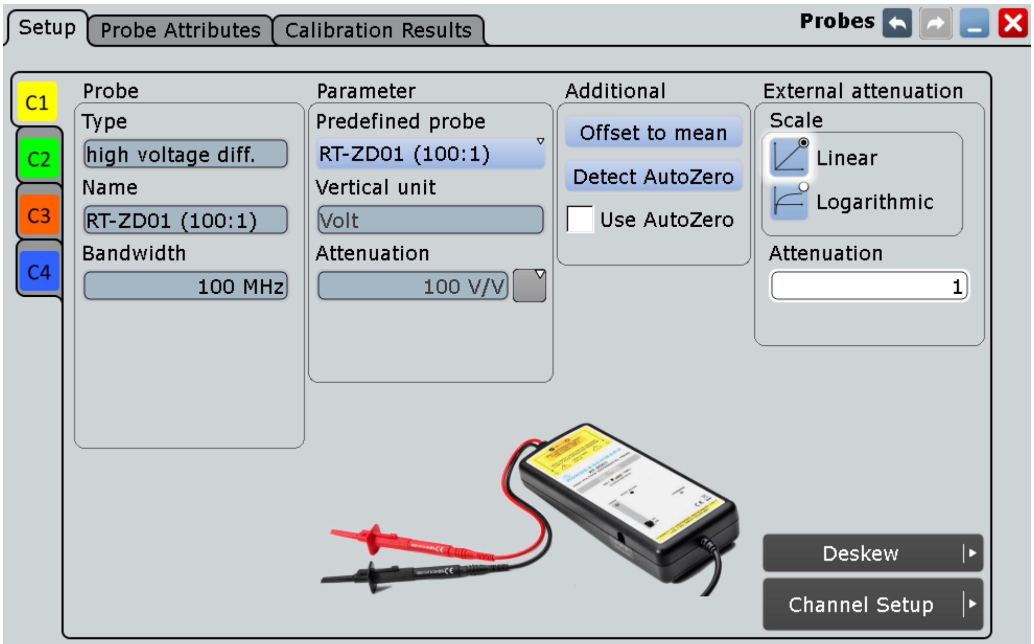


Figure 4-12: Probe setup for R&S RT-ZD01

If the R&S RTE cannot detect the probe, and the probe is not a predefined one, you can set the probe parameters manually: unit and attenuation of the probe as well as external attenuation.

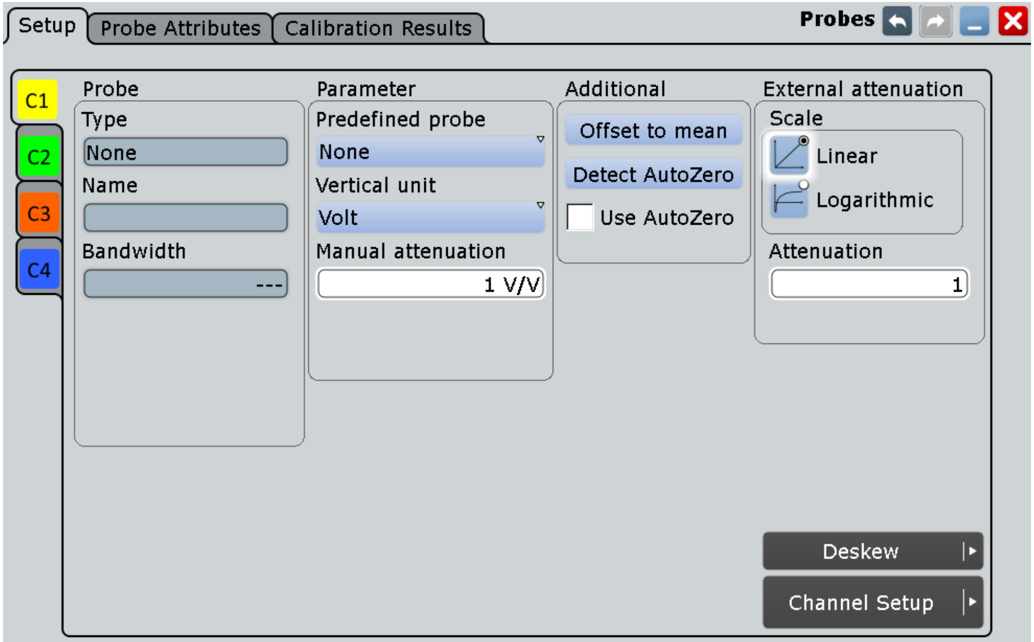


Figure 4-13: Probe setup for an unkown probe

Predefined probe

Current probes R&S RT-ZCxx, the high voltage active probe R&S RT-ZD01 and the transmission line probe R&S RT-ZZ80 are not recognized automatically but the parameters of these probes are known to the instrument. Select the correct probe type and enter additional parameters if required. The correspondent "Vertical unit" and the "Attenuation" or "Gain" are set.

For any other unrecognized probe, set "Predefined probe" to "None" and enter the "Vertical unit" and the "Manual attenuation".

See also: "Vertical unit, Attenuation, Gain" on page 169

Remote command:
`PROBe<m>:SETup:ATTenuation:DEFProbe` on page 933
`TRPRobe:SETup:ATTenuation:DEFProbe` on page 933 (trigger input)

Set offset to mean

Performs an automatic compensation for a DC component of the input signal using the result of a background mean measurement. The result is shown in "Offset". The function is probe-independent and supports quick and convenient measurements of input signals with different DC offsets. It detects offset values even when the signal is out of the current measurement range, sets the zero level to the determined DC offset in the middle of the screen and thus prevents clipping of the waveform.

Remote command:
`PROBe<m>:SETup:OFFSet:TOMean` on page 934

Line impedance

If the transmission line probe R&S RT-ZZ80 is selected, enter the impedance of the measured line.

The actual attenuation of the transmission line probe depends on the impedance of the line Z_0:

Attenuation = 10 + Z_0 */ 100*

The instrument uses the actual attenuation to determine the measurement values.

4.5.4 Setup for Current Probes

The setup and adjustment of current probes depends on the output connector of the probe.

The current probes **R&S RT-ZCxx** have BNC connectors. They are known to the R&S RTE as predefined probes, see Chapter 4.5.3, "Setup for Predefined and Unknown Probes", on page 174. Demagnetizing and zero adjustment is done on the probe, see the probe's User Manual for details. Make sure to demagnetize and adjust the probe before taking measurements.

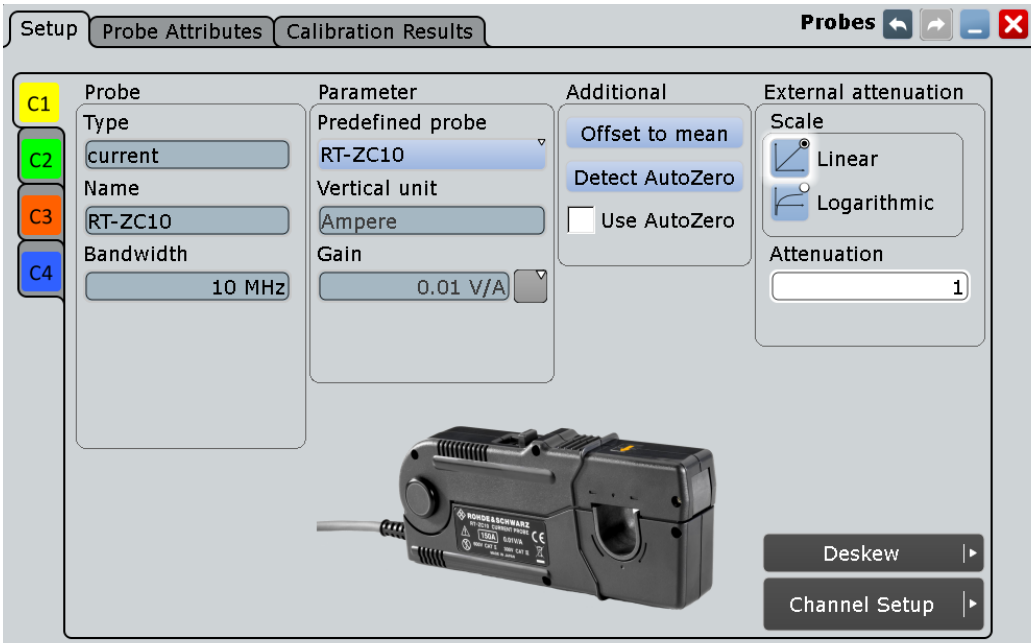


Figure 4-14: Probe setup for current probes R&S RT-ZC10

Current probes **R&S RT-ZCxx*B*** have a Rohde & Schwarz probe interface; they are powered and remotely controlled by the oscilloscope. All adjustment is done on the oscilloscope and described below.

When the probe is connected, demagnetization is performed automatically.

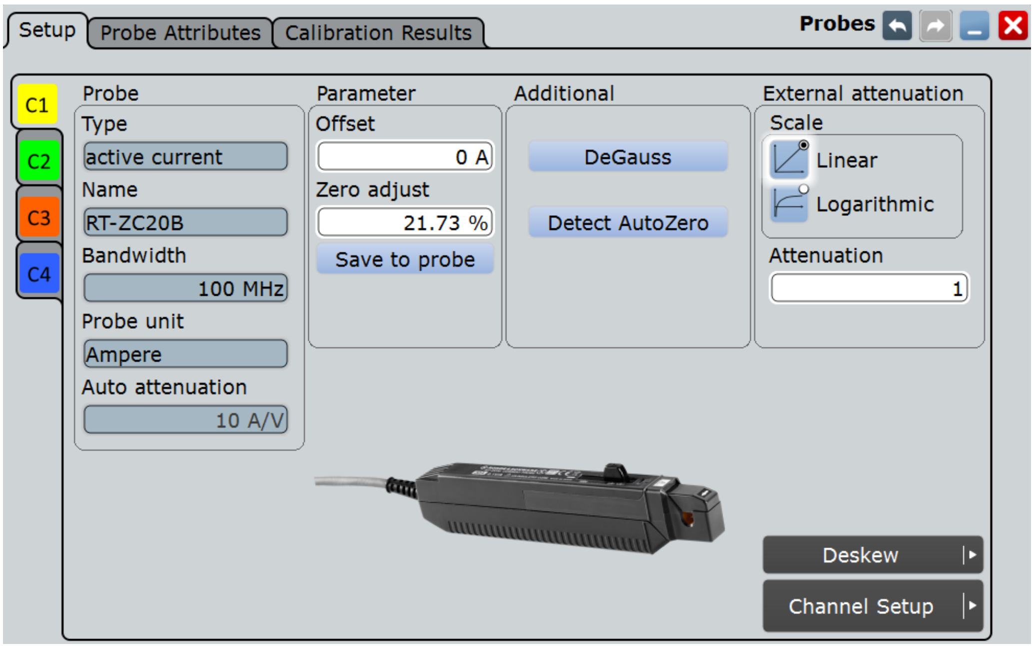


Figure 4-15: Probe setup for current probes R&S RT-ZC20B

DeGauss

Demagnetizes the core if it has been magnetized by switching the power on and off, or by an excessive input. Always carry out demagnetizing before measurement.

The demagnetizing process takes about one second. During demagnetizing, a demagnetizing waveform is displayed.

Demagnetizing is done automatically when R&S RT-ZCxxB is connected to the oscilloscope, or when "Detect AutoZero" is performed.

Remote command:
`PROBe<m>:SETup:DEGauss` on page 934
`TRPRobe:SETup:DEGauss` on page 934

Detect AutoZero

If a current probe is connected, the function demagnetizes the probe's sensor head and sets the waveform to zero position to correct the error offset. Thus, it compensates for the remanence and offset caused by temperature drift.

For R&S RT-ZCxxB probes, the determined "Zero adjust" value is displayed and can be saved in the probe head.

See also "Detect AutoZero, Use AutoZero" on page 169.

Remote command:
`PROBe<m>:SETup:OFFSet:AZERo` on page 927
`TRPRobe:SETup:OFFSet:AZERo` on page 927 (trigger input)

Zero adjust

Zero adjust corrects the effect of an offset caused by temperature drift, and compensates for the remanence. The setting is only availabe if DC coupling is set.

To set the waveform to zero level by the instrument, use "Detect AutoZero". The detected value is displayed.

Alternatively, you can adjust the value manually until the waveform is set to zero level. Make sure to demagnetize the probe before zero adjustment.

The value is given in percent of the maximum range, which is internally defined. The actual setup range depends on the temperature drift, the measured current and other variables, and it may change over time. If you measure high currents, the probe core magnetizes, which impairs the measurement results. Therefore, repeat "Detect AutoZero" before the measurement.

Remote command:
`PROBe<m>:SETup:OFFSet:ZADJust` on page 935

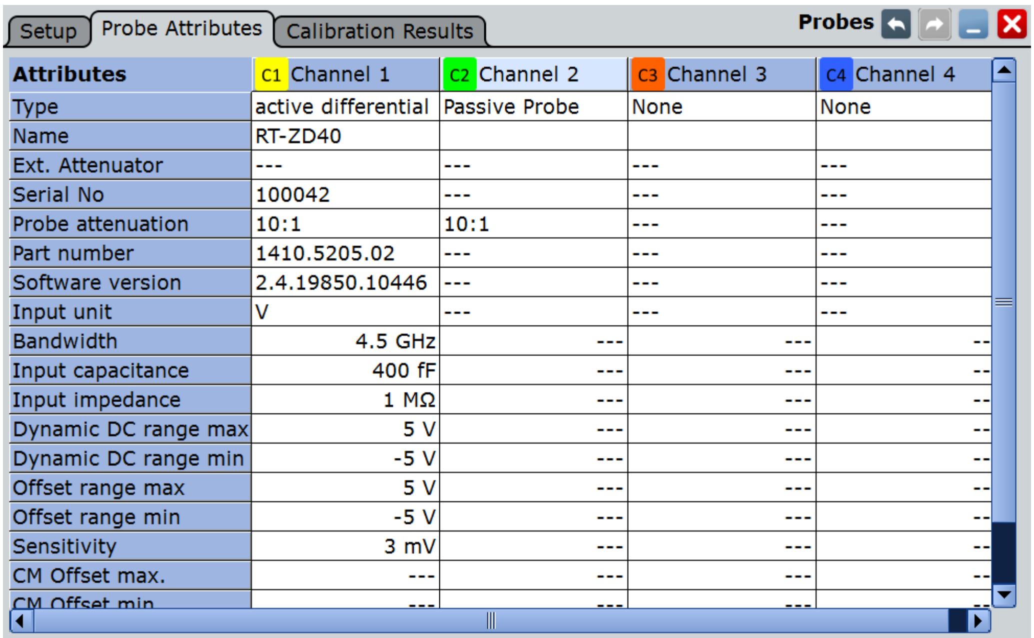
Save to probe
Saves the "Zero adjust" value in the probe box. If you connect the probe to another channel or to another R&S RTx oscilloscope, the value is read out again, and you can use the probe without further adjustment.

Remote command:
`PROBe<m>:SETup:OFFSet:STPRobe` on page 935

4.5.5 Probe Attributes

The "Probe Attributes" tab provides an overview of all R&S probes connected to an input channel.

For a specification of the probe parameters refer to the data sheet.



Attributes	C1 Channel 1	C2 Channel 2	C3 Channel 3	C4 Channel 4
Type	active differential	Passive Probe	None	None
Name	RT-ZD40			
Ext. Attenuator	---	---	---	---
Serial No	100042	---	---	---
Probe attenuation	10:1	10:1	---	---
Part number	1410.5205.02	---	---	---
Software version	2.4.19850.10446	---	---	---
Input unit	V	---	---	---
Bandwidth	4.5 GHz	---	---	--
Input capacitance	400 fF	---	---	--
Input impedance	1 MΩ	---	---	--
Dynamic DC range max	5 V	---	---	--
Dynamic DC range min	-5 V	---	---	--
Offset range max	5 V	---	---	--
Offset range min	-5 V	---	---	--
Sensitivity	3 mV	---	---	--
CM Offset max.	---	---	---	--
CM Offset min	---	---	---	--

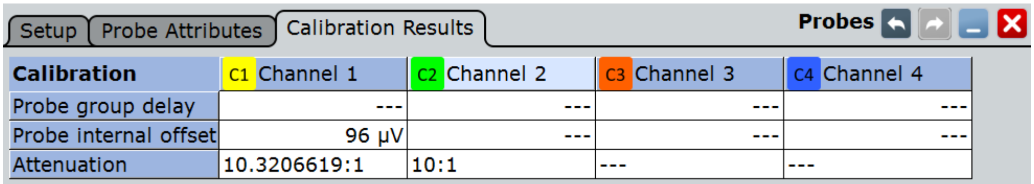
Remote commands:

- `PROBe<m>:ID:SWVersion?` on page 935

- PROBe<m>:ID:PRDate? on page 936
- PROBe<m>:ID:PARTnumber? on page 936
- PROBe<m>:ID:SRNumber? on page 936
- PROBe<m>:SETup:CAPacitance? on page 937
- PROBe<m>:SETup:IMPedance? on page 937
- TRPRobe:ID:SWVersion? on page 935
- TRPRobe:ID:PRDate? on page 936
- TRPRobe:ID:PARTnumber? on page 936
- TRPRobe:ID:SRNumber? on page 936
- TRPRobe:SETup:CAPacitance? on page 937
- TRPRobe:SETup:IMPedance? on page 937

4.5.6 Calibration Results

The "Calibration Results" tab provides the calibration data stored in the probe for all R&S probes connected to an input channel.



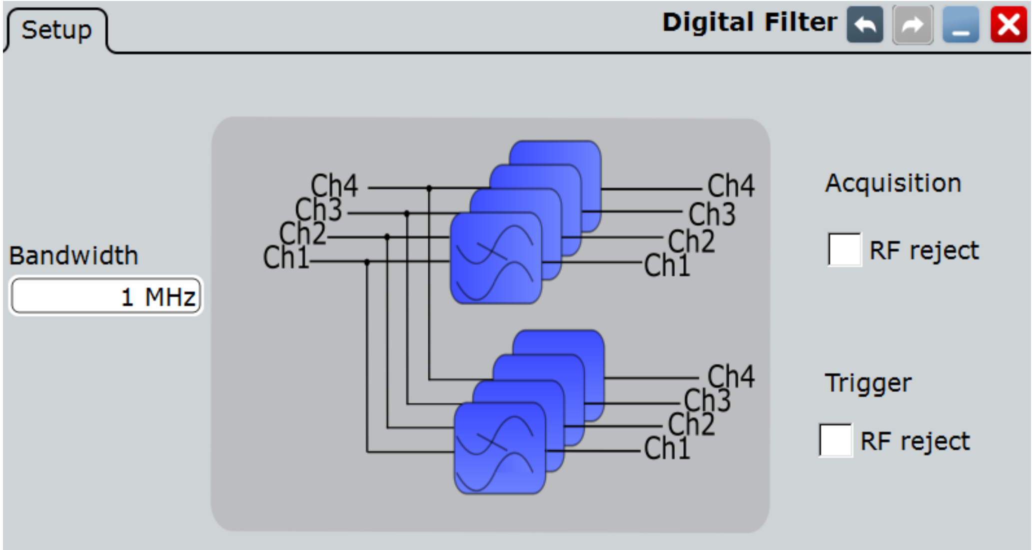
Calibration	C1 Channel 1	C2 Channel 2	C3 Channel 3	C4 Channel 4
Probe group delay	---	---	---	---
Probe internal offset	96 µV	---	---	---
Attenuation	10.3206619:1	10:1	---	---

4.6 Digital Filter Setup

After processing by the A/D converter, the channel and trigger signals are digitized signals. These digitized signals can be filtered to reject high frequency - also known as Digital Signal Processing (DSP). You can filter the acquisition channels as well as the trigger channel signal. For example, RF reject for the trigger signal ensures that triggering will not be caused by unexpected glitches.

If High Definition mode (option R&S RTE-K17), digital filter settings are enabled automatically. You can change the high definition bandwidth in the Digital Filter Setup, which is applied to the channels.

Access: "Vertical" menu > "Digital Filter"



Bandwidth
Sets the limit frequency. This limit is applied to the trigger channel and to the acquisition channels that are enabled for filtering.

Remote command:
`TRIGger<m>:RFReject` on page 938

Acquisition RF reject
Enables the DSP filter for the input channels. Frequencies higher than the "Bandwidth" are rejected, lower frequencies pass the filter.

Remote command:
`CHANnel<m>:DIGFilter:STATe` on page 937

Trigger RF reject
Enables the DSP filter for the trigger channel. Frequencies higher than the "Bandwidth" are rejected, lower frequencies pass the filter.

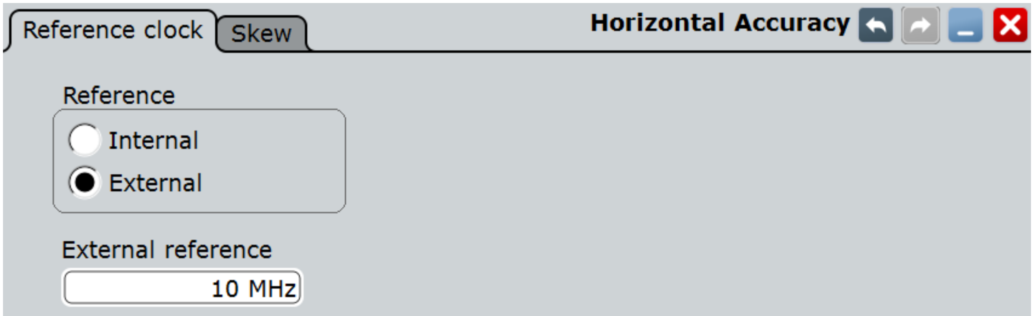
Remote command:
`TRIGger<m>:RFSReject` on page 938

4.7 Horizontal Accuracy

The Horizontal Accuracy contains standard and optional settings to improve measurement and analysis accuracy and to reduce jitter effects.

4.7.1 Reference Clock

Input and output reference signals are connected to the REF IN/OUT connector on the rear panel of R&S RTE. You can select an internal or external reference clock on the "Reference clock" tab.



Reference
Sets the reference clock that is to be used.

"Internal" uses the internal reference signal.

"External" uses an external reference signal.

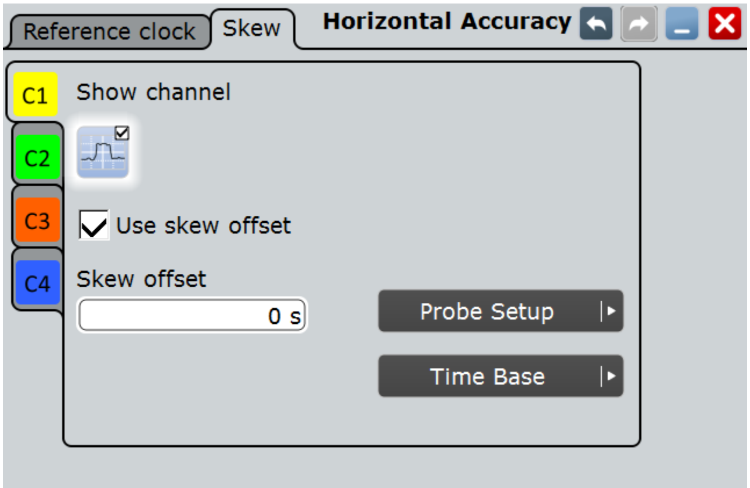
Remote command:
SENSe[:ROSCillator]:SOURce on page 941

External reference
Sets the frequency of an external reference input signal: 10 MHz.

Remote command:
SENSe[:ROSCillator]:EXTernal:FREQuency on page 941

4.7.2 Skew

Skew compensates signal propagation differences between channels caused by the different length of cables, probes, and other sources. Correct skew values are important for accurate triggering and timing relations between channels.



Make sure that the correct channel tab is selected.

Show channel
Switches the channel signal on or off. The signal icon appears on the signal bar. The waveform of the last acquisition is displayed in the diagram.

Remote command:
`CHANnel<m>:STATe` on page 918

Use skew offset
If enabled, the "Skew offset" value is used for compensation. This improves horizontal and trigger accuracy.

Remote command:
`CHANnel<m>:SKEW:MANual` on page 938

Skew offset
Sets an delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically. It affects only the selected input channel.

Remote command:
`CHANnel<m>:SKEW:TIME` on page 938

4.8 Setting Up the Waveform

This chapter contains the fundamental procedures for setting up the acquisition and adjusting the channel waveforms.

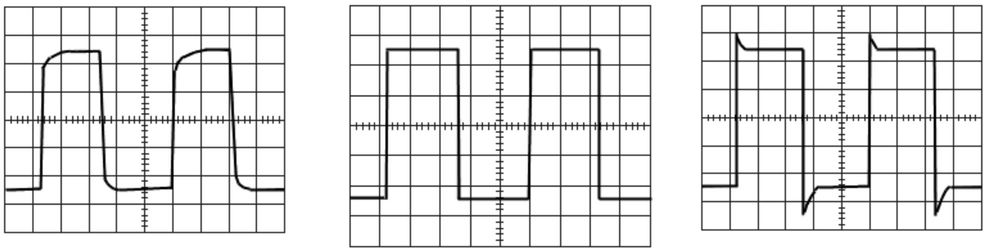
4.8.1 Adjusting Passive Probes

R&S RT-ZP10 passive probes are already pre-compensated to the R&S RTE front-end characteristics, and a compensation procedure is not required.

If you use other passive probes, the R&S RTE allows you to compensate it when it is connected to the instrument the first time. Compensation matches the probe cable capacitance to the oscilloscope input capacitance to assure good amplitude accuracy from DC to upper bandwidth limit frequencies. A poorly compensated probe reduces the performance of the probe-oscilloscope system and introduces measurement errors resulting in distorted waveforms and inaccurate results.

1. Connect the BNC connector of the probe to input CH1.
2. Connect the probe's ground connector to the right compensation pin, and the tip with the left pin.
3. Press AUTOSET.

   A square wave appears on the display.
4. Adjust the compensation trimmer of the probe to optimum square wave response. For details, refer to the documentation of your probe.



4.8.2 Setting Up the Signal Input with Autoset

Autoset is the solution for the major part of routine test-setup. It is also a good start if you need to use more complex trigger settings. Autoset finds appropriate horizontal and vertical scales, vertical offset, and trigger conditions to present a stable waveform.

1. Connect the probe to the input connector CH ×.

   The instrument recognizes the probe and turns the channel on.

2. Press the AUTOSET button on the left of the display.

4.8.3 Adjusting the Signal Input Manually

1. Connect the probe to the input connector CH ×.

   The instrument recognizes the probe and turns the channel on.

2. On the "Horizontal" menu, tap "Setup".
3. Set the "Time scale".
4. If you want to analyze the signal some time before or after the trigger, use the "Position" and "Reference point" to adjust the visible section of the waveform.
5. Select to set either the resolution or the record length and enter the required value.
6. Press the channel button corresponding to the input channel. It is illuminated with the color of the channel waveform.
7. In the "Channels" tab, select the "Coupling".
8. Adjust the vertical "Scale", and the vertical "Position".
9. Tap "Acquisition" to proceed with the acquisition setup.

4.8.4 Setting the Acquisition

Prerequisites:

- Probes are connected.

- Vertical and horizontal settings are adjusted.

The settings are described in Chapter 4.2.2, "Acquisition", on page 154.

1. On the "Horizontal" menu, tap "Acquisition".
2. To configure the channel-specific acquisition settings, select the "Channel" subtab.
3. Select the "Mode" - for example, Peak detect or High res.
4. Select the "Wfm Arithmetic" - for example, Average or Envelope.
   The instrument precludes incompatible combinations, like "Peak detect" with "Average".
5. If "Average" is selected for a waveform, enter the "Average count", that is the number of waveforms used for average calculation.

4.8.5 Starting and Stopping Acquisition

You can control the acquisition in two ways:

- Running continuous acquisition until you stop it.
- Running one acquisition or a given number of acquisitions.
  If "Envelope" or "Average" is selected in the "Acquisition" tab, one acquisition means a cycle containing as many acquired waveforms as required to satisfy the reset conditions.

Prerequisites:

- Probes are connected.
- Vertical and horizontal settings are adjusted.
- Triggering is set.
- Channels to be acquired are turned on.

To start and stop continuous acquisition

1. Check if the trigger mode is set to "Normal". The trigger mode is shown in the trigger label in the upper right edge of the screen.
   If not, press the trigger MODE key on the front panel to toggle the setting.
2. Press the RUN CONT key to start acquisition.

   The acquisition starts if a trigger occurs.
3. To stop , press the RUN CONT key again.

   The acquisition stops immediately.

To acquire a limited number of acquisitions

1. Press the TRIGGER key and tap the "Control" tab.
2. In the "Control" area, select the "Normal" trigger mode.
3. Enter the number of acquisitions in the "Average count" field.

4. Press the RUN N× SINGLE key on the front panel.
   You can stop the running acquisition before it is finished by pressing the key again.

4.8.6 Using the Roll Mode

The roll mode can be used if the acquisition process is slow - that is if the time scale is large. In roll mode, the instrument shows the waveform immediately and saves waiting for the waveform display. The roll mode can be activated by the instrument if several conditions are fulfilled.

To set the roll mode manually

1. Make sure that all requirements for the roll mode are fullfilled: see "Roll mode" on page 153.
2. Press the HORIZONTAL key.
3. In the "Roll mode" section of the "Setup" tab, set "Mode" to "Auto".
4. In the "Min roll mode gain" field, enter the acquisition time at which the instrument starts the roll mode.

4.8.7 Using Ultra Segmentation

Ultra Segmentation reduces the dead time between two waveform acquisition cycles.

The settings are described in Chapter 4.2.3, "Ultra Segmentation", on page 158.

1. On the "Horizontal" menu, tap "Ultra Segmentation".
2. Tap "Enable" to activate the Ultra Segmentation mode.
3. If you want to sample the maximum number of acquisitions in a series, select "Acquire maximum".
   If you want to capture a defined number of acquisitions, disable "Acquire maximum" and enter the "Required" number of acquisitions.
4. Set the "Replay time", the display time of each acquisition.

4.8.8 Using Digital Filters

Before using digital filters, you determine if you want to filter input channels only or if the trigger signal will be filtered too. The filter settings depend on this decision.

For details on filter settings and dependencies, see Chapter 4.6, "Digital Filter Setup", on page 180.

1. On the "Vertical" menu, tap "Digital Filter Setup".
2. To filter the input channels, enable "Acquisition RF reject".

3. To filter the input channels, enable "Trigger RF reject".
4. Set the frequency limit for the filter: "Bandwidth".
   This limit is applied to the trigger channel and to the acquisition channels enabled for filtering.

5 Triggers

5.1 Basics of Triggering

Triggering means to capture the interesting part of the relevant waveforms. Choosing the right trigger type and configuring all trigger settings correctly allows you to detect various incidents in analog, digital, and protocol signals.

Trigger

A trigger occurs if the complete set of trigger conditions is fulfilled. The trigger is the determining point in the waveform record. The instrument acquires continuously and keeps the sample points to fill the pre-trigger part of the waveform record. When the trigger occurs, the instrument continues acquisition until the post-trigger part of the waveform record is filled. Then it stops acquiring and waits for the next trigger. When a trigger is recognized, the instrument does not accept another trigger until the acquisition is complete and the holdoff time has expired.

Trigger setup

A simple trigger setup includes:

- Source of the trigger signal, its coupling and filtering
- Trigger type selection and setup
- Horizontal position of the trigger: see: Chapter 4.1.3.2, "Horizontal Position", on page 146
- Trigger mode

The R&S RTE provides various trigger types for troubleshooting and signal analysis, for example, edge trigger, glitch trigger, interval trigger, pattern trigger, and much more.

For complex tasks like verifying and debugging designs, advanced trigger settings are available:

- Hysteresis, that is the rejection of noise to avoid unwanted trigger events caused by noise
- Holdoff to define exactly which trigger event causes the trigger
- Qualification to consider the states of digital signals on other input channels and their logical combination
- Trigger sequences to combine two trigger type conditions

Action on trigger

A trigger can initiate one or more actions, for example, saving a screenshot or saving waveform data. All available actions can be initiated at the same time.

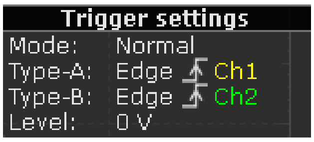
Trigger sequence

A complex trigger sequence joins two separate trigger type conditions with an optional delay time. This combination is called "A → B" trigger sequence. Similar setups are also known as multi-step trigger or A/B trigger.

Trigger information

Information on the most important trigger settings is shown in the trigger label on top of the signal bar. If you double-tap the trigger label, the "Trigger" dialog box opens. The label shows:

- Trigger mode
- Trigger type, edge/polarity and trigger source, for A- and B-trigger
- Trigger level



When no trigger has been found for longer than one second, a message box appears that shows the current state of the trigger. For long timebases, the state indicates the remaining pretrigger time, the waiting time if no trigger occurs, and after the trigger the time until the acquisition is completed. While waiting for the trigger, the "Force trigger" button is available to get a waveform quickly. You can also drag the message box to the signal bar.

External trigger input

If the trigger source is a channel input, the trigger system uses the digitized signal. The trigger system of the instrument is a separate system, thus the signal processing by enhancement, decimation and arithmetic has no impact on the trigger signal. Most of the R&S RTE trigger types use the digitized trigger signal.

If the trigger source is the external trigger input, the trigger comparator uses the analog input signal. For the external trigger signal, only the edge trigger of the A-trigger is available. Trigger sequence is not supported.

5.2 Setting Up the Trigger

This chapter provides step-by-step procedures for the important stages of trigger setup.

5.2.1 Configuring a Simple Trigger

Prerequisites:
- Horizontal and vertical settings are set appropriately to the signals.
- The acquisition is running, the RUN CONT key lights green.

For details on settings, see Chapter 5.3, "Trigger Types", on page 191.

Proceed as follows:

1. Press the TRIGGER key on the front panel.

   The "Trigger" dialog box opens with the "Setup" tab.
2. At the left hand-side, select the "A" vertical sub tab.
3. Tap the "Source" button and select the trigger source.
4. Check the trigger coupling and filter settings. To change the settings, tap the "Channel Setup" button and "Digital Filter" button.
   If the trigger source is "Extern", you can adjust the coupling and filters directly in the "Setup" tab.
5. Tap the "Type" button and select the trigger type.
6. Under "Trigger type dependent settings", configure the settings for the selected trigger type.
   See: Chapter 5.3, "Trigger Types", on page 191
7. To let the instrument find the trigger level, tap "Find level".
8. Set the normal trigger mode. Do either of the following:
   - Press the MODE key on the front panel until "Normal" is shown in the trigger label.
   - Tap the "Normal" trigger mode option in the "Ctrl/Action" tab.

5.2.2 Positioning the Trigger

By positioning the trigger on the time axis, you define which part of the waveform is displayed: mainly the pre-trigger part, or the post-trigger part, or the part around the trigger point.

For details on position settings, see Chapter 4.2.2, "Acquisition", on page 154.

1. Press the HORIZONTAL key.
   Alternatively, tap the "Horizontal" menu and then "Setup".
2. Set the "Reference point" and the "Position".
   If you want to set the trigger position outside the waveform display, make sure that "Restrict horizontal position to acquisition range" is disabled.

5.2.3 Using Holdoff

For details on holdoff settings, see Chapter 5.4, "Holdoff", on page 216.

1. Press the TRIGGER key and select the "Holdoff" tab.
   Alternatively, tap the "Trigger" menu and then "Holdoff".
2. Select the "Holdoff mode".
3. Enter the "Holdoff settings" belonging to the selected mode.

5.2.4 Setting Up a Trigger Sequence

The complete configuration of a complex "A → B" trigger sequence consists of:

- A-trigger condition
- B-trigger condition in the same way as for the A-trigger, and optional delay time between the two triggers

For details on sequence settings, see Chapter 5.7, "Sequence", on page 223.

1. Press the TRIGGER key and select the "Setup" tab.
2. Select the type of the "Sequence": "A → B".
3. Tap the "A" subtab and configure the first condition.
   See: Chapter 5.2.1, "Configuring a Simple Trigger", on page 190.
4. Select the "B" subtab and configure the B-trigger condition.
5. Optionally, set the "Delay A -> B" that the instrument waits after an A-trigger until it recognizes B-triggers.
6. Set the "B event count". The last B-trigger causes the trigger.

5.3 Trigger Types

The setup of the trigger type is the most important part of the trigger definition. It determines the method to identify specific signal phenomena. Almost all trigger types are available for all conditions in a trigger sequence, that is, you can combine different types in the sequence. The instrument checks the trigger settings for compatibility and feasibility, and disables settings that do not fit the previous settings in the sequence.

Make sure that the correct trigger tab is selected on the left before you enter the settings.

The settings in the "Setup" tab are:

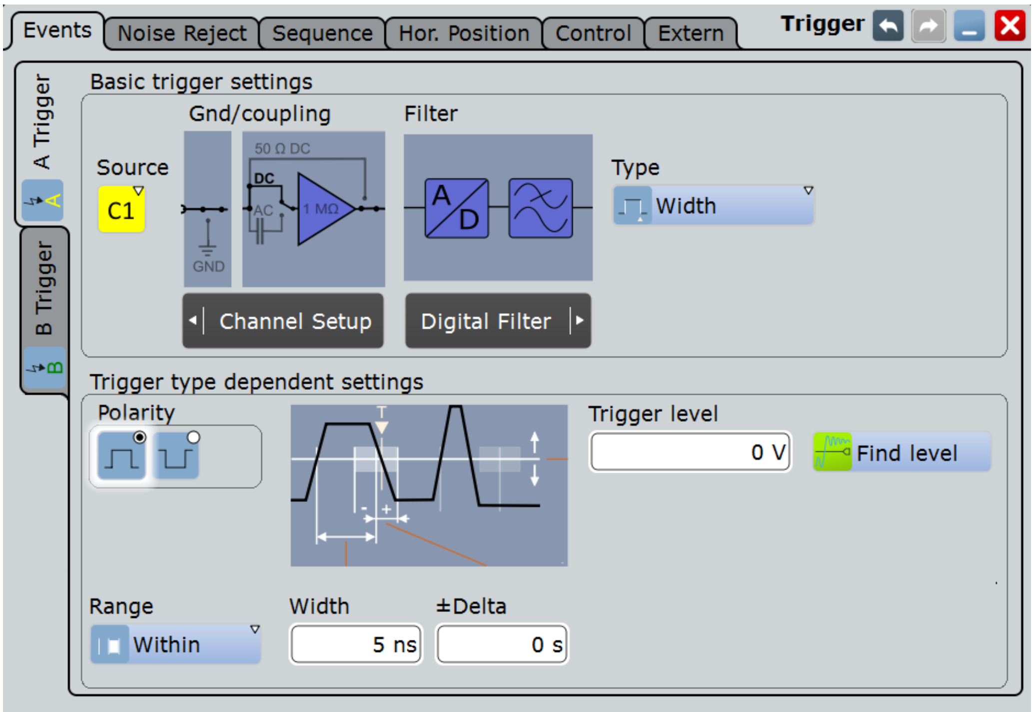
5.3.1 Basic Trigger Settings

Access: TRIGGER > "Setup" tab

The basic trigger settings are the trigger source and the trigger type, including the trigger level. These settings are specific for each condition in a trigger sequence "A → B". For the trigger source, the current ground/coupling settings are displayed, filtering is also possible.

Depending on the trigger type, additional settings are available. These settings are located under "Trigger type dependent settings".

- Let the R&S RTE find the trigger level: "Find level".
- Set the trigger levels to the same value for all channels.



Source

Selects the source of the trigger signal for the current trigger condition. The trigger source works even if it is not displayed in a diagram. It must be synchronized to the signal to be displayed and analyzed.

The trigger source can be:

- Channel 1...4: An analog input channel
- Extern: External analog signal connected to the external trigger input
  The external trigger source is supported for the "A only" sequence. It is not available if a longer trigger sequence is selected, or if qualification is enabled.
- Line: The instrument generates the trigger from the AC power input and synchronizes the signal to the AC power frequency. Use this source if you want to analyze signals related to the power line frequency, such as lighting equipment and power supply devices.
- Serial bus, D0...D15, Logic, Parallel bus 1...4:
  If options with trigger functionality are installed, the variety of trigger sources of the A-setup is enhanced with specific trigger sources.

Available sources depend on the trigger sequence setting. If "A only" is selected, all inputs (analog input channels, serial and parallel buses, digital channels) can be used as trigger source. If any other trigger sequence is selected, only channel inputs Ch1...4 can be set as trigger source, and all other input sources are disabled. See also: Chapter 5.7, "Sequence", on page 223

Remote command:

`TRIGger<m>:SOURce` on page 942

Type

Selects the trigger type specific for each condition in a trigger sequence. The current trigger type is shown on the button.

The following trigger types are available:

- Edge, see page 194
- Glitch, see page 196
- Width, see page 197
- Runt, see page 199
- Window, see page 201
- Timeout, see page 202
- Interval, see page 203
- Slew Rate, see page 204
- Data2Clock, see page 206
- Serial Pattern, see page 210
- TV/Video Trigger, see page 211

Restrictions:

- If the external trigger input is used as trigger source, the analog edge trigger is the only available trigger type.

Remote command:
`TRIGger<m>:TYPE` on page 943

Find level
Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*. The function is not available for an external trigger source and the TV trigger.

Remote command:
`TRIGger<m>:FINDlevel` on page 945

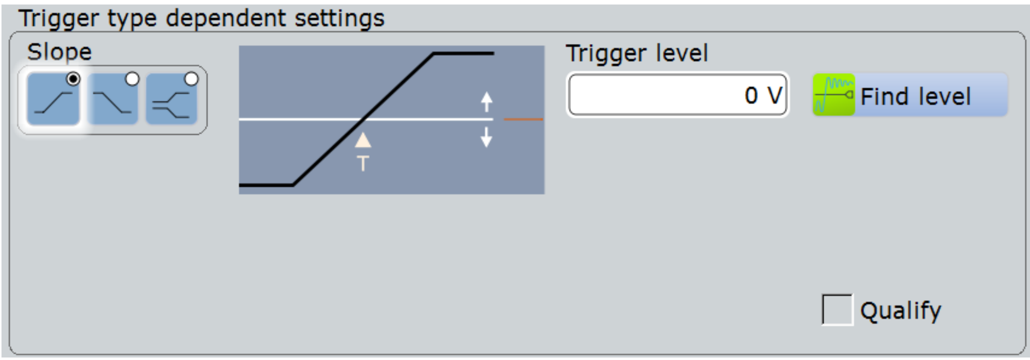
5.3.2 Edge

Access: TRIGGER > "Setup" tab > "Type = Edge"

The edge trigger is the most common trigger type. It is well-known from analog oscilloscopes; and you can use it for analog and digital signals.

The trigger condition is fulfilled when the signal from the trigger source passes the specified threshold voltage in the specified direction (slope).

If the trigger source is a channel signal, the edge trigger uses the digitized trigger signal. This signal can be qualified and filtered with the DSP filter. If the trigger source is the external trigger input, the coupling and filter for this signal is set directly in the trigger setup.



Slope

Sets the edge type for the trigger condition.

"Positive"	Selects the rising edge, that is a positive voltage change.
"Negative"	Selects the falling edge, that is a negative voltage change.
"Both"	Selects the rising as well as the falling edge. This option is not available if the trigger source is the external trigger input.

Remote command:
`TRIGger<m>:EDGE:SLOPe` on page 945
`TRIGger<m>:ANEDge:SLOPe` on page 947
`TRIGger<m>:SLEW:SLOPe` on page 958

Trigger level

Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display).

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 944

5.3.3 Analog Edge

Access: TRIGGER > "Setup" tab > "Source = Extern" > "Type = Analog edge"

This edge trigger is available for trigger signals connected to the external trigger input.

The "Find level" function is not available for external trigger signals.

See also: "External trigger input" on page 189

Ground

If the selected trigger source is the external trigger input, you can connect the trigger input to the ground.

Remote command:
`TRIGger<m>:ANEDge:GND` on page 947

Coupling

If the selected trigger source is the external trigger input, you can set the coupling directly in the trigger configuration.

"DC 50 Ω"	Direct connection with 50 Ω termination, passes both DC and AC components of the trigger signal.
"DC 1 MΩ"	Direct connection with 1 MΩ termination, passes both DC and AC components of the trigger signal.
"AC"	Connection through capacitor, removes unwanted DC and very low-frequency components.

Remote command:
`TRIGger<m>:ANEDge:COUPling` on page 945

Filter
If the selected trigger source is "Extern" (external trigger input), you can directly select a filter to reject high or low frequencies.

For all other trigger sources, you can add a digital filter using the Digital Filter Setup.

"Off"	The trigger signal is not filtered.
"Highpass"	Frequencies below the "Cut-off" frequency are rejected, higher frequencies pass the filter. You can adjust the "Cut-off" frequency, the default is 50 kHz.
"Lowpass"	Frequencies higher than the "Cut-off" frequency are rejected, lower frequencies pass the filter. You can adjust the "Cut-off" frequency, the default is 50 kHz.

Remote command:
TRIGger<m>:ANEDge:FILTer on page 946
TRIGger<m>:ANEDge:CUToff:HIGHpass on page 946
TRIGger<m>:ANEDge:CUToff:LOWPass on page 947

Slope
Sets the edge type for the trigger condition.

"Positive"	Selects the rising edge, that is a positive voltage change.
"Negative"	Selects the falling edge, that is a negative voltage change.
"Both"	Selects the rising as well as the falling edge. This option is not available if the trigger source is the external trigger input.

Remote command:
TRIGger<m>:EDGE:SLOPe on page 945
TRIGger<m>:ANEDge:SLOPe on page 947
TRIGger<m>:SLEW:SLOPe on page 958

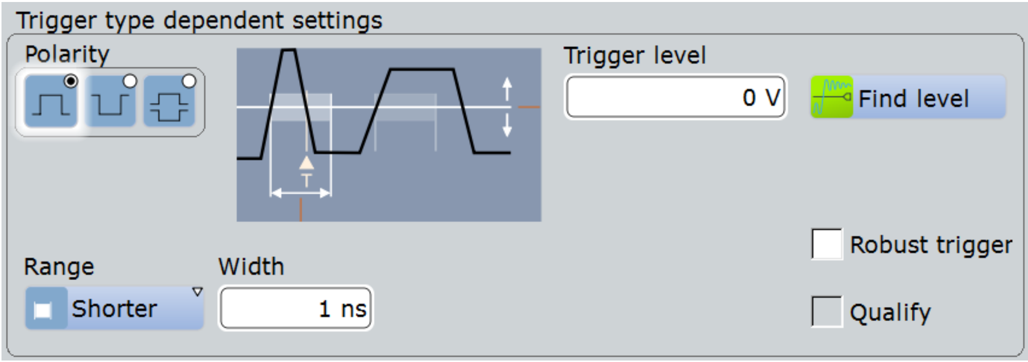
Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
TRIGger<m>:LEVel<n>[:VALue] on page 944

5.3.4 Glitch

Access: TRIGGER > "Setup" tab > "Type = Glitch"

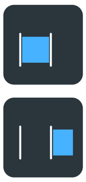
The glitch trigger detects pulses shorter or longer than a specified time. It identifies deviation from the nominal data rate and helps to analyze causes of even rare glitches and their effects on other signals.



Polarity
Indicates the polarity of a pulse, that is the direction of the first pulse slope.

"Positive"	Selects positive going pulses.
"Negative"	Selects negative going pulses.
"Either"	Selects both positive and negative going pulses.

Remote command:
`TRIGger<m>:GLITch:RANGe` on page 948
`TRIGger<m>:RUNT:POLarity` on page 951



Range
Selects which glitches are identified: shorter or longer than the specified "Width".

Remote command:
`TRIGger<m>:GLITch:RANGe` on page 948

Width
Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value. The minimum width is 100 ps.

You need to know the expected pulse widths of the circuit to set the glitch width correctly.

Remote command:
`TRIGger<m>:GLITch:WIDTh` on page 949

Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

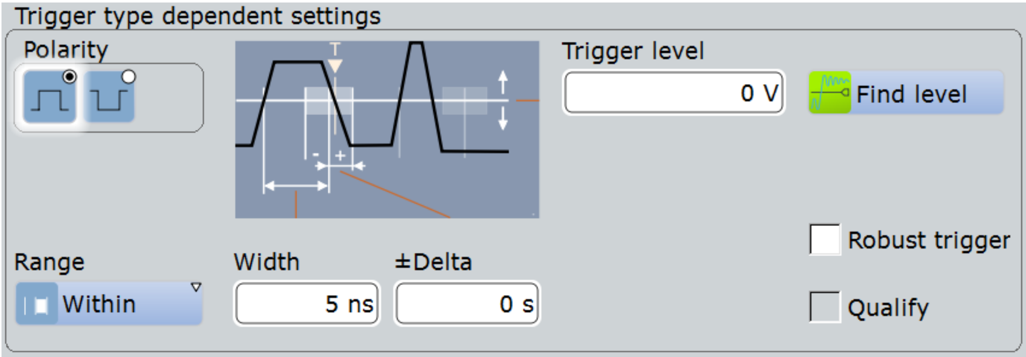
Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 944

5.3.5 Width

Access: TRIGGER > "Setup" tab > "Type = Width"

The width trigger compares the pulse width (duration of a pulse) with a given time limit. It detects pulses with an exact pulse width, pulses shorter or longer than a given time, and pulses inside or outside the allowable time range. The pulse width is measured at the trigger level.

Using the width trigger, you can define the pulse width more precisely than with the glitch trigger. However, using the range settings "Shorter" and "Longer", you can also trigger on glitches.



While the width trigger can only analyze **either** positive **or** negative polarity, searching for a width is also possible for both polarities at the same time ("Either").

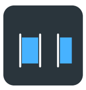
Polarity

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

"Positive" Triggers on positive going pulses.

"Negative" Triggers on negative going pulses.

Remote command:
`TRIGger<m>:WIDTh:POLarity` on page 949



Range

Selects how the range of a pulse width is defined:

"Within" Triggers on pulses inside a given range. The range of the pulse width is defined by "±Delta" related to "Width".

"Outside" Triggers on pulses outside a given range. The range definition is the same as for "Within" range.

"Shorter" Triggers on pulses shorter than the given "Width".

"Longer" Triggers on pulses longer than the given "Width".

Remote command:
`TRIGger<m>:WIDTh:RANGe` on page 949

Width
For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits ±Delta.

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Remote command:
`TRIGger<m>:WIDTh:WIDTh` on page 950

±Delta
Defines a range around the given width value.

The combination "Range" = Within and "±Delta" = 0 triggers on pulses with a pulse width that equals "Width".

The combination "Range" = Outside and "±Delta" = 0 means to trigger on pulse widths ≠ "Width".

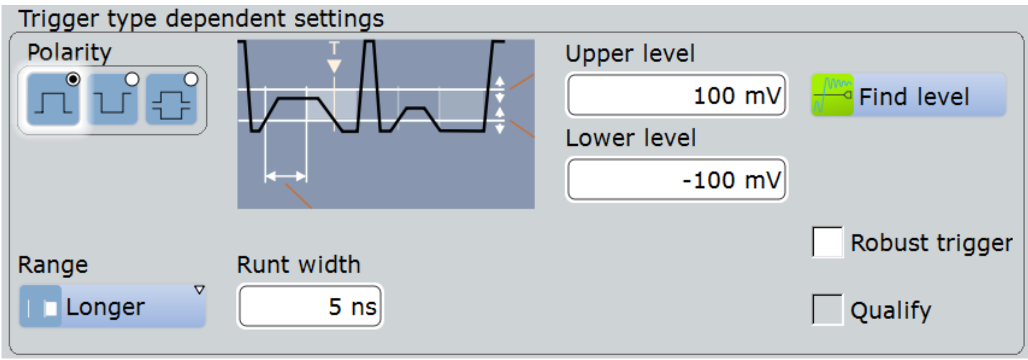
Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 944

5.3.6 Runt

Access: TRIGGER > "Setup" tab > "Type = Runt"

A runt is a pulse lower than normal in amplitude. The amplitude crosses the first threshold twice in succession without crossing the second one. In addition to the threshold amplitudes, you can define a time limit for the runt in the same way as for width triggers. For example, this trigger can detect logic, digital, and analog signals remaining below a specified threshold amplitude because I/O ports are in undefined state.



Polarity
Indicates the polarity of a pulse, that is the direction of the first pulse slope.

"Positive" Selects positive going pulses.

"Negative" Selects negative going pulses.

"Either" Selects both positive and negative going pulses.

Remote command:
`TRIGger<m>:GLITch:RANGe` on page 948
`TRIGger<m>:RUNT:POLarity` on page 951

Upper level
Sets the upper voltage threshold.

Remote command:
`TRIGger<m>:LEVel<n>:RUNT:UPPer` on page 951

Lower level
Sets the lower voltage threshold.

Remote command:
`TRIGger<m>:LEVel<n>:RUNT:LOWer` on page 951

Range
Selects how the time limit of the runt pulse is defined:

"Any runt" Triggers on all runts fulfilling the level condition, without time limitation.

"Longer" Triggers on runts longer than the given "Runt width".

"Shorter" Triggers on runts shorter than the given "Runt width".

"Within" Triggers if the runt length is inside a given time range. The range is defined by "Runt width" and "±Delta".

"Outside" Triggers if the runt length is outside a given time range. The range definition is the same as for "Within" range.

Remote command:
`TRIGger<m>:RUNT:RANGe` on page 952

Runt width
For the ranges "Shorter" and "Longer", the runt width defines the maximum and minimum pulse width, respectively.

For the ranges "Within" and "Outside", the runt width defines the center of a range which is defined by "±Delta".

Remote command:
`TRIGger<m>:RUNT:WIDTh` on page 952

±Delta
Defines a range around the given runt width.

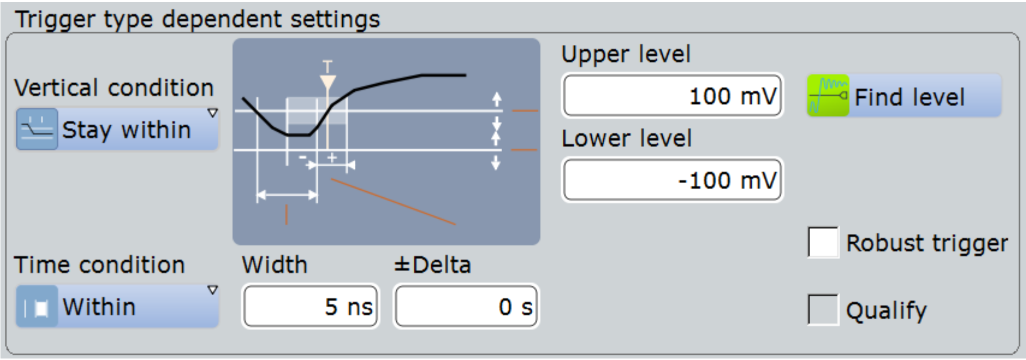
Remote command:
`TRIGger<m>:RUNT:DELTa` on page 953

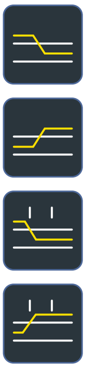
5.3.7 Window

Access: TRIGGER > "Setup" tab > "Type = Window"

The window trigger checks the signal run in relation to a "window". The window is formed by the upper and lower voltage levels. The trigger condition is fulfilled, if the waveform enters or leaves the window, or if the waveform stays inside or outside for a time longer or shorter than specified.

With the window trigger, you can display longer transient effects.





Vertical condition
Selects how the signal run is compared with the window:

"Enter" Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.

"Exit" Triggers when the signal leaves the window.

"Stay within" Triggers if the signal stays between the upper and lower level for a specified time. The time is defined in various ways by the Time condition.

"Stay outside" Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is also defined by the "Time condition".

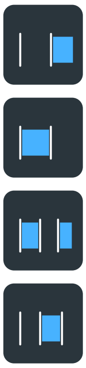
Remote command:
`TRIGger<m>:WINDow:RANGe` on page 954

Upper level
Sets the upper voltage limit for the window.

Remote command:
`TRIGger<m>:LEVel<n>:WINDow:UPPer` on page 953

Lower level
Sets the lower voltage limit for the window.

Remote command:
`TRIGger<m>:LEVel<n>:WINDow:LOWer` on page 954



Time condition

Selects how the time limit of the window is defined. Time conditioning is available for the vertical conditions "Stay within" and "Stay outside".

"Within" — Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width - Delta* and for *Width + Delta* at the most.

"Outside" — "Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width - Delta* or longer than *Width + Delta*.

"Shorter" — Triggers if the signal crosses vertical limits before the specified "Width" time is reached.

"Longer" — Triggers if the signal crosses vertical limits after the specified "Width" time is reached.

Remote command:

`TRIGger<m>:WINDow:TIME` on page 954

Width

For the ranges "Within" and "Outside", the width defines the center of a time range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

Remote command:

`TRIGger<m>:WINDow:WIDTh` on page 955

±Delta

Defines a range around the "Width" value.

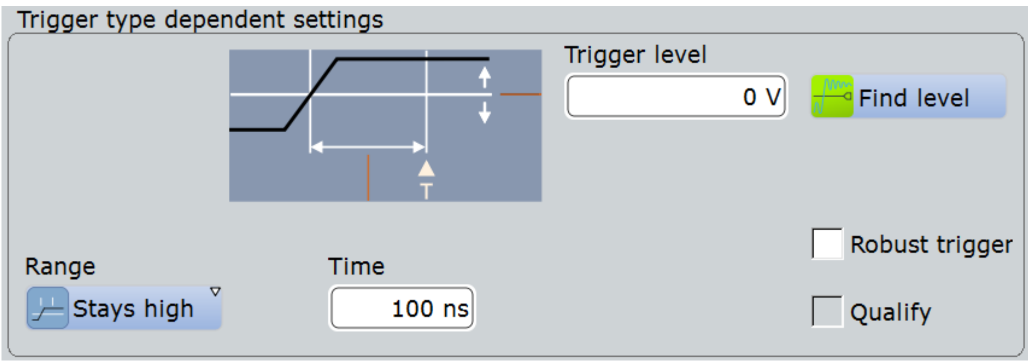
Remote command:

`TRIGger<m>:WINDow:DELTa` on page 955

5.3.8 Timeout

Access: TRIGGER > "Setup" tab > "Type = Timeout"

The timeout trigger checks if the signal stays above or below the threshold voltage for a specified time lapse. In other words, the trigger occurs if the trigger source does not have the expected transition within the specified time.



Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 944

Range
Selects the relation of the signal level to the trigger level:

"Stays high"	The signal level stays above the trigger level.
"Stays low"	The signal level stays below the trigger level.
"High or low"	The signal level stays above or below the trigger level.

Remote command:
`TRIGger<m>:TIMeout:RANGe` on page 956

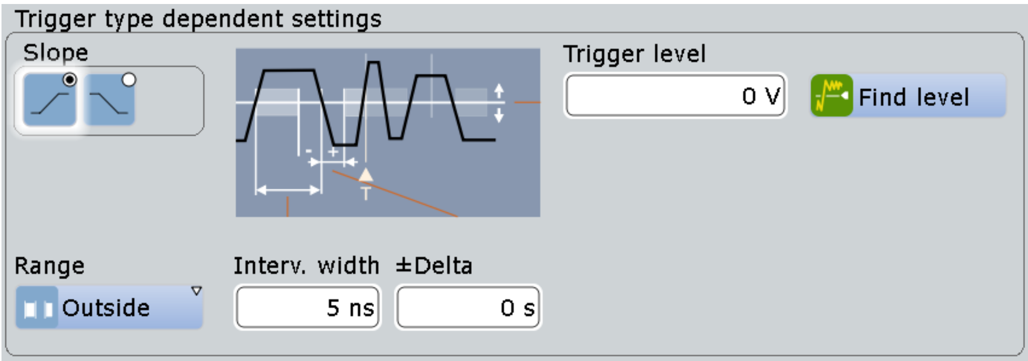
Time
Defines the time limit for the timeout at which the instrument triggers.

Remote command:
`TRIGger<m>:TIMeout:TIME` on page 956

5.3.9 Interval

Access: TRIGGER > "Setup" tab > "Type = Interval"

The interval trigger analyzes the time between two pulses.



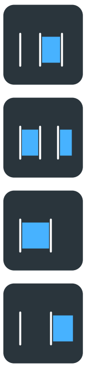
While the interval trigger can only analyze **either** rising **or** falling edges, searching for an interval is also possible for both edges at the same time ("Either").

Slope
Sets the edge for the trigger. You can analyze the interval between positive edges or between negative edges.

Remote command:
`TRIGger<m>:INTerval:SLOPe` on page 957

Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 944



Range
Selects how the range of an interval is defined:

"Within"	Triggers on pulse intervals inside a given range. The range is defined by "Interv. width" and "±Delta".
"Outside"	Triggers on intervals outside a given range. The range definition is the same as for "Within" range.
"Shorter"	Triggers on intervals shorter than the given "Interv. width".
"Longer"	Triggers on intervals longer than the given "Interv. width".

Remote command:
`TRIGger<m>:INTerval:RANGe` on page 957

Interv. width
Defines the time between two pulses.

Remote command:
`TRIGger<m>:INTerval:WIDTh` on page 957

±Delta
Defines a range around the "Interval width" value.

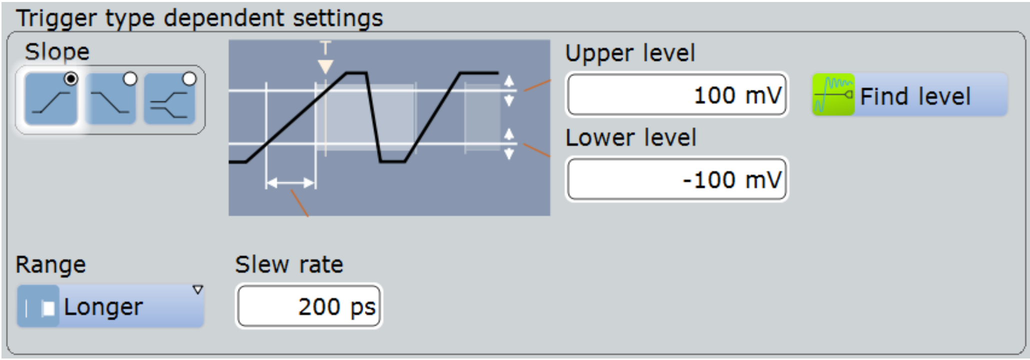
Remote command:
`TRIGger<m>:INTerval:DELTa` on page 958

5.3.10 Slew Rate

Access: TRIGGER > "Setup" tab > "Type = Slew rate"

The slew rate trigger is also known as transition trigger. It triggers if the transition time from the lower to higher voltage level (or vice versa) is shorter or longer as defined, or outside or inside a specified time range.

The slew rate trigger finds slew rates faster than expected or permissible to avoid overshooting and other interfering effects. It also detects slow edges violating the timing in pulse series.



Slope

Sets the edge type for the trigger condition.

"Positive" Selects the rising edge, that is a positive voltage change.

"Negative" Selects the falling edge, that is a negative voltage change.

"Both" Selects the rising as well as the falling edge. This option is not available if the trigger source is the external trigger input.

Remote command:
TRIGger<m>:EDGE:SLOPe on page 945
TRIGger<m>:ANEDge:SLOPe on page 947
TRIGger<m>:SLEW:SLOPe on page 958

Upper level

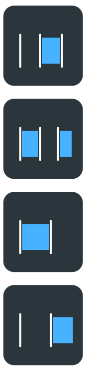
Sets the upper voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:
TRIGger<m>:LEVel<n>:SLEW:UPPer on page 959

Lower level

Sets the lower voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:
TRIGger<m>:LEVel<n>:SLEW:LOWer on page 959



Range

Selects how the time limit for the slew rate is defined. The time measurement starts when the signal crosses the first trigger level - the upper or lower level depending on the selected slope. the measurements stops when the signal crosses the second level.

"Within" Triggers on slew rates inside a given time range. The range is defined by "Slew rate" and "±Delta".

"Outside" Triggers on slew rates outside a given time range. The range definition is the same as for "Within" range.

"Shorter" Triggers on slew rates shorter than the given "Slew rate" limit.

"Longer" Triggers on slew rates longer than the given "Slew rate" limit.

Remote command:
TRIGger<m>:SLEW:RANGe on page 959

Slew rate
For the ranges "Within" and "Outside", the slew rate defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the slew rate defines the maximum and minimum slew rate limits, respectively.

Remote command:
TRIGger<m>:SLEW:RATE on page 960

±Delta
Defines a time range around the given slew rate.

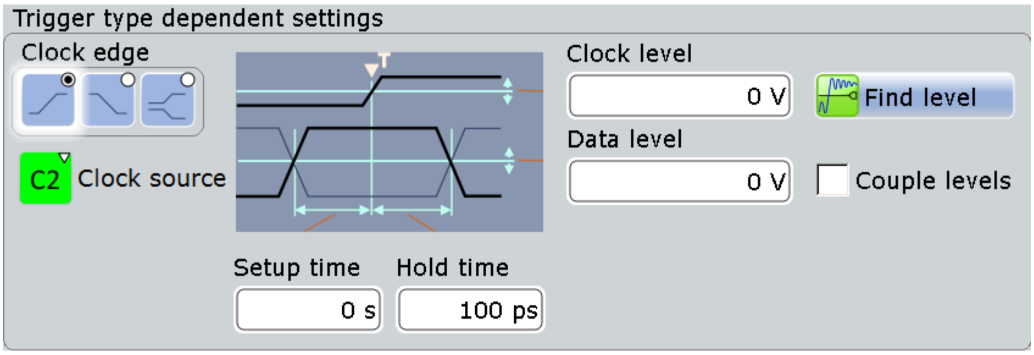
Remote command:
TRIGger<m>:SLEW:DELTa on page 960

5.3.11 Data2Clock

Access: TRIGGER > "Setup" tab > "Type = Data2Clock"

With the Data2Clock trigger - also known as setup/hold trigger - you can analyze the relative timing between two signals: a data signal and the synchronous clock signal. Many systems require, that the data signal must be steady for some time before and after the clock edge, for example, the data transmission on parallel interfaces. With this trigger type, you can also test the time correlation of sideband and in-band signals.

The trigger occurs if the data signal crosses the data level during the setup and hold time. The reference point for the time measurement is defined by clock level and clock edge.



Clock source
Selects the input channel of the clock signal.

Remote command:
TRIGger<m>:DATatoclock:CSOurce[:VALue] on page 961
TRIGger<m>:SPATtern:CSOurce[:VALue] on page 968

Clock edge
Sets the edge of the clock signal to define the time reference point for the setup and hold time:

"Positive"	Rising edge, a positive voltage change.
"Negative"	Falling edge, a negative voltage change.
"Both"	Both the rising and the falling edge.

Remote command:
`TRIGger<m>:DATatoclock:CSOurce:EDGE` on page 961

Clock level
Sets the voltage level for the clock signal. Both "Clock level" and "Clock edge" define the starting point for calculation of the setup and hold time.

Remote command:
`TRIGger<m>:DATatoclock:CSOurce:LEVel` on page 961

Data level
Sets the voltage level for the data signal. At this level, the setup and hold time is measured.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 944

Couple levels (Trigger level and hysteresis coupling)
Sets the trigger levels and hysteresis values for all channels to the values of the currently selected trigger source. The function affects only the levels defined for the selected condition. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.

Remote command:
`TRIGger<m>:SCOupling` on page 962

Setup time
Sets the minimum time **before** the clock edge while the data signal must stay steady above or below the data level.

The setup time can be negative. In this case, the hold time is always positive. If you set a negative setup time, the hold time is adjusted by the instrument.

Remote command:
`TRIGger<m>:DATatoclock:STIMe` on page 962

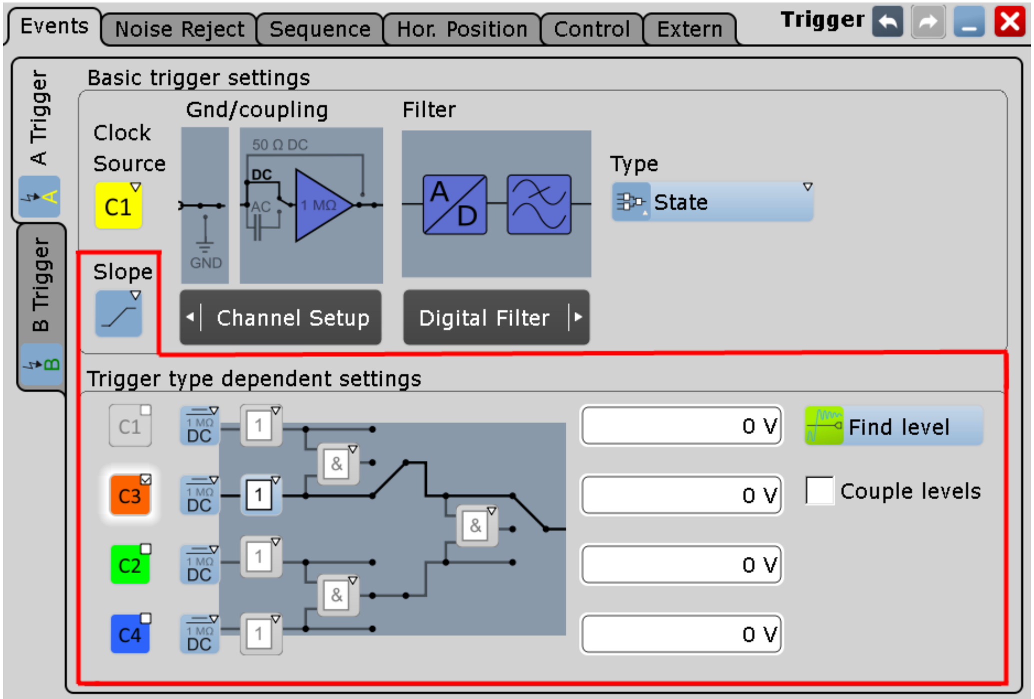
Hold time
Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

The hold time can be negative. In this case, the setup time is always positive. If you set a negative hold time, the setup time is adjusted by the instrument.

Remote command:
`TRIGger<m>:DATatoclock:HTIMe` on page 962

5.3.12 State

The state trigger is a qualified edge trigger. It combines the edge trigger settings with trigger qualification.



The individual settings are:

- "Slope" on page 195
- "Pattern" on page 208
- "Trigger Levels" on page 209
- "Find level" on page 194
- "Couple levels (Trigger level and hysteresis coupling)" on page 207

Robust triggering is not relevant for the state trigger.

5.3.13 Pattern

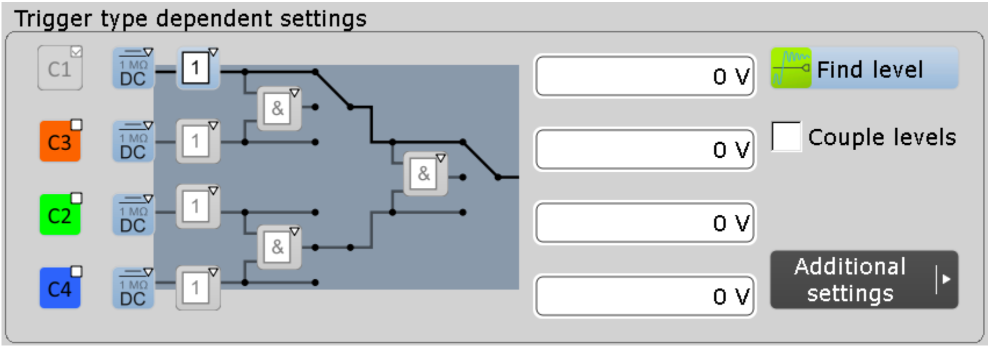
Access: TRIGGER > "Setup" tab > "Type = Pattern"

The pattern trigger is a logic trigger. It provides logical combinations of the input channels and supports you in verifying the operation of digital logic.

The setup of the pattern trigger is similar to trigger qualification. In addition to the pattern and the trigger levels, you can define a timing condition. The complete settings for the pattern trigger are provided in the "Qualification" tab.

Pattern

The pattern contains the channel selection, and the logical operations structure of hardware based boolean logic.



"Channel" Select the channels to be considered. For qualification, you can select all channel signals except for the trigger source. In Pattern trigger setup, the trigger source channel is selected by default, and you can select all other channel signals.

"Coupling" The current coupling or ground connection is shown for each channel and can be changed directly in the pattern, if necessary.

"Boolean operator" Defines the logical operation on the digital signal resulting from the comparison with the trigger level.

- 1 "Direct": leaves the input value unchanged
- 1 "NOT": inverts the input value

"Logical operator" defines the logic combination of two sources. The sources are channel 1/2 and channel 3/4 on the first step, and in the second step the logical combination resulting from the first step.

- & "AND": logical AND, conjunctive combination
- & "NAND": logical NOT AND
- ≥1 "OR": logical OR, disjunctive combination
- ≥1 "NOR": logical NOT OR

Remote command:
`TRIGger<m>:QUALify<n>:A:LOGic` on page 963
`TRIGger<m>:QUALify<n>:A[:ENABle]` on page 963
`TRIGger<m>:QUALify<n>:AB:LOGic` on page 964
`TRIGger<m>:QUALify<n>:ABCD:LOGic` on page 964
`TRIGger<m>:QUALify<n>:B:LOGic` on page 963
`TRIGger<m>:QUALify<n>:B[:ENABle]` on page 963
`TRIGger<m>:QUALify<n>:C:LOGic` on page 964
`TRIGger<m>:QUALify<n>:C[:ENABle]` on page 963
`TRIGger<m>:QUALify<n>:CD:LOGic` on page 964
`TRIGger<m>:QUALify<n>:D:LOGic` on page 964
`TRIGger<m>:QUALify<n>:D[:ENABle]` on page 963

Trigger Levels
Define the trigger level for each input channel. For qualification and pattern trigger, the trigger level is a decision threshold: If the signal value is higher than the trigger level, the signal state is high (1 or true for the boolean logic). Otherwise, the signal state is considered low (0 or false) if the signal value is below the trigger level.

You can set the trigger levels for all channels to the same value, see "Couple levels (Trigger level and hysteresis coupling)" on page 207.

Additional settings: Timing
"State timing" adds time limitation to the state pattern. You find this setting in the "Qualification" tab.

"Off" No time limitation. The trigger occurs if the pattern condition is fulfilled.

"Timeout" Defines how long the result of the state pattern condition must be true or false.

"Width" Defines a time range for keeping up the true result of the state pattern condition. The range is defined in the same way as for width and interval triggers, see "Range" on page 198.

Remote command:
`TRIGger<m>:PATTern:MODE` on page 965
`TRIGger<m>:PATTern:TIMeout:MODE` on page 966
`TRIGger<m>:PATTern:TIMeout[:TIME]` on page 966
`TRIGger<m>:PATTern:WIDTh:DELTa` on page 967
`TRIGger<m>:PATTern:WIDTh:RANGe` on page 967
`TRIGger<m>:PATTern:WIDTh[:WIDTh]` on page 967

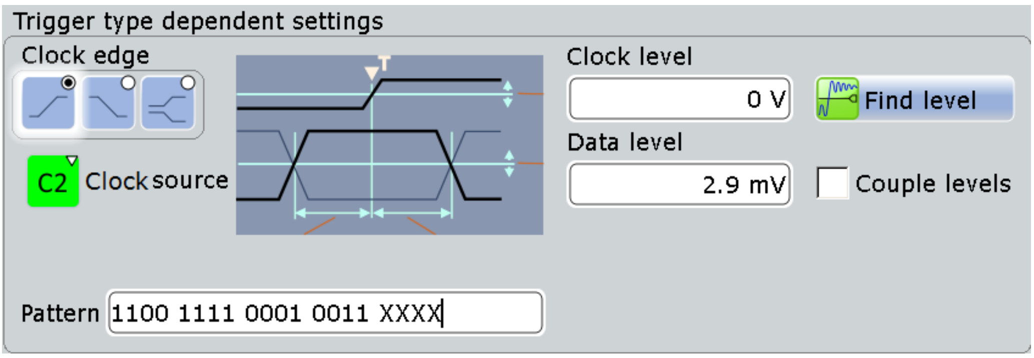
5.3.14 Serial Pattern

Access: TRIGGER > "Setup" tab > "Type = Serial Pattern"

The serial pattern is used to trigger on signals with serial data patterns in relation to a clock signal - for example, on bus signals like the I²C bus.

The instrument expects the bits coming in LSB first order. A triggered waveform in the diagram shows the LSB on the left and the MSB on the right side.

For convenient and comprehensive triggering on specific serial data, options for serial protocol analysis are provided, see Chapter 12, "Protocol Analysis", on page 438.



Clock source
Selects the input channel of the clock signal.

Remote command:
TRIGger<m>:DATatoclock:CSOurce[:VALue] on page 961
TRIGger<m>:SPATtern:CSOurce[:VALue] on page 968

Clock edge
Together with the clock level, the clock edge sets the point in time when the state of the data signal is checked:

"Positive"	Rising edge, a positive voltage change.
"Negative"	Falling edge, a negative voltage change.
"Both"	Both the rising and the falling edge.

Remote command:
TRIGger<m>:SPATtern:CSOurce:EDGE on page 968

Clock level
Sets the voltage level for the clock signal.

Remote command:
TRIGger<m>:SPATtern:CSOurce:LEVel on page 969

Data level
Sets the voltage level for the data signal.

If the signal value is higher than the data level, the state is 1. Below the level, the signal state is 0.

Remote command:
TRIGger<m>:LEVel<n>[:VALue] on page 944

Couple levels (Trigger level and hysteresis coupling)
Sets the trigger levels and hysteresis values for all channels to the values of the currently selected trigger source. The function affects only the levels defined for the selected condition. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.

Remote command:
TRIGger<m>:SCOupling on page 962

Pattern
The pattern contains the bits of the serial data to be found in the data stream. The maximum length of the pattern is 128 bit. Touch and hold the "Pattern" field to open the "Bit Pattern Editor" where you can enter the pattern in various formats.

In binary format, an *X* indicates that the logical level for the bit is not relevant (don't care).

Remote command:
TRIGger<m>:SPATtern:PATTern on page 969

5.3.15 TV/Video Trigger

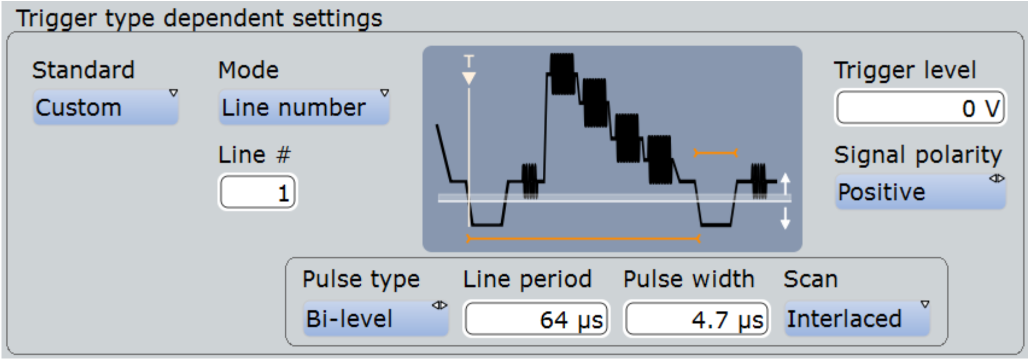
Access: TRIGGER > "Setup" tab > "Type = TV"

The TV or video trigger is used to analyze analog baseband video signals. You can trigger on baseband video signals from standard definition and high definition standards, and also on user defined signals.

The instrument triggers on the line start - the horizontal sync pulse. You can trigger on all lines, or specify a line number. You can also trigger on the field or frame start.

Additionally, a delay can be set: Set the "Holdoff events" in the "Holdoff" tab to the number of fields to be skipped. See also: Chapter 5.4, "Holdoff", on page 216.

Make sure that the trigger level crosses the synchronizing pulses of the video signal, see "Trigger level" on page 214.



Most video signals have an output impedance of 75 Ω. The channel inputs of the R&S RTE have an input impedance of 50 Ω or 1 MΩ. Make sure to provide the adequate matching to ensure amplitude fidelity. A simple 75 Ω feed-through termination combined with 1 MΩ oscilloscope inputs is suitable for most applications.

Once the trigger is set correctly, you can use cursor and automatic measurements to perform amplitude and timing measurements.

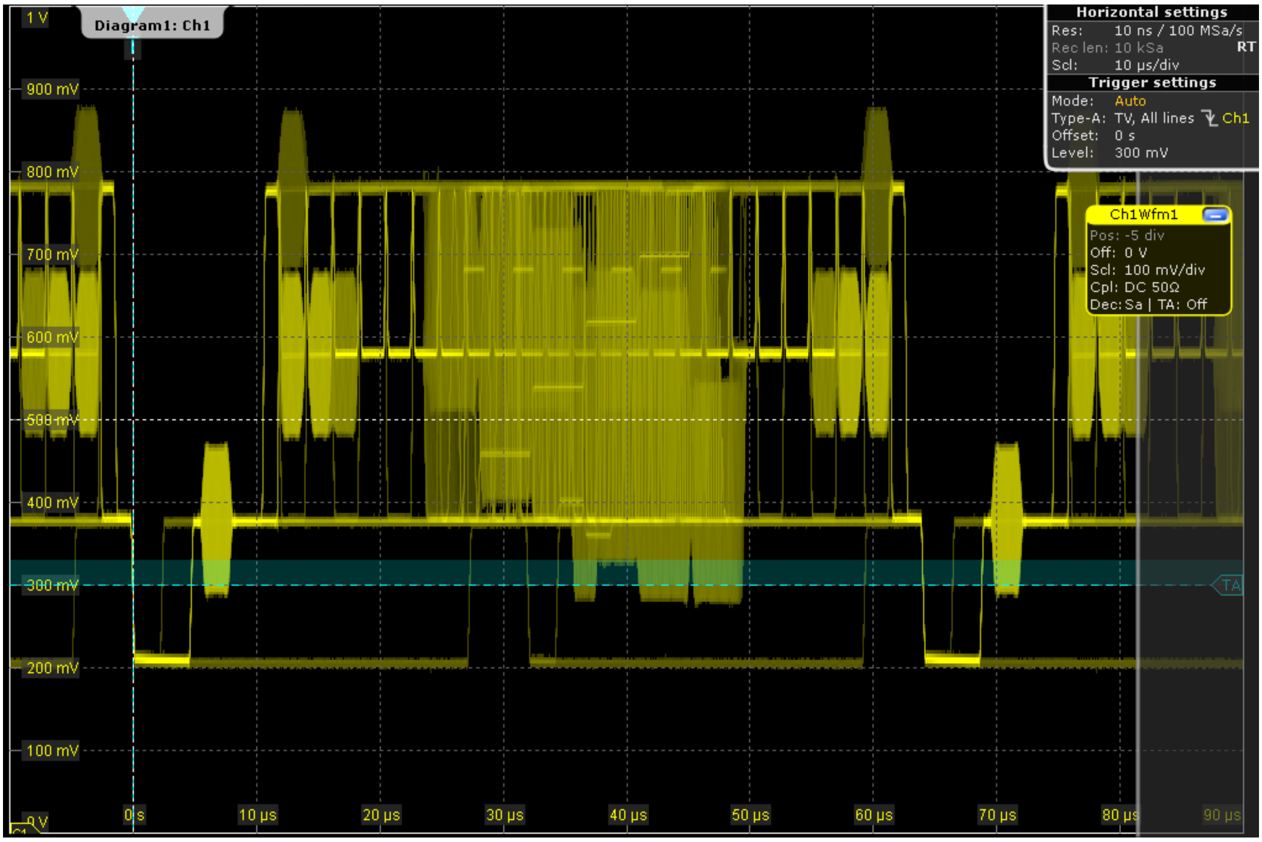


Figure 5-1: Trigger on all lines of a PAL signal with positive signal polarity, trigger level = 300 mV

Standard

Selects the TV standard or "Custom" for user-defined signals.

HDTV standards are indicated by the number of active lines, the scanning system (p for progressive scanning, i for interlaced scanning) and the frame rate. For interlaced scanning, the field rate is used instead of the frame rate. 1080p/24sF is an HDTV standard using progressive segmented frame scanning.

"Custom" can be used for signals of other video systems, for example, medical displays, video monitors, and security cameras. To trigger on these signals, you have to define the pulse type and length of the sync pulse, the scanning system and the line period.

Remote command:
`TRIGger<m>:TV:STANdard` on page 969

Mode

Selects the lines or fields on which the instrument triggers. Available modes depend on the scanning system of the selected standard.

"All fields" Triggers on the first video line of the frame (progressive scanning) or field (interlaced scanning), for example, to find amplitude differences between the fields.

"Odd fields / Even fields"	Triggers on the first video line of the odd or even field. These modes are available for interlaced scanning (PAL, PAL-M, SECAM, NTSC, 1080i) and progressive segmented frame scanning (1080p/24sF). They can be used, for example, to analyze the components of a video signal.
"All lines"	Triggers on the line start of all video lines, for example, to find maximum video levels.
"Line number"	Triggers on a specified line. Enter the line number in "Line #".

Remote command:
`TRIGger<m>:TV:MODE` on page 970

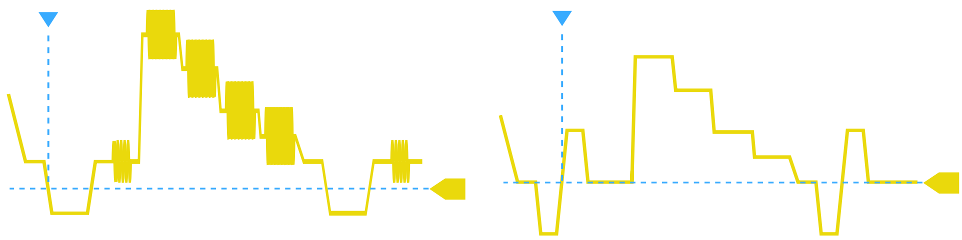
Line #
Sets the number of the line to be triggered on if "Mode" is set to "Line number". Usually the lines of the frame are counted, beginning from the frame start.

For NTSC signals, the lines are counted per field, not per frame. Therefore, you have to set the "Field" (odd or even), and the line number in the field.

Remote command:
`TRIGger<m>:TV:LINE` on page 971
`TRIGger<m>:TV:LFIeld` on page 972

Trigger level
Sets the trigger level as threshold for the sync pulse. Make sure that the trigger level crosses the synchronizing pulses of the video signal.

The hysteresis is set according to the settings in the "Noise Reject" tab.



Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 944

Signal polarity
Sets the polarity of the signal. Note that the sync pulse has the opposite polarity, for example, a positive signal has a negative sync pulse.

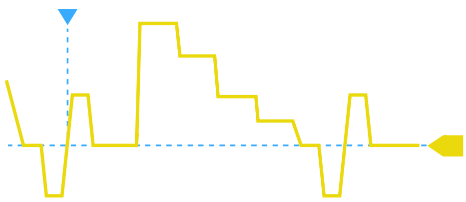


Figure 5-2: Signal with positive polarity and tri-level sync pulse

Remote command:
TRIGger<m>:TV:POLarity on page 971

Pulse type
Sets the type of the sync pulse, either bi-level sync pulse (used in SDTV signals), or tri-level sync pulse (used in HDTV signals).

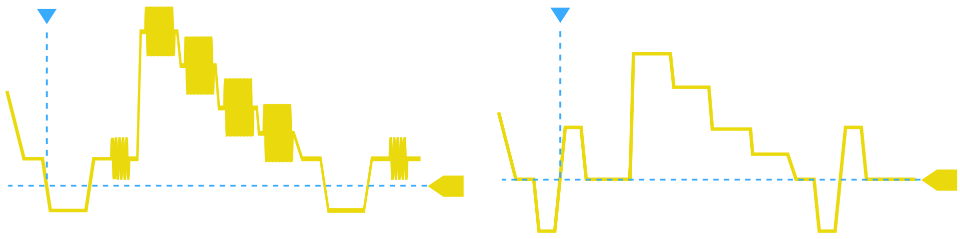
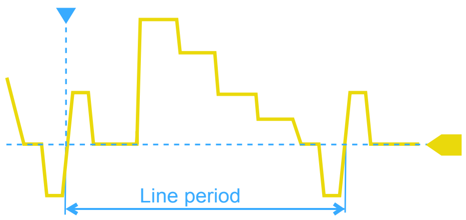


Figure 5-3: Bi-level (left) and tri-level (right) sync pulses

This setting is available for user-defined video signals if "Standard" is set to "Custom".

Remote command:
TRIGger<m>:TV:CUSTom:STYPe on page 973

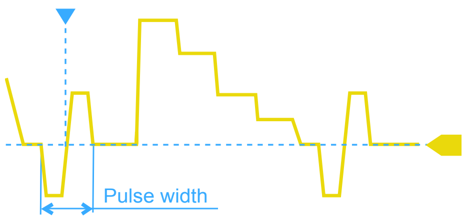
Line period
Sets the duration of a single video line, the time between two successive sync pulses.



This setting is available for user-defined video signals if "Standard" is set to "Custom".

Remote command:
TRIGger<m>:TV:CUSTom:LDURation on page 973

Pulse width
Sets the width of the sync pulse.



This setting is available for user-defined video signals if "Standard" is set to "Custom".

Remote command:
TRIGger<m>:TV:CUSTom:SDURation on page 974

Scan

Sets the scanning system.

This setting is available for user-defined video signals if "Standard" is set to "Custom".

"Interlaced"	Interlace scanning uses two fields to create a frame. One field contains all the odd lines (odd, first, or upper filed), the other contains all the even lines of the image (even, second, or lower field). First the lines of the odd filed are processed, then the lines of the even field.
"Progressive"	Progressive scanning is a method to capture, transmit and display all lines of a frame in sequence.
"Segmented"	Progressive segmented frame uses progressive scanning to capture the frame, and interlaced scanning for transmission and display.

Remote command:

`TRIGger<m>:TV:CUSTom:SCANmode` on page 973

5.3.16 Triggering on Serial Buses

Protocol analysis including configuration, triggering, and decoding is described in Chapter 12, "Protocol Analysis", on page 438

For information on triggering on serial buses, see:

- Chapter 12.2.3, "I²C Trigger", on page 450
- Chapter 12.3.3, "SPI Trigger", on page 468
- Chapter 12.4.3, "UART Trigger", on page 480
- Chapter 12.6.3, "LIN Trigger", on page 526
- Chapter 12.5.2, "CAN / CAN FD Trigger", on page 489
- Chapter 12.7.2, "FlexRay Trigger", on page 540
- Chapter 12.9.3, "MIL-STD-1553 Trigger ", on page 579
- Chapter 12.10.3, "ARINC 429 Trigger", on page 598

5.3.17 Triggering on Parallel Buses and Digital Channels

Triggering on digital signals requires the Mixed Signal Option. The option is described in Chapter 13, "Mixed Signal Option (MSO, R&S RTE-B1)", on page 750.

For information on triggering, see Chapter 13.3.1, "Trigger Settings for Digital Signals and Parallel Buses", on page 761.

5.4 Holdoff

Access: "Trigger" menu > "Holdoff"

Holdoff conditions define a waiting time after the current trigger until the next trigger can be recognized.

Holdoff mode

Selects the method to define the holdoff condition.

The trigger holdoff defines when the next trigger after the current will be recognized. Thus, it affects the next trigger to occur after the current one. Holdoff helps to obtain stable triggering when the oscilloscope is triggering on undesired events.

Holdoff settings are not available if the trigger source is an external trigger input or serial bus. For the TV trigger, only the "Events" mode is useful.

Example:

You want to analyze the first pulse in a burst of several pulses. At first, you select a sufficiently slow time base to display the entire burst. Then, you set the holdoff time a little longer than the length of the burst. Now, each trigger corresponds to the first pulse in successive bursts, and you can change the time base to display the waveform in more detail.

The following methods are available:

"Time"	Defines the holdoff directly as a time period. The next trigger occurs only after the "Holdoff time" has passed.
"Events"	Defines the holdoff as a number of trigger events. The next trigger only occurs when this number of events is reached. The number of triggers to be skipped is defined in "Holdoff events".
"Random"	Defines the holdoff as a random time limited by "Random minimum time" and "Random maximum time". For each acquisition cycle, the instrument selects a new random holdoff time from the specified range. Random holdoff prevents synchronization to discover effects invisible with synchronized triggering, for example, the features of a pulse train.
"Auto"	The holdoff time is calculated automatically based on the current horizontal scale. "Auto time scaling" defines the factor the horizontal scale is multipied with. "Auto time" shows the resulting holdoff time: *Auto time = Auto time scaling * Horizontal scale*.
"Off"	No holdoff

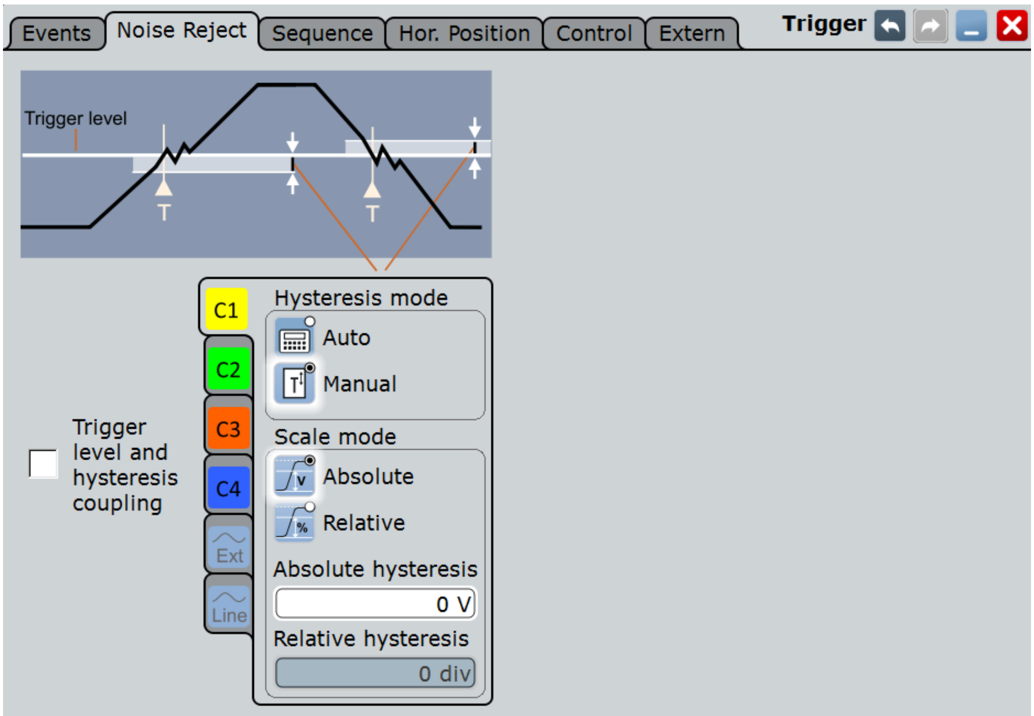
Remote command:

`TRIGger<m>:HOLDoff:MODE` on page 974
`TRIGger<m>:HOLDoff:TIME` on page 975
`TRIGger<m>:HOLDoff:EVENts` on page 976
`TRIGger<m>:HOLDoff:MAX` on page 976
`TRIGger<m>:HOLDoff:MIN` on page 976
`TRIGger<m>:HOLDoff:AUTotime?` on page 977
`TRIGger<m>:HOLDoff:SCALing` on page 977

5.5 Noise Reject

The rejection of noise by setting a hysteresis avoids unwanted trigger events caused by noise oscillation around the trigger level.

You can select the hysteresis mode and value for each channel separately, or couple the trigger levels and set the same hysteresis for channels. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.



Hysteresis mode

Selects how the hysteresis is set.

"Auto"	This is the recommended mode. The hysteresis is set by the instrument to reject the internal noise of the instrument.
"Manual"	The hysteresis is defined directly in absolute or relative values.

Remote command:

`TRIGger<m>:LEVel<n>:NOISe[:STATe]` on page 978

Scale mode

Selects whether the hysteresis is defined in absolute or relative values. The setting is available only in manual hysteresis mode.

Remote command:

`TRIGger<m>:LEVel<n>:NOISe:MODE` on page 978

Absolute hysteresis

Defines a range in absolute values around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs.

Remote command:
`TRIGger<m>:LEVel<n>:NOISe:ABSolute` on page 979

Relative hysteresis
Defines a range in divisions around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs.

Remote command:
`TRIGger<m>:LEVel<n>:NOISe:RELative` on page 979

Noise reject (external trigger)
Enables the noise reject for the external trigger input.

Remote command:
`TRIGger<m>:ANEDge:NREJect` on page 980

Couple levels (Trigger level and hysteresis coupling)
Sets the trigger levels and hysteresis values for all channels to the values of the currently selected trigger source. The function affects only the levels defined for the selected condition. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.

Remote command:
`TRIGger<m>:SCOupling` on page 962

5.6 Control / Action

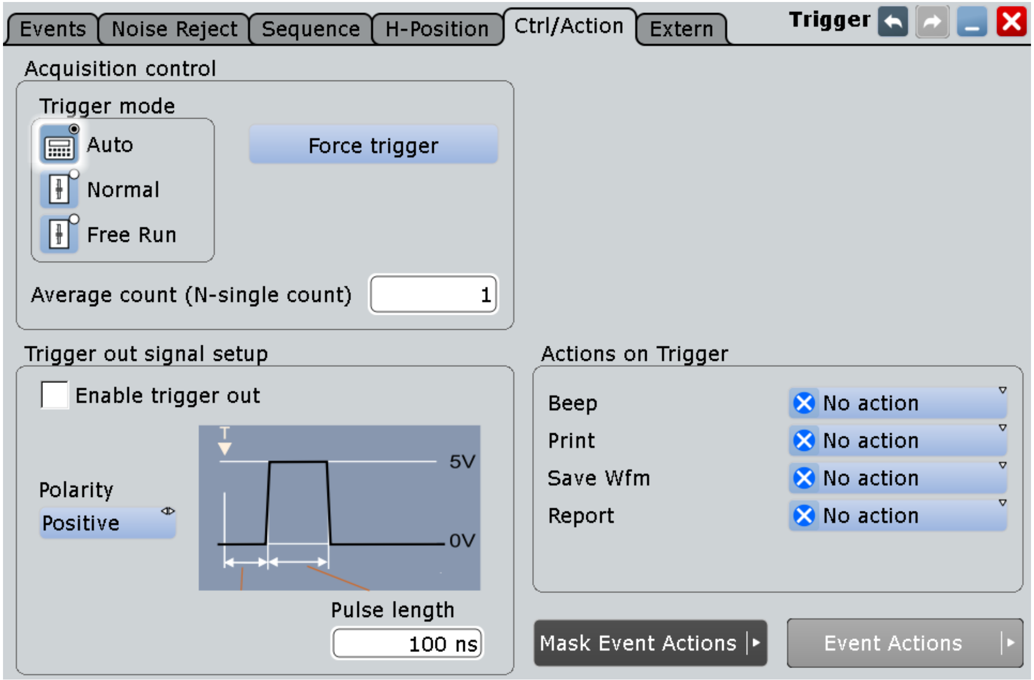
Access: TRIGGER > "Ctrl/Action" tab

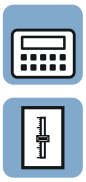
The settings and functions of trigger control define when the instrument triggers. They affect all trigger types and all triggers in a trigger sequence.

In addition to the settings in the dialog box, you need the RUN CONT and RUN N× SINGLE keys on the front panel to start and stop the acquisition and thus the triggering.

The action settings define what happens when a trigger occurs. All available actions can be initiated at the same time.

The R&S RTE can provide an external trigger signal to synchronize the measurements of other instruments. The trigger out signal is also adjusted and enabled in the "Control" tab.





Trigger mode

Sets the trigger mode which determines the behavior of the instrument if no trigger occurs. The current setting is shown on the trigger label on top of the signal bar.

To toggle quickly between "Auto" and "Normal" mode, use the MODE key on the front panel (in "Trigger" section).

"Auto"	The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. This mode helps to see the waveform even before the trigger conditions are set correctly. The waveform on the screen is not synchronized, and successive waveforms are not triggered at the same point of the waveform. The time interval depends on the time base settings.
"Normal"	The instrument acquires a waveform only if a trigger occurs, that is, if all trigger conditions are fulfilled. If no trigger occurs, no waveform is acquired and the last acquired waveform is displayed. If no waveform was captured before, none is displayed. When no trigger has been found for longer than one second, a message box appears that shows the time elapsed since the last trigger.
"Free Run"	The instrument starts acquisition immediately and triggers after a very short time interval independet of the time base settings and faster than in "Auto" mode. Real triggers are ignored. Use this mode if the "Auto" mode is too slow.

Remote command:

`TRIGger<m>:MODE` on page 982

Acquisition/average count

Access:
- TRIGGER > "Control" tab > "Average count (N-single count)"
- ACQUISITION > "Average count"
- HORIZONTAL > "Ultra Segmentation" tab > disable "Acquire maximum" > "Required"
- MATH > "Setup" tab > "Average count"

The acquisition and average count has several effects:
- It sets the number of waveforms acquired with RUN N× SINGLE
- It defines the number of waveforms used to calculate the average waveform. Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the value is, the better the noise is reduced.
- It sets the number of acquisitions to be acquired in an ultra segmentation acquisition series. Thus, you can acquire exactly one ultra segmentation acquisition series with RUN N× SINGLE.
  If ultra segmentation is enabled and configured to acquire the maximum number of acquisitions, the acquisition count is set to that maximum number and cannot be changed. See also: "Number of acquisitions" on page 159.
- It is the "Finished" criteria for the state of a mask test.

Remote command:
`ACQuire:COUNt` on page 917

Force Trigger

If the acquisition is running in normal mode and no valid trigger occurs, forcing the trigger provokes an immediate single acquisition. Thus you can confirm that a signal is available and use the waveform display to determine how to trigger on it.

Remote command:
`TRIGger<m>:FORCe` on page 982

RUN CONT / RUN N× SINGLE

Front panel keys to start and stop a continuous acquisition or a defined number of acquisition cycles, respectively. The number of acquisitions is set with "Average count".

Remote command:
`RUN` on page 909
`SINGle` on page 909
`STOP` on page 909

Trigger out signal setup

Defines the pulse that is provided to the TRIGGER OUTPUT connector on the rear panel.

A trigger out pulse can be provided either when a trigger occurs, or when a mask test violaton occurs, or when a limit check violation in a measurement occurs.

"Enable trigger out"	Generates the trigger out signal on trigger event. The setting is not available if ● A mask test is running with "Trigger Out Pulse" set to "On violation". ● A measurement running with limit check enabled and "Trigger Out Pulse" set to "On violation".
"Polarity"	Sets the polarity of the trigger out pulse, that is the direction of the first pulse edge.
"Pulse length"	Sets the length of the trigger out pulse.
"Delay"	Sets the delay of the first pulse edge to the trigger point. The setting is only available if "Enable trigger out" is active.

Remote command:
`TRIGger<m>:OUT:STATe` on page 982
`TRIGger<m>:OUT:POLarity` on page 983
`TRIGger<m>:OUT:PLENgth` on page 983
`TRIGger<m>:OUT:DELay` on page 983

Show trigger lines permanently

Displays the trigger levels and the hysteresis in the diagrams until you disable this option.

Remote command:
`DISPlay:TRIGger:LINes` on page 942

Hysteresis transparency

Defines the transparency of the hysteresis area above or below the trigger level. The hysteresis is only visible if "Show trigger lines permanently" is enabled.

Actions on trigger

The trigger can initiate several actions, each time a trigger occurs. To activate an action, set it to "On trigger". The following actions are available:

"Beep"	Generates a beep sound.
"Print"	Saves a screenshot according to settings in "File" menu > "Print Setup".
"Save Wfm"	Saves the waveform data to a file according to settings in FILE > "Waveform / Results" > "Waveforms".
"Report"	Creates and saves a report using the settings defined in "File" menu > "Report Setup".

Remote command:
`TRIGger<m>:EVENt:BEEP` on page 984
`TRIGger<m>:EVENt:PRINt` on page 984
`TRIGger<m>:EVENt:WFMSave` on page 984

5.7 Sequence

A trigger sequence consists of at least one trigger condition and additional conditions defining when the trigger occurs.

The simple sequence "A only" only contains the A-trigger condition.

The complex trigger sequence "A → B" consists of two subsequent conditions - A and B.

After the A-trigger conditions have been met, and an optional delay has passed, the B-trigger with independent conditions is enabled. A- and B-triggers are configured in the same way.

The instrument waits until one or a specified number of B-trigger conditions occur. The last B-trigger causes the trigger event, and then the sequence starts again. The B-trigger can only cause the trigger event if it occurs after the A-trigger and after the delay time.

The complex trigger sequence requires that input channels CH1...4 are set as trigger sources for all conditions. All other input sources are disabled.

The "A → B" sequence is not available for the following trigger types.

- Data2Clock
- TV

The instrument checks the trigger settings for compatibility and disables settings that do not fit the previous settings in the sequence.

See also: Chapter 5.2.4, "Setting Up a Trigger Sequence", on page 191.

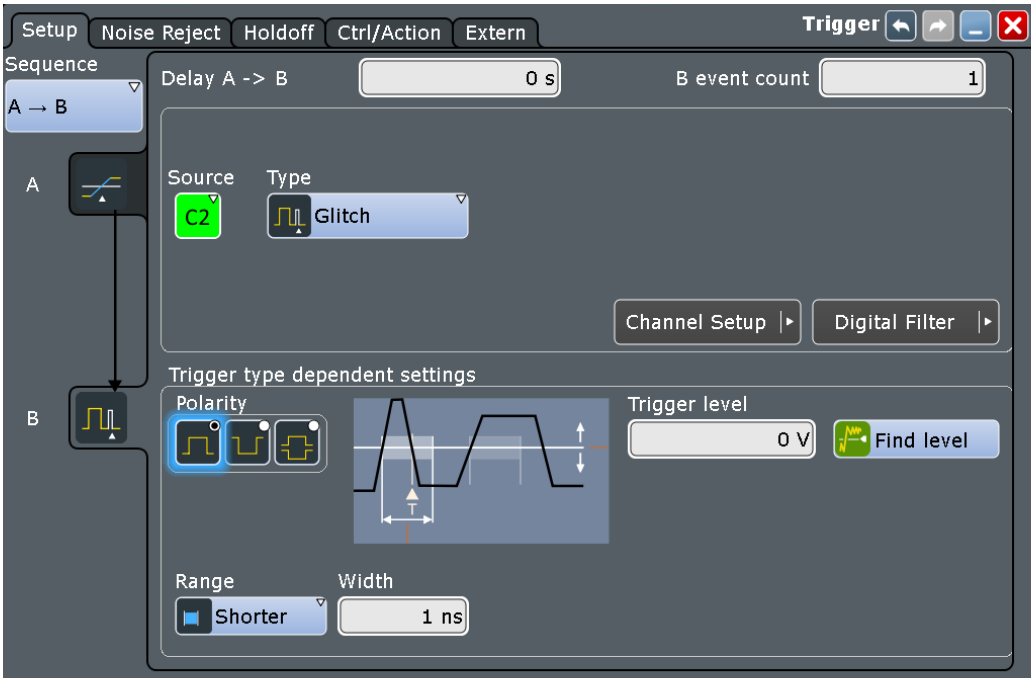
Remote command:

- `TRIGger<m>:SEQuence:MODE` on page 980

5.7.1 B-Trigger Setup

Access: TRIGGER > "Setup" tab > "A → B" sequence > "B" subtab

The B-trigger is the second condition of the trigger sequence. You can configure a delay between the A- and B-trigger, and define a number of fulfilled B-trigger conditions to be ignored. The B-trigger condition is configured in the same way as the A-trigger. The instrument disables settings that do not fit the previous settings in the sequence.



Delay

Sets the time that the instrument waits after an A-trigger until it recognizes B-triggers.

Remote command:

`TRIGger<m>:SEQuence:DELay` on page 981

B-event count

Sets the number of B-trigger conditions to be fulfilled after an A-trigger. The last B-trigger causes the trigger event.

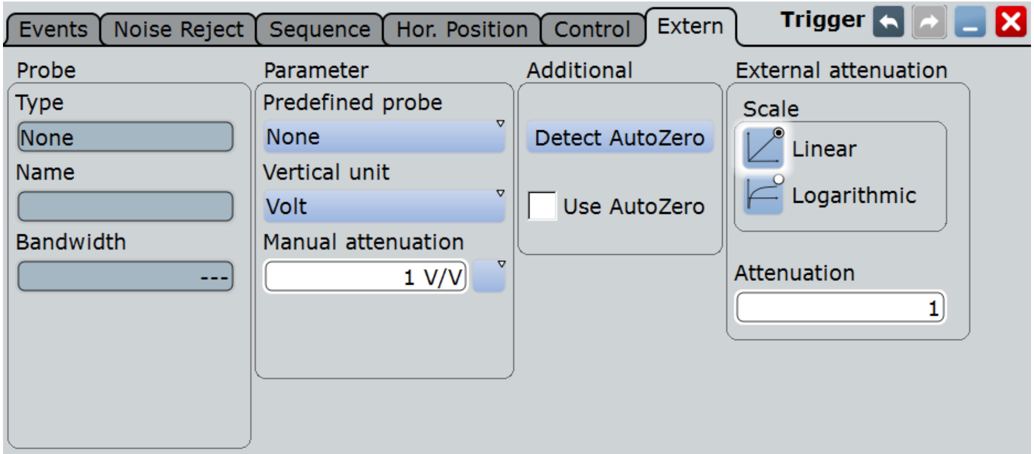
Remote command:

`TRIGger<m>:SEQuence:COUNt` on page 981

5.8 Extern

The "Extern" tab is relevant if you use an external trigger signal. It provides all settings that are relevant for the probe that is connected to the external trigger input. The functionality on the tab changes according to the type of the attached probe. They are the same as for probe setup of input channels: see Chapter 4.5, "Probes", on page 167.

If the external trigger input is overloaded, a message informs you.



Remote commands:

- `TRIGger<m>:EXTern:OVERload` on page 985
- `TRPRobe:ID:PARTnumber?` on page 936
- `TRPRobe:SETup:STATe?` on page 925
- `TRPRobe:SETup:TYPE?` on page 925
- `TRPRobe:SETup:ATTenuation:DEFProbe` on page 933
- `TRPRobe:SETup:ATTenuation:MANual` on page 927
- `TRPRobe:SETup:ATTenuation:MODE` on page 926
- `TRPRobe:SETup:ATTenuation:UNIT` on page 926
- `TRPRobe:SETup:ATTenuation[:AUTO]?` on page 926
- `TRPRobe:SETup:NAME?` on page 925
- `TRPRobe:SETup:BANDwidth?` on page 926
- `TRPRobe:SETup:CMOFfset` on page 929
- `TRPRobe:SETup:GAIN:MANual` on page 927
- `TRPRobe:SETup:OFFSet:AZERo` on page 927
- `TRPRobe:SETup:ZAXV` on page 930

R&S ProbeMeter: remote commands:

- `TRPRobe:SETup:DISPlaydiff` on page 930
- `TRPRobe:PMETer:VISibility` on page 931
- `TRPRobe:PMETer:RESults:COMMon?` on page 931
- `TRPRobe:PMETer:RESults:DIFFerential?` on page 932
- `TRPRobe:PMETer:RESults:NEGative?` on page 932
- `TRPRobe:PMETer:RESults:POSitive?` on page 933
- `TRPRobe:PMETer:RESults:SINGle?` on page 931

Probe attributes: remote commands

- `TRPRobe:ID:PRDate?` on page 936
- `TRPRobe:ID:SRNumber?` on page 936

- TRPRobe:ID:SWVersion? on page 935
- TRPRobe:SETup:MODE on page 928
- TRPRobe:SETup:CAPacitance? on page 937
- TRPRobe:SETup:IMPedance? on page 937

5.9 Acquisition Info

Access: "Trigger" menu > "Acquisition Info"

Shows the current number of acquisitions that have been acquired. The count is shown for a running acquisition cycle and as well for the last stopped acquisition cycle.

Remote command:

ACQuire:CURRent? on page 985

6 Waveform Analysis

This chapter describes general methods to check and analyze waveforms. These are:

6.1 Zoom

The zoom functions allow you to magnify a specific section of the diagram in order to view more details. You can define several zoom areas for the same diagram and even couple them, or you use the hardware zoom.

6.1.1 Methods of Zooming

The R&S RTE provides various ways of zooming: You define the section of a diagram that you want to magnify, and the zoomed view is shown in a separate zoom diagram. Additionally, you can magnify the diagram directly: The hardware zoom changes the horizontal and vertical scales of the diagram so that you see the selected section.

There are different ways to initiate and configure the zoom function:

- **Fingertip zoom**: magnifies the waveforms around your fingertip. When you drag your finger, the magnifier moves, too. You can convert the fingertip zoom into a standard zoom diagram.
- **Graphical method**: you draw, move and adjust the zoom area on the touchscreen – a very quick and simple method for standard zoom and hardware zoom.
- **Numeric method**: you enter x- and y-values in a dialog box or adjust them using navigation controls. These are precise ways which can be used to optimize a graphically defined zoom.
  With the numeric method there are two ways of defining the zoom area:
  – Specifying **start and stop values** for the x- and y-axes; the acquired data within those values is zoomed.

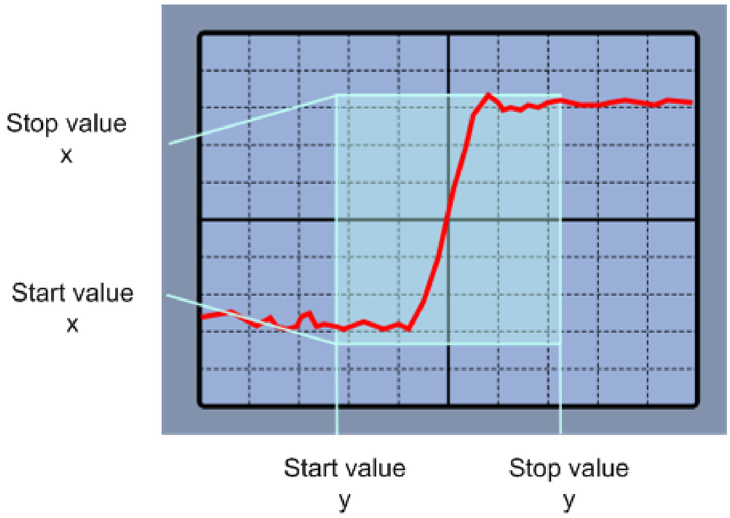


Figure 6-1: Numeric zoom using start and stop values

– Specifying the x- and y-**position** of the centerpoint of the area plus a **range** for the x- and y-axes; the area defined by that centerpoint and the ranges is zoomed.

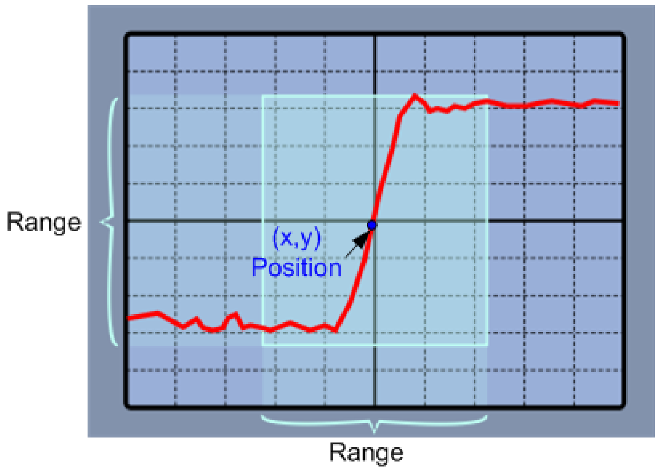


Figure 6-2: Numeric zoom using position and range

- **Coupled zoom** creates a copy of the selected zoom area. Coupled zoom areas always have the same size (size coupling). They can be positioned separately or together (position coupling).

Zoom areas can be used for gating, for example, to define a measurement gate. You can set the gate exactly to the limits of the zoom.

Evaluation gates - available histogram areas, masks, and measurement gates - can be displayed in zoom diagrams to simplify the graphical gate adjustment on the touch-screen. See: "Show evaluation gate(s) in zoom" on page 123.

6.1.2 Zoom Settings

The zoom area, i.e. the section to be enlarged, can be defined using two different methods:

- Using the zoom functions on the toolbar and draw the zoom area on the touch-screen
- Specifying numeric values:
  - start and stop values for the x- and y-axes
  - x- and y-position of one point in the diagram plus a range for the x- and y-axes

  See also: Chapter 6.1.1, "Methods of Zooming", on page 227.

6.1.2.1 Zoom Functions on the Toolbar

The zoom icon on the toolbar shows the last selected zoom type. A short tap on the icon activates the selected zoom. If you touch the icon and drag your finger down, a menu opens where you can select another zoom type.

Standard zoom
Displays a magnified section of the diagram in an additional zoom diagram. It is a display zoom, instrument settings are not changed.

Touch and hold the zoom area to open the "Zoom" dialog box.

Remote command:
`LAYout:ZOOM:ADD` on page 986

Hardware zoom
Changes the instrument settings - horizontal and vertical scales as well as trigger level and offset - to display a part of the diagram in greater detail.

Coupled zoom
Creates a coupled zoom area and its related zoom diagram. If you change the size of one zoom area, the size of all coupled zoom areas is changed as well.

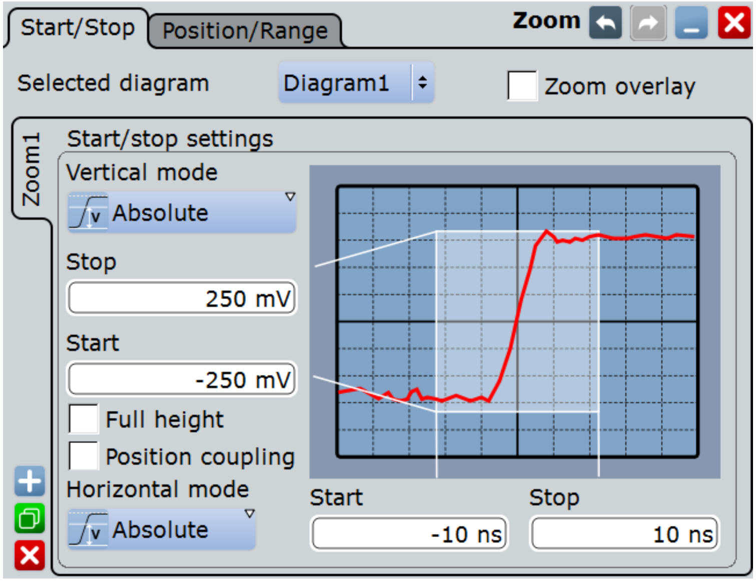
Remote command:
`LAYout:ZOOM:ADDCoupled` on page 987

Fingertip zoom
Magnifies the waveforms around your fingertip.

Tap the icon and put your finger on the waveform. The touched part of the waveform is displayed in a magnifier. Drag your finger on the screen to move the magnifier. You can change the zoom factor using the Navigation knob.

6.1.2.2 Start and Stop Settings

The "Start/Stop" tab allows you to specify start and stop values for the x- and y-axes. The acquired data within these ranges is zoomed.



Selected diagram
Indicates which of the waveform diagrams is selected for zooming.

Zoom overlay
Shows all zooms of a diagram in one zoom window. The zoomed areas are overlaid for better comparison of the zoomed waveforms.

The setting affects all zoom diagrams.

Remote command:
`LAYout:ZOOM:ONEDiagram` on page 987

Vertical
Defines whether absolute or relative values are used to specify the y-axis values.

Remote command:
`LAYout:ZOOM:VERTical:MODE` on page 991
`SEARch:RESDiagram:VERT:MODE` on page 1134

Stop / Relative stop
Defines the upper limit of the zoom area on the y-axis.

Remote command:
`LAYout:ZOOM:VERTical:RELative:STOP` on page 993
`LAYout:ZOOM:VERTical:ABSolute:STOP` on page 992

Start / Relative start
Defines the lower limit of the zoom area on the y-axis.

Remote command:
LAYout:ZOOM:VERTical:RELative:STARt on page 993
LAYout:ZOOM:VERTical:ABSolute:STARt on page 991

Full height
Uses the full diagram height for the zoom area. Only horizontal zoom settings can be changed.

Position coupling
Enables or disables the position coupling of coupled zooms. If position coupling is enabled and you move one zoom area, the other coupled zoom areas are moved, too, and keep their distance.

Remote command:
LAYout:ZOOM:POSCoupling on page 987

Horizontal
Defines whether absolute or relative values are used to specify the x-axis values.

Remote command:
LAYout:ZOOM:HORZ:MODE on page 988
SEARch:RESDiagram:HORZ:MODE on page 1132

Start / Relative start
Defines the lower limit of the zoom area on the x-axis.

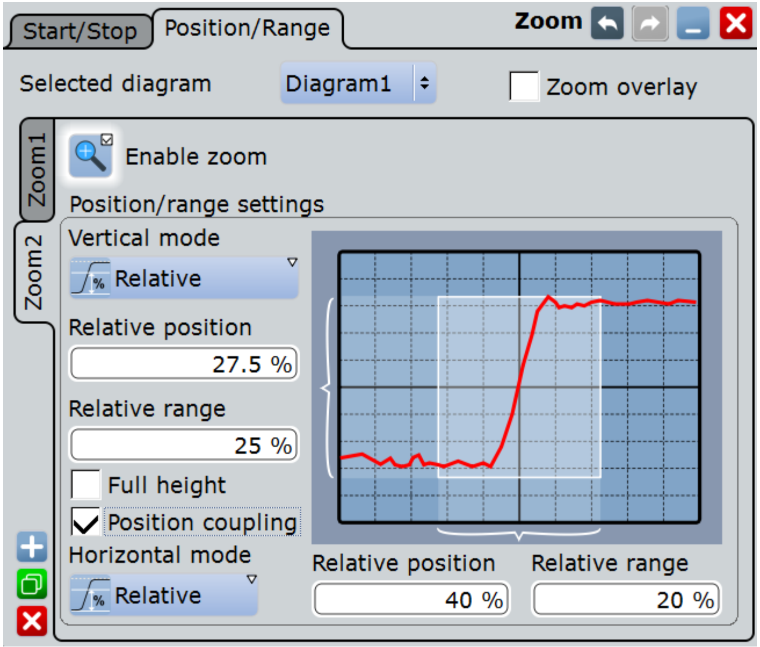
Remote command:
LAYout:ZOOM:HORZ:ABSolute:STARt on page 989
LAYout:ZOOM:HORZ:RELative:STARt on page 990

Stop / Relative stop
Defines the upper limit of the zoom area on the x-axis.

Remote command:
LAYout:ZOOM:HORZ:ABSolute:STOP on page 989
LAYout:ZOOM:HORZ:RELative:STOP on page 990

6.1.2.3 Position and Range Settings

In the "Position/Range" tab, you specify the x- and y-position of center point of the zoom area plus a range for the x- and y-axes; the area defined by that point and the ranges is zoomed.



Vertical
Defines whether absolute or relative values are used to specify the y-axis values.

Remote command:
`LAYout:ZOOM:VERTical:MODE` on page 991
`SEARch:RESDiagram:VERT:MODE` on page 1134

Position / Relative position (vertical)
Defines the y-value of the centerpoint of the zoom area.

Remote command:
`LAYout:ZOOM:VERTical:ABSolute:POSition` on page 991
`LAYout:ZOOM:VERTical:RELative:POSition` on page 992
`SEARch:RESDiagram:VERT:ABSolute:POSition` on page 1133
`SEARch:RESDiagram:VERT:RELative:POSition` on page 1134

Range / Relative Range (vertical)
Defines the height of the zoom area.

Remote command:
`LAYout:ZOOM:VERTical:RELative:SPAN` on page 992
`LAYout:ZOOM:VERTical:ABSolute:SPAN` on page 991
`SEARch:RESDiagram:VERT:ABSolute:SPAN` on page 1134
`SEARch:RESDiagram:VERT:RELative:SPAN` on page 1134

Full height
Uses the full diagram height for the zoom area. Only horizontal zoom settings can be changed.

Position coupling
Enables or disables the position coupling of coupled zooms. If position coupling is enabled and you move one zoom area, the other coupled zoom areas are moved, too, and keep their distance.

Remote command:
`LAYout:ZOOM:POSCoupling` on page 987

Horizontal
Defines whether absolute or relative values are used to specify the x-axis values.

Remote command:
`LAYout:ZOOM:HORZ:MODE` on page 988
`SEARch:RESDiagram:HORZ:MODE` on page 1132

Position / Relative position (horizontal)
Defines the x-value of the centerpoint of the zoom area.

Remote command:
`LAYout:ZOOM:HORZ:ABSolute:POSition` on page 988
`LAYout:ZOOM:HORZ:RELative:POSition` on page 989
`SEARch:RESDiagram:HORZ:ABSolute:POSition` on page 1132
`SEARch:RESDiagram:HORZ:RELative:POSition` on page 1133

Range / Relative Range (horizontal)
Defines the width of the zoom area.

Remote command:
`LAYout:ZOOM:HORZ:ABSolute:SPAN` on page 988
`LAYout:ZOOM:HORZ:RELative:SPAN` on page 990
`SEARch:RESDiagram:HORZ:ABSolute:SPAN` on page 1132
`SEARch:RESDiagram:HORZ:RELative:SPAN` on page 1133

6.1.3 Zooming for Details

The usage of the various zoom methods is described in the following procedures:

- Chapter 2.3.4.2, "Using the Fingertip Zoom", on page 57
- To define the zoom area graphically on the touchscreen
- To define the zoom area numerically using start-stop values
- To define the zoom area numerically using position and range values
- To define multiple zoom areas
- To define coupled zoom areas
- To close the zoom diagram
- To use the hardware zoom

The usage of zooms is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Zoom".

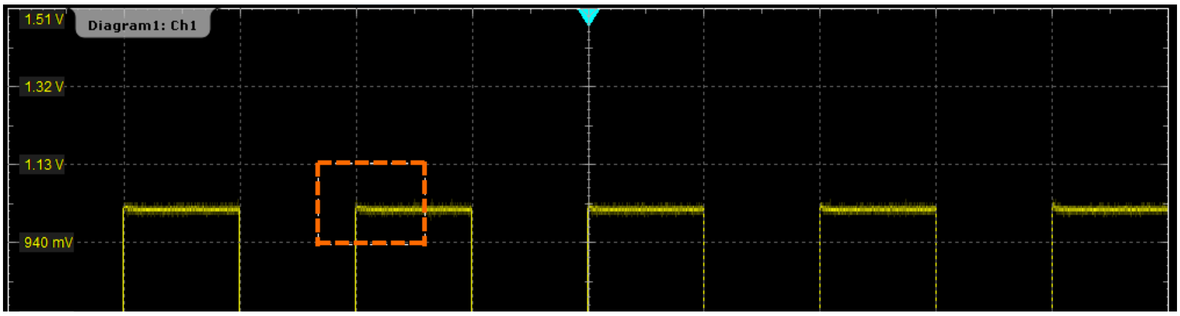
To define the zoom area graphically on the touchscreen

For graphical zooming, you use your finger on the screen.

1. On the toolbar, tap the "Standard Zoom" icon.

2. Touch the position that you want to define as one corner of the zoom area. Then drag your finger to the opposite corner of the zoom area.
   While you drag your finger on the touchscreen, a dotted rectangle indicates the current zoom area. When the rectangle covers the required zoom area, remove your finger.



The indicated area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle.

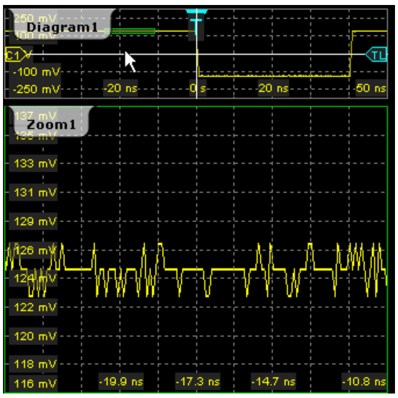


Figure 6-3: Zoom diagram and overview diagram

3. If the position of the zoom area is not correct, drag the rectangle in the overview to the correct position.

4. If the size of the zoom area is not yet ideal, tap the rectangle in the overview diagram.
   Now, 4 red lines indicate the edges of the zoom area. A dashed red line indicates the selected edge, which you can adjust.

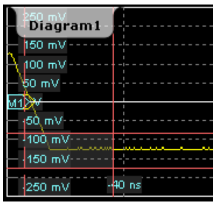


Figure 6-4: Zoom area indicated by edges

Note: Tapping the zoom area toggles between area and edge adjustment.
If the rectangle area is too small to select by tapping, press the CHECKMARK key in the navigation area to toggle between area adjustment and edge adjustment modes.

5. Touch the edge that you want to move, and drag it to the required position.

To optimize the zoom definition of an active zoom diagram, double-tap the zoom diagram. The "Zoom" dialog box for numeric definition is opened.

To adjust the zoom area using navigation controls

If you have created a zoom, and the size and position are not yet ideal, you can adjust them using the navigation knob and the navigation keys. You can adjust the size and position of the zoom area, or adjust the edges of the zoom area individually.

1. To adjust the size and position of the zoom area:
   a) Press the ☑ key until the zoom area is active (grey rectangle with white border).
   b) Turn the navigation knob to shift the zoom area. Press the knob twice to toggle between vertical and horizontal move.
   c) To adjust the size of the zoom area, press the navigation knob until "Span" is shown in the upper left corner.
   d) Turn the knob to increase or decrease the zoom area.

   Note: Pressing the navigation knob toggles between: horizontal position > horizontal span > vertical position > vertical span.

   Tip: If several zoom areas are visible, or cursors are active in addition, the ⇤ FIELD and ⇥ Field keys toggle between the zoom areas and the cursor sets.
2. To adjust the edges of the zoom area:
   a) Press the ☑ key until 4 red lines indicate the edges of the zoom area. A dashed red line indicates the selected edge, which you can adjust.
   b) Press the navigation knob until the required edge is selected (dashed red line).
   c) Turn the navigation knob to move the active edge to the required position.
   d) Press the navigation knob again. Adjust the next edge.

   Tip: Pressing the ⇧ or ⇩ keys moves the selected edge to the next division line left (DOWN) or right (UP). In area adjustment mode, these keys move the zoom area one division to the left (DOWN) or right (UP).

To create a new zoom using the Zoom dialog box

1. There are two ways to create a new zoom:
   - If you want to create a new, unconfigured zoom, tap the "Add" icon.
   - If you want to create zoom based on an existing one, tap the "Copy" icon.

2. Enter a name for the zoom using the on-screen keyboard.

To define the zoom area numerically using start-stop values

1. On the "Display" menu, tap "Zoom".
2. Select the Start and Stop Settings tab.
3. Under "Vertical mode", select whether you want to define absolute or relative y-axis values. Relative values cause the zoom area to adapt to the input values dynamically.
4. Define the "Start" and "Stop" values that define the lower and upper borders (respectively) of the zoom area on the y-axis (see Figure 6-1).
5. Under "Horizontal mode", select whether you want to define absolute or relative x-axis values.
6. Define the "Start" and "Stop" values that define the lower and upper borders (respectively) of the zoom area on the x-axis.

   When you close the dialog box, the specified area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle (see Figure 6-3).

To define the zoom area numerically using position and range values

1. On the "Display" menu, tap "Zoom".
2. Select the Position and Range Settings tab.
3. Under "Vertical mode", select whether you want to define absolute or relative y-axis values. Relative values cause the zoom area to adapt to the input values dynamically.
4. Under "Position", define the y-value of the center point of the zoom area (see Figure 6-2).
5. Under "Range", define the height of the zoom area.
6. Under "Horizontal mode", select whether you want to define absolute or relative x-axis values.
7. Under "Position", define the x-value of the center point of the zoom area.

8. Under "Range", define the width of the zoom area.

   When you close the dialog box, the specified area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle.

To define multiple zoom areas

You can define more than one zoom area for the same diagram, for example to compare several peaks in a measurement. These zoom areas can be displayed in separate zoom diagrams, or together in one zoom diagram.

To define multiple zoom areas graphically, simply repeat the steps described in To define the zoom area graphically on the touchscreen - for each area. Numerically, proceed as follows:

1. On the "Display" menu, tap "Zoom".
2. Select the required tab according to the method you want to use to define the zoom area.
3. To copy the current zoom area definition, tap the "Copy" icon.
   Alternatively, tap the "Add" icon to add a new zoom area.
4. Enter a name for the new zoom diagram using the displayed on-screen keyboard.
5. Define the zoom area as described for the first zoom.

   An additional zoom diagram is displayed for the new zoom area, and another rectangle in the original diagram indicates the new zoom area. Each rectangle in the overview has the same color as the corresponding zoom diagram frame.
6. In the "Zoom" dialog box, enable "Zoom overlay".

   The zooms are shown in the same zoom diagram, as if the zoom areas are overlaid.

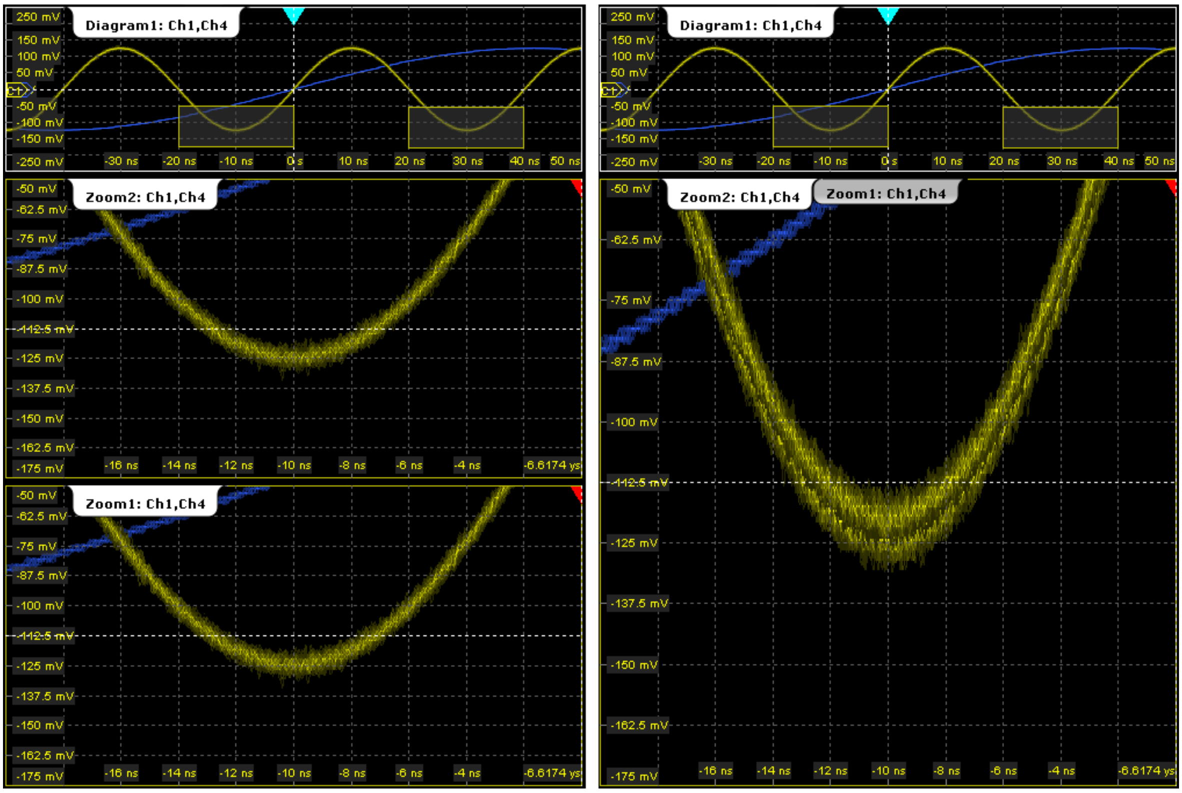


Figure 6-5: Multiple zoom diagrams. Left: separate zoom diagrams. Right: overlaid zoom

To define coupled zoom areas

You can define multiple zoom areas for one diagram that are coupled. If you change the size of one zoom area, the size of all coupled zoom areas is changed as well. Furthermore, you can couple also the position in order to move all coupled zooms at once. Coupling is useful, for example, if you want to compare recurring peaks in a signal.

1. On the toolbar, tap the "Coupled Zoom" icon.

2. In the diagram overview, tap an existing zoom area.

   The selected zoom area is duplicated.

3. Drag the duplicate zoom area to the required position.
4. To create further coupled zooms, repeat the steps above.

   Now, if you change the zoom area size of any of the coupled zoom areas in the "Zoom" dialog box, the settings are changed for all coupled zoom areas.

5. In the "Zoom" dialog box, select the diagram that contains the coupled zooms.
6. Select a zoom tab.
7. Enable "Position coupling".

If you move one of the coupled zoom areas in the diagram, all other coupled zooms are moved as well, and their distance is kept unchanged.

To close the zoom diagram

1. Tap the "Delete" icon on the toolbar.
2. Tap the zoom diagram.

   The diagram in the overview diagram returns to the original display size.

To use the hardware zoom

In contrast to the normal zoom, the hardware zoom changes the instrument settings - horizontal and vertical scales, and also the trigger level and offset. Thus, the selected area is displayed in the diagram instead of the original waveform. No additional zoom diagram is opened.

1. On the toolbar, tap the "Hardware Zoom" icon.

2. Drag your finger on the touch screen to mark the zoom area.
   A dotted rectangle indicates the current zoom area. When the rectangle covers the required zoom area, remove your finger. The diagram changes and shows the magnified area.

   Tip: To return to the previous display, use the "Undo" icon.

   Note: You can combine hardware zoom and normal zoom - first use the hardware zoom, then the zoom into the display. The reverse approach is also possible: Create a zoom diagram, and then apply the hardware zoom to the waveform diagram. Both the waveform and the zoom diagrams are changed.

6.2 Reference Waveforms

You can configure up to four reference waveforms to display stored waveforms. Any active signal or mathematical waveform can be stored as a reference waveform. It can then be loaded again later to restore the waveform on the screen.

6.2.1 Working with Reference Waveforms

Reference waveforms can be displayed in addition to the signal waveforms, saved to file, and loaded back for further analysis. Reference waveforms can be loaded only from BIN files.

Note: Saving and loading reference waveforms, and preset with active reference waveform delete the undo stack. After these actions, undo is not possible.

To update a reference waveform using the toolbar icon

If you often need to update a reference waveform, you can use the "Update Ref Wfm" toolbar icon.

1. Add the "Update Ref Wfm" icon to the toolbar, see Chapter 2.4.5.2, "Configuring the Toolbar", on page 92.
2. Touch the icon and open the icon menu.

3. Select the reference waveform to be used.
4. Tap the waveform to be used as reference waveform.

To display a reference waveform

1. In the "Math" menu, select "Reference Waveform > Setup", or press the REF key.
2. Select the tab for the reference waveform you want to display ("Ref1"-"Ref4").
3. Load a stored reference waveform as described in "To load a reference waveform" on page 241, or select a source to be displayed as a reference:
   a) In the "Reference" tab, tap the "Selected source" icon and select a source from the selection list. The source can be any active signal, math, or other reference waveform.
   b) Tap the "Update with" button to update the current reference waveform with the source data.
4. Tap the "Show reference waveform" icon so it is highlighted.

   The reference waveform is displayed on the screen.
   It has the same scaling as the origin.

To save a reference waveform

1. In the "Math" menu, select "Reference Waveform > Setup", or press the REF key.

   Tip: Alternatively, you can save a waveform as a reference waveform in the "File" dialog box, see Chapter 11.2.6, "Saving and Loading Waveform Data", on page 427.
2. Select the tab for the reference waveform you want to store ("Ref1"-"Ref4").
3. Display and configure the reference waveform as described in "To display a reference waveform" on page 240.
4. Select the fille format.

Note: Reference waveforms can be loaded only from BIN files. XML and CSV formats are meant for further processing in other applications.

5. To save the waveform to the currently selected file, tap "Save". By default, the prefix for reference waveform files is "RefCurve".
   To save the waveform to another file, select "Save As".
   Enter a file name and select the directory. The file type is already defined according to the selection in the previous step. In order to load the reference waveform on the instrument again later, use the file type BIN.

   The source settings of the reference waveform and the current scaling settings are stored to the specified file.

To load a reference waveform

Note: Reference waveforms can be loaded only from BIN files.

1. In the "Math" menu, select "Reference Waveform > Setup", or press the REF key.
2. Select the tab for the reference waveform you want to load ("Ref1" - "Ref4").
3. To load the waveform from the specified file, tap "Load".
   To load the waveform from a different file, tap "Open". Select the file from the file selection dialog box. Only BIN files are displayed in the file list.

   The selected waveform is loaded as the specified reference waveform.
4. If the reference waveform is not visible, tap the "Show reference waveform" icon.

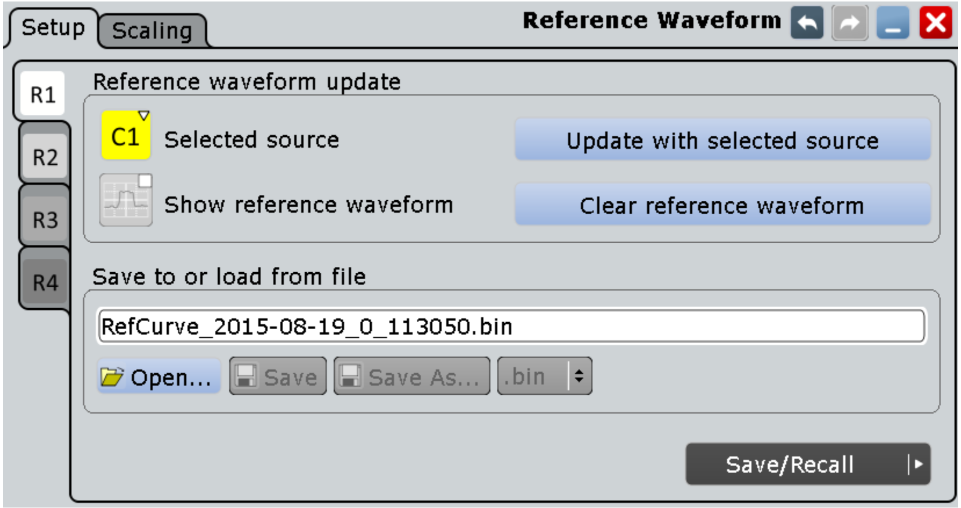
6.2.2 Settings for Reference Waveforms

To compare waveforms and analyze differences between waveforms, you can use up to four reference waveforms R1 to R4. Each reference waveform has its own memory on the instrument. You can also save an unlimited number of reference waveforms and load them for further use.

6.2.2.1 Reference Waveform Setup

Access: REF key

In the "Setup" tab, you select the reference waveform and its source. The source can be an active waveform - trace of an input channel, math waveform or another reference waveform - or a stored waveform.



Ref 1/2/3/4

Each tab contains the settings for one of the four available reference waveforms.

Source

Selects the source waveform from the active waveforms of input channels, math signals and other reference waveforms.

Remote command:

`REFCurve<m>:SOURce` on page 994

Update with selected source

Copies the selected source waveform with all its settings to the memory of the reference waveform. If the acquisition is running, the reference waveform is a snapshot.

Remote command:

`REFCurve<m>:UPDate` on page 995

Show reference waveform

Displays the reference waveform in the diagram.

Remote command:

`REFCurve<m>:STATe` on page 994

Clear reference waveform

The selected reference waveform disappears, its memory is deleted.

Remote command:

`REFCurve<m>:CLEar` on page 996

Save to or load from file
Enter the file name of the stored reference waveform and select the file format with the format button on the right. Double-tap the file name to open the file selection dialog box, see also Chapter 11.1.7, "File Selection Dialog", on page 408.

By default, the file name has the prefix "RefCurves_". You can define a pattern for automatic naming in the "Autonaming" tab.

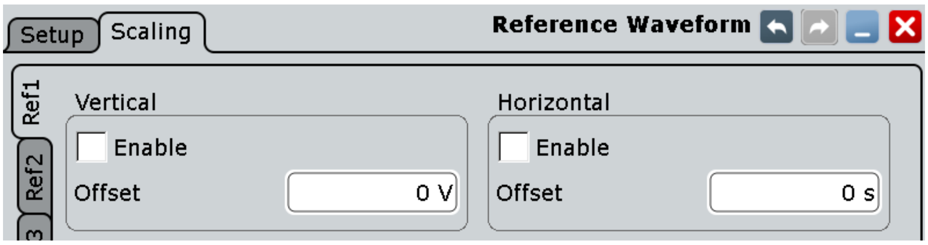
Note: Note that reference waveforms can be loaded from `.bin` files only. xml and csv formats are meant for further processing in other applications.

"Load"	Loads the specified reference waveform.
"Open"	Opens a file selection dialog box and loads the selected reference waveform file
"Save"	Saves the waveform as a reference waveform in the selected file.
"Save As..."	Opens the file selection dialog box and saves the waveform to the selected file.
".bin/.xml/.csv"	Selects the file format.

Remote command:
`REFCurve<m>:OPEN` on page 995
`REFCurve<m>:SAVE` on page 995
`REFCurve<m>:DELete` on page 995

6.2.2.2 Scaling

A reference waveform can have its own vertical and horizontal offset.



Vertical
Vertical reference scaling changes the vertical display of the reference waveform independently of the settings of the source waveform.

Enable ← Vertical
If enabled, the vertical offset is applied to the reference waveform.

Remote command:
`REFCurve<m>:RESCale:VERTical:STATe` on page 996

Offset ← Vertical
Moves the reference waveform vertically. Enter a value with the unit of the waveform. Like vertical offset of a channel waveform, the offset of a reference waveform is subtracted from the measured value. Negative values shift the waveform up, positive values shift it down.

Note: As for all waveforms, a vertical offset of a reference waveform can be set using the vertical POSITION / REF POINT knob. This offset is independent from the reference scaling offset, which is described here. If both offsets are set, their values are added up.

Remote command:
`REFCurve<m>:RESCale:VERTical:OFFSet` on page 996

Horizontal
Horizontal reference scaling changes the horizontal display of the reference waveform independently of the settings of the source waveform and of the diagram settings.

Enable ← Horizontal
If enabled, the horizontal offset is applied to the reference waveform.

Remote command:
`REFCurve<m>:RESCale:HORizontal:STATe` on page 997

Offset ← Horizontal
Moves the waveform horizontally. Enter a value with a time unit suitable for the time scale of the diagram. Positive values shift the waveform to the right, negative values shift it to the left.

Remote command:
`REFCurve<m>:RESCale:HORizontal:OFFSet` on page 997

6.3 Mathematics

Math waveforms are calculated waveforms. You can define up to four math waveforms and display them on the screen, and use it as source for further analysis.

Math waveforms are defined by mathematical expressions (formulas). You can enter mathematical expressions using two different methods:

- "Basic": you define a simple math function in a graphical editor by selecting the source waveform(s) and the operator.
- "Advanced": you define sophisticated math functions in a formula editor, as required to your needs.

The result of an FFT analysis is a specific math waveform. For information on FFT and spectrum analysis, see Chapter 8, "Spectrum Analysis", on page 328.

The vertical scale of a math waveform is adapted automatically to the measurement results to ensure optimal display. Furthermore, you can scale each math waveform manually in vertical direction like a channel waveform.

As for channel waveforms, you can also change the arithmetic mode for the waveform to display the envelope or an average over several calculations.

You can store a math waveform as a reference waveform and restore it later, see "To save a reference waveform" on page 240.

6.3.1 Displaying Math Waveforms

Math waveforms can be displayed in addition to the channel and other waveforms. They also can be used for analysis, e.g. measurements, even if the math waveform is not active.

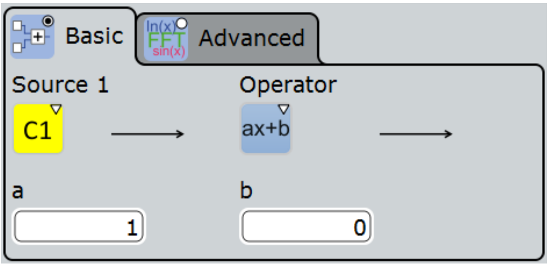
1. In the "Math" menu, select "Math Setup".
   Alternatively, press the MATH key.
2. Define the math expression for calculation in one of the following ways:
   - Chapter 6.3.2.2, "Defining a Formula in the Basic Editor", on page 248
   - Chapter 6.3.3, "Advanced Expressions", on page 248
   - Chapter 8.1.2, "Configuring Spectrum Waveforms", on page 332
3. In the "Math Setup" dialog box, in the "Setup" tab, tap the "Enable math signal" icon.

   The math waveform is displayed on the screen.
4. To change the vertical scaling of the math waveform, tap the "Manual" icon.
5. Enter the "Vertical scale" factor (per division). If necessary, add a "Vertical offset".
   By default, automatic scaling is performed.

   Tip: You can also use the vertical SCALE rotary knob for scaling. In this case, the scale mode is set to "Manual" temporarily.
6. If you need the envelope or average of the math waveform over several calculations, change the arithmetic mode for the waveform as for channel waveforms.
   See also: "Arithmetic" on page 157.
7. Close the "Math Setup" dialog box.

6.3.2 Basic Editor

In the basic editor, you can define the most common mathematical formulas without knowing their correct syntax.



Remote command:

- `CALCulate:MATH<m>[:EXPRession][:DEFine]` on page 1000

6.3.2.1 Settings in the Basic Editor

Source 1 / 2

Defines the signal source to be evaluated by the math function. Channel waveforms can be selected.

Note: If you require other signal sources not listed here, use the formula editor provided in the "Advanced" tab. In advanced mode, any waveform of any input channel can be used as a source. See: Chapter 6.3.3, "Advanced Expressions", on page 248.

Operator

Defines the type of operation to be performed on the selected signal sources. The following functions are available:

Note: If you require other operators not listed here, use the formula editor provided in the "Advanced" tab. See: Chapter 6.3.3, "Advanced Expressions", on page 248.

"+"	Adds up the sources
"-"	Subtracts source 2 from source 1.
"x"	Multiplies source 1 by source 2.
"|x|"	Determines the absolute value of the source.
"dx/dt"	Differentiates the source value with respect to the time value. Not possible on envelope waveforms and waveforms with "Peak detect" decimation.
"log(x)"	Calculates the logarithm of the source value based on 10.
"ln(x)"	Calculates the natural logarithm of the source value (based on e).
"ld(x)"	Calculates the binary logarithm of the source value (binary logarithm, based on 2).
"Rescale"	Rescales the source values by a factor "a" and an offset "b": *ax+b*. See also: "a / b" on page 247.
"FIR filter"	Finite impulse response filter - highpass or lowpass filter for a specified cut-off frequency and characteristic. See also: "FIR: Type, Cut-Off, Characteristics" on page 247.
"Mag(FFT(x))"	Determines the magnitude of the FFT for the source values.

Noise reject

Only available for the "dx/dt" operator.

To suppress noise effects during differentiation, it can be useful not to consider two directly neighboring points to calculate *dx* (x_n-x_{n-1}). Instead, a number of samples in-between are skipped and a point a few samples further is used (e.g. x_n-x_{n-3}).

The "Basic" editor shows the default number of neighboring samples that are skipped for differentiation.

To adjust the number of samples, select the "Advanced" editor, see Table 6-4.

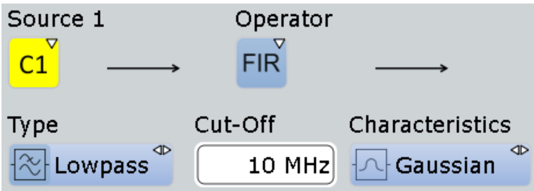
a / b

Defines the values for the "Rescale" function (ax+b).

"a"	Is the factor the signal source is multiplied with
"b"	Is the offset of the signal source on the y-axis

FIR: Type, Cut-Off, Characteristics

The finite impulse response filter ("Operator" = FIR) is a filter that requires three additional settings:



- "Type": defines whether the FIR filter is a highpass or lowpass filter.
- "Cut-Off": sets the limit frequency for the FIR filter.
- "Charcteristics": defines whether the FIR filter has a Gaussian or a rectangular shape

The cut-off frequency depends on the horizontal resolution and the filter characteristics. The frequency for the lowpass filter can only be set in this range:

f_g_3dB = (0.001 ... 0.2) f_a_in* for Gaussian FIR filter

f_g_3dB = (0,001 ... 0.4) f_a_in* for rectangular FIR filter

Where: *f_g_3dB* = cut-off frequency to be set for the lowpass filter, and *f_a_in* = reciprocal of the resolution, or sample rate.

To check limit frequency for the highpass filter, convert it to an equivalent lowpass frequency:

f_LP = f_a_in/2 - f_HP

Where f_HP is the requested highpass limit frequency and f_LP the equivalent lowpass frequency that has to comply with the limits given above.

For advanced expression, see Table 6-10.

Envelope wfm selection

Selects the upper or lower part of the waveform for mathematic calculation, or a combination of both.

The setting is relevant for waveforms with waveform arithmetic mode "Envelope" or with "Peak detect" decimation. All mathematic operations - except for derivation - can be applied to envelope waveforms and waveforms with "Peak detect" decimation.

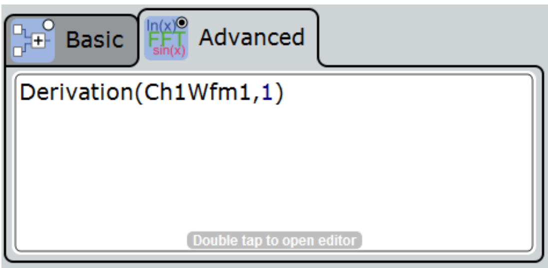
Remote command:
`CALCulate:MATH<m>:ENVSelection` on page 1001

6.3.2.2 Defining a Formula in the Basic Editor

1. In the "Math" menu, select "Math Setup".
   Alternatively, press the MATH key.
2. In the "Setup" tab, select the "Basic" tab.
3. Tap the "Source 1" and "Source 2" icons and select the signal sources to which the math function is applied. For details on available signal sources, see "Source 1 / 2" on page 246.
4. Tap the "Operator" icon and select the mathematical function.
   For details on available operators, see "Operator" on page 246.
5. If the operator requires additional parameters, enter them in the input fields.

6.3.3 Advanced Expressions

In the "Advanced" tab, you can enter complex formulas to define a math waveform. The formula editor helps to enter formulas easily with correct syntax, using a large selection of operators and signal sources. Double-tap the "Advanced" tab to display the formula editor.



6.3.3.1 Advanced Formula Editor

Using the formula editor you can define math functions freely, using a large selection of operators and signal sources. For a procedure on using the editor, see Chapter 6.3.3.2, "Defining a Formula in the Advanced Formula Editor", on page 254.

Remote command:

- CALCulate:MATH<m>[:EXPRession][:DEFine] on page 1000

The following tables describe the buttons of the formula editor and their usage.

Table 6-1: Basics

Icon	Description	Usage/Comment, *FormulaEditor expression*
(	left bracket	enclose operands
,	comma	separates operands
)	right bracket	enclose operands
e / π	math. constants	e: Euler number: 2.7182... Pi: 3.1415...
[	left square bracket	enclose unit
V / A / Ω	units	[<unit>]
]	right square bracket	enclose unit
x^a	exponentiation with base x	x: base, a: exponent *x^a*
/	division	
*	multiplication	
-	subtraction	
+	addition	
0...9	numeric characters	
.	decimal point	

Icon	Description	Usage/Comment, *FormulaEditor expression*
Exp	exponentiation with base 10	*e*
Enter	expression complete	insert expression in Setup dialog and close the formula editor
Clear	clear expression in editor	restart editing
Del	Delete	remove selected part of expression
Back	Backspace	remove last symbol, operator or operand to the left of the cursor
M / k / µ	SI-prefix for unit	<SI-prefix>[<unit>]

Table 6-2: Signal sources

Icon	Description	Usage/Comment, *FormulaEditor expression*
Ch	signal waveform	*Ch<1...4>Wfm<1...3>*
Math	math waveform	*Math<1...4>*
Ref	reference waveform	*Ref<1...4>*
Meas	measurement waveform	*Meas<1...8>*

Table 6-3: Cursor keys

Icon	Description	Usage/Comment, *FormulaEditor expression*
|←	move cursor to beginning	
←	move cursor 1 step to the left	
→	move cursor 1 step to the right	
→|	move cursor to end	

Table 6-4: Algebra

Icon	Description	Usage/Comment, *FormulaEditor expression*
$\|x\|$	absolute x value	*abs(x)*
$\sqrt{x}$	square root of x	*sqrt(x)*
x^2	x*x	*pow(x)*
$\log_{10}$	common logarithm (base 10)	*log(x)*
$\log_e$	natural logarithm (base e)	*ln(x)*
$\log_2$	binary logarithm (base 2)	*ld(x)*
e^x	exponentiation with base e	*exp(x)*
$\int x dx$	integral of x	*integral(x)*

Icon	Description	Usage/Comment, *FormulaEditor expression*
d/dx	derivation of x	*derivation(x,y)* with x = waveform and y = number of skipped samples (noise reject)
ax+b	scaling of x	*rescale(x,a,b)*

Table 6-5: Bit operations

Icon	Description	Usage/Comment, *FormulaEditor expression*
digitize	convert to 0 or 1	*digitize(x)*
not	negation	*not(x)*
and		*and*
nand	negation of and	*nand*
or		*or*
nor	negation of or	*nor*
xor	exclusive or	*xor*
nxor	negation of exclusive or	*nxor*

Table 6-6: Comparison

Icon	Description	Usage/Comment, *FormulaEditor expression*
=	equal	=
≠	not equal	<>
<	smaller	<
>	greater	>
≤	smaller or equal	<=
≥	greater or equal	>=
More	display additional keys	

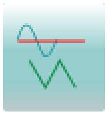
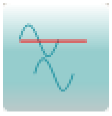
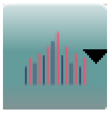
Table 6-7: FFT ("More" keys)

Icon	Description	Usage/Comment, *FormulaEditor expression*
|FFT|	magnitude of FFT value	*fftmag(x)*
FFT (φ)	FFT phase value	*fftphi(x)*
FFT -dφ*df	FFT group delay	*fftgroupdelay(x)*
FFT (re)	real part of FFT value	*fftre(x)*
FFT (im)	imag part of FFT value	*fftim(x)*

Table 6-8: Trigonometry ("More" keys)

Icon	Description	Usage/Comment, *FormulaEditor expression*
sinh	hyperbolic sine	*sinh(x)*
cosh	hyperbolic cosine	*cosh(x)*
tanh	hyperbolic tangent	*tanh(x)*

Table 6-9: Correlation ("More" keys)

Icon	Description	Usage/Comment, *FormulaEditor expression*
	Cross correlation function of two waveforms Measures the similarity of two waveforms as a function of a time-lag applied to one of them. Function limits the maximum record length to 4 MSa. Two modes of normalization are supported: biased and unbiased. The length of the correlation buffer is $N_0 + N_1 - 1$ samples. The length of the first input signal is N_0 samples and the length of the second signal is N_1 samples.	*correlation(x1, x2, biased)* *correlation(x1, x2, unbiased)* with x1 = waveform 1 and x2 = waveform 2 *correlation(x1, x2)* performs an unbiased correlation
	Auto correlation Used to find repeating patterns, for example, a periodic signal obscured by noise. The length of the auto correlation buffer is $2N - 1$ samples, if the length of the input signal is N samples. Two modes of normalization are supported: biased and unbiased.	*autocorrelation(x, biased)* *autocorrelation(x, unbiased)* with x = channel waveform *autocorrelation(x)* performs an unbiased autocorrelation
	biased / unbiased normalization for correlation and auto correlation	see above

Mathematic background for correlation:

$$Temp1\_R_{xy}(m) = \sum_{n=0}^{N1} y_n^* x_{n+m} \qquad m \in [0; N_1[$$

$$Temp0\_R_{xy}(m) = \sum_{n=1}^{N0} x_n^* y_{n+m} \qquad m \in [1; N_0[$$

The R&S RTE uses only the real part of the signal. Two modes of normalization are supported: biased and unbiased.

$$R_{xy}(m) = \begin{cases} \dfrac{1}{\min(N_0, N_1)} Temp1\_R_{xy}(m) & m \in [N_0 - 1; N_1 + N_0 - 1[\\ \dfrac{1}{\min(N_0, N_1)} Temp0\_R_{xy}^*(-m) & m \in [0; N_0 - 1[\end{cases}$$

Equation 6-1: Biased correlation

$$R_{xy}(m) = \begin{cases} \frac{1}{a(m)} Temp1\_R_{xy}(m) & m \in [N_0 - 1; N_1 + N_0 - 1[\\ \frac{1}{a(m)} Temp0\_R^{*}_{xy}(-m) & m \in [0; N_0 - 1[\end{cases}$$

Equation 6-2: Unbiased correlation

Mathematic background for auto correlation:

$$R_{xx}(m) = \begin{cases} \frac{1}{N} \sum_{n=0}^{N-m-1} x_n^{*} x_{n+m} & m \geq 0 \\ R_{xx}^{*}(-m) & m < 0 \end{cases}$$

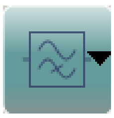
Equation 6-3: Biased auto correlation

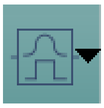
$$R_{xx}(m) = \begin{cases} \frac{1}{N - |m|} \sum_{n=0}^{N-m-1} x_n^{*} x_{n+m} & m \geq 0 \\ R_{xx}^{*}(-m) & m < 0 \end{cases}$$

Equation 6-4: Unbiased auto correlation

The R&S RTE uses only the real part of the signal.

Table 6-10: Filter and power ("More" keys)

Icon	Description	Usage, comment, *FormulaEditor expression*
	Electric power	Electric power is calculated from voltage, based on measurement impedance (see "Measurement impedance" on page 163) *elecpower(x)* = U²/R
	Finite impulse response (FIR) filter	*FIR(highpass,x,y,c)* or *FIR(lowpass,x,y, c)* with: x = source (channels only), y = cut-off frequency, c = Gaussian or rectangle characteristics Example: *FIR(lowpass,Ch1Wfm1,12e+006,gaussian)* sets a Gaussian lowpass filter with 12 MHz cut-off frequency See also: "FIR: Type, Cut-Off, Characteristics" on page 247.
	Type of FIR filter	*highpass* / *lowpass*, see FIR filter

Icon	Description	Usage, comment, *FormulaEditor expression*
	Characteristics of FIR filter	*gaussian* / *rectangle*, see FIR filter
	Moving average	Calculates a mean value of several adjacent sample points. The result is a smoothed waveform. The moving average uses the full data and can be used for non-periodic signals. It works like a low-pass filter and increases the vertical resolution at the expense of bandwidth reduction. *MovingAverage(x,y)* with: x = source (channels only), y = number of samples to be averaged Example: *MovingAverage(Ch1Wfm1,1000)* Averages 1000 subsequent samples of the channel 1 waveform

6.3.3.2 Defining a Formula in the Advanced Formula Editor

1. In the "Math" menu, select "Math Setup".
2. In the "Setup" tab, select the "Advanced" tab.
3. Double-tap the editing area.

   The "Formula Editor" is displayed.
4. Enter the math formula including all required signal sources and operators by selecting the corresponding keys in the editor. For details on the available keys, see Chapter 6.3.3.1, "Advanced Formula Editor", on page 248.
5. To insert a physical unit in the formula, proceed as follows:
   a) If necessary, insert a decimal prefix using the "M/k/µ" key.
   b) Insert an opening square bracket using the "[" key.
   c) Insert the physical unit using the "V/A/Ω" key.
   d) Insert a closing square bracket using the "]" key.

   The resulting expression could be, for example: `m[V]`
6. To perform a rescaling function, proceed as follows:
   a) Select the rescaling function using the "ax+b" key.
   b) Behind the left bracket, insert the signal source using one of the following keys:
      - "Ch" for a channel
      - "Math" for a math function
      - "Ref" for a reference waveform
      - "Meas" for a measurement

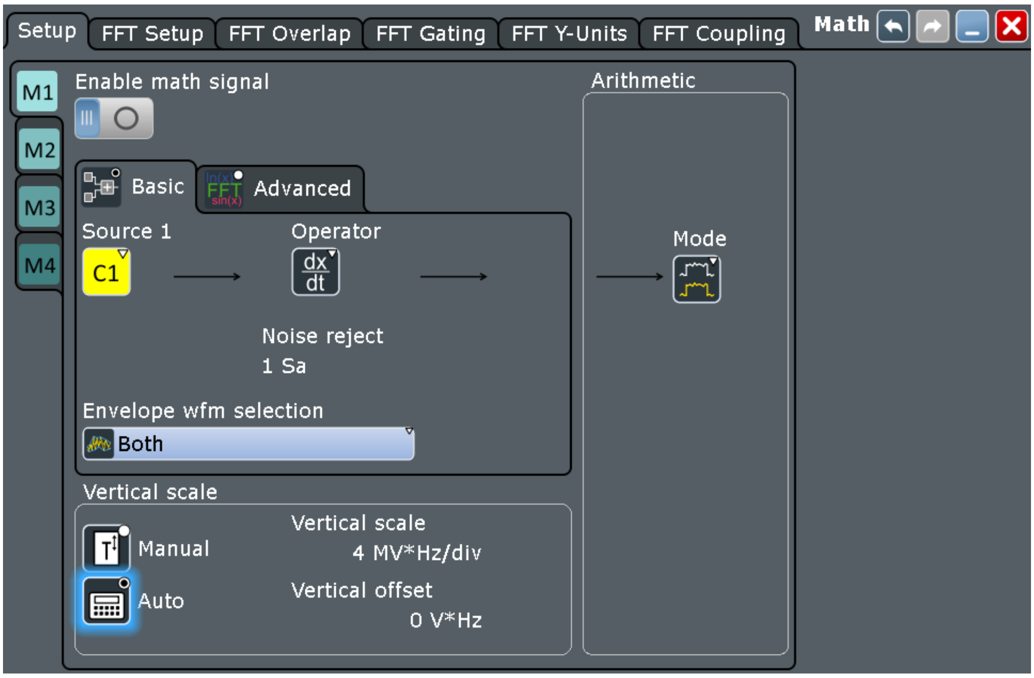
   c) Insert a comma using the "," key.
   d) Insert the "a" value, i.e. the scaling factor, using the number keys.

e) Insert a comma using the "," key.
f) Insert the "b" value, i.e. the scaling offset, using the number keys.
g) Insert the closing bracket using the ")" key.

The resulting expression could be, for example: `rescale(Ch1Wfm1,3,4)`

6.3.4 Math Setup - General Settings

You can define up to 4 different math waveforms. Each waveform is defined in a separate tab in the "Math" dialog box ("Math 1"-"Math 4").



The settings for input of mathematical formulas in basic and advanced editors are described in separate chapters:

- Chapter 6.3.2.1, "Settings in the Basic Editor", on page 246
- Chapter 6.3.3, "Advanced Expressions", on page 248

The general settings for enabling, scaling and waveform arithmetic are:

Enable Math Signal
If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:

CALCulate:MATH<m>:STATe on page 1000

Vertical Scale

Functions to set the vertical parameters of the math waveform.

Note: If an FFT expression is defined, the vertical scaling for spectrum displays is available: "Vertical maximum" and "Vertical range" instead of "Vertical Scale" and "Vertical Offset". See Chapter 8.1.3.2, "FFT Overlap", on page 339.

Vertical scaling mode (Manual/Auto) ← Vertical Scale

By default, the vertical scale is adapted to the current measurement results automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

Note: When you change the scaling values manually using the "Scale" rotary knob, the scale mode is set to "Manual" temporarily. When you edit the math function, scaling is automatically set back to "Auto" mode. "Manual" mode is only maintained during math function changes if you select it yourself.

"Manual"	Enter the required values for "Vertical scale" and "Vertical offset". For FFT, set "Vertical range" and "Vertical maximum".
"Auto"	"Vertical scale" and "Vertical offset" are read-only. For FFT, only the "Vertical maximum" is read-only.

Vertical Scale ← Vertical Scale

Defines the scale of the y-axis in the math function diagram. The value is defined as "<unit> per division", e.g. *50m V/div*. In this case, the horizontal grid lines are displayed in intervals of 50 mV.

If the "Vertical scaling mode (Manual/Auto)" on page 256 is set to "Auto", this setting is read-only.

Remote command:

CALCulate:MATH<m>:VERTical:SCALe on page 1003

Vertical Offset ← Vertical Scale

Sets a voltage offset to adjust the vertical position of the math function on the screen. Negative values move the waveform , positive values move it down.

If the "Vertical scaling mode (Manual/Auto)" on page 256 is set to "Auto", this setting is read-only.

Remote command:

CALCulate:MATH<m>:VERTical:OFFSet on page 1002

Arithmetic

Functions to specify the waveform arithmetic for the math waveforms.

Mode ← Arithmetic

Waveform arithmetic builds the resulting waveform from several consecutive acquisitions and subsequent math calculations of the signal. For details, see "Arithmetic" on page 157.

"Original"	The original results are displayed

"Envelope"	The envelope curve of all acquired and calculated results is displayed
"Average"	The average of all acquired and calculated results is displayed
"RMS"	The root mean square of the math data is displayed. The result is the average power spectrum. If you measure the channel power on this RMS spectrum, you get the same result as for the average channel power measurement on waveforms.
"MinHold"	Determines the minimum result for each input value from the data of the current acquisition and a number of acquisitions before.
"MaxHold"	Determines the maximum result for each input value from the data of the current acquisition and a number of acquisitions before.

Remote command:
`CALCulate:MATH<m>:ARIThmetics` on page 1001

Reset ← Arithmetic
Forces the immediate restart of the envelope and average calculation for all waveforms.

Remote command:
`ACQuire:ARESet:IMMediate` on page 917

Acquisition/average count ← Arithmetic
Access:
- TRIGGER > "Control" tab > "Average count (N-single count)"
- ACQUISITION > "Average count"
- HORIZONTAL > "Ultra Segmentation" tab > disable "Acquire maximum" > "Required"
- MATH > "Setup" tab > "Average count"

The acquisition and average count has several effects:
- It sets the number of waveforms acquired with RUN N× SINGLE
- It defines the number of waveforms used to calculate the average waveform. Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the value is, the better the noise is reduced.
- It sets the number of acquisitions to be acquired in an ultra segmentation acquisition series. Thus, you can acquire exactly one ultra segmentation acquisition series with RUN N× SINGLE.
  If ultra segmentation is enabled and configured to acquire the maximum number of acquisitions, the acquisition count is set to that maximum number and cannot be changed. See also: "Number of acquisitions" on page 159.
- It is the "Finished" criteria for the state of a mask test.

Remote command:
`ACQuire:COUNt` on page 917

6.4 History

The history accesses the data of previous acquisitions and provides them for further analysis.

6.4.1 About History

If a continuous acquisition runs, the captured data is stored in the sample memory and the current acquisition is processed and shown on the display. After the acquisition was stopped, the history accesses the captured samples that were stored, displays these samples as history waveforms, and makes them available for further analysis. It considers all channels that were enabled during the running acquisition. When a new acquisition is started with RUN CONT or RUN N× SINGLE, the memory is cleared and written anew.

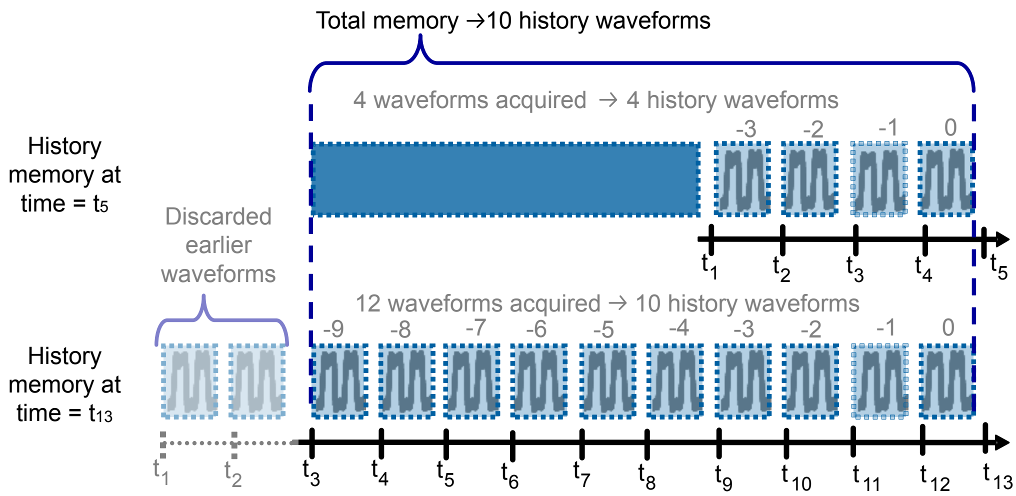


Figure 6-6: History memory. In this example, the memory can store 10 waveforms.

You can work with history waveforms in the same way as with the waveform of the latest acquisition: use zoom, cursor measurements, and automatic measurements, create math waveforms, perform mask testing and so on. Saving the history data is also possible, either completely or a part of the data.

The number of stored history waveforms depends on the memory size, the number of enabled channels, and the record length. The shorter the record length, the less the number of channels, and the larger the memory, the more history waveforms are saved.

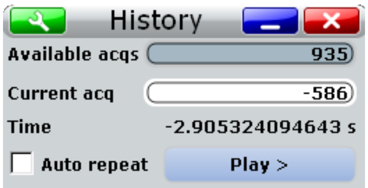
Memory extension

The memory can be enhanced with optional memory extension: 20 MSa per channel with option R&S RTE-B101, or 50 MSa with R&S RTE-B102.

Quick-access History dialog box

When you press the HISTORY key on the front panel or tap "Display" menu > "Show history", the history mode is enabled and the quick-access "History" dialog box is displayed. A running acquistion stops immediately.

The small quick-access "History" dialog box can remain visible on the screen during history replay, so that the history can be replayed at any time by a simple tap on the "Play" button. Closing the quick-access "History" dialog box, or starting a new acquisition disables the history mode.



Export of history waveforms

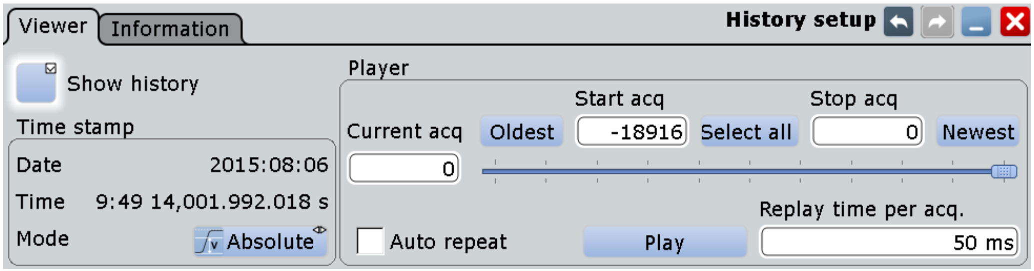
You can export history data, see "To save the history data" on page 263.

6.4.2 History Setup

The "History" dialog box contains the complete functionality on history viewing and information. Out of these, the most important information and functions are also provided in the quick-access history dialog box.

6.4.2.1 Viewer

The settings in the "Viewer" tab control the display of history waveforms.



The numbering of the waveforms refers to the current memory content. With every RUN CONT or RUN N× SINGLE action, the memory content changes.

Show history / Export history

Enables the history mode and allows to save history waveforms to file.

The history display is enabled automatically when you press the HISTORY button. It is disabled when you close the quick-access "History" dialog box.

For details on data export, see "Export history" on page 419.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HIStory[:STATe]` on page 1005

Current acq
Accesses a particular acquisition in the memory to display it, or to save it. The newest acquisition always has the index "0". Older acquisition have a negative index.

If a history replay is running, the field shows the number of the currently shown acquisition.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HIStory:CURRent` on page 1005

Start acq
Sets the index of the first (oldest) acquisition to be displayed or exported. The index is always negative. The number of stored history acquisitions is shown in Available acquisitions on the "Information" tab.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HIStory:STARt` on page 1006

Stop acq
Sets the index of the last (newest) acquisition to be displayed or exported. The newest acquisition of the complete acquisition series always has the index "0".

Remote command:
`CHANnel<m>[:WAVeform<n>]:HIStory:STOP` on page 1006

Select all
All acquisitions saved in the memory will be shown in the viewer.

Current
Sets the newest acquisition in the sample memory as "Stop acq" and "Current acq". This acquisition always has the index "0".

Oldest
Sets the oldest acquisition in the sample memory as "Start acq" and "Current acq".

Auto repeat
If selected, the replay of the history waveform sequence repeats automatically. Otherwise, the replay stops at the "Stop index".

Remote command:
`CHANnel<m>[:WAVeform<n>]:HIStory:REPLay` on page 1007

Play
Starts and stops the replay of the history waveforms from "Start acq" to "Stop acq".

Remote command:
`CHANnel<m>[:WAVeform<n>]:HIStory:PLAY` on page 1007

Replay time per acq.
Sets the display time for one acquisition. The shorter the time, the faster is the replay. The setting takes effect for history replay and the display of an Ultra Segmentation series, see Chapter 4.2.3, "Ultra Segmentation", on page 158.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:TPACq` on page 1006

Time stamp
The time stamp shows the time of the currently displayed history acquisition. Thus, the time relation between acquisitions is always available.

The time stamp "Mode" can be absolute or relative:
- In "Absolute" mode, the instrument shows the date and the daytime of the current acquisition.
- In "Relative" mode, the time difference to the newest acquisition (index = 0) is shown.

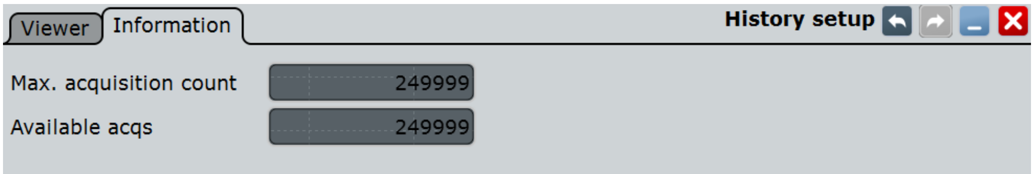
The time stamp can be included in waveform data export, see "Timestamps" on page 420.

During history replay, the time value is displayed and updated if the replay speed ("Time per acquisition") is slow enough, that is 40 ms or slower.

The quick-access history dialog box always shows the relative time. In the "History Viewer" tab, you can select the time mode.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:TSDate?` on page 1007
`CHANnel<m>[:WAVeform<n>]:HISTory:TSABsolute?` on page 1008
`CHANnel<m>[:WAVeform<n>]:HISTory:TSRelative?` on page 1008
`CHANnel<m>[:WAVeform<n>]:HISTory:TSRReference?` on page 1008

6.4.2.2 Information



Max. acquisition count
Displays the maximum number of acquisitions that can be saved in the sample memory and displayed with the history viewer. With Ultra Segmentation, it is also the maximum number of acquisitions in an Ultra Segmentation acquisition series.

Available acquisitions
Displays the number of acquisitions currently saved in the sample memory. This memory is also used to save an Ultra Segmentation acquisition series, so the number of acquisitions available for history viewing is the same as the number of acquisitions in an Ultra Segmentation acquisition series.

Remote command:
`ACQuire:AVAilable?` on page 1005

6.4.3 Using History

You can access the history waveforms in two ways:

- Display a particular acquisition.
- Replay all or a part of the saved waveforms to track the signal run.

Furthermore, you can export history data to a file.

- "To open the history and get information" on page 262
- "To display a particular acquisition" on page 262
- "To replay history waveforms" on page 263
- "To exit the history" on page 263
- "To save the history data" on page 263

To open the history and get information

1. Press the HISTORY key on the front panel. A running acquisition is stopped, the history mode is enabled and the quick-access "History" dialog box is displayed.

   The HISTORY key is illuminated as long as the history mode is active.

2. Open the full configuration dialog box:
   - Tap the icon.
   - Press the HISTORY key again.
   - On the "Display" menu, tap "History setup".

3. In the "History" configuration dialog box, select the "Information" tab to see how many history waveforms are saved, and how many can be saved as maximum.

To display a particular acquisition

1. In the quick-access "History" dialog box, enter the number of the required acquisition in the "Current index" field. The newest acquisition always has the index "0", older acquisitions have a negative index

2. Tap "Play" to start.

Alternatively, you can configure and start the history display from the "History" configuration dialog box:

1. Open the "History" configuration dialog box and select the "Viewer" tab.

2. If the history mode is off (the HISTORY key is not illuminated), select "Show history".

   The quick-access dialog box is displayed.

3. Drag the slider to the required acquisition. The current number is shown in the "Current index" field.

Alternatively, enter the number of the required acquisition in the "Current index" field.

4. Tap "Play" to start.

To replay history waveforms

If you want to see the complete acquisition series without any setup, simply tap "Play" in the quick-access "History" dialog box. For specific analysis of history data, use the hestory "Viewer" setup.

1. In the "History" configuration dialog box, select the "Viewer" tab.
2. If the history mode is off (the HISTORY key is not illuminated), enable "Show history".
   The quick-access dialog box is displayed.
3. Define the part of the history you want to see by doing one of the following:
   - Tap "Select all" to see the complete history.
   - Enter the "Start Index" of the oldest acquisition to display and the "Stop Index" of the newest acquisition to display. All waveforms between the two indexes will be displayed.
     To enter the oldest or newest acquisition for either index, tap the appropriate button. The newest acquisition always has the index "0". The "Start index" is always negative.
4. Tap "Play" to start.

To exit the history

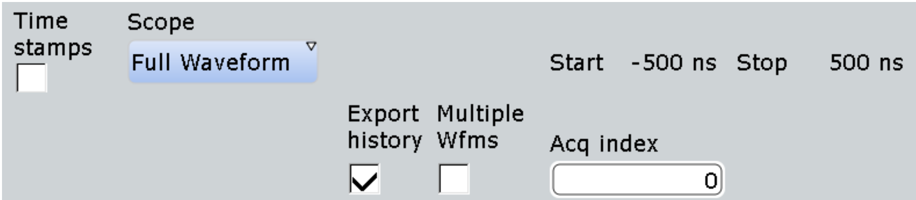
► Choose one of the following ways:
   - Close the quick-access "History" dialog box.
   - On the "Display" menu, tap "Show history".
   - In the "Viewer" tab, disable "Show history".
   - Start the acquisition.

To save the history data

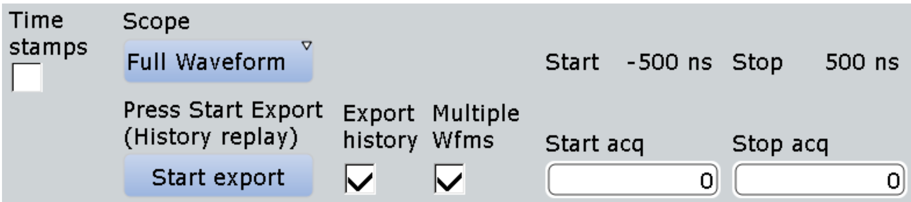
You can save the complete history, or some subsequent waveforms from the history, or a single history waveform. You can also decide to save the complete waveforms, or a part of each waveform.

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "Waveform" tab.
4. Tap the source icon to select the waveform you want to save.
5. If you want to save only a part of each waveform, set the "Scope".
   For settings, see "Scope" on page 418.
6. Enable "Export history".

7. If you want to write the timestamps into the data file, enable "Timestamps".
8. To save one waveform out of the history memory:
   a) Make sure that "Multiple Wfms" is disabled.
   b) Enter the number of the required acquisition in "Acq index". The newest acquisition in the memory always has the index "0". Older acquisition have a negative index.



   c) Tap "Save" or "Save As" to save the waveform data to the specified file.
9. To save several subsequent history waveforms:
   a) Enable "Multiple Wfms".
   b) Define the range of the waveforms to be saved with "Start acq" and "Stop acq".



   c) Tap "Start Export" to play the history and to save the history data to the specified file.

Se also Chapter 11.2.2, "Waveforms - Export Settings", on page 416.

6.5 XY-diagram

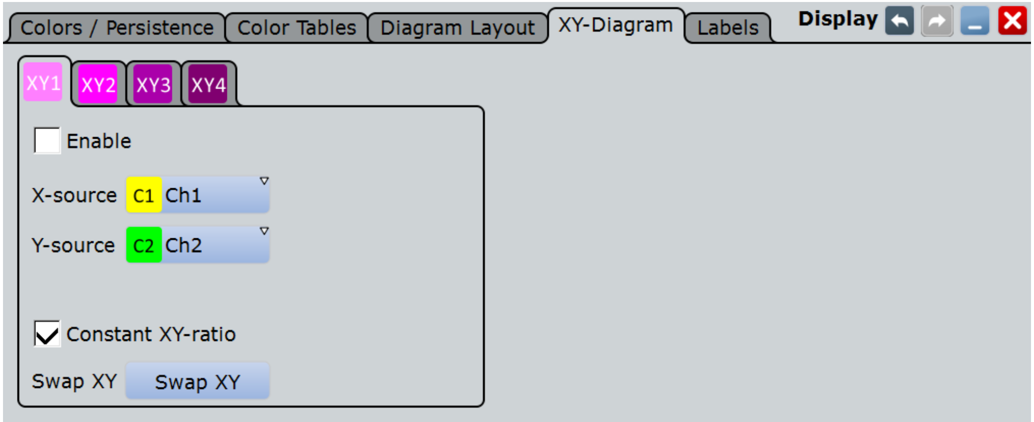
XY-diagrams combine the voltage levels of two waveforms in one diagram. They use the voltage level of a second waveform as the x-axis, rather then a time base. This allows you to perform phase shift measurements, for example. You can display up to four different XY-diagrams.

XY-diagrams can be used to display the IQ representation of a signal.

6.5.1 Settings for XY-Diagrams

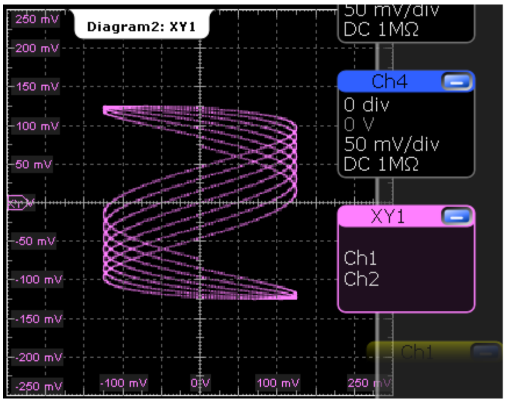
You can display up to four different XY-diagrams that use the voltage level of a waveform as the x-axis, rather then a time base.

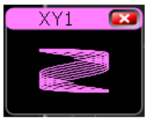
Make sure to select the tab of the required XY-diagram.



Enable

If activated, the XY-waveform is active and shown in a diagram, or it is minimized in a signal icon.





Remote command:

WAVeform<m>:XYCurve:STATe on page 1009

X-source

Defines the signal source that supplies the x-values of the XY-diagram. Select one of the following:

- One of the waveforms of any channel
- A reference waveform
- The results of a mathematical function

Remote command:

WAVeform<m>:XYCurve:XSOurce on page 1010

Y-source

Defines the source to be used as the y-axis of the XY-diagram. Select one of the following:

- One of the waveforms of any channel
- A reference waveform
- The results of a mathematical function

Remote command:
WAVeform<m>:XYCurve:YSOurce on page 1010

Constant XY-ratio
If enabled, the x- and y-axes maintain a constant ratio in the diagram.

Remote command:
WAVeform<m>:XYCurve:RATio on page 1009

Swap XY
Replaces the source of the x-axis with the source of the y-axis and vice versa.

Remote command:
WAVeform<m>:XYCurve:SWAP on page 1009

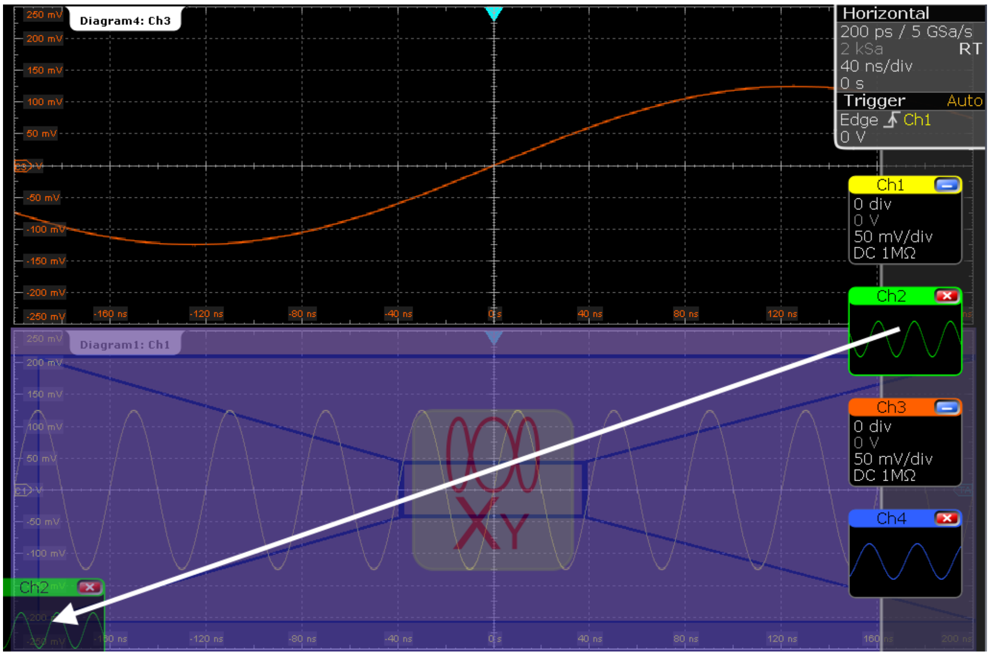
6.5.2 Displaying an XY-diagram

You can create the diagram from active waveforms with drag&drop, or use the dialog box for setup.

To display an XY-diagram with drag&drop

Prerequisites: The source waveform for the y-axis is active in a diagram, the source waveform for the x-axis is either active or minimized.

1. Drag the x-axis waveform to the lower left corner of the diagram with the y-axis waveform.
2. Drop the icon when it overlaps the left and lower diagram borders.



The diagram is converted into an XY-diagram.

To set up an XY-diagram

1. On the "Display" menu, tap "XY-diagram".
2. Activate the "State" option.
3. In the "X-source" field, define the signal source that supplies the x-values of the XY-diagram. Select one of the following:
   - One of the waveforms of any channel
   - A reference waveform
   - The results of a mathematical function
4. In the "Y-source" field, define the signal source that supplies the y values of the XY-diagram.
5. To switch the x- and y-values quickly, tap the "Swap XY" button.
6. In order to maintain a constant ratio while the x- and y-axes are adapted to the acquired data dynamically, activate the "Constant XY-ratio" option.

If the XY-diagram is active or minimized, touch and hold the signal icon to open the "XY-diagram" tab.

7 Measurements

Using the R&S RTE you can perform and display different measurements simultaneously, based on the active signal or math waveforms. The color of the results in the result table corresponds with the source waveform color.

The following measurement methods are available:

- Cursor measurements: measurements can be configured for up to 2 cursor sets to determine specific results at the manually defined cursor positions of an active waveform; the results are displayed in a result box.
- Automatic measurements: up to eight measurements can be configured and performed simultaneously on different sources; the results of each measurement are displayed in a result box.
- Quick measurements: performs a set of automatic measurements on the selected waveform at the push of a button. You can configure the set of measurement types.

7.1 Cursor measurements

7.1.1 Cursors and Results of Cursor Measurements

Cursor measurements determine the results at the current cursor positions. The cursors can be positioned manually or can be configured to follow the peaks of the waveform. Up to 2 cursor sets can be configured and displayed. Each cursor set consists of a pair of horizontal or vertical cursors, or both. Cursor lines can be coupled so that the initially defined distance is always maintained.

How to set up cursor measurements is decribed in Chapter 7.1.2, "Performing Cursor Measurements", on page 270. The Chapter 7.1.3, "Settings for Cursor Measurements", on page 273 provides a detailed description of all settings.

Cursors can also define a gate to limit the measurement to the section of the waveform between the cursor lines. See Chapter 7.2.3.1, "Gate Settings for Measurements", on page 286.

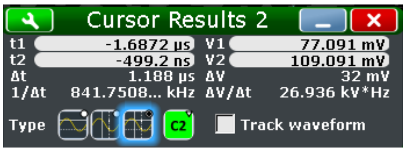
The cursors can be displayed in the source waveform diagram(s). For each measurement, labels can be defined for the cursors. By default, the cursors are labeled as C1.1, C1.2, C2.1, C2.2.

7.1.1.1 Cursor Measurements on Time Based Waveforms

The results of cursor measurements are displayed in a result box on the screen. For each measurement, a separate result box is displayed. The result box is displayed automatically when a cursor measurement is enabled. Similar to waveform diagrams, you can minimize the result box to a result icon on the signal bar, and display results in a separate diagram on the screen.

For details on using the result box, see Chapter 2.4.6, "Displaying Results", on page 98.

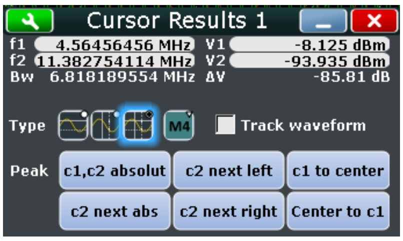
The following information may be provided in the result box, depending on the selected source.



Label	Description
t1, t2	Time at the position of the vertical cursors. You can change the values directly in the result box.
V1, V2	Vertical values of the waveform at the position of the horizontal cursors in V, A, dB etc. depending on the type of the source waveform. If the cursor lines track the waveform, the measurement result is displayed. If tracking is disabled, you can change the values directly in the result box.
f1, f2	The frequency at the position of the vertical cursors.
Δt	Difference between the vertical cursor (time) values
BW	Difference between the vertical cursor (frequency) values
ΔV	Difference between the horizontal cursor values
1/Δt	Inverse time difference
ΔV/Δt	Slope of the waveform between the cursors
Type	Cursor type - horizontal, vertical, or both
Track waveform	If enabled, the horizontal cursors track the peaks of the waveform

7.1.1.2 Cursor Measurements on Spectrum Waveforms

If the measurement source is a spectrum waveform, the result box provides buttons for easy center definition and peak search.



The peak search functions "c1, c2 absolute", "c2 next abs", "c2 next right", and "c2 next left" are also available in the Chapter 7.1.3.3, "Peak Search Tab", on page 276.

Center definition functions are only available in the result box.

c1 to center

Sets the vertical cursor line c1 to the center frequency.

Remote command:

`CURSor<m>:FFT:TOCenter` on page 1017

Center to c1

Sets the center frequency to the frequency value that is measured at cursor line c1.

Remote command:

`CURSor<m>:FFT:SETCenter` on page 1017

7.1.2 Performing Cursor Measurements

Cursor measurements determine the results at the current cursor positions. The cursors can be positioned manually or can be configured to follow the waveform. Up to 2 sets of cursors can be configured and displayed. Each set of cursors consists of a pair of horizontal or vertical cursors, or both. The cursor display can also be configured.

Cursor measurements can be performed and displayed simply by tapping the "Cursor" icon on the toolbar and then the waveform to be measured.

7.1.2.1 Performing a Simple Cursor Measurement

To display cursors

1. Select the waveform to be measured.
2. Choose one of the following methods:
   - Press the CURSOR key.
   - Tap the "Cursor"icon, and then tap the diagram where you want to set the cursors, or draw a rectangle in the diagram to position the cursor lines.

   The cursor lines appear and the "Cursor Results" box for the selected waveform opens.

   You can move the cursor lines in the diagram manually, or adjust the cursor type, source and position in the result box.
   For details on cursor measurement results, see Chapter 7.1.1, "Cursors and Results of Cursor Measurements", on page 268.

To disable all cursor measurements

1. Press the CURSOR key.
2. Select the "Cursor Setup" tab.
3. Tap the "All Off" button.

   All cursor measurements are disabled, the cursors and cursor result boxes are removed from the display.

7.1.2.2 Configuring a Cursor Measurement

1. If a cursor measurement was already enabled via the toolbar icon or CURSOR key, tap the icon in the result box, or press the CURSOR key to display the "Cursor Setup" dialog box.
   Otherwise, from the "Cursor" menu, select "Setup".
2. Select the "Cursor Setup" tab.
3. Select the tab for the cursor set you want to perform a measurement on.
4. Tap the "Source" icon and select a waveform for which the measurement is to be performed. Any input channel, math, reference or XY-waveform can be selected.
   If you enabled the cursor measurement via the toolbar icon or CURSOR key, the source is automatically defined as the selected or active waveform.
5. Select the icon for the type of cursors to be used - horizontal, vertical, or both.
6. Define the position of the cursors.
   a) To define the position of the cursors manually, enter the X-position for each vertical cursor and the Y-position for each horizontal cursor. Horizontal cursors can only be positioned manually if the "Track waveform" setting is disabled.
   b) To position the horizontal cursors automatically, select "Track waveform". In this case, cursor 1 indicates the current maximum, cursor 2 indicates the current minimum. If both horizontal and vertical cursors are displayed, the horizontal cursors are placed at the crossing points of the vertical cursors with the waveform. The vertical cursors must be positioned manually.
   If the waveform arithmetics are set to "Envelope" and the "Trace Curve" setting is enabled, select which horizontal cursor is positioned to the maximum and which to the the minimum envelope values. Under "Envelope wfm selection 1", select the crossing point for cursor 1. Under "Envelope wfm selection 2", select the crossing point for cursor 2.
   c) To maintain the distance between the vertical cursors when one cursor is moved, select the "Coupling" option.

d) To set the cursors for a spectrum measurement to peak values automatically, select the "Peak Search" tab.
Optionally, define a peak excursion, i.e. the minimum level value by which the waveform must rise or fall so that it will be identified as a maximum or a minimum by the search functions.
Tap one of the search function buttons to place the cursor(s) on the selected peak value. For details see Chapter 7.1.3.3, "Peak Search Tab", on page 276.

When you close the dialog box you can move the cursors on the touchscreen manually; the results are adapted accordingly.

7. Optionally, select "Show in all diagrams" in the "Setup" tab to enable the cursor display for all waveform diagrams based on the same domain (time or spectrum) as the selected source, for example a zoom or XY-diagram.
8. Tap the "Enable" icon in the "Setup" tab to activate the cursor measurement.

   The cursors are displayed in the waveform diagram(s) of the measurement source and the "Cursor" result box is displayed. For details on cursor measurement results, see Chapter 7.1.1, "Cursors and Results of Cursor Measurements", on page 268.

7.1.2.3 Configuring the Cursor Display

By default, the cursors are displayed as lines in the diagrams and labeled according to the syntax:

C<cursor set number>.<1|2>

The cursors for the cursor set 3, for example, are labeled 3.1 and 3.2. Both the horizontal and the vertical cursors have the same labels.

You can change the default cursor display.

1. Press the CURSOR key.
2. Select the "Cursor Style And Label" tab.
3. Select the tab for the cursor set you want to configure.
4. For each vertical and horizontal cursor enter a label to be displayed in the diagrams.
5. Select "Show labels".
6. To display only the crossing points of the cursors with the waveform, select the cursor style "Rhombus".
   To display both the crossing points and the cursor lines, select the cursor style "Line & Rhombus".

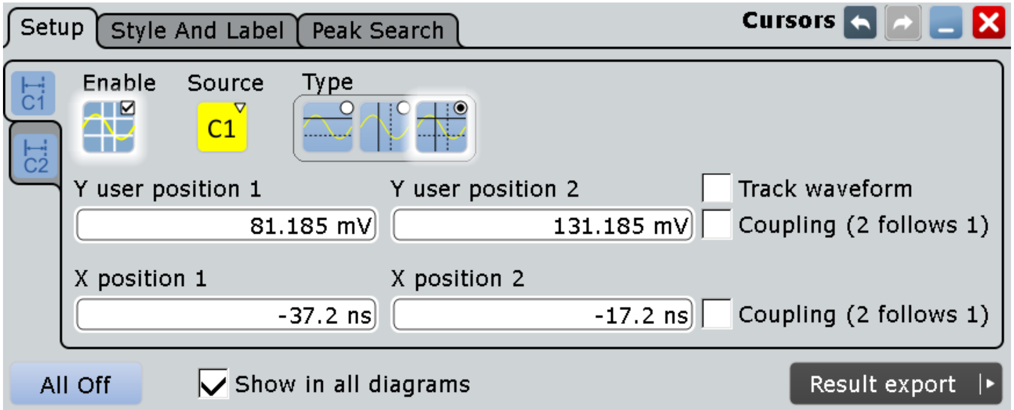
7.1.3 Settings for Cursor Measurements

Cursor measurements are configured in the "Cursors" dialog box.

7.1.3.1 Cursor Setup Tab

Access: CURSOR key

This tab contains general settings for cursor measurements. If you want to save the measurement results to a file, tap "Result export". See also: Chapter 11.2.4, "Numeric Results", on page 423.



Cursor set (vertical tab)
The settings for each cursor measurement (or cursor set) are configured on separate tabs. For each measurement, a horizontal pair of cursors, a vertical pair of cursors, or both can be displayed.

Enable
Enables the selected cursor measurement.

Remote command:
`CURSor<m>:STATe` on page 1011

Source
Defines the source of the cursor measurement. Any of the input signal, math, reference or XY waveforms can be selected.

Remote command:
`CURSor<m>:SOURce` on page 1012

Type
Defines the cursor type to be used for the measurement.

"Horizontal cursors"	The horizontal cursors are positioned automatically along the waveform or can be positioned manually.
"Vertical cursors"	The vertical cursors are positioned manually.
"Both horizontal and vertical cursors"	The horizontal cursors are positioned automatically along the waveform or can be positioned manually. The vertical cursors are positioned manually.

Remote command:
`CURSor<m>:FUNCtion` on page 1012

Y user position 1|2
Defines the position of the horizontal cursor lines. The setting corresponds to the V1 and V2 values in the "Cursor Results" box.

If "Track waveform" is enabled, the user setting is disabled and the measurement results are displayed in the "Cursor Results" box.

Remote command:
`CURSor<m>:Y1Position` on page 1014
`CURSor<m>:Y2Position` on page 1014

Track waveform
The horizontal cursors track the waveform, i.e. one cursor line indicates the actual vertical maximum, and the second cursor line indicates the minimum. If the waveform changes, e.g. during a running measurement, the cursors move along with it. If both horizontal and vertical cursors are displayed, the horizontal cursors are positioned to the crossing points of the vertical cursors with the waveform. The measurement results are displayed in the "Cursor Results" box.

Tracking disables the Y-coupling (coupling horizontal cursor lines) and the Y user position settings.

Remote command:
`CURSor<m>:TRACking[:STATe]` on page 1012

X position 1|2
Defines the position of the vertical cursors.

Remote command:
`CURSor<m>:X1Position` on page 1013
`CURSor<m>:X2Position` on page 1013

Coupling (2 follows 1)
Couples the horizontal and vertical cursor pairs so that the distance between the two lines remains the same if one cursor is moved.

Remote command:
`CURSor<m>:YCOupling` on page 1014
`CURSor<m>:XCOupling` on page 1013

Envelope wfm selection 1|2
This settings is available under the following conditions:
- The waveform arithmetic of the cursor source waveform is set to envelope waveform (see "Arithmetic" on page 157)
- Both horizontal and vertical cursors are enabled ("Type" = *Both*).
- "Track waveform" is enabled

The setting defines which horizontal cursor is positioned to the maximum and which to the the minimum envelope values.

"Minimum" The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope.

"Maximum" The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope.

Remote command:
`CURSor<m>:X1ENvelope` on page 1015
`CURSor<m>:X2ENvelope` on page 1015

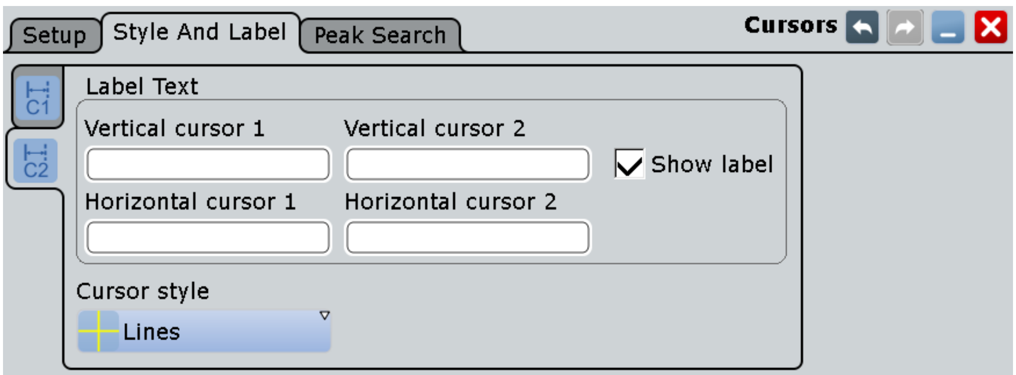
All Off
Disables all cursor measurements at once.

Remote command:
`CURSor<m>:AOFF` on page 1011

Show in all diagrams
Shows the enabled cursor measurements in all active diagrams of the same (time/spectrum) domain.

7.1.3.2 Cursor Style and Label Tab

The settings in this tab configure the display of the cursors.



Cursor set (vertical tab)
The settings for each cursor measurement (or cursor set) are configured on separate tabs. For each measurement, labels can be defined for the cursors.

By default, the cursors are labeled as C1.1, C1.2, C2.1, C2.2.

Vertical cursor 1|2
Defines a label to be displayed with the vertical cursors.

Horizontal cursor 1|2
Defines a label to be displayed with the horizontal cursors.

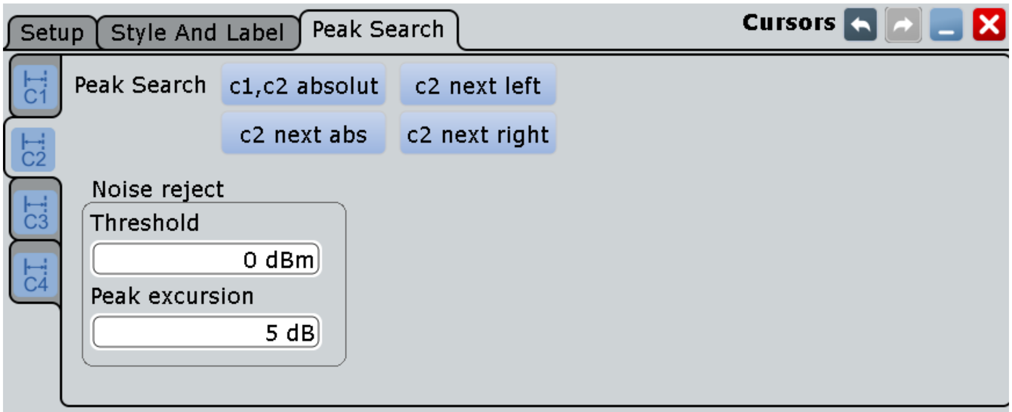
Show label
Shows the cursor labels in the diagram.

Cursor style
Defines how the cursor is displayed in the diagram.

"Lines"	The cursors are displayed as lines.
"Line & Rhombus"	The cursors are displayed as lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.
"Rhombus"	The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

7.1.3.3 Peak Search Tab

The settings on this tab are only available in spectrum mode, i.e. the source of the cursor measurement is an FFT math waveform. In this case, the cursors can indicate the results of a peak search on the waveform. You can define which peaks the instrument will find by defining the noise reject settings.



Threshold
Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

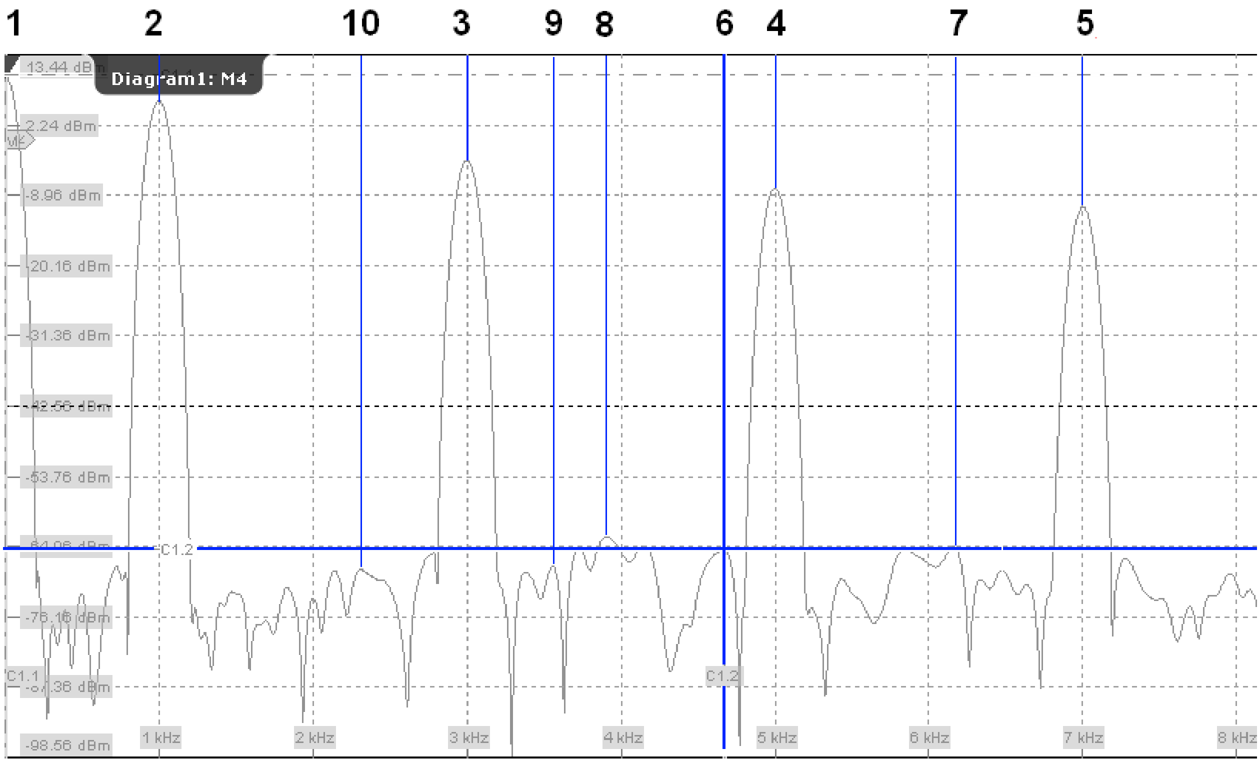
This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Remote command:
`CURSor<m>:THReshold` on page 1018
`MEASurement<m>:SPECtrum:ATHReshold` on page 1038

Peak excursion
Defines a relative threshold, the minimum level value by which the waveform must rise or fall to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

The following figure shows a cursor measurement on a spectrum waveform:



If "Peak excursion" is 30 dB, the peaks 1 to 5 are found. If "Peak excursion" is 20 dB, also the peaks 6 to 10 are found. The cursor position is on peak 6.

Remote command:
CURSor<m>:PEXCursion on page 1018
MEASurement<m>:SPECtrum:PEXCursion on page 1037

c1, c2 absolute
Both cursors are set to the absolute peak value.

Remote command:
CURSor<m>:MAXimum[:PEAK] on page 1017

c2 next abs
Cursor 2 is set to the next smaller absolute peak from the current position.

Remote command:
CURSor<m>:MAXimum:NEXT on page 1018

c2 next right
Cursor 2 is set to the next peak to the right of the current position.

Remote command:
CURSor<m>:MAXimum:RIGHt on page 1017

c2 next left
Cursor 2 is set to the next peak to the left of the current position.

Remote command:
`CURSor<m>:MAXimum:LEFT` on page 1017

7.2 Automatic Measurements

The R&S RTE can perform up to 8 automatic measurements and a quick measurement simultaneously. For each measurement, various measurement types are available to measure the characteristics of a source waveform. The measurement types are grouped in categories.

The basic measurement settings are source, category, and measurement type. You can refine the setup to get more specific results:

- Multiple measurement
- Gating
- Statistics and long term measurements

Measurement types and categories

The R&S RTE provides various measurement types in several categories, depending on the selected source.

Time domain

- Amplitude and time measurements
- Eye measurements
- Histogram measurements
- Jitter measurements (option R&S RTE-K12)
- Protocol measurements (with at least one serial protocol option)

Frequency domain

- Spectrum measurements
- Histogram measurements

Multiple measurements

For best performance, only one measurement is performed for each acquired waveform. With multiple measurement, more than one result is taken from one acquired waveform. This is useful when calculating statistics or generating tracks.

See: "Multiple measurement" on page 322.

Gating

A gate limits the measurement to a user-defined part of the waveform.

See: Chapter 7.2.3, "Measurement Gates", on page 286.

Statistics and long term measurements

To evaluate time-dependent behavior of measurement results, you can use statistics, long term measurements, and tracks.

See: Chapter 7.2.9, "Long Term Measurements and Statistics", on page 317.

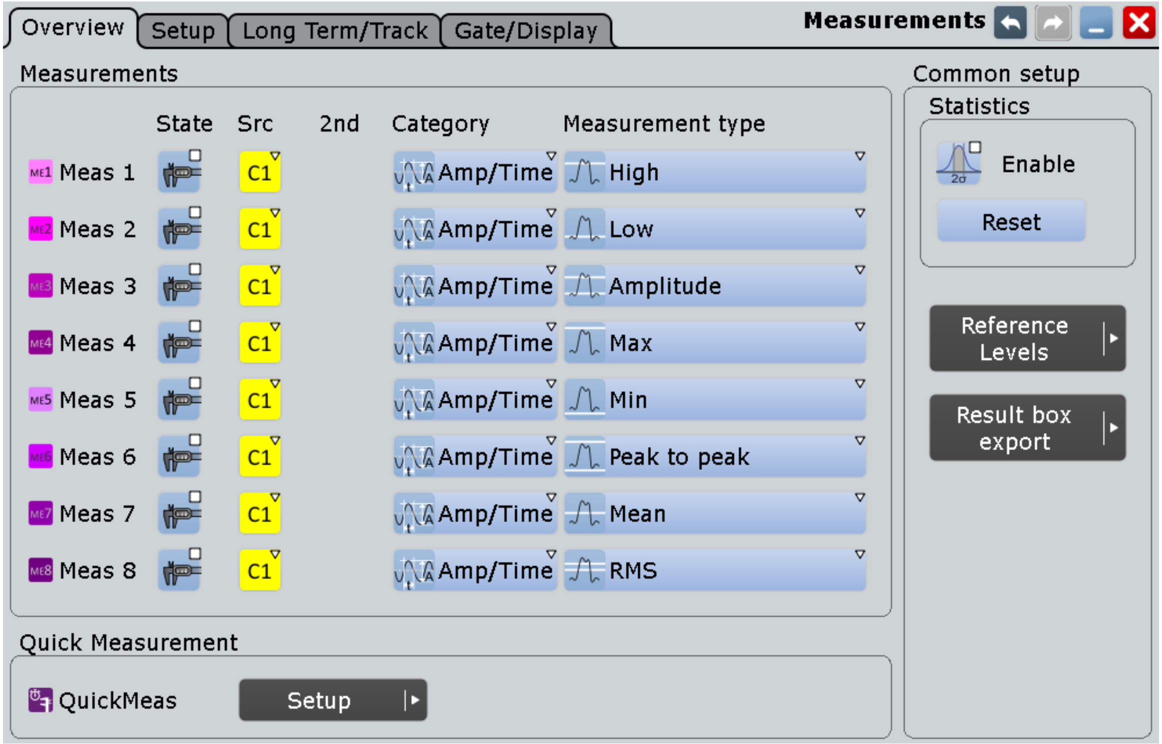
7.2.1 Measurement Setup in General

7.2.1.1 General Measurement Settings

Access: "Meas" menu > "Overview"

Automatic measurements are configured in the "Measurements" dialog box.

Up to 8 measurements can be defined. The "Overview" tab shows the general settings for all 8 measurements. For each measurement, the source, category, and measurement type can be defined in the "Overview" tab, and you can also enable statistic evaluation for all measurements. For some measurement types, specific settings are available. These settings are defined on the "Setup" tab.



This section describes the settings that relate to all measurement types. Specific settings are described in the corresponding category chapter:

- Chapter 7.2.5.2, "Amplitude/Time Measurement Settings ", on page 298
- Chapter 7.2.6.2, "Eye Diagram Measurement Settings", on page 306
- Chapter 7.2.7.2, "Spectrum Measurement Settings ", on page 307
- Chapter 7.2.8.3, "Histogram Measurement Settings ", on page 315

State

Enables the measurement.

Remote command:

`MEASurement<m>[:ENABle]` on page 1019

Source

Define the source(s) of the measurement. The source can be any input signal, math or reference waveform. Depending on the selected source, not all measurement types are available. The 2nd source is required for amplitude/time measurements that are performed on two waveforms (e.g. delay, phase).

Remote command:

`MEASurement<m>:SOURce` on page 1019

Statistics

Enables the calculation and display of statistical results.

Remote command:

`MEASurement<m>:STATistics[:ENABle]` on page 1050

`MEASurement<m>:RESult:AVG?` on page 1025

MEASurement<m>:RESult:EVTCount? on page 1025
MEASurement<m>:RESult:NPEak? on page 1025
MEASurement<m>:RESult:PPEak? on page 1025
MEASurement<m>:RESult:RMS? on page 1025
MEASurement<m>:RESult:STDDev? on page 1025
MEASurement<m>:RESult:WFMCount? on page 1025
MEASurement<m>:RESult[:ACTual]? on page 1025
MEASurement<m>:ARNames on page 1024
MEASurement<m>:ARES? on page 1024

Envelope

This setting is only relevant for measurements on envelope waveforms, see "Arithmetic" on page 157. If the measurement source is not an envelope, the setting is ignored.

"Maximum"	Measurements are performed on the upper envelope.
"Minimum"	Measurements are performed on the lower envelope.
"Both"	The upper and the lower envelope are used in measurements. For time measurements, the averages of min and max values are used, that is, the measurement is performed on the average waveform built from the upper and lower envelope.

Remote command:
MEASurement<m>:ENVSelect on page 1029

Category

Measurement category. The following categories are available:

- Amp/Time: amplitude and time measurements
- Eye: eye diagram measurements
- Spectrum: measurements in the frequency domain, require a spectrum waveform as source
- Histogram: measurements on histograms
- Protocol: only available for audio signals (option R&S RTEK5).

Measurement type

Defines the measurement type for the selected measurement and category.

For details on the available measurement types, see:
- Chapter 7.2.5.1, "Amplitude/Time Measurement Types", on page 294
- Table 7-5
- Table 7-6
- Table 7-7

Remote command:
MEASurement<m>:MAIN on page 1022

7.2.1.2 Starting an Automatic Measurement

There are three methods to start an automatic measurement, each with slightly different effects:

- Using the "Measurement" icon on the toolbar:
  The icon starts the measurement with the lowest number.
  See: "To start a measurement using the toolbar icon" on page 282.
- Pressing the MEAS key on the front panel.
  If no measurement is running, the measurement with the lowest number is started.
  If a measurement is already running, the key opens the "Measurement" dialog box for the currently selected measurement.
  See: "To start a measurement with the MEAS key" on page 282.
- Using the menu.
  Tap "Meas" menu > "Overview", configure the measurement and enable "State".
  See: Chapter 7.2.1.3, "Configuring Measurements", on page 282.

To start a measurement using the toolbar icon

1. Select the waveform that you want to measure.
2. Tap the "Measurement" icon on the toolbar.

3. Define the measurement range in one of these ways:
   - To measure the complete waveform, tap the diagram with the waveform.
   - To define a gate that limits the measurement, draw a rectangle on the screen.

   The "Measurements" result box is displayed.

To start a measurement with the MEAS key

1. Select the waveform on the screen.
2. Press the MEAS key.

   The measurement for the selected waveform is enabled using the next available measurement configuration. The "Measurements" result box is displayed.

7.2.1.3 Configuring Measurements

Up to eight automatic measurements can be configured and performed simultaneously.

Spectrum measurements require an FFT math waveform as measurement source. Histogram measurements require a histogram as source.

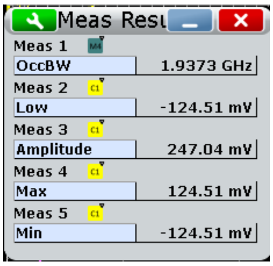
1. If a measurement is already running, tap the icon in the result box, or press the MEAS key to display the "Measurements" dialog box.
   Otherwise, tap the "Meas" menu and select "Overview".
2. Tap "Source" and select the waveform to be measured. For histogram measurements, select the histogram.
   If you enabled the measurement with the toolbar icon or MEAS key, the source is already defined. However, you can select any other input channel, math or reference waveform.

3. Select the measurement category, for example, "Amp/Time".
4. Select the "Measurement type".
5. Depending on the selected measurement type, further settings may be required. These settings are shown on the "Setup" tab. On the left of the tab, select the measurement to be configured.
   the settings are explained in the following chapters:
   - Chapter 7.2.5.2, "Amplitude/Time Measurement Settings ", on page 298
   - Chapter 7.2.6.2, "Eye Diagram Measurement Settings", on page 306
   - Chapter 7.2.7.2, "Spectrum Measurement Settings ", on page 307
   - Chapter 7.2.8.3, "Histogram Measurement Settings ", on page 315
6. Optionally, define a gate to restrict the measurement to a part of the waveform, as described in Chapter 7.2.3.2, "Using Measurement Gates", on page 288.
   If you enabled the measurement with the toolbar icon and drew a rectangle on the diagram, the gate is automatically defined and enabled.
7. To compile and display statistics for the measurement, enable "Statistics". See also Chapter 7.2.9.5, "Compiling Measurement Statistics", on page 325.
8. Enable "State" to start the measurement.

   The results of the measurement are displayed in the result box.

7.2.2 Measurement Results

The results of automatic measurements are displayed in a result box on the screen. The result box is displayed automatically when at least one automatic measurement is enabled.



If you want to save space in the display, minimize the result boxes. The most important results are also displayed and updated in the signal icon.

The function "Clear screen results" in the "Display" menu resets all results including long term measurement and statistic results and deletes the current measurement waveforms.

Which results are displayed depends on the measurement type and is described in detail in the following chapters.

The following additional results are available:

- **Statistics**
  You can enable stastical evaluation of the measurement results. Statistic information is provided in the result box for each measurement type.
  Stopping and restarting the acquisition does not reset statistics but only stops and continues them.
  See Chapter 7.2.9, "Long Term Measurements and Statistics", on page 317
- **Measurement histograms**
  Additionally, the results of measurements can be displayed in a histogram which shows the density distribution of the measurement results in a graphic and thus illustrates the statistics of the measurements.
  See Chapter 7.2.8, "Histograms and Histogram Measurements", on page 310
- **Long term measurements**
  Long term measurements show the behavior of measurement results over a longer time or for a large number of samples. You can define the number of long term points and export the long term data, including statistical results. The measurement histogram is a vertical histogram shown in the long term diagram.
  See: Chapter 7.2.9, "Long Term Measurements and Statistics", on page 317
- **Intermediate results**
  You can display auxiliary result lines and reference levels required to perform some measurement types in the source diagram, see Chapter 7.2.2.3, "Configuring the Results Display", on page 286

From the result box, you can open the settings dialog box using the icon.

Remote commands:

- `MEASurement<m>:ARES?` on page 1024
  `MEASurement<m>:ARNames` on page 1024
  `MEASurement<m>:RESult[:ACTual]?` on page 1025
  `MEASurement<m>:RESult:COUNt?` on page 1026

7.2.2.1 Measurement Status

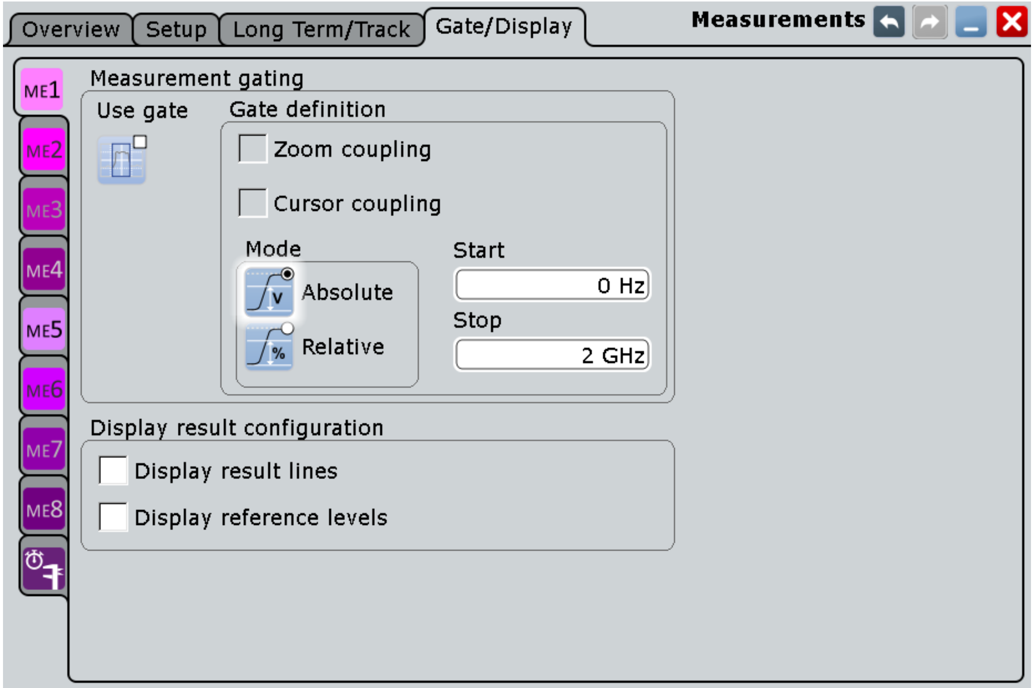
Normally, the result box displays the measurement results.

If no icon and no result value ("---") is shown, the instrument cannot measure the required value. Theis may happen, for example, if the acquisition does not contain at least one complete period for frequency and cycle measurements. Check and adjust the waveform settings to get results.

A blue icon with question mark means that the measurement result might not be correct due to insufficient amplitude level. Check your amplitude and reference level settings.

7.2.2.2 Result Display Settings

The display settings for measurement results are set on the "Gate/Display" tab. Display settings are measurement-specific, each measurement can have its own settings.



Gate settings are described in Chapter 7.2.3.1, "Gate Settings for Measurements", on page 286.

ME 1/2/3/4/5/6/7/8/Quick Meas
For each of the eight measurements, and for the quick measurement, a subtab contains the configuration settings. A green dot on the tab indicates that the measurement is active.

Display result lines
Displays intermediate result lines in the measurement waveform (e.g. signal thresholds) required to obtain the measurement result.

Remote command:
`MEASurement<m>:DISPlay:RESults` on page 1049

Display reference levels
Displays the reference levels used for the measurement in the diagram.

Remote command:
`MEASurement<m>:DISPlay:LEVels` on page 1049

7.2.2.3 Configuring the Results Display

The measurement results can be displayed in a result box, in a minimized result icon on the signal bar, or as table in a separate diagram area. For details, see Chapter 2.4.6, "Displaying Results", on page 98.

The display settings for measurements are provided on the "Gate/Display" tab, see Chapter 7.2.2.2, "Result Display Settings", on page 285.

To display measurement information in the diagram

You can display auxiliary lines in the diagram to determine how a measurement result was obtained. Such lines include gate areas, reference levels or intermediate result lines, such as the signal thresholds for rise and fall time measurements.

1. From the "Meas" menu, select "Gate/Display".
2. Select the tab for the measurement you want to configure.
3. To display intermediate result lines, select "Display result lines".
4. To display reference levels, select "Display reference levels".

To clear the measurement results

► On the "Display" menu, tap "Clear screen results".

The results of all measurements are cleared.

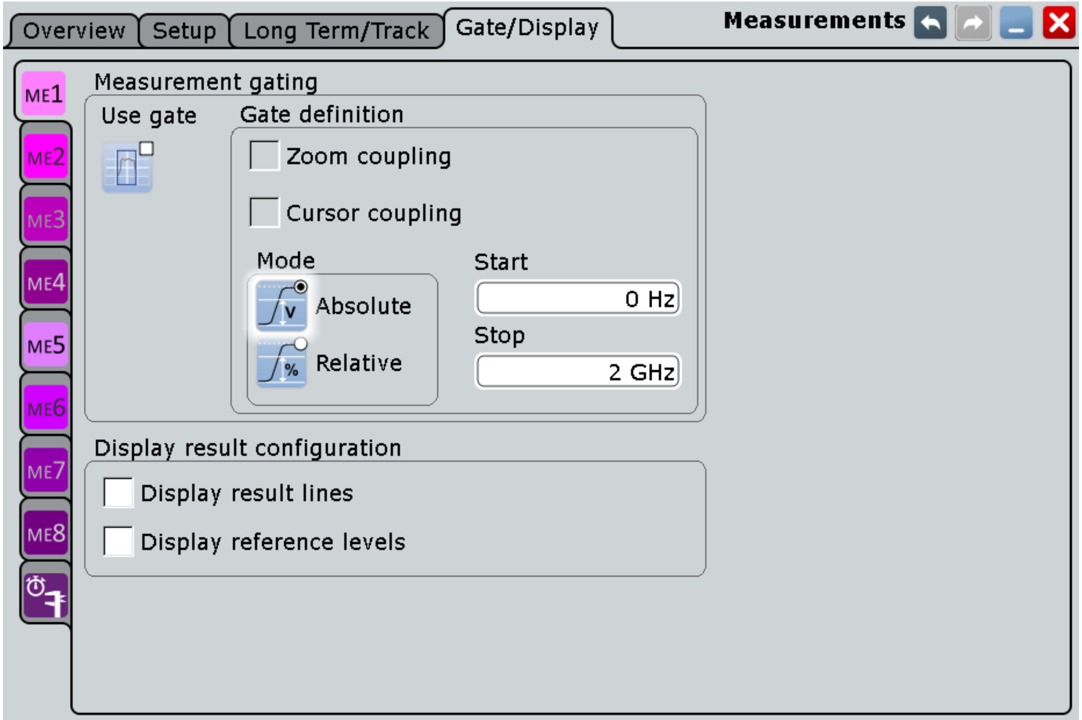
7.2.3 Measurement Gates

7.2.3.1 Gate Settings for Measurements

Gate areas limit the measurement to a user-defined range of the waveform. The gate settings are defined on the "Gate/Display" tab.

The R&S RTE provides one gate, thus all measurements share the same gate.

Result display settings are described in Chapter 7.2.2.2, "Result Display Settings", on page 285.



Use gate
Considers the gating settings for the selected measurement and displays the gate.

Remote command:
`MEASurement<m>:GATE[:STATe]` on page 1057

Zoom coupling
Zoom coupling is available if a zoom is defined. As long as "Zoom coupling" is enabled, the gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.

If several zoom diagrams are defined, select the zoom diagram to be used for gating. The "Start" and "Stop" values of the gate are adjusted accordingly.

Zoom coupling can be set for measurement gates, FFT gates, and search gates.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:ZCOupling` on page 1078
`MEASurement<m>:GATE:ZCOupling` on page 1059
`MEASurement<m>:GATE:ZDIagram` on page 1059
`SEARch:GATE:ZCOupling` on page 1129
`SEARch:GATE:ZDIagram` on page 1129

Cursor coupling
If enabled, the gate area is defined by the cursor lines of an active cursor measurement. If several cursor measurements are enabled, select the cursor set to be used for gating. The "Start" and "Stop" values of the gate are adjusted to the values of the cursor line positions limiting the measurement to the part of the waveform between the cursor lines.

Remote command:
MEASurement<m>:GATE:CCOupling on page 1058
MEASurement<m>:GATE:CURSor on page 1058

Mode
Defines whether the gate settings are configured using absolute or relative values.

"Absolute" The gate is defined by absolute start and stop values.

"Relative" The gate's start and stop values are defined by a percentage of the value range.

Remote command:
CALCulate:MATH<m>:FFT:GATE:MODE on page 1077
MEASurement<m>:GATE:MODE on page 1057
SEARch:GATE:MODE on page 1128

(Relative) Start
Defines the starting value for the gate.

Remote command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt on page 1077
CALCulate:MATH<m>:FFT:GATE:RELative:STARt on page 1077
MEASurement<m>:GATE:ABSolute:STARt on page 1057
MEASurement<m>:GATE:RELative:STARt on page 1057
SEARch:GATE:ABSolute:STARt on page 1128
SEARch:GATE:RELative:STARt on page 1128

(Relative) Stop
Defines the end value for the gate.

Remote command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP on page 1077
CALCulate:MATH<m>:FFT:GATE:RELative:STOP on page 1078
MEASurement<m>:GATE:ABSolute:STOP on page 1057
MEASurement<m>:GATE:RELative:STOP on page 1057
SEARch:GATE:ABSolute:STOP on page 1128
SEARch:GATE:RELative:STOP on page 1129

7.2.3.2 Using Measurement Gates

If you enabled the measurement with the toolbar icon and drew a rectangle on the diagram, the gate is automatically defined and enabled. Otherwise, or if you want to define a more precise gate area, configuration is done in the "Measurement" > "Gate/Display" dialog box.

1. On the "Meas" menu, tap "Gate/Display".
2. Select the tab for the measurement you want to configure.

3. To define the gate, use one of the following methods:
   - Define the start and stop values of the gate area by entering either absolute or relative values.
   - If a zoom area has already been defined for the waveform, couple the gate area to the zoom area by selecting the "Zoom coupling" option.
   - If a cursor measurement has already been defined for the waveform, couple the gate area to the cursor lines by selecting the "Cursor coupling" option.
4. Tap the "Use gate" icon to enable the gate area usage.

   The measurement is performed on the selected part of the waveform. The gate is shown in the diagram.

7.2.4 Reference Levels

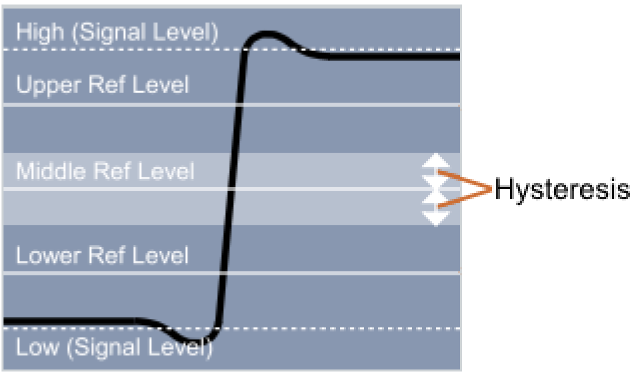
Some measurement types require reference levels to obtain the measurement points, e.g. time measurements or pulse count. Reference levels are referred to the signals, for each waveform you can define specific reference levels. Thus, for all measurements on a waveform the same reference levels are used.

Usually, reference levels are determined automatically. The instrument determines the high and low signal levels based on amplitude and histogram mesasurements of the acquisition. The reference levels are set relativly to the determined signal levels.

However, for irregular data and in special measurement setups it may be useful to configure the levels manually:

- Data signals may contain intervals where no data is transmitted, so that a high and low state can not be determined for each acquisition. In this case, you can define the high and low signal levels manually, in order to evaluate other measurement results.
- If the signal levels vary strongly or have large overshoots, the rise and fall levels may be difficult to determine.
- If fixed levels are defined for the DUT, you can configure the reference levels in the R&S RTE correspondingly and analyze the resulting measurement data.

In manual configuration, the reference levels can be set relativly to the determined signal levels or as absolute values.



The instrument sets a default hysteresis for the middle reference level. Hysteresis is useful for measurements that determine zero-crossings. Period, frequency, and pulse measurements are based on hysteresis - the instrument returns results if the amplitude of the signal exceeds the hysteresis. Thus, measurements during the transient oscillation is also possible.

Reference levels and result lines can be displayed in the diagram.

7.2.4.1 Level Settings

On the "Levels" tab, you set the reference levels to a percentage of the high signal level.

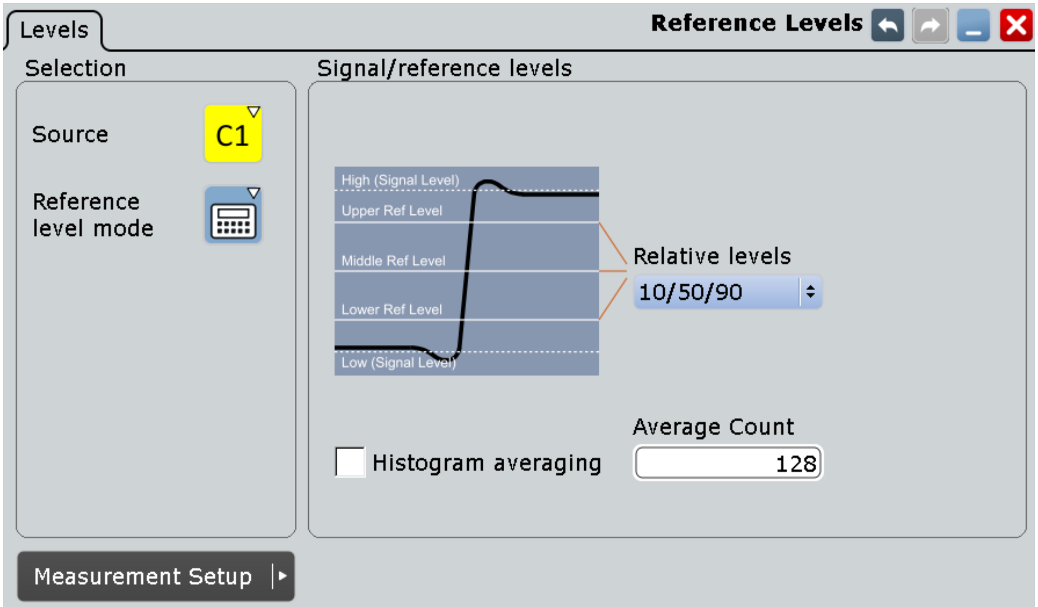


Figure 7-1: Automatic reference level definition

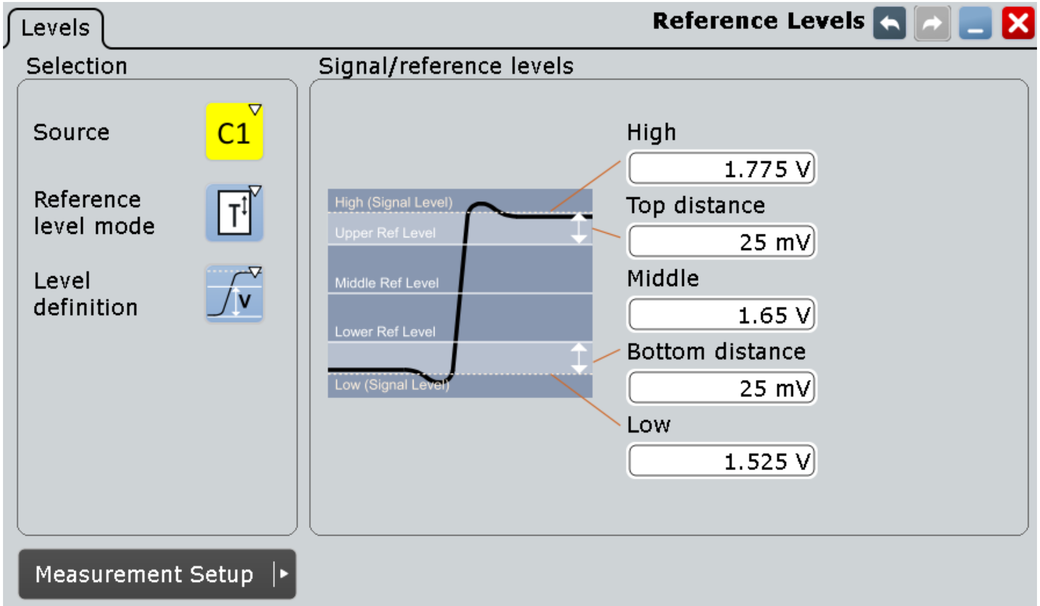


Figure 7-2: Manual reference level definition

Source

Defines the source from which the reference is taken. The source can be any signal input, math or reference waveform.

Remote command:

Source is defined by suffix <m> in "REFLevel" subsystem, see Chapter 16.12.11, "Reference Level", on page 1059

Reference level mode

Defines whether the reference level is configured manually or automatically.

Remote command:

`REFLevel<m>:LDETection` on page 1060

Level definition

In manual reference level mode, the setting defines whether the reference is configured using absolute or relative values.

Remote command:

`REFLevel<m>:LMODe` on page 1060

Relative levels

The lower, middle and upper reference levels, defined as percentages of the high signal level.

Available relative levels:

- 5/50/95
- 10/50/90
- 20/50/80
- User defined: Enter "Upper ref level", "Middle ref level", and "Lower ref level".

For example, for "5/50/95" the levels are set to the following values:

- lower reference level = 5% of high signal level
- middle reference level = 50% of high signal level
- upper reference level = 95% of high signal level

Remote command:
REFLevel<m>:RELative:MODE on page 1060

Upper ref level, Middle ref level, Lower ref level
Define any reference levels in percent, if "Relative levels" is set to "User-defined".

Remote command:
REFLevel<m>:RELative:UPPer on page 1065
REFLevel<m>:RELative:MIDDle on page 1066
REFLevel<m>:RELative:LOWer on page 1066

High
The signal value that represents a high level - for manual reference level mode, absolute level definition and user signal level.

Remote command:
REFLevel<m>:ABSolute:HIGH on page 1062
MEASurement<m>:REFLevel:RESult:SIGHigh? on page 1067

Low
The signal value that represents a low level - for manual reference level mode, absolute level definition and user signal level.

Remote command:
REFLevel<m>:ABSolute:LOW on page 1062
MEASurement<m>:REFLevel:RESult:SIGLow? on page 1067

Top distance
The distance between the high signal level and the upper reference level - for manual reference level mode and absolute level definition.

Remote command:
REFLevel<m>:ABSolute:TDIStance on page 1063

Bottom distance
The distance between the lower reference level and the low signal value - for manual reference level mode and absolute level definition.

Remote command:
REFLevel<m>:ABSolute:BDIStance on page 1063

Upper level
The upper reference level, required e.g. to determine a rise - for manual reference level mode, absolute level definition and user reference level.

Remote command:
REFLevel<m>:ABSolute:ULEVel on page 1064
MEASurement<m>:REFLevel:RESult:UPPer? on page 1067

Lower level
The lower reference level, required e.g. to determine a fall - for manual reference level mode, absolute level definition and user reference level.

Remote command:
`REFLevel<m>:ABSolute:LLEVel` on page 1065
`MEASurement<m>:REFLevel:RESult:LOWer?` on page 1067

Histogram averaging
Enables averaging over several histograms to determine the reference levels.

This function is only available in automatic reference level mode.

Remote command:
`REFLevel<m>:AUTO[:STATe]` on page 1061

Average Count
Defines the number of histograms to calculate the average from.

This function is only available in automatic reference level mode.

Remote command:
`REFLevel<m>:AUTO:COUNt` on page 1062

7.2.4.2 Configuring Reference Levels

To determine reference and signal levels automatically

By default, the histogram of the measurement data is evaluated to determine the required levels automatically. However, you can define several parameters to adapt the evaluation to your data.

1. On the "Meas" menu, select "Reference Level > Levels" to open the "Reference Levels" dialog box.
2. Select the "Levels" tab.
3. Define the "Source" from which the reference is taken. The source can be any signal input, math or reference waveform.
4. Select automatic "Reference level mode".
5. By default, the lower reference level is defined at 10% of the signal level, the middle reference level at 50% and the upper reference level at 90%. You can select other "Relative levels" to be used for evaluation.
   If default percentages do not fit, select "User defined" and enter the percentages for the upper, middle, and lower reference levels.
   The signal levels are determined using histograms.
6. To determine the reference levels using average values from several histograms, enable the "Histogram averaging" option and define an "Average Count" to define how many histograms are averaged.

To determine reference levels manually

You can configure the reference levels manually as fixed absolute or relative values.

1. From the "Meas" menu, select "Reference Level > Levels".
2. Select the "Levels" tab.
3. Define the "Source" from which the reference is taken. The source can be any signal input, math or reference waveform.
4. Select manual "Reference level mode".
5. Under "Level definition", select whether you want to define the levels using absolute or relative values.
6. If you have selected absolute level definition, enter the values of the high, middle and low signal levels; and the distances of the reference levels to the signal levels.
7. If you have selected relative level definition, enter the values of the high and low signal levels; and the relative reference levels.

7.2.5 Amplitude/Time Measurements

7.2.5.1 Amplitude/Time Measurement Types

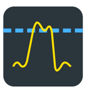
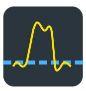
The R&S RTE provides a variety of voltage, time, area and counting measurements in the category "Amp/Time". Some measurements require reference levels to be set according to the measurement purpose.

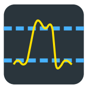
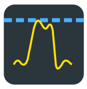
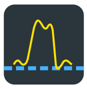
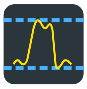
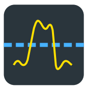
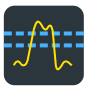
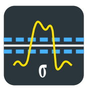
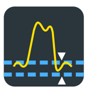
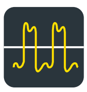
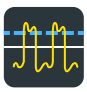
Reference levels are explained in Chapter 7.2.4, "Reference Levels", on page 289.

Amplitude Measurements

Access: "Meas" menu > "Setup" > "Amp/Time" category

Table 7-1: Amplitude measurements

	Meas. type	Symbol	Description/Result
	High	X_{High}	High signal level
	Low	X_{Low}	Low signal level

	Meas. type	Symbol	Description/Result
	Amplitude	X_{Ampl}	Amplitude of the signal: the difference of high and low signal levels $X_{Ampl} = X_{High} - X_{Low}$
	Max	X_{Max}	Absolute maximum value of the waveform
	Min	X_{Min}	Absolute minimum value of the waveform
	Peak to peak	X_{PkPk}	Peak-to-peak value of the waveform: the difference of maximum and minimum values $X_{Ampl} = X_{Max} - X_{Min}$
	Mean	X_{Mean}	Arithmetic average of the waveform voltage values $X_{Mean} = \frac{1}{N_{Eval}} \sum_{i=1}^{N_{Eval}} x(i)$
	RMS	X_{RMS}	RMS (Root Mean Square, quadratic mean) of the waveform voltage values $X_{RMS} = \sqrt{\frac{1}{N_{Eval}} \sum_{i=1}^{N_{Eval}} x^2(i)}$
	σ (S-dev)	σ_X	Standard deviation of the waveform samples $\sigma_X = \sqrt{\frac{1}{N_{Eval}-1} \sum_{i=1}^{N_{Eval}} (x(i) - X_{Mean})^2}$
	Pos. overshoot	R_{Pos}	Positive overshoot of a square wave, calculated from measurement values High, Max, and Amplitude $+Ovr = \frac{V_{top} - V_{P+}}{V_{Amp}} \cdot 100\%$
	Neg. overshoot	R_{Neg}	Negative overshoot of a square wave, calculated from measurement values Min, Low, and Amplitude $-Ovr = \frac{V_{base} - V_{P-}}{V_{Amp}} \cdot 100\%$
	Cycle mean		The mean value of one cycle
	Cycle RMS		The RMS (Root Mean Square) value of one cycle

	Meas. type	Symbol	Description/Result
	Cycle σ (S-dev)		The standard deviation of one cycle
	ProbeMeter		The DC voltage from the connected probe

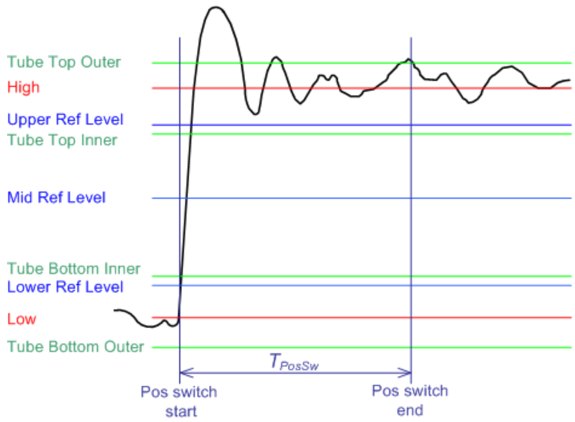
Time Measurements

Access: "Meas" menu > "Setup" > "Amp/Time" category

See also: Chapter 7.2.4, "Reference Levels", on page 289.

Table 7-2: Time measurement types

	Meas. type	Symbol	Description/Result
	Rise time	T_{Rise}	Rise time of the left-most rising edge of the waveform. This is the time it takes the signal to rise from the low reference level to the high reference level. Multiple measurement is possible.
	Fall time	T_{Fall}	Falling time of the left-most falling edge of the waveform. This is the time it takes the signal to fall from the high reference to the low reference. Multiple measurement is possible.
	Pos. pulse	$T_{PosPulse}$	Width of a positive pulse: time between a rising edge and the following falling edge measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible.
	Neg. pulse	$T_{NegPulse}$	Width of a negative pulse: time between a falling edge and the following rising edge measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible.
	Period	T_{Period}	Time between two consecutive waveform edges of the same direction, measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible.
	Frequency	f_{Period}	Frequency of the signal, reciprocal value of the period. $f_{Period} = 1 / T_{Period}$
	Pos. duty cycle	R_{PosCyc}	Positive duty cycle: Width of a positive pulse in relation to the period in %. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible. $$R_{PosCyc} = \frac{T_{PosPulse}}{T_{Period}} \cdot 100\%$$
	Neg. duty cycle	R_{NegCyc}	Negative duty cycle: Width of a negative pulse in relation to the period in %. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible. $$R_{NegCyc} = \frac{T_{NegPulse}}{T_{Period}} \cdot 100\%$$

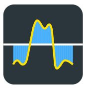
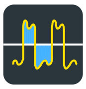
	Meas. type	Symbol	Description/Result
	Delay		Time difference between any two edges of two measurement sources at any reference level. The measurement result is negative if the edge of the second source comes before the edge of the first source. Slope and reference level have to be defined for each source. See: "Delay settings (analog sources)" on page 299
	Phase		The phase difference between two waveforms (*delay / period * 360*)
	Burst width		The duration of one burst, measured from the first edge to the last
	Pos. switching	T_{PosSw}	Settling time at rising edges: Time between crossing the lower reference level and the last return of the signal into the top tolerance tube. 
	Neg. switching	T_{NegSw}	Settling time at falling edges: Time between crossing the upper reference level and the last return of the signal into the bottom tolerance tube. See also "Pos. switching" above.
	Pulse train		Duration of N positive pulses, measured from the rising edge of the first pulse to the falling edge of the N-th pulse. N has to be configured.
	Setup Hold Setup/Hold time	T_{Setup} and T_{Hold}	Setup and Hold time measurement with positive and/or negative clock edge. See: "Setup/Hold measurement settings" on page 300
	Setup/Hold ratio	$T_{Setup} / (T_{Setup} + T_{Hold})$	Setup/Hold ratio measurement with positive and/or negative clock edge. See: "Setup/Hold measurement settings" on page 300
	Delay to trigger		Time between the trigger event and a following signal slope. High accuracy even if the trigger event is outside the acquisition data. See: ● "Delay to trigger measurement settings" on page 302 ● Chapter 7.2.5.3, "Measuring the Delay to Trigger", on page 303

Area Measurements

Access: "Meas" menu > "Setup" > "Amp/Time" category

Area mesurements are voltage over time measurements.

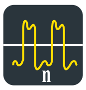
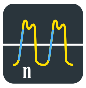
Table 7-3: Area measurement types

	Meas. type	Symbol	Description/Result
	Area	A_{Ref}	Area between the waveform and a reference level ("Area level", X_{Ref}). $A_{Ref} = \frac{T_{Eval}}{N_{Eval}} \cdot \sum_{i=1}^{N_{Eval}} (x(i) - X_{Ref})$ T_{Eval}: Evaluation time, time of a full waveform or limited by a gate
	Cycle area	A_{RefCyc}	Area between the waveform and a reference level ("Area level") measured for one period, see also "Area" measurement. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible.

Counting

Access: "Meas" menu > "Setup" > "Amp/Time" category

Table 7-4: Counting measurement types

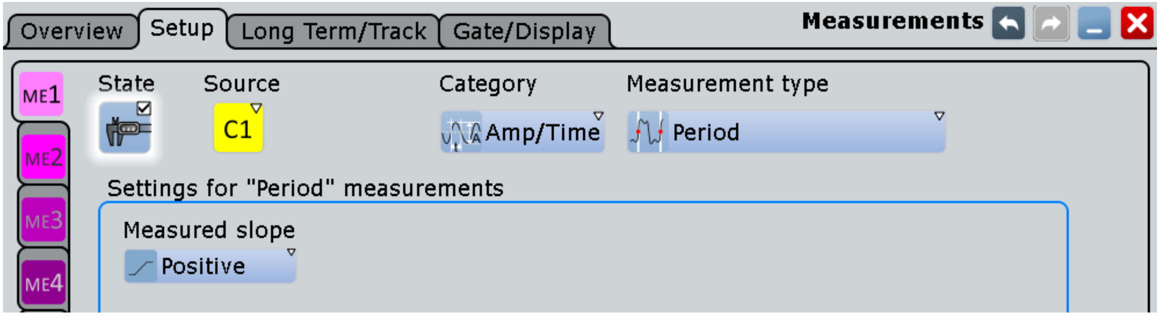
	Meas. type	Symbol	Description/Result
	Pulse count		The number of positive or negatve pulses of the waveform, or of both positive and negative pulses. The mean value of the signal is determined. If the signal passes the mean value, an edge is counted. A positive pulse is counted if a rising edge and a following falling edge are detected. A negative pulse is counted if a falling edge and a following rising edge are detected.
	Edge count		The number of positive or negative edges, or of both positive and negative edges. The instrument determines the mean value of the signal and counts an edge every time the signal passes the mean value.

7.2.5.2 Amplitude/Time Measurement Settings

Access: "Meas" menu > "Setup" > "Amp/Time" category

Amplitude and time measurements are available for sources in the time domain. For some amplitude/time measurements, such as delay, setup/hold and delay to trigger, further setting are required to get a measurement result.

This chapter explains all available settings for amplitude/time measurements.



Pulses slope

Sets the first slope of the pulses to be counted.

The setting is available only for the "Pulse count" measurement.

"Positive" Positive pulses are counted.

"Negative" Negative pulses are counted.

"Either" Both positive and negative pulses are counted.

Remote command:
`MEASurement<m>:AMPTime:PSLope` on page 1030

Measured slope

Selects the slope direction for frequency and period measurements.

"Positive / Negative" Measures the time between rising or falling edges, respectively.

"Either" In multiple measurements, the time is measured both between rising edges and between falling edges.
In single measurements. The first edge is taken for the measurement.

"First edge" Time is measured either between rising edges or between falling edges. The first edge is taken for the measurement. In single measurements, it works the same way as "Either".
Only available for analog measurement sources.

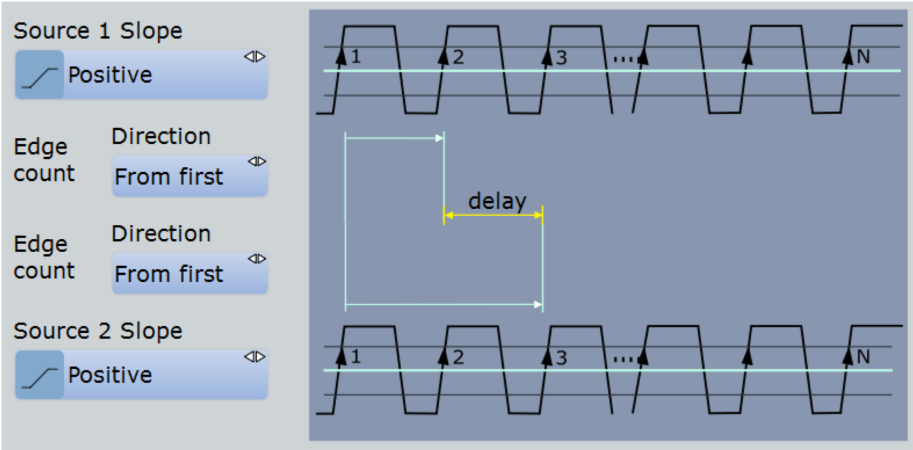
Remote command:
`MEASurement<m>:AMPTime:PFSLope` on page 1030

Delay settings (analog sources)

The specific settings for delay measurement allow you to measure the time between any two slopes at middle reference level. Therefore, the slopes must be defined for each source individually. The measurement result is negative if the edge of the second source comes before the edge of the first source.

Example:

With the settings shown in the picture, the time between the second rising edge and the third from last falling edge is measured.



"Slope" Sets the edge of each source, between which the delay is measured: positive, negative, or either of them.

"Direction" Selects the direction for counting slopes for each source: from the beginning of the waveform, or from the end.

Remote command:
`MEASurement<m>:AMPTime:DELay<n>:SLOPe` on page 1031
`MEASurement<m>:AMPTime:DELay<n>:DIRection` on page 1030
`MEASurement<m>:AMPTime:DELay<n>:ECOunt` on page 1031

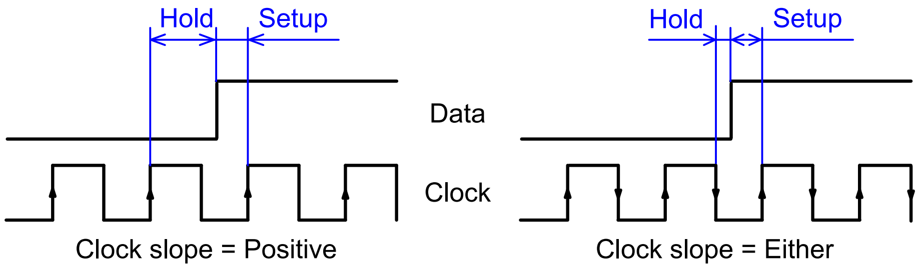
Delay settings (digital sources)
Delay measurement on digital channels is reduced to measure the time between two subsequent rising or two subsequent falling edges.

The edge direction is set with Edges slope.

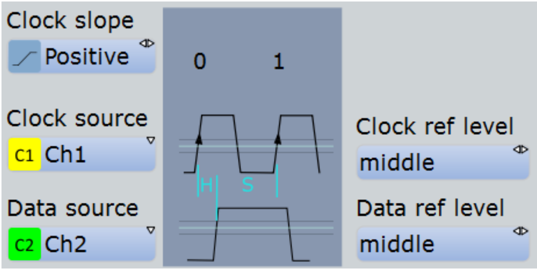
Setup/Hold measurement settings
Setup/Hold measurements analyze the relative timing between two signals: a data signal and the synchronous clock signal. Setup time is the time that the data signal is steady before clock edge - the time between a data transition and the next specified clock edge. Hold time is the time that the data signal is steady after clock edge - the time between a data transition and the previous specified clock edge.

Setup/Hold Time measures and displays the setup and hold durations. Setup/Hold Ratio measurements return the ratio of the setup time to the sum of hold and setup time: $T_{Setup} / (T_{Setup} + T_{Hold})$.

The clock edge can be defined, the polarity of the data signal does not matter.



If at least one of the setup/hold measurements is selected, more settings appear to specify the measurement.



"Clock slope"	Sets the edge of the clock from which the setup and hold times are measured: positive, negative, or either of them. If "Either" is selected, the clock edges next to the data edge are considered regardless of the clock slope.
"Clock source"	The "Clock source" is identical to the measurement "Source". It defines the waveform used as clock in the setup/hold measurement.
"Data source"	The "Data source" is identical to the "2nd Source" of the measurement. It sets the data signal.
"Clock ref level"	See "Clock ref level" on page 301
"Data ref level"	See "Data ref level" on page 301

Remote command:
Clock slope: `MEASurement<m>:AMPTime:CSLope` on page 1032

Clock ref level
Selects the reference level of the clock on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

Remote command:
`MEASurement<m>:AMPTime:CLCK<n>:LSELect` on page 1033

Data ref level
Selects the reference level of the data on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

Remote command:
`MEASurement<m>:AMPTime:DATA<n>:LSELect` on page 1033

Pulse train count

Sets the number N of positive pulses for the "Pulse train" measurement. This measurement measures the duration of N positive pulses from the rising edge of the first pulse to the falling edge of the N-th pulse.

Remote command:
`MEASurement<m>:AMPTime:PTCount` on page 1032

Edges slope

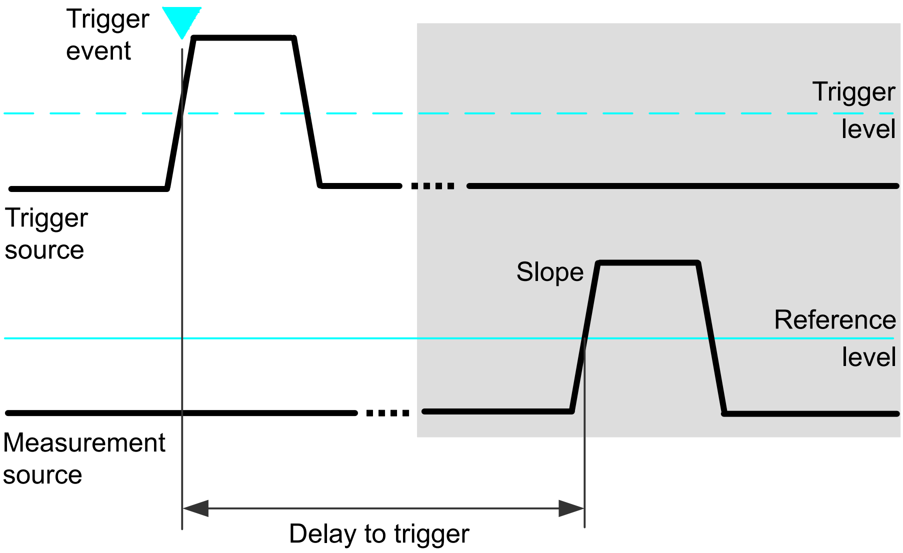
Sets the edge direction to be considered. The setting is relevant for edge count measurement and delay measurement on digital channels.

"Positive"	Positive edges are considered.
"Negative"	Negative edges are considered.
"Either"	Both positive and negative edges are counted (edge count). Delay is measured either between rising edges or between falling edges. The first edge is taken for the measurement.

Remote command:
`MEASurement<m>:AMPTime:ESLope` on page 1032

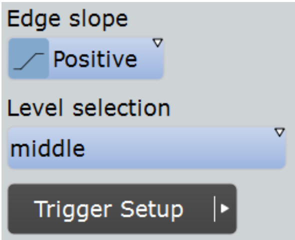
Delay to trigger measurement settings

Delay to trigger measures the time between the trigger point and the following slope of a waveform. The delay between the trigger and the slope can be high compared to the accuracy of the acquisition, and the trigger point can even be outside of the current acquisition.



See also: Chapter 7.2.5.3, "Measuring the Delay to Trigger", on page 303

To configure the trigger conditions, use the trigger setup. To set up the slope, additional settings appear in the measurements "Setup" dialog box.



"Edge slope" — Sets the edge direction to be used for delay measurement: positive, negative, or either edge.

"Level selection" — Selects the reference level of the measurement source on which the delay is measured: upper, middle, or lower level.

Remote command:
MEASurement<m>:AMPTime:DTOTrigger<n>:SLOPe on page 1033
MEASurement<m>:AMPTime:DTOTrigger<n>:LSELect on page 1034

7.2.5.3 Measuring the Delay to Trigger

Delay to trigger measures the time between the trigger point and the following slope of a waveform. If the delay is completely unknown. it can be measured in two stages - first a coarse and then a precise measurement.

See also: "Delay to trigger measurement settings" on page 302

1. Set the horizontal scale and horizontal position so that the trigger point and the slope both are visible on the screen.
2. Configure the delay to trigger measurement:
   a) On the "Measurements Setup" tab, select "Delay to trigger" as main or additional measurement.
   b) Select the source, that is the waveform with the delayed slope to be measured.
   c) Select the slope, and the reference level
   d) Check the trigger settings.
   e) Enable the measurement and note the result.
3. Turn the horizontal POSITION / REF POINT knob and enter the measured delay as horizontal position.

   Thus, the slope is moved to the center of the screen.
4. Adjust the horizontal scale and the horizontal resolution parameters (RES REC LEN) to the required accuracy: "Sample rate", "Resolution", or "Acquisition time".

   The trigger is outside the display and is not part of the current acquisition.
5. Repeat the "Delay to trigger" measurement.

   Now the delay is measured with high accuracy. You can analyze the variance of delay values using statistical evaluation and histogram functions.

7.2.6 Eye Diagram Measurements

The eye diagram is a superposition of repetively sampled digital data. It is a tool for evaluation of signal quality and shows the combined effects of channel noise and inter-symbol interference. The eye diagram is a significant means of visualizing jitter and allows you to analyze the reasons for it. By creating histograms of the eye diagram, important jitter parameters can be determined.

The waveform display style must be set to vectors: DISPLAY > "Signal Colors / Persistence" tab > "Style = Vectors"

The following characteristic values can be determined:

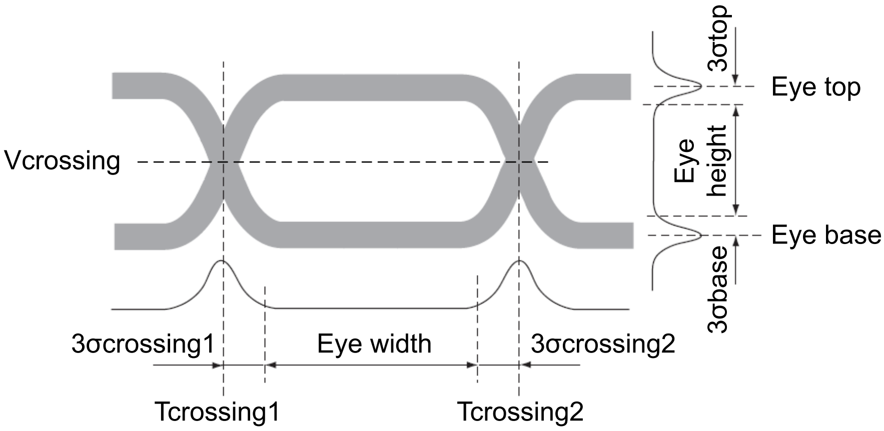


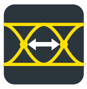
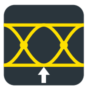
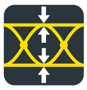
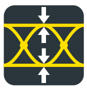
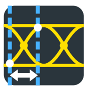
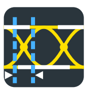
Figure 7-3: Basic eye diagram characteristics

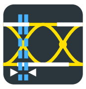
Eye top = Mean of the upper vertical histogram
σtop = Standard deviation of the upper vertical histogram
Eye base = Mean of the lower vertical histogram
σbase = Standard deviation of the lower vertical histogram
Tcrossing = First and second mean of the horizontal histogram
σcrossing = Standard deviation of the horizontal histogram

7.2.6.1 Eye Diagram Measurement Types

Table 7-5: Eye measurement types

	Meas. type	Description/Result
	Extinction ratio (%)	The extinction ratio is an indication of efficiency. It describes the ratio of the power used to transmit a logic level 1, to the energy used to transmit a logic level 0. The R&S RTE provides extinction ratio measurements as a percentage, and in decibels: ER (%) = Eye base / Eye top *100 Prerequisite: Eye base > 0 and Eye top > 0 because extinction ratio is defined only for positive values.
	Extinction ratio (dB)	ER (dB) = 10*log (Eye top / Eye base)

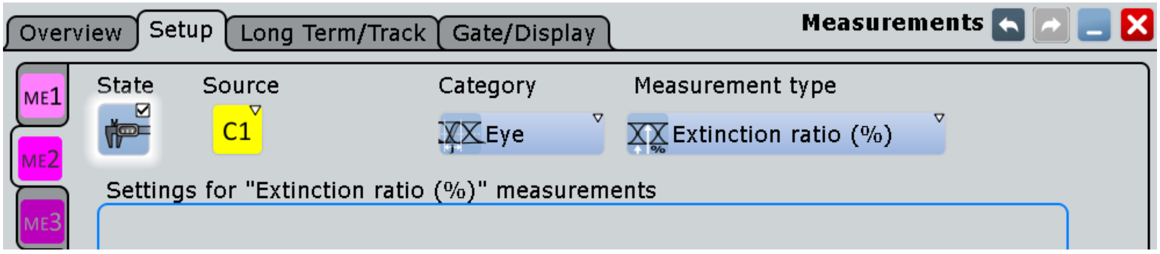
	Meas. type	Description/Result
	Eye height	The vertical eye opening indicates the sensitivity of the transmission to noise. (Eye top – 3 * σtop) – (Eye base + 3 * σbase)
	Eye width	The horizontal eye opening indicates the time range during which the sampling of the logical state is possible. (Tcrossing2 – 3 * σcrossing2) – (Tcrossing 1 – 3 * σcrossing1)
	Eye top	Mean of the upper vertical histogram
	Eye base	Mean of the lower vertical histogram
	Q factor	Q factor = (Eye top – Eye base) / (σtop + σbase)
	Noise (RMS)	Quadratic mean of the noise of eye top and eye base
	S/N ratio	Signal-to-noise ratio SNR = 10 * log (Eye amplitude / Noise RMS)
	Duty cycle distortion	Duty cycle distortion = 20 * log (Eye amplitude / Noise RMS)
	Eye rise time	Duration for signal to rise from 10% to 90% of the high signal level
	Eye fall time	Duration for signal to fall from 90% to 10% of the high signal level
	Eye bit rate	Frequency between two crossings
	Eye amplitude	Eye top - Eye base
	Jitter (peak to peak)	Average of the jitter for both crossing points. Jitter = (σcrossing1 + σcrossing2) / 2

	Meas. type	Description/Result
	Jitter (6*σ)	Jitter (6*σ) = Jitter * 6
	Jitter (RMS)	Quadratic mean of the jitter at both crossing points

7.2.6.2 Eye Diagram Measurement Settings

Access: "Meas" menu > "Setup" > "Eye" category

Eye diagram measurements are only available for sources in the time domain.



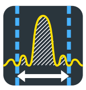
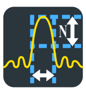
For eye measurements, no further settings are required.

7.2.7 Spectrum Measurements

Spectrum analysis determines the frequencies of a given input signal over time. Various measurements can then be performed based on the signal spectrum.

7.2.7.1 Spectrum Measurement Types

Table 7-6: Spectrum measurement types

	Meas. type	Description, result
	Channel power	Power integrated over the sample values defined by a center frequency and a bandwidth; based on a defined impedance; the result is given in dBm
	Occupied bandwidth	From the defined center frequency, symmetric sample value pairs to the left and right are integrated until a user-defined percentage of the total power is reached. The occupied bandwidth is the difference between the frequencies at which the requested power was reached.
	Bandwidth	n dB down bandwidth; the samples to the left and right of the peak value are analyzed until the n dB threshold is exceeded. The frequencies at which the threshold is exceeded define the limits of the requested bandwidth.

	Meas. type	Description, result
	THD[dB], THD[%] Total harmonic distortion	Power sum of the harmonic waves divided by the power of the fundamental wave: $THD = \frac{\sum_{n=2}^{\infty} P_n}{P_1}$
	THD_a, THD_u, THD_r Total harmonic distortion	These measurements require option R&S RTE-K18 Spectrum Analysis. Root mean square of the sum of all amplitudes of the harmonic waves in relation to the amplitude of the fundamental waveform $THD_A = \frac{\sqrt{\sum_{n=2}^{\infty} V_n^2}}{V_1}$ Root mean square of the power sum of harmonic waves in relation to the power of the fundamental waveform $THD_U = \frac{\sqrt{P^2 - P_1^2}}{P_1}$ Root mean square of the power sum of harmonic waves in relation to the power of all waveforms $THD_R = \frac{\sqrt{P^2 - P_1^2}}{P} = \frac{THD_U}{\sqrt{1 + THD_U^2}}$
	Peak list	This measurement requires option R&S RTE-K18 Spectrum Analysis. Table with measured peaks. For each peak, the frequency and the value is listed in a table row. The number of determined peaks can be defined.
	Harmonic search	Table with measured harmonics. For each harmonic, the frequency and the value is listed in a table row.

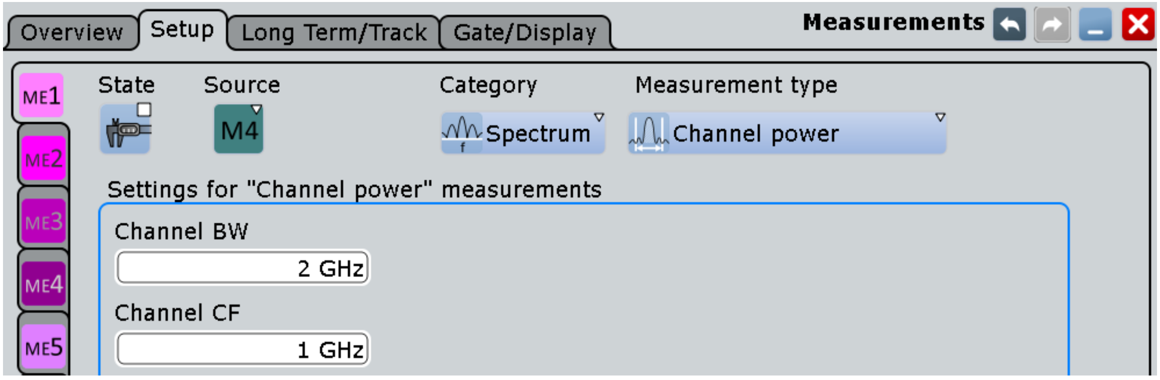
For remote command parameters and suffix types see Table 16-6.

7.2.7.2 Spectrum Measurement Settings

Access: "Meas" menu > "Setup" > "Spectrum" category

Spectrum measurements are only available if a source in the frequency domain is selected, i.e. a math waveform with an FFT operation.

For spectrum measurements, make sure that the start frequency and other FFT parameters are set correctly, and the fundamentals are not covered by the DC component of the signal. Consider also a gated measurement if the instrument cannot return any result.



N db down

The threshold until which the samples to the left and right of the peak value are analyzed in order to determine the "Bandwidth".

Remote command:

`MEASurement<m>:SPECtrum:NDBDown` on page 1037

Channel BW

Bandwidth over which the channel power is calculated.

Remote command:

`MEASurement<m>:SPECtrum:CPOWer:BANDwidth` on page 1036

Channel CF

Center frequency from which the channel power is calculated over the specified bandwidth.

Remote command:

`MEASurement<m>:SPECtrum:CPOWer:CFRequency` on page 1037

Occup. BW

Percentage of the total power used to determine the occupied bandwidth.

Remote command:

`MEASurement<m>:SPECtrum:OBANdwidth` on page 1036

Threshold

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Remote command:

`CURSor<m>:THReshold` on page 1018

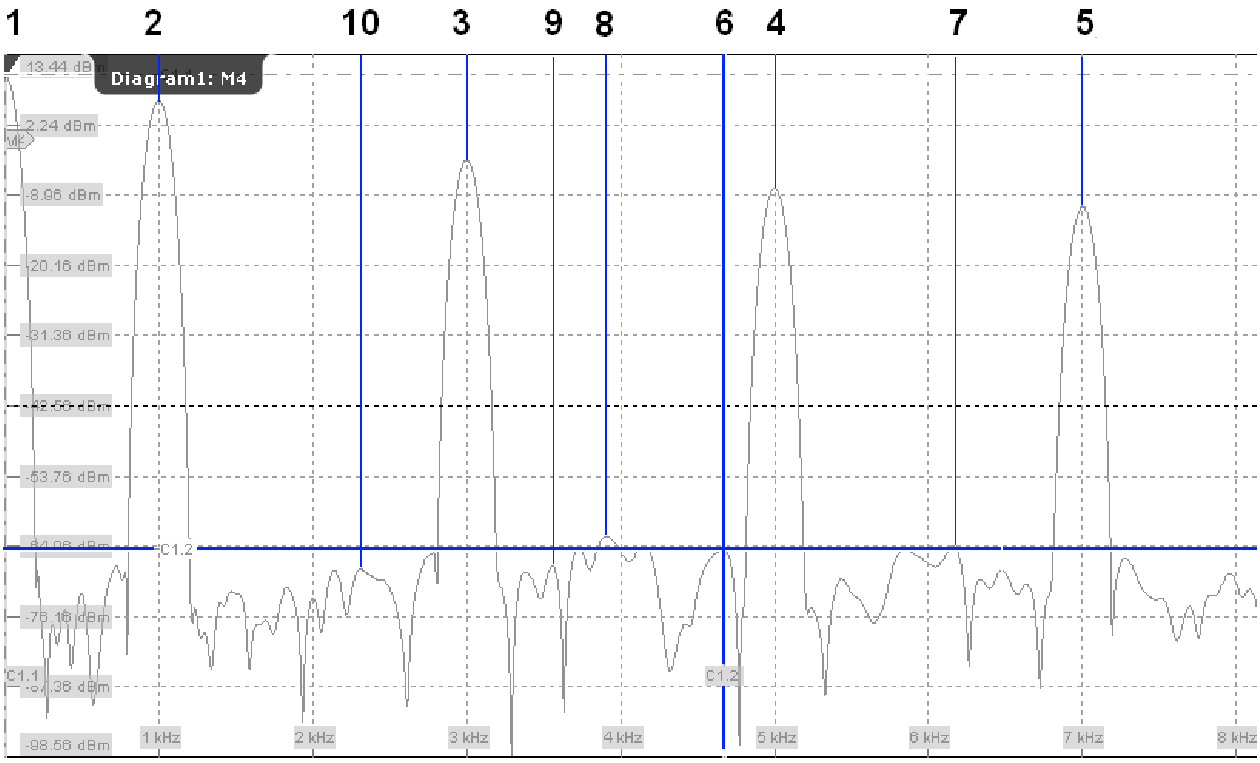
`MEASurement<m>:SPECtrum:ATHReshold` on page 1038

Peak excursion

Defines a relative threshold, the minimum level value by which the waveform must rise or fall to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

The following figure shows a cursor measurement on a spectrum waveform:



If "Peak excursion" is 30 dB, the peaks 1 to 5 are found. If "Peak excursion" is 20 dB, also the peaks 6 to 10 are found. The cursor position is on peak 6.

Remote command:
`CURSor<m>:PEXCursion` on page 1018
`MEASurement<m>:SPECtrum:PEXCursion` on page 1037

Result labels
For peak lists only: a description of each detected peak can be provided using labels in the spectrum diagram.

"Enable"	Displays a description for each detected peak in the spectrum diagram.
"Label frame type"	Defines the layout of the labels (frame, line, or none).
"Inverse"	Displays black font on white background using the "Full frame" label type.
"Max. number of peaks"	Defines the maximum number of peaks that are listed in the peak list and labeled in the diagram.
"Show Frequency"	Includes the frequency of the detected peak in the diagram labels.

Remote command:
MEASurement<m>:RESult:SHLabels on page 1041
MEASurement<m>:RESult:LAFRame on page 1039
MEASurement<m>:RESult:INVerse on page 1039
MEASurement<m>:RESult:MAXCount on page 1038
MEASurement<m>:RESult:SHFRequency on page 1040

7.2.8 Histograms and Histogram Measurements

7.2.8.1 Histogram Characteristics and Measurement Types

Histograms are used to plot density of data, i.e. to display graphically how often which signal values occur. The histogram can be based on the input signal levels (amplitudes) or the timebase in a time domain measurement, or on frequencies or frequency levels in a spectrum measurement. They are a prerequisite for histogram measurements.

Depending on which data the histogram is based on, a vertical or horizontal histogram can be selected. A vertical, or amplitude, histogram displays horizontal bars across amplitude values. A horizontal or time/frequency histogram displays vertical bars over time/frequencies.

You can define up to 8 histograms in a diagram, one of them is displayed. They can be created quickly using toolbar icons, or in the "Meas" menu > "Histogram" dialog box. To switch the histogram display, tap the required histogram area, or select it in the "Histogram" dialog box. For histogram measurements, the measured histogram is selected independently in the measurement setup.

In a histogram, the maximum count of a waveform value is assigned to the full height (histogram peak). All other count values are displayed relative to the maximum.

The following characteristic values can be determined for histograms (illustrated for a vertical histogram):

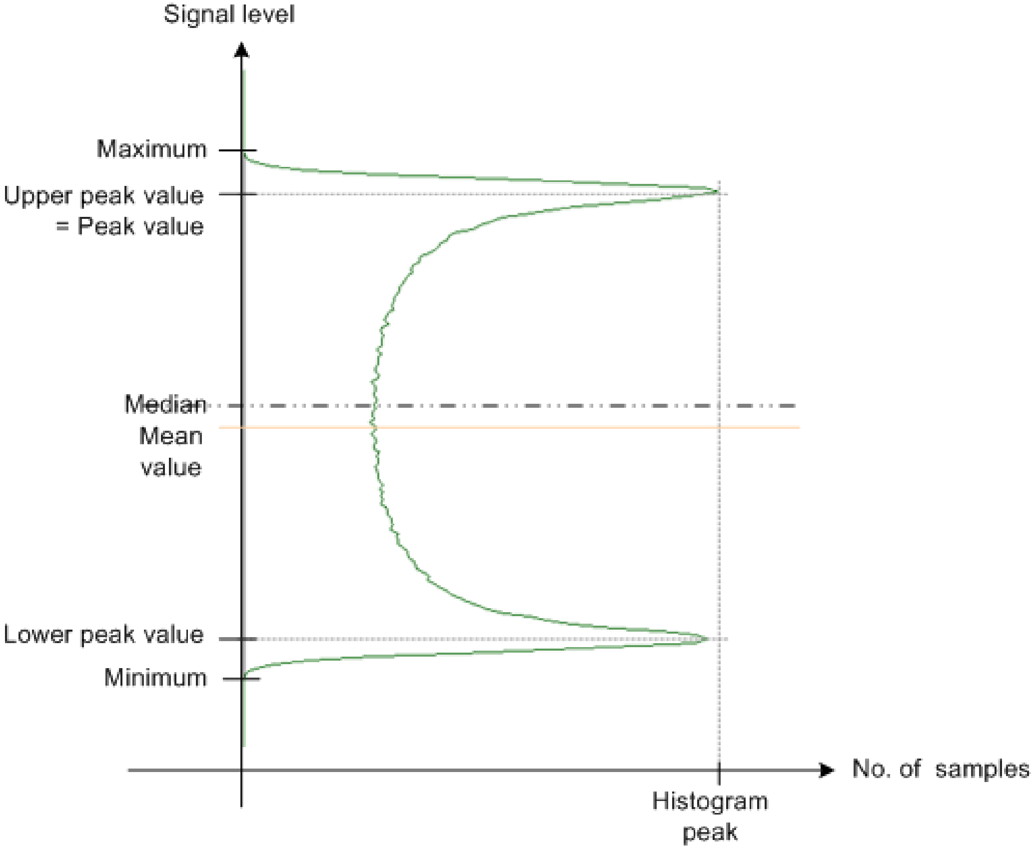
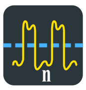


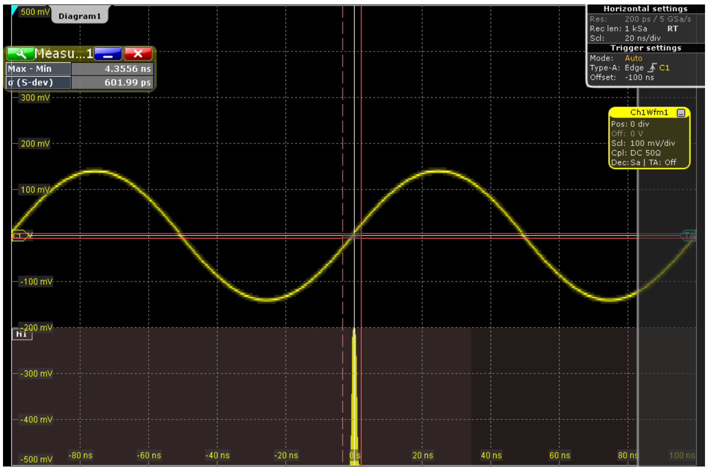
Table 7-7: Histogram measurement types

	Meas. type	Description/Result
	Waveform count	The number of acquisitions (waveforms) the histogram is based on
	Waveform samples	The number of samples from the most recent acquisition included in the current histogram
	Histogram samples	The number of samples from all acquisitions included in the current histogram
	Histogram peak	The maximum count value in the histogram
	Peak value	The signal value at the histogram peak
	Upper peak value	The signal value at the maximum count value in the upper half of the histogram

	Meas. type	Description/Result
	Lower peak value	The signal value at the maximum count value in the lower half of the histogram
	Maximum	The highest signal value with a probability > 0
	Minimum	The lowest signal value with a probability > 0
	Median	The signal value for which half the samples lie above, the other half below in the histogram The sample count of one signal value after the other are accumulated until half the total number of samples in the histogram is reached. The signal value for which 50% of the samples are accumulated is the median.
	Max - Min	The range of signal values with a probability > 0
	Mean	The weighted arithmetic average of the histogram
	σ (S-dev)	Standard deviation of the sample numbers
	Mean ±σ	The range between (mean value + standard deviation) and (mean value - standard deviation)
	Mean ±2*σ	The range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)
	Mean ±3*σ	The range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)
	Marker + Probability %	The marker value (according to the selected probability domain marker type) plus the defined limit. Note that the value is restricted to the histogram range.
	Marker - Probability %	The marker value (according to the selected probability domain marker type) minus the defined limit. Note that the value is restricted to the histogram range.

Rough jitter evaluation using a histogram

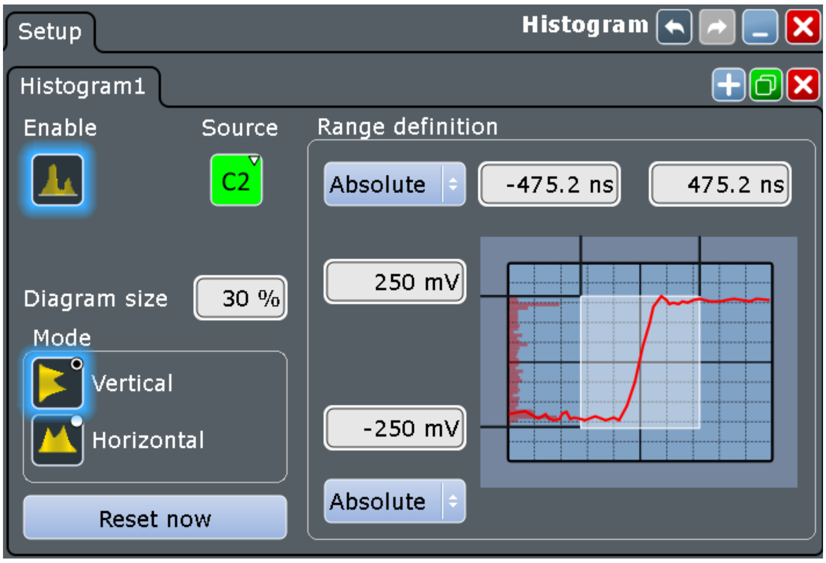
You can use a horizontal histogram to perform a rough jitter measurement. Define a histogram for a narrow amplitude range close to the trigger time. The "Max-Min" value indicates the peak jitter, while the "StdDev" value indicates the RMS jitter.



In addition to histograms on channel, math and reference waveforms, histograms can be created based on statistic measurement results. These histograms are enabled in the "Long Term/Track" tab, see Chapter 7.2.9, "Long Term Measurements and Statistics", on page 317.

7.2.8.2 Histogram Setup

In this dialog box you configure histograms on which you can perform further measurements.



Enable
Enables or disables the histogram evaluation and display. The histogram settings are kept until the histogram is deleted.

Source
Defines the source of the histogram. Any analog channel waveform, math or reference waveform can be selected. Also measurements can serve as histogram source. In this case, the density distribution of the results of the main measurement is displayed.

Remote command:
`LAYout:HISTogram:SOURce` on page 1042

Diagram size
Defines the size of the histogram in percent of the diagram.

Mode
Defines the type of histogram.

"Vertical"	Amplitude histogram (horizontal bars across amplitude)
"Horizontal"	Time histogram (vertical bars over time). For spectrum waveforms, horizontal histograms over spectrum are not available.

Remote command:
`LAYout:HISTogram:MODE` on page 1043

Reset now
Resets the values to begin a new histogram.

Remote command:
`LAYout:HISTogram:RESet` on page 1046

Range definition mode (Absolute/Relative)
Defines whether the value range limits are entered as absolute or relative values.

Remote command:
`LAYout:HISTogram:HORZ:MODE` on page 1043
`LAYout:HISTogram:VERTical:MODE` on page 1045

Horizontal start/stop value
Defines the horizontal value range of the histogram.

Remote command:
`LAYout:HISTogram:HORZ:ABSolute:STARt` on page 1043
`LAYout:HISTogram:HORZ:ABSolute:STOP` on page 1044
`LAYout:HISTogram:HORZ:RELative:STARt` on page 1044
`LAYout:HISTogram:HORZ:RELative:STOP` on page 1044

Vertical start/stop value
Defines the vertical value range of the histogram.

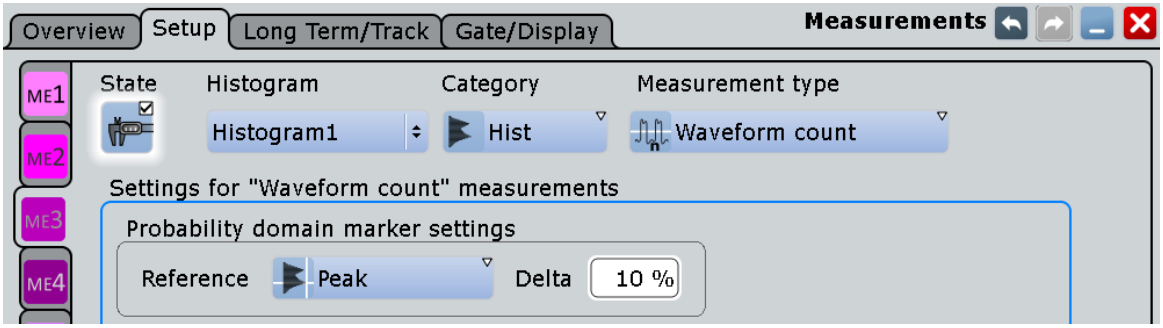
Remote command:
`LAYout:HISTogram:VERTical:ABSolute:STARt` on page 1045
`LAYout:HISTogram:VERTical:ABSolute:STOP` on page 1045

LAYout:HISTogram:VERTical:RELative:STARt on page 1045
LAYout:HISTogram:VERTical:RELative:STOP on page 1046

7.2.8.3 Histogram Measurement Settings

Access: "Meas" menu > "Setup" > "Hist" category

You can perform measurements on histograms. Before, you have to define a histogram, see Chapter 7.2.8.4, "Creating a Histogram ", on page 316.



Histogram

Selects the histogram on which the measurement is based. Histograms are defined via the "MEAS > Histogram" menu item.

Remote command:
MEASurement<m>:HISTogram:SELect on page 1047

Probability domain marker reference

Defines the marker reference in the probability domain.

"Peak"	The y-value with the maximum sample value in the histogram
"Upper Peak"	The y-value at the maximum sample value in the upper half of the histogram
"Lower Peak"	The y-value at the maximum sample value in the lower half of the histogram
"Maximum"	The highest y-value with a probability > 0
"Minimum"	The lowest y-value with a probability > 0
"Median"	The y-value for which half the samples lie above, the other half below in the histogram
"Mean"	The weighted arithmetic average of the histogram

Remote command:
MEASurement<m>:HISTogram:PROBability:TYPE on page 1048

Delta

Defines a range around the marker.

Remote command:
MEASurement<m>:HISTogram:PROBability:LIMit on page 1048

7.2.8.4 Creating a Histogram

Histograms can be used to evaluate the sample value occurrences directly. They are a prerequisite for histogram measurements.

The usage of histograms is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Histogram".

To create a histogram quickly with toolbar icons

1. Select the waveform for which you need a histogram.
2. Touch the histogram icon on the toolbar and drag your finger down. Tap the "Vertical histogram" or the "Horizontal histogram" icon.

3. Tap the diagram with the waveform to be measured, or draw a rectangle on the screen to define the area on which the histogram is to be based.

   The histogram range is indicated in the diagram and a histogram with the selected waveform as a source is defined and displayed.

To create and configure a histogram in the dialog box

1. Select "Meas > Histogram", or touch and hold an existing histogram or histogram area.

   The "Histogram Setup" dialog box is displayed.

2. To create a new histogram, tap the "Add" icon in the upper right corner of the dialog box.

3. To copy an existing histogram and configure a new one based on those settings, tap the "Copy" icon.
4. To change the name of a histogram, double-tap the tab label and enter a name for the histogram using the on-screen keyboard.
5. Select a "Source" for the histogram. The source can be any input signal, math or reference waveform.
6. Define the histogram "Mode": vertical for an amplitude, horizontal for a time-based histogram.
7. Define the range of the waveform for which the histogram is to be generated. Enter the start and stop values in x and in y direction, either as absolute or relative values.
8. Enable the histogram.

7.2.9 Long Term Measurements and Statistics

The behavior of measurement results over time can be evaluated in different ways:

- Long Term Measurements
- Statistics
- Histograms on measurement results
- Track (requires option)

7.2.9.1 About Long Term Measurements and Statistics

Long term measurements

Long term measurements show the behavior of measurement results over a longer time or for many samples. Therefore the measurement results of a specified time period are summarized into one long term point. For each point, the current value measured at the end of the time period is written to the long term waveform, and statistical results for each time period are calculated, saved, and reset. This reset avoids constantly rising maximum or constantly falling minimum values until the end of the measurement.

You can define the number of long term points and export the long term data, including statistical results. The measurement histogram is a vertical histogram shown in the long term diagram.

Statistics

If statistics are enabled for the measurement, the following information is provided in the result box for each measurement type.

Label	Description
Current	Currently measured value
+Peak	Positive peak value (maximum)
-Peak	Negative peak value (minimum)
μ (Avg)	Average
RMS	Root mean square
σ (S-dev)	Standard deviation
Event count	Number of measured events (e.g. rising edges, pulses etc.)
Wave count	Number of waveforms (acquisitions) the measurement is based on

Remote commands:

- MEASurement<m>:RESult:AVG? on page 1025
- MEASurement<m>:RESult[:ACTual]? on page 1025
- MEASurement<m>:RESult:COUNt? on page 1026
  MEASurement<m>:RESult:EVTCount? on page 1025

MEASurement<m>:RESult:NPEak? on page 1025
MEASurement<m>:RESult:PPEak? on page 1025
MEASurement<m>:RESult:RMS? on page 1025
MEASurement<m>:RESult:STDDev? on page 1025
MEASurement<m>:RESult:STARt? on page 1026
MEASurement<m>:RESult:STOP? on page 1026
MEASurement<m>:RESult:WFMCount? on page 1025

The peak and average values and the standard deviation of the long term points are also shown in the graph of the long term measurement.

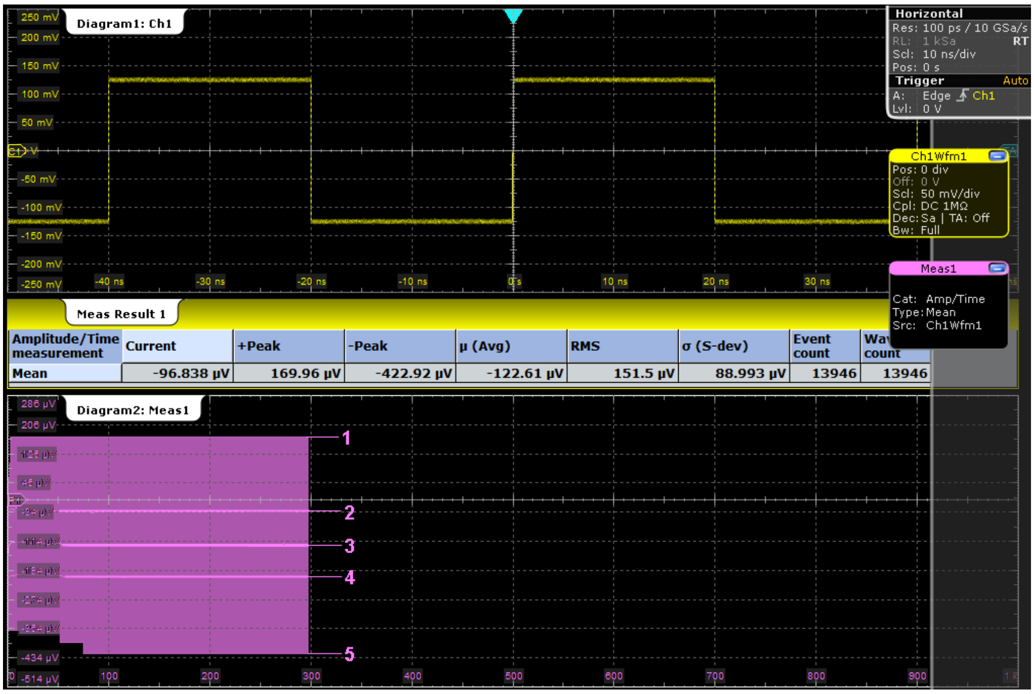


Figure 7-4: Long term measurement with statistics

1 = +Peak, maximum
2 = Average + standard deviation
3 = Average
2 = Average - standard deviation
1 = -Peak, minimum

Stopping and starting the acquisition does not reset statistics but only stops and continues them.

The instrument only resets statistical evaluation if you change measurement setup:

- Measurement types
- Gate
- Enable/disable long term measurement and histogram
- Enable continuous autoscale with enabled histogram
- Switch on/off channels
- Enable/disable cursors
- Tap "Reset" or "Clear sreen results"

After a reset, new statistics are compiled beginning with the next acquired waveform.

Histogram on measurement results

Histograms are available not only for channel, math and reference waveforms, but also on measurement results. These histograms cannot be configured, and they are shown in a separate diagram. The source is a measurement Px. If the histogram is based on long term measurement, it is shown in the long term diagram.

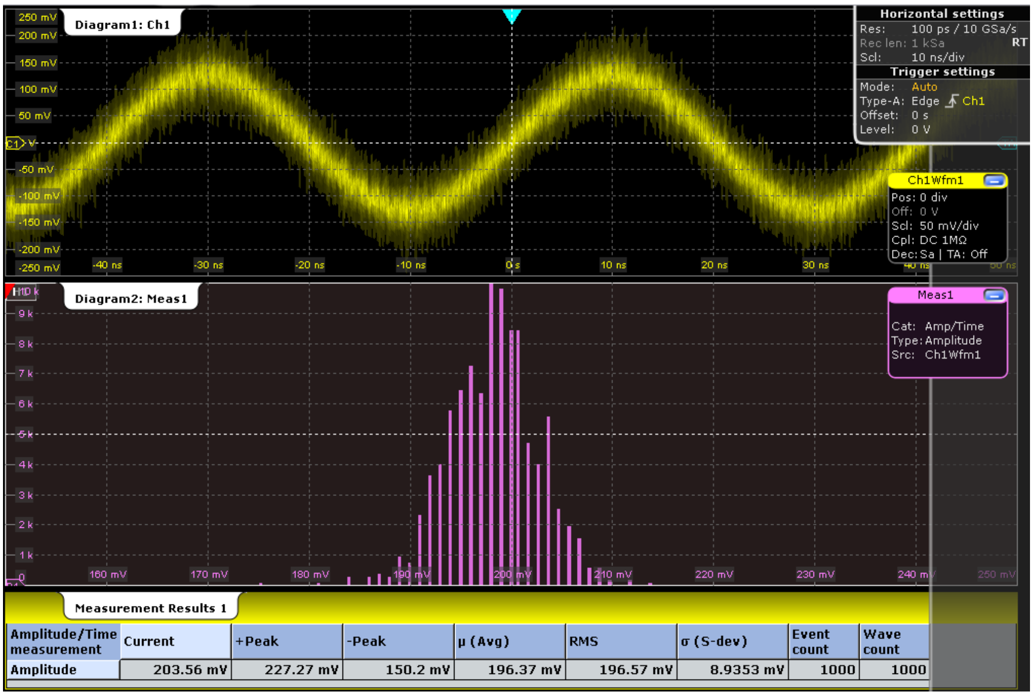


Figure 7-5: Statistical results and measurement histogram of an amplitude measurement

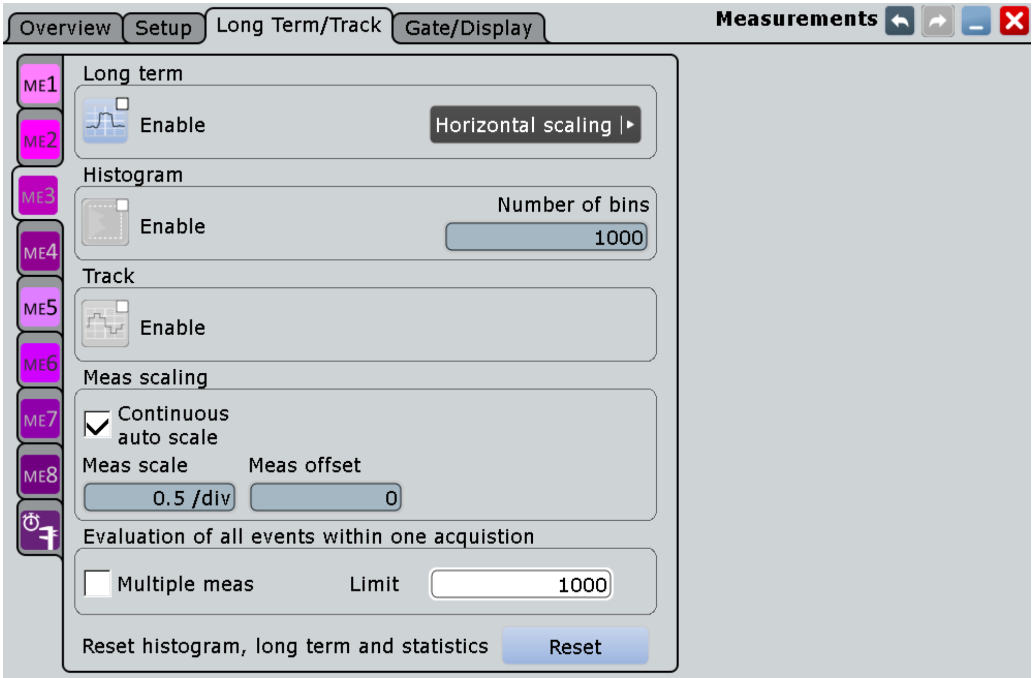
7.2.9.2 Long Term/Track Settings

Access: "Meas" menu > "Long Term/Track"

The settings in the "Long Term/Track" tab allow you to configure long term measurements, including statistics and measurement histogram over a longer period of time.

For scaling settings of the long term diagram, see Chapter 7.2.9.3, "Horizontal Long Term Scaling", on page 322.

The track function requires an option, see "Enable (Track)" on page 321.



ME 1/2/3/4/5/6/7/8/Quick Meas
For each of the eight measurements, and for the quick measurement, a subtab contains the configuration settings. A green dot on the tab indicates that the measurement is active.

Enable (Long term)
Enables long term measurement of the main measurement.

Remote command:
`MEASurement<m>:LTMeas[:STATe]` on page 1054

Statistics
Enables the calculation and display of statistical results.

Remote command:
`MEASurement<m>:STATistics[:ENABle]` on page 1050
`MEASurement<m>:RESult:AVG?` on page 1025
`MEASurement<m>:RESult:EVTCount?` on page 1025
`MEASurement<m>:RESult:NPEak?` on page 1025
`MEASurement<m>:RESult:PPEak?` on page 1025
`MEASurement<m>:RESult:RMS?` on page 1025
`MEASurement<m>:RESult:STDDev?` on page 1025
`MEASurement<m>:RESult:WFMCount?` on page 1025
`MEASurement<m>:RESult[:ACTual]?` on page 1025
`MEASurement<m>:ARNames` on page 1024
`MEASurement<m>:ARES?` on page 1024

Enable (Histogram)
Displays a histogram of measurement results - the cumulative occurrence distribution of measurement results in a graphic. Enabling the histogram enables also the statistics.

Remote command:
`MEASurement<m>:STATistics:HISTogram` on page 1051

Number of bins
Sets the number of bins - the number of vertical bars that build the histogram.

If "Continuous auto scale" is enabled, the instrument determines the number of bins based on the timebase, the current measurements, and other settings. To set the number of bins manually, disable "Continuous auto scale".

Remote command:
`MEASurement<m>:STATistics:HBINs` on page 1051

Enable (Track)
Enables the track measurement and displays the track of the selected waveform.

The track functionality requires at least one option:
- Option R&S RTE-K31 Power Analysis
  Enables the track for amplitude and time measurements.
- Option R&S RTE-K5 I²S Audio Signals
  Enables the track for protocol measurements on decoded audio buses, see Chapter 12.8.5.1, "Track", on page 566.

Remote command:
`MEASurement<m>:TRACk[:STATe]` on page 1055

Meas scaling
The measurement scale of a long term measurement diagram or measurement histogram is set automatically by the instrument, or manually.

Use automatic scaling if the measurement is running and you cannot see the expected results.

"Continuous auto scale"
Performs an automatic scaling whenever the long term waveform or the histogram does not fit in the diagram during the measurement period.

"Auto scale" Performs an automatic scaling once so that the scaling is adapted to the current measurement results. Available only for long term measurement.

"Meas scale" Defines the scaling per division for long term measurement period and the measurement histogram.

"Meas offset" Defines an offset for the long term measurement and the measurement histogram.

Remote command:
`MEASurement<m>:VERTical:CONT` on page 1053
`MEASurement<m>:VERTical:AUTO` on page 1053

MEASurement<m>:VERTical:SCALe on page 1054
MEASurement<m>:VERTical:OFFSet on page 1054

Multiple measurement

Performs multiple measurements on the same source waveform and includes the results in evaluation. For example, it measures the rise time for all pulses in the waveform, not only the first.

The result box shows only the first result of the waveform, the following results are only used for evaluation.

Multiple measurements are useful when calculating statistics or generating tracks; however, it reduces the performance of the instrument.

The number of considered measurement results can be restricted, see Limit.

Remote command:
MEASurement<m>:MULTiple on page 1023

Limit

Sets the maximum number of measurements per acquisition if "Multiple measurement" is enabled.

Remote command:
MEASurement<m>:MNOMeas on page 1023

Reset now

Resets the histogram, the long term measurement and the statistics.

Stopping and starting the acquisition does not reset these analyses but only stops and continues them.

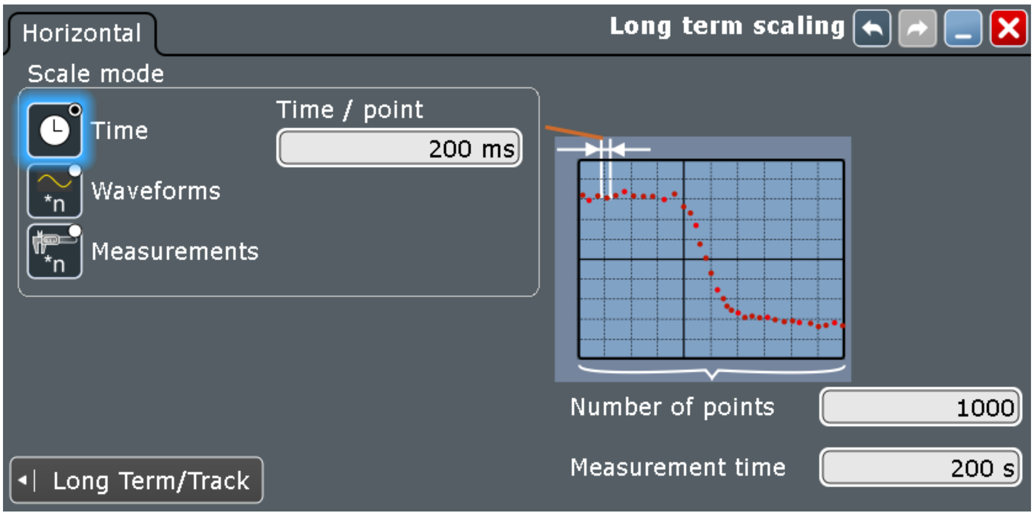
To clear only statistical results, use "Clear results" on the "Gate/Display" tab. To delete all results and waveforms, select "Display" menu > "Clear screen results".

Remote command:
MEASurement<m>:STATistics:RESet on page 1053

7.2.9.3 Horizontal Long Term Scaling

In this dialog box, you define the horizontal scale of long term measurement diagrams. The length of the long term measurement is defined by the number of points.

If option R&S RTE-K5 I²S Audio Signals is installed, the trend diagram is configured here.



Number of points

Defines the total number of points to be displayed in the long term measurement diagram.

Remote command:

MEASurement<m>:LTMeas:COUNt on page 1055

Scale mode

Defines when the points of a long term measurement are created.

If statistics are enabled, each long term measurement point shows the statistical mean and standard deviation of the results measured during the defined period.

If statistics are disabled, the first measurement result of each period is taken as long term measurement point.

"Time"	Sets one long term measurement point for the time defined in "Time/ point".
"Waveforms"	Sets one long term measurement point for a number of acquired waveforms defined in "Waveforms/point".
"Measure-ments"	Sets one long term measurement point for a number of measurement results defined in "Measurements/point".

Remote command:

MEASurement<m>:STATistics:MODE on page 1051

Time / point

Defines the time to create one point of the long term measurement.

This setting is only available if "Scale mode" is set to "Time".

Remote command:

MEASurement<m>:STATistics:RTIMe on page 1053

Measurement time

Defines the total duration of the long term measurement: *Time/point * Number of points*.

This setting is only available if "Scale mode" is set to "Time".

Remote command:
`MEASurement<m>:LTMeas:TIME` on page 1055

Waveforms / point
Defines the number of measured waveforms from which one point of the long term measurement is created.

This setting is only available if "Scale mode" is set to "Waveforms".

Remote command:
`MEASurement<m>:STATistics:RCOunt` on page 1052

Measurements / point
Defines the number of measurement results from which one point of the long term measurement is created.

This setting is only available if "Scale mode" is set to "Measurements".

Remote command:
`MEASurement<m>:STATistics:RMEascount` on page 1052

7.2.9.4 Performing Long-term Measurements

To evaluate time-dependant behavior of a measurement, you can perform the measurement over a long period of time or for a large number of samples.

1. From the "Meas" menu, select "Long Term/Track".
2. Select the tab for the measurement you want to configure.
3. Under "Long term", tap "Enable".
4. Since the waveform may change in the process of time, enable "Continuous auto scale" to have the scaling adapted automatically.
   Alternatively, tap the "Auto scale" to adjust the scale once and to see the long term waveform.
5. Tap "Horizontal scaling".
6. Define the "Number of points" to be shown in the long term diagram.
7. Set the "Scale mode" that defines the period of time from which one long term point is created.
   See "Scale mode" on page 323 for setting details.

   For each long term measurement point, the current measurement value is added to the long term waveform.
8. If you need the statistical data of the long term points:
   a) Tap "Long Term/Track" to return to the measurement settings.
   b) Enable statistics.

c) Let the measurement run and export the data when finished, see Chapter 11.2.5, "Long Term / Meas Histograms", on page 425.

7.2.9.5 Compiling Measurement Statistics

Statistics can be compiled for all measurement types, and also for long-term measurements. If enabled, statistics for the measurement are included in the result box.

To obtain meaningful results, it may be useful to configure specific measurement settings:

- "Multiple measurement" on the "Gate/Display" tab: the measurement result is not only determined once within one acquisition, but repeatedly, if available. This provides a larger basis for statistical evaluation.
- Reference/signal levels: configuring user-defined levels may compensate for irregular data, see Chapter 7.2.4.2, "Configuring Reference Levels", on page 293.
- Gate areas: restricting the waveform range for measurement can eliminate irregular data, see Chapter 7.2.3, "Measurement Gates", on page 286.
- Spectrum measurements: you can eliminate noise from the evaluation, see Threshold and "Peak excursion" on page 276

To enable statistics

1. From the "Meas" menu, select "Setup".
2. Tap the "Enable Statistics" icon.

7.2.10 Protocol Measurements

Measurements on serial buses are available for audio signals (option R&S RTE-K5). The results of these measurements are track and trend waveforms.

7.3 Quick Measurements

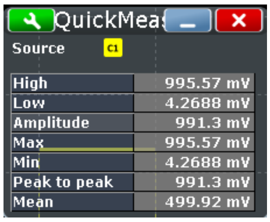
Quick measurement performs a set of up to eight different measurements on one source, simply by tapping the "Quick measurement" toolbar icon. The results are displayed in a results box. You can configure the measurement types to be included in quick measurement. The current configuration can be saved to repeat the measurement very quickly.

7.3.1 Starting Quick Measurement

1. Tap the waveform that you want to measure.
2. Tap the "Quick measurement" icon on the toolbar.

3. Tap the the diagram.

   The result box shows the results of the default quick measurement.

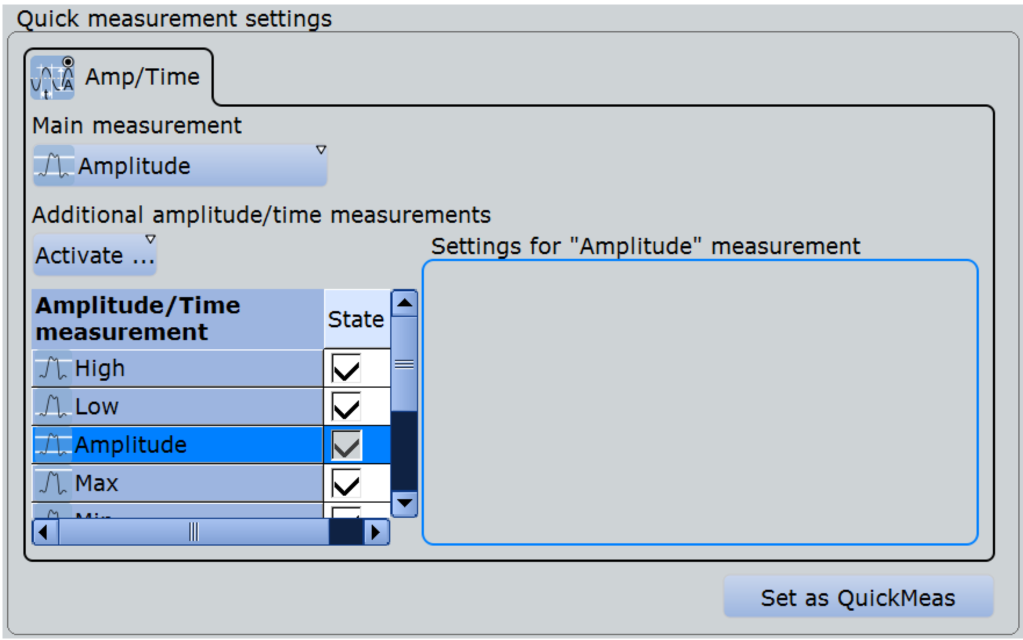


7.3.2 Quick Measurement Settings

Access: "Meas" menu > "Setup" > "QuickMeas" tab

In the "QuickMeas" tab, you can change the setup of the quick measurement and apply it to the "Quick Measurement" icon in the toolbar.

The saved configuration remains until you save another QuickMeas setup, there is no reset.



Main measurement
Selects the main measurement type for quick measurement. If you enable long term measurements for a quick measurement, the long term measurement is performed only on the main measurement.

Activate

Selects a further measurement type of the selected category to the QuickMeas configuration. You can select up to 7 additional measurement types of the same category.

The selected measurement types are displayed in an overview table. The main measurement is also listed in the overview table, but cannot be disabled here.

Beside the table, specific settings for the selected measurement type are shown. When you select a measurement type, check and adjust its specific setting(s).

For details on the available measurement types, see Chapter 7.2.5.1, "Amplitude/Time Measurement Types", on page 294.

Set as QuickMeas

Saves the current QuickMeas setup. The saved QuickMeas configuration is used when you start a new quick measurement. It remains until you save another QuickMeas setup, or until you reset the instrument to "Factory defaults". The "Set as QuickMeas" is not available if the the current configuration already has been saved.

7.3.3 Configuring the Quick Measurement

See also: Chapter 7.3.2, "Quick Measurement Settings", on page 326

1. Start a quick measurement.
2. Tap the  icon in the QuickMeas results box.
3. Tap "Main measurement" and select the measurement type. Long term measurements are performed only on the main measurement.
4. In the table, disable the measurement types that you do not need.
5. Tap "Activate" and select a measurement type you want to add to the quick measurement.
6. Repeat the previous step until the setup is complete.
7. Tap "Save as QuickMeas" to save the setup. The saved QuickMeas setup is used when you start a new quick measurement.

8 Spectrum Analysis

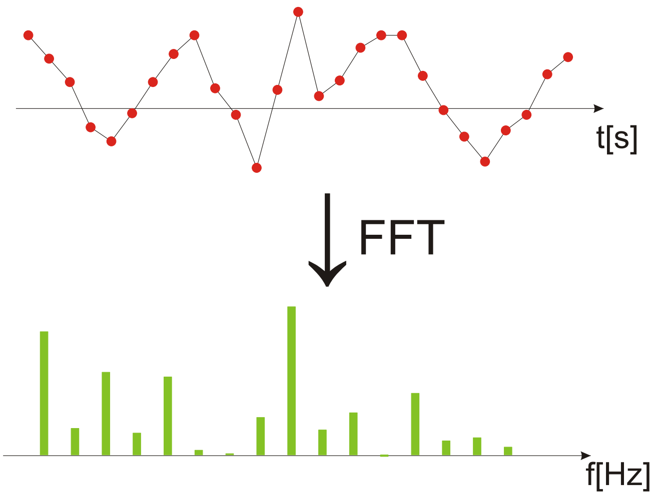
The R&S RTE provides two ways of spectrum analysis:

- Basic FFT calculation, which is included in the firmware
- Spectrum analysis option R&S RTE-K18, which is hardware-supported and provides a wide range of analysis possibilities, for example, spectrogram, cursor and automatic measurements.

8.1 FFT Analysis

8.1.1 Fundamentals of FFT Analysis

During FFT analysis, a signal in the time domain is converted to a spectrum of frequencies. As a result, either the magnitude or the phase of the determined frequencies can be displayed. FFT analysis can be restricted to an extract of the original time base, and the results display can be restricted to a specified frequency range.

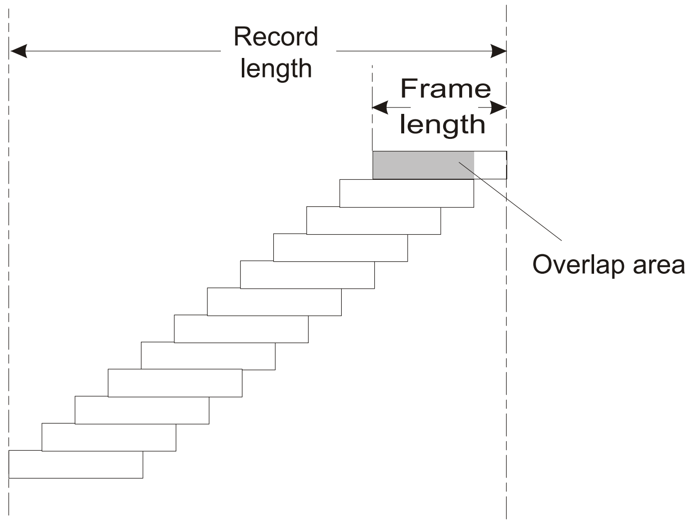


Frames/Segments

In order to convert the time domain signal to a frequency spectrum, an FFT (Fast Fourier Transformation) unit is used which converts a vector of input values into a discrete spectrum of frequencies.

Conventional oscilloscopes calculate one FFT per capture. The R&S RTE can calculate multiple FFTs per capture by dividing one capture into several *segments*, or *frames*. Thus, the R&S RTE can visualize how the frequency content of a signal changes over time which helps to detect intermittent or sporadic signal details. Furthermore, the R&S RTE allows consecutive frames to overlap. This is especially useful in conjunction with window functions since it enables a gap-free frequency analysis of the signal.

The overlapping factor can be set freely. The higher the overlap factor, the more frames are used. This leads to more individual results and improves detection of transient signal effects. However, it also extends the duration of the calculation. The size of the frame depends on the number of input signal values (record length), the overlap factor, and the FFT size (number of samples used for FFT calculation).



Window functions

Each frame is multiplied with a specific window function after sampling in the time domain. Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

There are a number of window functions that can be used in FFT analysis. Each of the window functions has specific characteristics, including some advantages and some trade-offs. These characteristics need to be considered carefully to find the optimum solution for the measurement task.

For details, see "Window type" on page 338.

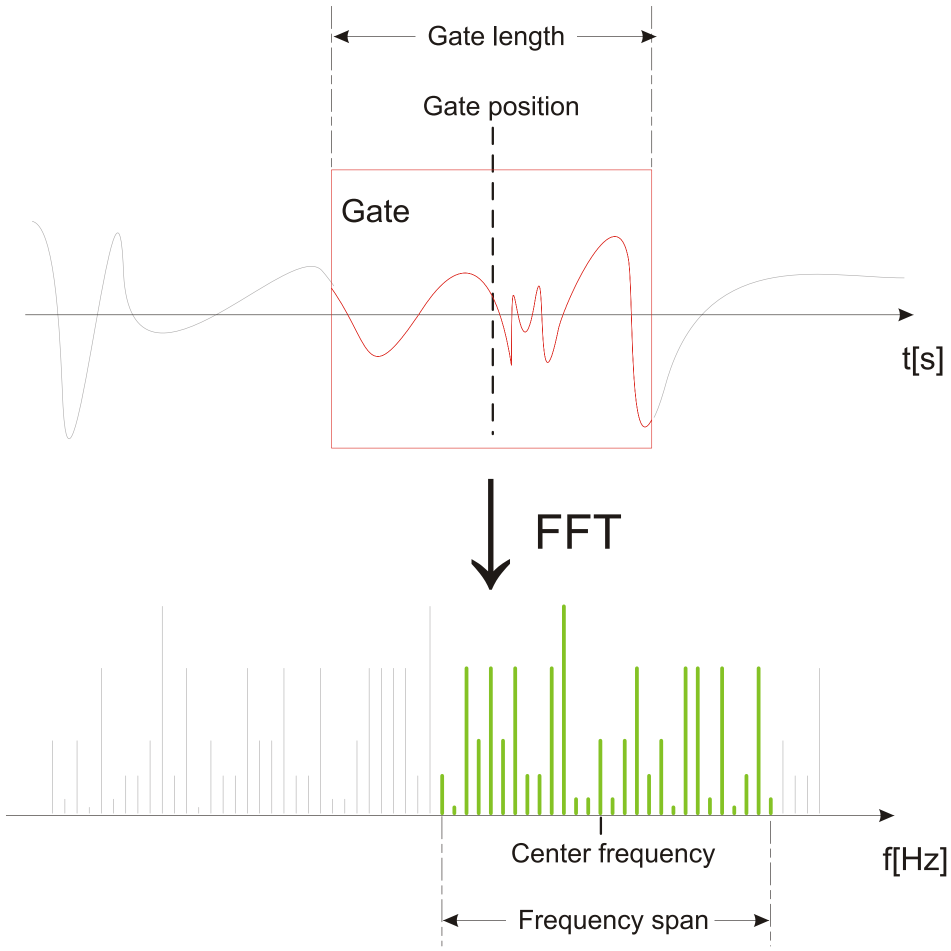
Combining FFT results

After the window function has been applied to the FFT results for each segment, the results for all segments of the data acquisition must be combined to obtain the final waveform. Various arithmetic functions are available for FFT segments, such as averaging, enveloping, or minimum and maximum calculation.

Gating functions

You can restrict the time base of the input signal for which FFT analysis is to be performed. There are various methods to do so:

- Define absolute start and stop times for the time base extract
- Define relative start and stop values that define a percentage of the original time base
- Couple the time base extract for FFT to an active zoom area.



Restricting the result range

You can restrict the results of the FFT analysis to a specified frequency range. The frequency range can be defined in two ways:

- Define a center frequency and frequency span
- Define start and stop frequencies

Using the new cursor functions for spectrum waveforms you can easily determine the results for the current center frequency by moving the cursor to that frequency ("C1 to Center"). On the other hand, if you detect a point of interest in the spectrum diagram, you can place the cursor on it and then move the center frequency to the position of the cursor automatically ("Center to c1").

See Chapter 7.1, "Cursor measurements", on page 268.

Magnitude vs. phase display

The result of an FFT analysis is a spectrum of frequencies. Either the magnitudes or the phases of those frequencies are displayed, depending on the used FFT function. In "Basic" mode, and for the "Advanced" mode FFT functions |FFT|, FFT (re) and FFT (im), the magnitude is displayed. For the "Advanced" mode FFT (φ) function, the phase is displayed.

For magnitude display, you can select the scale and range of magnitudes to be displayed. For linear scaling, the vertical value range of the input signal is used. For logarithmic scaling, the logarithmic power of the frequency is displayed. In this case, the input signal must be given in either Volt or Watt. The resulting value range is defined by a maximum value and a range size. Logarithmic scaling can also be set in relation to a given reference value.

For phase display, you can select the unit and suppress phases beneath a threshold value which are most likely caused by noise. The value range [-π, + π] or [-180°, +180°] is used. Phase shifts due to a limitation of the value range can be eliminated using the "Unwrap" function.

Dependencies between FFT parameters

FFT analysis in the R&S RTE is highly configurable. Several parameters, including the resolution bandwidth, frequency span and center frequency, can be defined according to the user's requirements. Note, however, that several parameters are correlated and not all can be configured independently of the others.

The **resolution bandwidth** defines the minimum frequency separation at which the individual components of a spectrum can be distinguished. Small values result in high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase measurement speed.

The minimum achievable RBW is dependent on the integration time which is equivalent to the number of samples available for FFT calculation. If a higher spectral resolution is required the number of samples must be increased by using a higher sample rate or longer record length. To simplify operation some parameters are coupled and automatically calculated, such as record length and RBW.

The **frequency span** and **center frequency** define the start and stop frequency of the spectral diagram. By default, a suitable frequency range according to the resolution bandwidth is selected, in respect to performance and precision. Span and RBW settings are coupled, so that the parameters can be adjusted automatically as necessary.

With a **Span/RBW ratio** of 100 and a screen resolution of 1000 pixels, each frequency in the spectrum is displayed by 10 pixels. A span/RBW ratio of 1000 provides the highest resolution. For full flexibility the span/RBW coupling can also be disabled. Note, however, that a higher span/RBW ratio (i.e. low RBW values and large frequency spans) result in large amounts of data and extend the duration of the calculation.

Advanced FFT functions

In "Advanced" math definition mode, other FFT results than the basic frequency magnitude can be displayed.

- **FFT (φ)**: phase display
- **FFT (im)**: imaginary part of FFT value (magnitude)
- **FFT (re)**: real part of FFT value (magnitude)

- **FFT -dφ*df** (group delay): the negative derivative of the phase with respect to frequency; useful to measure phase distortion

8.1.2 Configuring Spectrum Waveforms

During FFT analysis, a signal in the time domain is converted to a spectrum of frequencies. A basic spectrum waveform can be displayed very quickly. By defining additional FFT parameters, the waveform can be configured in more detail.

As a result, either the magnitude or the phase of the determined frequencies can be displayed, or more complex FFT functions. Analysis can be restricted to an extract of the original time base, and the results display can be restricted to a specified frequency range.

The usage of FFT is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > FFT".

To display a basic spectrum waveform

1. Tap the "FFT" icon on the toolbar, then tap the waveform for which the FFT is to be performed.

   The first available math waveform is configured to use the selected waveform as a source and the "Mag(FFT(x))" operator, and is enabled. The spectrum waveform is displayed in a new diagram.

2. Alternatively:
   a) Press the MATH key to open the "Math" dialog box.
   b) In the "Setup" tab, in the "Basic" editor, select the input signal as "Source 1".
   c) Select "Mag(FFT(x))" as the "Operator".
   d) Select the "Enable math signal" icon.

3. If required, edit the spectrum waveform parameters as described in the following procedures.

To display advanced spectrum waveforms

In "Advanced" math definition mode, other FFT results than the basic frequency magnitude can be displayed.

1. In the "Setup" tab of the "Math" dialog box, select the "Advanced" expression editor.

2. Double-tap the edit area.

   The "FormulaEditor" is displayed.

3. Tap the "More" key to display further functions in the editor.

4. Tap the required function key.

5. Select the source channel.

6. Close the parenthesis and tap "Enter".

To configure the spectrum of FFT analysis

By default, a suitable frequency range for the expected horizontal values according to the resolution bandwidth is selected, in respect to performance and precision. Span and RBW settings are coupled. If a more precise evaluation is required, for example for postprocessing in a different application, disable the coupling and change the frequency ranges and resolution bandwidth values as required.

1. Select the "FFT Setup" tab of the "Math" dialog box.
2. Tap the "Frequency axis" button to select the type of scaling you want to use: linear or logarithmic.
3. Disable the "Span/RBW coupling".
4. Specify the frequency range to be displayed using one of the following methods:
   - Enter a "Center frequency" and a "Frequency span" that define the spectrum.
   - Enter a "Start frequency" and "Stop frequency" that define the spectrum.
   - Tap the "Full Span" button to display the complete spectrum resulting from the FFT analysis.
5. Define the resolution bandwidth for the FFT result.
   The resolution bandwidth defines how precise the results are, i.e. how close together the individual frequencies can be. Small values result in high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase performance.

   You can define the RBW manually, or couple it to other FFT settings. Do one of the following:
   - To couple the RBW to the span, enable the "Span/RBW coupling" option and define the "Span/RBW ratio". The smaller the ratio, the higher the RBW becomes to display the same frequency span.
   - Enter the "Resolution BW" manually. The "Span/RBW coupling" option is automatically disabled.
   - To couple the RBW to the specified record length, in the "FFT Gating" tab of the "Math" dialog box, select the "Record length controlled" option. This option is only available if no gate is being used ("Use Gate" disabled).
6. Select the most suitable "Window type" for your source data. Window functions are multiplied with the input values and thus can improve the FFT display. For details, see "Window type" on page 338.
7. Optionally, select an arithmetic mode for the FFT segments. This mode defines how the individual segment results are combined to a final spectrum waveform. In the "FFT Overlap" tab of the "Math" dialog box, tap "FFT Segment Arithmetic" and select the required mode from the list.
8. If you use an arithmetic mode, increase the "Overlap factor" for neighboring segments to increase the accuracy of the results.

To restrict the input values (gating)

By default, the FFT is calculated for the entire record length as defined for the data acquisition. However, you can restrict the time range for which the FFT is calculated, resulting in a restricted spectrum. Alternatively, the record length can be determined automatically according to the selected RBW.

1. Select the "FFT Gating" tab of the "Math" dialog box.
2. Determine how the input length is configured by selecting one of the following options:
   - To ensure that the FFT is calculated for the full defined record length, select the "Record length controlled" option. This option is only available if no gate is being used ("Use Gate" disabled). The RBW is adapted so that the record length can be acquired in the specified acquisition time. However, the RBW is restricted, so that data acquisition may fail if the record length is too long for the specified acquisition time.
   - To couple the used record length to the required RBW, select the "RBW controlled" option. This option is only available if no gate is being used ("Use Gate" disabled).
     The required acquisition time for the defined RBW value is indicated.
   - To restrict the basis of the FFT calculation to a certain time base, configure a time gate, that is: an extract of the time base in the original diagram. To do so, enable the "Use Gate" option, then do one of the following:
     – Select the "Absolute" mode and enter the "Start" and "Stop" times that define the gate area.
     – Select the "Relative" mode and enter the percentages of the total time base that define the "Relative Start" and "Relative Stop" times.
     – If a zoom area has already been defined in the original diagram and you want to use the same time base for FFT analysis, select "Zoom coupling".

   The spectrum waveform displays the spectrum for the specified time span.

To configure magnitude results

1. Open the "FFT Y-Units" tab of the "Math" dialog box.
2. Select the scaling unit. Use logarithmic scaling only for input values in Volt or Watt.
3. Decide whether you want to configure the value range manually or use the automatic settings by tapping the corresponding icon.
4. In manual mode, define the size of the "Vertical range" and the "Vertical maximum" to be displayed.
   In automatic mode, define the size of the "Range" to be displayed.
   For logarithmic scaling in dB, also define the "Reference level" to be used.

To configure phase results

1. Open the "FFT Y-Units" tab of the "Math" dialog box.
2. Select the scaling unit.

3. To eliminate phase shifts due to a limitation of the value range, enable the "Unwrap" function.
4. To suppress small phase values due to noise, enable the "Suppression" function and enter a "Threshold" value.

To couple spectrum displays

The settings for one or more spectrums can be coupled. Thus, if any FFT setting for any of the coupled spectrums are changed, they are changed for all coupled spectrums.

1. Open the "FFT Coupling" tab of the "Math" dialog box.
2. Select the spectrums to be coupled. The spectrum for the currently selected math waveform cannot be selected. Its settings are applied to the selected spectrums.
3. If necessary, define an FFT function to be used for the coupled math waveforms so that a spectrum is displayed. See Chapter 6.3.1, "Displaying Math Waveforms", on page 245.

8.1.3 FFT Configuration Settings

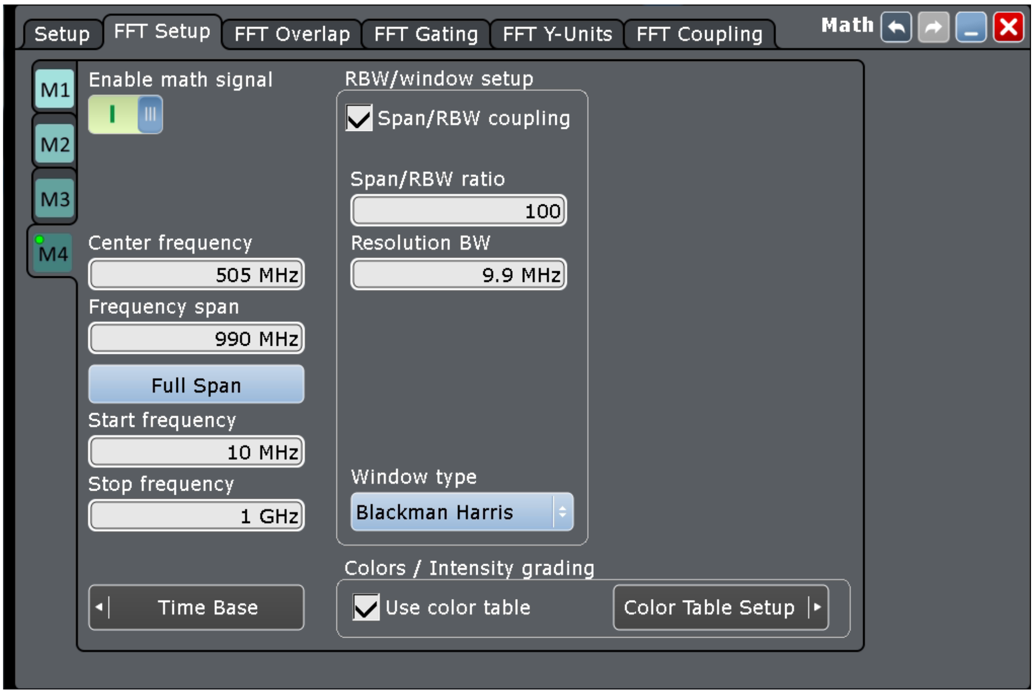
8.1.3.1 FFT Setup

Access: MATH > "FFT Setup"

In this tab you define the settings for the FFT window. The display can be restricted to the results for a certain time base extract and to a specified frequency range.

Additional settings are available on this tab if the Spectrum Analysis option (R&S RTE-K18) is installed.

See Chapter 8.2.4, "Spectrogram Configuration Settings", on page 350.



Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:

`CALCulate:MATH<m>:STATe` on page 1000

Frequency axis (R&S RTE -K18 only)

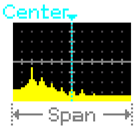
Defines the scaling method for the frequency (x-)axis of the spectrogram.

"Logarithmic"	Logarithmic scaling
"Linear Unit"	Linear scaling

Remote command:

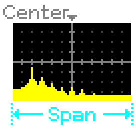
`CALCulate:MATH<m>:FFT:LOGScale` on page 1070

Center frequency
Defines the position of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The width of the range is defined using the "Frequency span" setting.



Remote command:
CALCulate:MATH<m>:FFT:CFRequency on page 1071

Frequency span
The span is specified in Hertz and defines the width of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The position of the span is defined using the "Center frequency" setting.



Remote command:
CALCulate:MATH<m>:FFT:SPAN on page 1071

Full span
Displays the full frequency span.

Remote command:
CALCulate:MATH<m>:FFT:FULLspan on page 1071

Start frequency
Defines the start frequency of the displayed frequency span.

Remote command:
CALCulate:MATH<m>:FFT:STARt on page 1070

Stop frequency
Defines the stop frequency of the displayed frequency span.

Remote command:
CALCulate:MATH<m>:FFT:STOP on page 1070

Span/RBW Coupling
Couples the frequency span to the "Resolution BW" setting.

Remote command:
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO on page 1072

Span/RBW Ratio
Defines the coupling ratio for Span/RBW. This setting is only available if CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO is ON.

Remote command:
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:RATio on page 1072

Resolution BW
Defines the resolution bandwidth. Note that the resolution bandwidth is correlated with the span, record length and acquisition time. If a constant record length is to be used, the RBW may be adapted if the required number of samples cannot be acquired. If span and RBW values are coupled, changing the span will also change the RBW.

For details see Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 328.

Remote command:
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution][:VALue] on page 1073
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:ADJusted? on page 1072

Window type
Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

Various different window functions are provided in the R&S RTE to suit different input signals. Each of the window functions has specific characteristics, including some advantages and some trade-offs. These characteristics need to be considered carefully to find the optimum solution for the measurement task.

Window type	Frequency resolution	Magnitude resolution	Measurement recommendation
Rectangular	Best	Worst	Separation of two tones with almost equal amplitudes and a small frequency distance
Hamming Hann	Good	Poor	Frequency response measurements, sine waves, periodic signals and narrow-band noise
Blackman Harris (default)	Worst	Best	Mainly for signals with single frequencies to detect harmonics Accurate single-tone measurements
Gaussian	Good	Good	Weak signals and short duration
Flattop2	Poor	Best	Accurate single-tone measurements
Kaiser Bessel	Poor	Good	Separation of two tones with differing amplitudes and a small frequency distance

Remote command:
CALCulate:MATH<m>:FFT:WINDow:TYPE on page 1073

Use color table
If enabled, the spectrum waveform (and a spectrogram, if available) is displayed according to the assigned color table. For information on the available color tables, see Chapter 3.4.2.2, "Color Tables", on page 119.

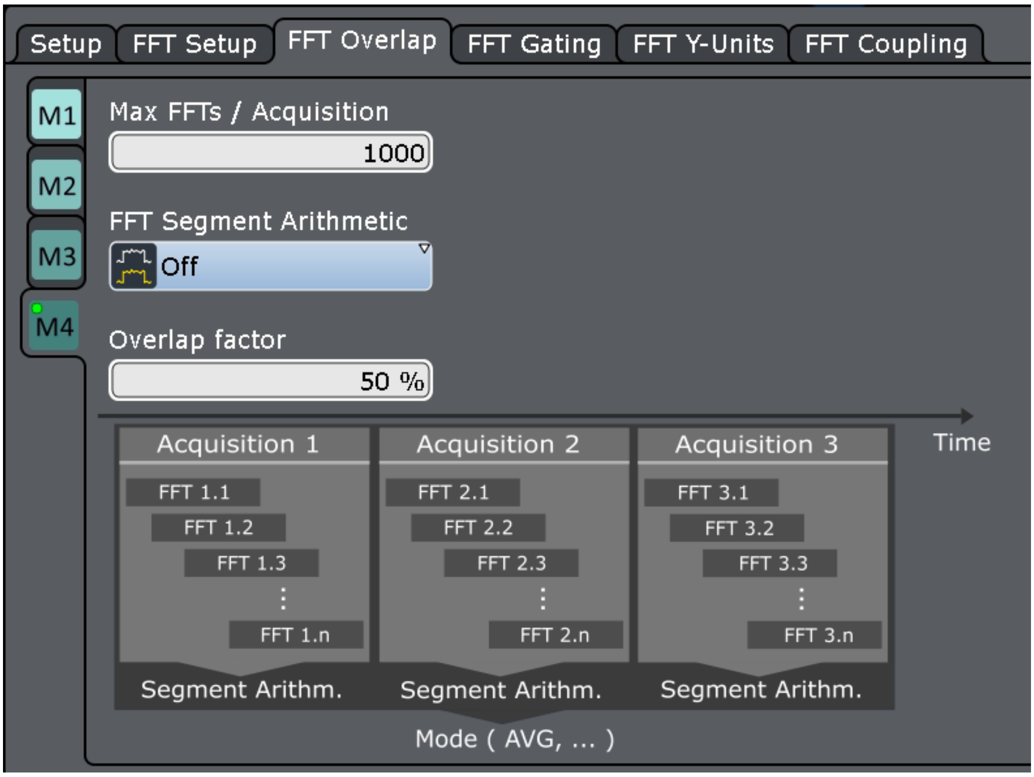
If this option is disabled, the preset color of the selected channel source is displayed, and the intensity of the specific signal color varies according to the cumulative occurrence of the values. For spectrum diagrams, this setting corresponds to the common waveform display. The spectrogram, on the other hand, is then displayed in gray tones, which is not very useful.

Remote command:
`CALCulate:MATH<m>:FFT:USEColtab` on page 1084

8.1.3.2 FFT Overlap

Access: MATH > "FFT Overlap"

In this tab you define the settings for the magnitude and phase of the frequencies.



Enable Math Signal
If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:
`CALCulate:MATH<m>:STATe` on page 1000

Max FFTs / Acquisition

Restricts the maximum number of FFTs to be calculated for each data acquisition. Due to the other parameter settings, the required number of FFTs may become very high, thus slowing performance. By restricting the number of FFTs, you can avoid performance loss without changing the other parameters.

However, if the maximum number of FFTs is lower than the required number to cover the entire waveform, the waveform may only be analyzed partially. In this case, the "Frame coverage" indicates the percentage of the waveform that was analyzed, i.e. which part of the data was included in the FFT calculation.

Remote command:
`CALCulate:MATH<m>:FFT:FRAMe:MAXCount` on page 1075
`CALCulate:MATH<m>:FFT:FRAMe:COVerage?` on page 1075

FFT Segment Arithmetics

FFT analysis can only be performed on a maximum number of values at once. If more values must be calculated, the input signal is divided into segments, each of which is calculated separately. The segments need not be disjunct, that is: they may overlap, so that some values have several FFT results. In this case, the arithmetic mode defines how the final result is calculated from the individual results.

The following methods are available:

"Off"	The data of only one segment is taken into consideration. In effect, no arithmetics are processed.
"Envelope"	Detects the minimum and maximum values for FFT calculation over all segments. The resulting diagram shows two envelope waveforms: the minimums (floor) and maximums (roof). These envelopes indicate the range of all FFT values that occurred.
"Average"	The average is calculated over all segments.
"RMS"	The root mean square is calculated over all segments. The result is the average power spectrum. If you measure the channel power on this RMS spectrum, you get the same result as for the average channel power measurement on segments.
"MinHold"	Determines the minimum result for each input value from the data of the current acquisition and the acquisitions before.
"MaxHold"	Determines the maximum result for each input value from the data of the current acquisition and the acquisitions before.

Remote command:
`CALCulate:MATH<m>:FFT:FRAMe:ARIThmetics` on page 1074

Overlap Factor

Defines the minimum factor by which two neighboring segments overlap. If the required number of segments to cover the input values allows for more overlap, the factor is increased.

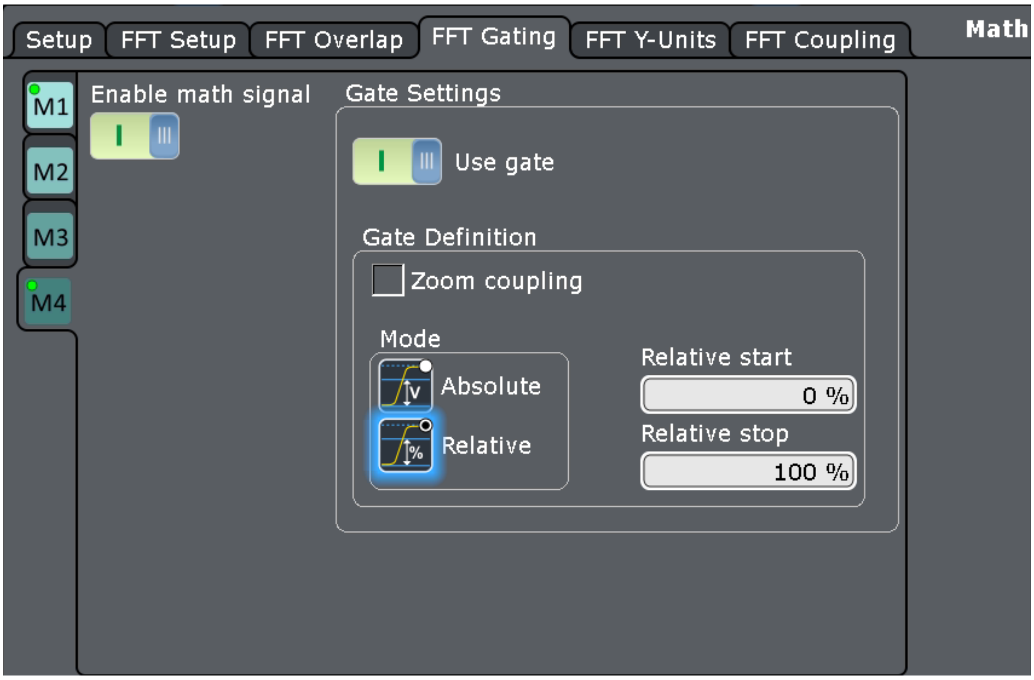
The higher the overlap factor, the more segments are used. This leads to more individual results and improves detection of transient signal effects. However, it also extends the duration of the calculation.

Remote command:
CALCulate:MATH<m>:FFT:FRAMe:OFACtor on page 1075

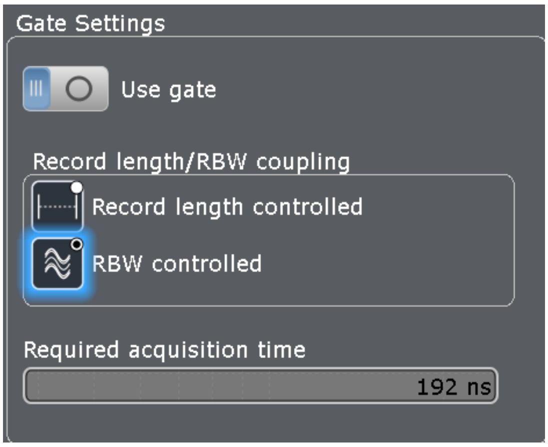
8.1.3.3 FFT Gating

Access: MATH > "FFT Gating"

FFT gating allows you to restrict FFT analysis to a certain time base of the input signal.



If no gate is used, you can define the record length as dependent on the RBW, or the RBW as dependent on the record length (which is defined by the acquisition time).



Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:

`CALCulate:MATH<m>:STATe` on page 1000

Use Gate

Enables FFT gating and shows the gate.

If enabled, the "Gate Definition" settings are displayed.

If disabled, the relation between the record length and the RBW can be defined manually instead.

When a gate is used, the RBW is adapted, if necessary. The smaller the gate, the higher the RBW.

For details see Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 328.

Gate Definition

Defines the gate settings for FFT gating.

Zoom coupling ← Gate Definition

Zoom coupling is available if a zoom is defined. As long as "Zoom coupling" is enabled, the gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.

If several zoom diagrams are defined, select the zoom diagram to be used for gating. The "Start" and "Stop" values of the gate are adjusted accordingly.

Zoom coupling can be set for measurement gates, FFT gates, and search gates.

Remote command:

`CALCulate:MATH<m>:FFT:GATE:ZCOupling` on page 1078
`MEASurement<m>:GATE:ZCOupling` on page 1059
`MEASurement<m>:GATE:ZDIagram` on page 1059
`SEARch:GATE:ZCOupling` on page 1129
`SEARch:GATE:ZDIagram` on page 1129

Mode ← Gate Definition

Defines whether the gate settings are configured using absolute or relative values.

"Absolute"	The gate is defined by absolute start and stop values.
"Relative"	The gate's start and stop values are defined by a percentage of the value range.

Remote command:

`CALCulate:MATH<m>:FFT:GATE:MODE` on page 1077
`MEASurement<m>:GATE:MODE` on page 1057
`SEARch:GATE:MODE` on page 1128

(Relative) Start ← Gate Definition
Defines the starting value for the gate.

Remote command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt on page 1077
CALCulate:MATH<m>:FFT:GATE:RELative:STARt on page 1077
MEASurement<m>:GATE:ABSolute:STARt on page 1057
MEASurement<m>:GATE:RELative:STARt on page 1057
SEARch:GATE:ABSolute:STARt on page 1128
SEARch:GATE:RELative:STARt on page 1128

(Relative) Stop ← Gate Definition
Defines the end value for the gate.

Remote command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP on page 1077
CALCulate:MATH<m>:FFT:GATE:RELative:STOP on page 1078
MEASurement<m>:GATE:ABSolute:STOP on page 1057
MEASurement<m>:GATE:RELative:STOP on page 1057
SEARch:GATE:ABSolute:STOP on page 1128
SEARch:GATE:RELative:STOP on page 1129

Record Length/RBW Coupling
The record length and resolution bandwidth are coupled during FFT analysis. If you change one value, the other must be adapted accordingly. You can keep either value constant, thus preventing automatic adaptation when the other parameter is changed. However, this may cause the FFT analysis to fail.

This setting is only available if gating is not enabled (otherwise the gate determines the RBW automatically).

For details see Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 328.

"Record length controlled"	The record length remains constant. If not enough samples are available for the selected RBW, the RBW will be decreased.
"RBW controlled"	The RBW is not adapted, i.e. remains as defined by the user. The required acquisition time for this RBW is indicated. If necessary and possible, the record length is extended to acquire the required number of samples.

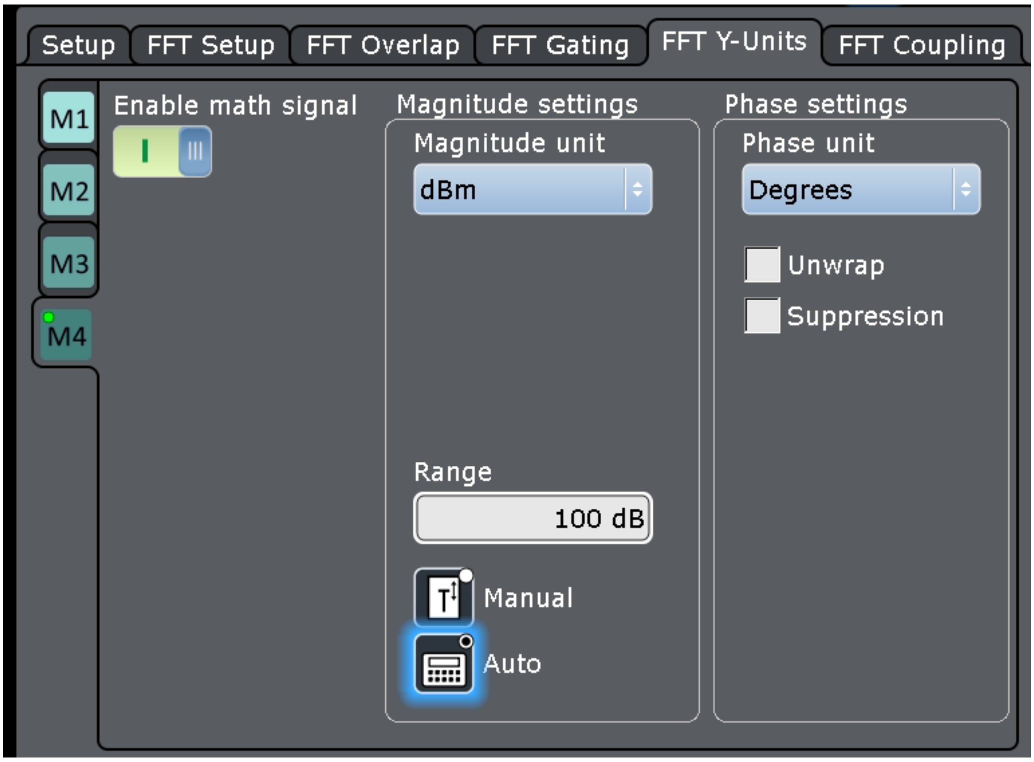
Remote command:
CALCulate:MATH<m>:FFT:GATE:COUPling on page 1076

Required acquisition time
The required acquisition time is calculated for the defined RBW value if "RBW constant" is selected, and is displayed for information only. If the required acquisition time is not available (e.g. because acquisition has already been stopped), an error message is displayed in the FFT Setup tab indicating that not enough samples are available for the defined RBW.

Remote command:
TIMebase:RACTime? on page 1076

8.1.3.4 FFT Y-Units

Access: MATH > "FFT Y-Units"



Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:

`CALCulate:MATH<m>:STATe` on page 1000

Magnitude unit

Defines the scaling of the y-axis. The display values are valid for 50Ω termination impedance.

"Linear"	Linear scaling; displays the RMS value of the voltage
"dBm"	Logarithmic scaling; related to 1 mW

"dB" Logarithmic scaling; related to reference level

"dBµV, dBmV, dBV"
Logarithmic scaling; related to voltage 1 µV, 1 mV, 1 V, respectively

"dBps, dBns, dBµs, dBms, dBs"
Logarithmic scaling; related to time 1 ps, 1 ns, 1 µs, 1 ms, 1 s, respectively

"dBHz, dBkHz, dBMHz, dBGz"
Logarithmic scaling; related to frequency

"dBA, dBmA, µdBA"
Logarithmic scaling; related to current

Remote command:
`CALCulate:MATH<m>:FFT:MAGNitude:SCALe` on page 1079

Reference level
Defines the reference level for dB scaling.

Remote command:
`CALCulate:MATH<m>:FFT:MAGNitude:LEVel` on page 1079

Vertical scaling mode (Manual/Auto)
By default, the vertical scale is adapted to the current measurement results automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

Note: When you change the scaling values manually using the "Scale" rotary knob, the scale mode is set to "Manual" temporarily. When you edit the math function, scaling is automatically set back to "Auto" mode. "Manual" mode is only maintained during math function changes if you select it yourself.

"Manual" Enter the required values for "Vertical scale" and "Vertical offset". For FFT, set "Vertical range" and "Vertical maximum".

"Auto" "Vertical scale" and "Vertical offset" are read-only. For FFT, only the "Vertical maximum" is read-only.

Vertical maximum
Defines the maximum value on y-axis for spectrum displays. Only available for "Manual" scale mode.

Vertical range
Defines the range of FFT values to be displayed.

Remote command:
`CALCulate:MATH<m>:VERTical:RANGe` on page 1003

Range
Defines the vertical value range in spectrum mode.

Remote command:
`CALCulate:MATH<m>:FFT:MAGNitude:RANGe` on page 1079

Phase unit
Defines the scaling unit for phase display.

- Radians
- Degrees

Remote command:
`CALCulate:MATH<m>:FFT:PHASe:SCALe` on page 1080

Unwrap
If enabled, phase shifts due to a limitation of the value range are eliminated.

Remote command:
`CALCulate:MATH<m>:FFT:PHASe:UNWRap` on page 1081

Suppression
Enables noise suppression. Phase calculation is restricted to frequencies with a minimum magnitude, the threshold value.

Remote command:
`CALCulate:MATH<m>:FFT:PHASe:SUPPression` on page 1080

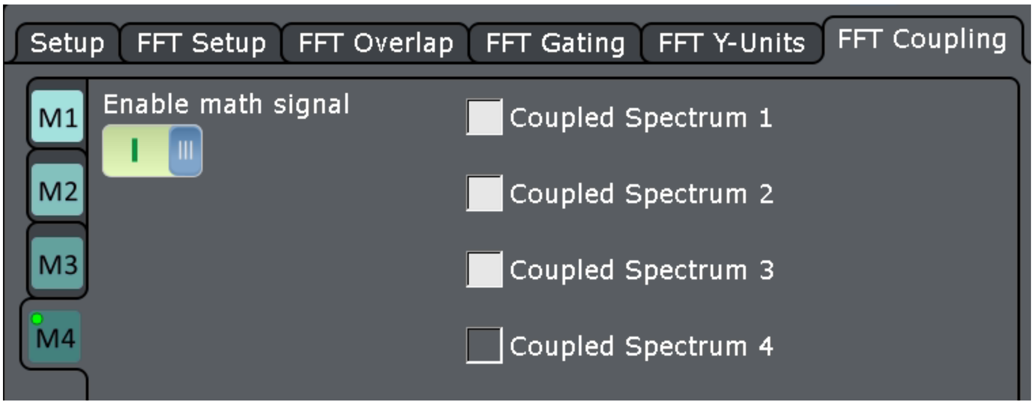
Threshold
Defines the minimum frequency magnitude for which phases are calculated. This setting is only available if "Suppression" is enabled.

Remote command:
`CALCulate:MATH<m>:FFT:PHASe:THReshold` on page 1081

8.1.3.5 FFT Coupling

Access: MATH > "FFT Coupling"

Up to four spectrum displays can be shown simultaneously, one for each math waveform. The settings for one or more spectrums can be coupled. Thus, if any FFT setting for any of the coupled spectrums are changed, they are changed for all coupled spectrums.



Enable Math Signal
If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:
CALCulate:MATH<m>:STATe on page 1000

Coupled Spectrum 1/2/3/4
Copies the current FFT settings of the selected math waveform (M1/M2/M3/M4) to the other selected math waveforms, and couples those waveforms. Thus, if any FFT setting for any of the coupled spectrums are changed, they are changed for all coupled spectrums.

Two different sets of spectrums can be coupled at the same time, for instance Spectrum 1 can be coupled to Spectrum 2, while Spectrum 3 is coupled to Spectrum 4.

Note that the formula of the coupled math waveforms is not changed. If necessary, you must select an FFT function for the math waveform manually before the FFT settings of the coupled waveform are applied. See Chapter 6.3.1, "Displaying Math Waveforms", on page 245.

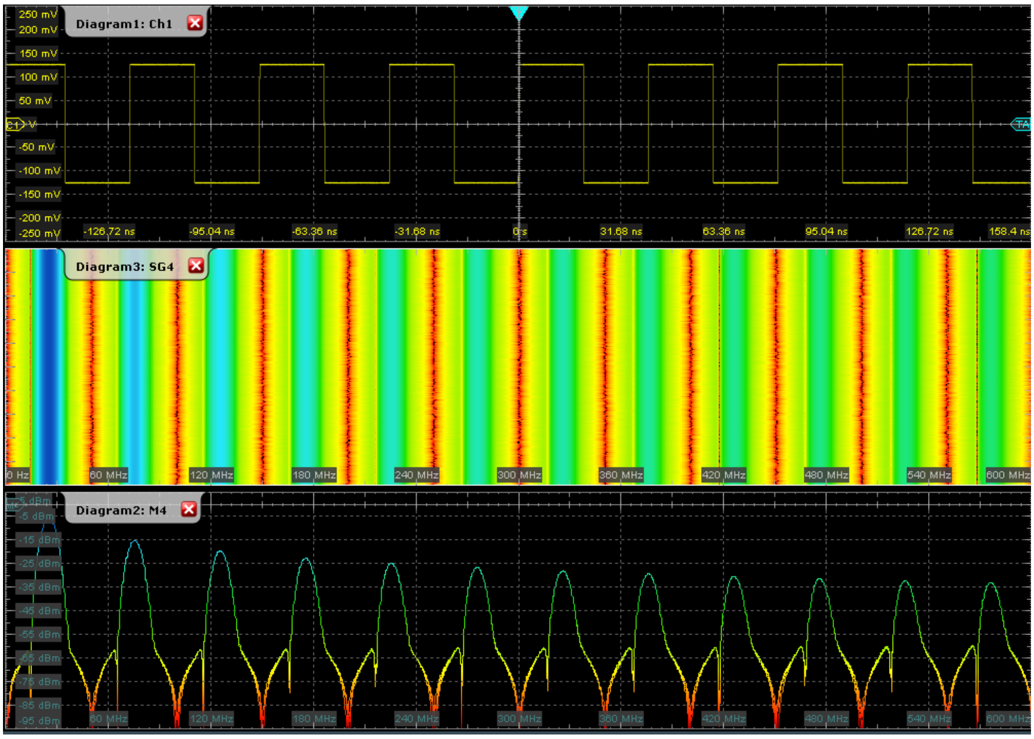
Remote command:
CALCulate:MATH<m>:FFT:COUPled:WITH<m2> on page 1081

8.2 Spectrum Analysis (Option R&S RTE-K18)

Spectrum Analysis is only available if the Spectrum Analysis (R&S RTE-K18) option is installed.

8.2.1 Spectrogram Display

The Spectrum Analysis option provides a new diagram for spectrum waveforms: a spectrogram. When you enable a spectrogram, three windows are displayed: the power vs. time diagram at the top, the spectrogram in the middle (labeled "SG") and the power vs. frequency (=spectrum) diagram at the bottom.



A spectrogram shows how the spectral density of a signal varies over time. The x-axis shows the frequency, the y-axis shows the time. A third dimension, the power level, is indicated by different colors. Thus you can see how the strength of the signal varies over time for different frequencies.

The spectrogram is updated with each data acquisition, from top to bottom, so that the most recent trace is at the bottom. Up to two time lines can be shown at a specified position so that you can analyze the spectrum at a specific point in time.

The spectrum diagram indicates the power vs. frequency values for a single data acquisition. If a time line is enabled, the spectrum shows the results at the selected time. Otherwise, the spectrum shows the results of the most recent data acquisition.

8.2.2 Spectrum Analysis Functions

In addition to spectrograms, the Spectrum Analysis option also provides some new automatic measurements based on spectrum waveforms.

- A peak list measurement detects all peaks above a user-definable threshold and optionally indicates the peaks in the spectrum diagram.

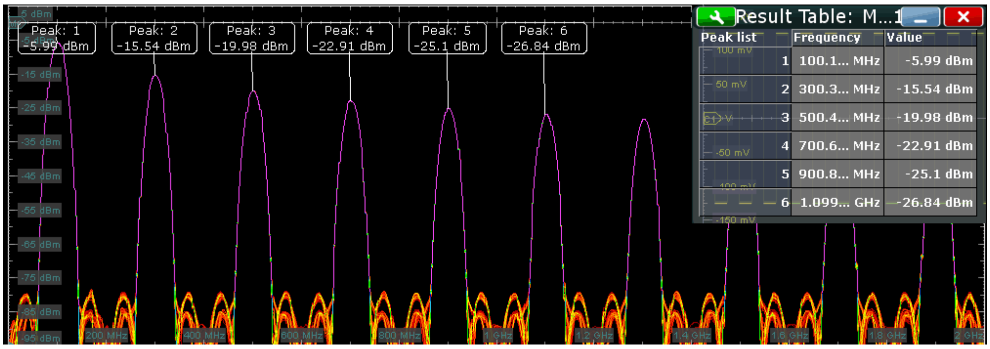


Figure 8-1: Peak list with labels for spectrum waveform

For a description of the measurement settings see Chapter 7.2.7.2, "Spectrum Measurement Settings ", on page 307.

- The new THD measurements are an extension to the basic THD measurement that was already available. See Chapter 7.2.7, "Spectrum Measurements", on page 306 for details.
- Cursor measurements on spectrum waveforms provide easy center definition and peak search functions, see Chapter 7.1.1.2, "Cursor Measurements on Spectrum Waveforms", on page 269.

8.2.3 Configuring Spectrograms

Spectrograms are only available if the Spectrum Analysis (R&S RTE-K18) option is installed.

1. Tap the "FFT" icon on the toolbar, then tap the waveform for which the FFT is to be performed.

   The first available math waveform is configured to use the selected waveform as a source and the "Mag(FFT(x))" operator, and is enabled. The spectrum waveform is displayed in a new diagram.
2. Select the "FFT Setup" tab of the "Math" dialog box.
3. In the "Spectrogram" area, select "Enable".

   A spectrogram diagram is displayed. A new signal icon for the spectrogram is displayed in the signal bar ("SGx").
   Additional settings for time lines become available in the dialog box.
4. Optionally, to display a time line and thus mark a specific waveform in the spectrogram, select "Enable" for one of the two time lines.

   A small arrow icon labeled "T1" / "T2" indicates the position of the time line in the spectrogram.
   The spectrum diagram displays the results for the selected waveform(s). A new signal icon is displayed in the signal bar for each time line ("SGxTL1|2").

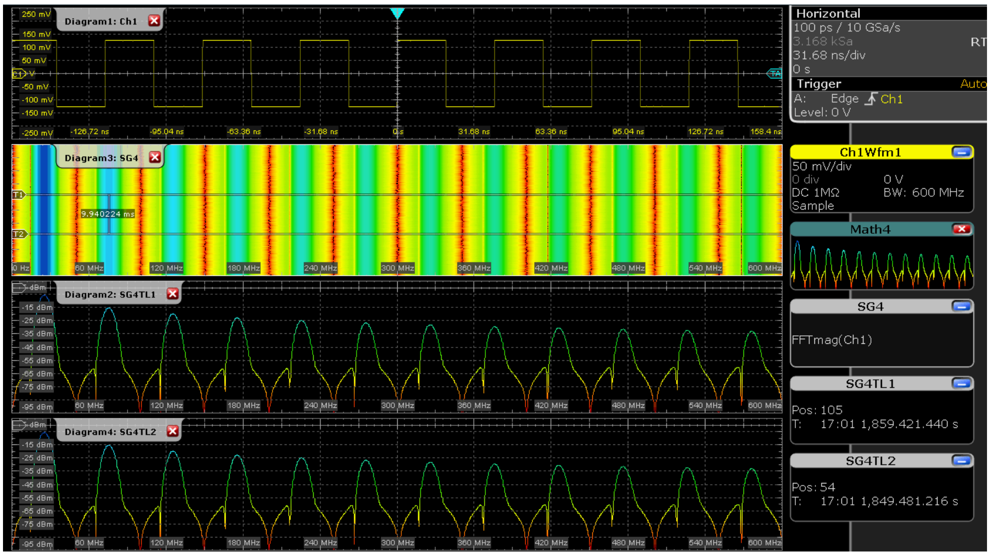


Figure 8-2: Signal icons for the spectrogram time lines (example from the R&S RTO2000)

5. To view the spectrum for each time line in a separate diagram, drag the signal icon for one time line to the diagram area and drop it.

   A new window is displayed for the selected time line, and the original diagram displays the other time line.

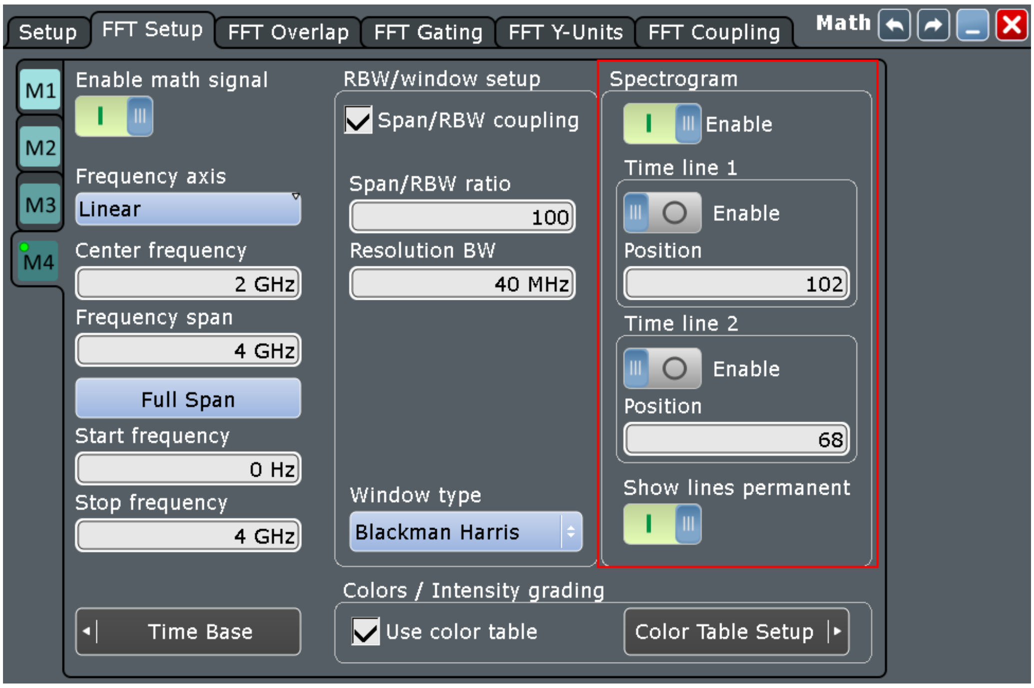
6. To view a different waveform from the spectrogram, move the time lines in the spectrogram.

8.2.4 Spectrogram Configuration Settings

Access: MATH > "FFT Setup"

Spectrograms are only available if the Spectrum Analysis (R&S RTE-K18) option is installed. Furthermore, a math (FFT) waveform must be configured and enabled.

See Chapter 8.1.2, "Configuring Spectrum Waveforms", on page 332.



Enable

Enables the spectrogram display.

If enabled, a new signal icon for the spectrogram is displayed in the signal bar ("SGx").

Remote command:
`CALCulate:MATH<m>:FFT:SPECtrogram:STATe` on page 1084

Time line 1/2

A time line marks a single spectrum in the spectrogram, that is: the power vs frequency results for the data acquired at a specific time. After enabling a time line, the results for that time are displayed in the spectrum diagram. A small arrow icon labeled "T1" / "T2" indicates the position of the time line in the spectrogram. A new signal icon is displayed in the signal bar for each time line ("SGxTL1|2").

You can enable and display two time lines at the same time. This allows you to compare the results at different times.

The position of the time line is defined by the index of the data acquisition in the history. How many acquisitions are available depends on the history settings.

See "Max. acquisition count" on page 261 and Chapter 6.4.2.1, "Viewer", on page 259.

Remote command:
`CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:STATe` on page 1085
`CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:POSition` on page 1084

Show lines permanently

Displays the spectrogram time lines in the diagrams until you disable this option.

If disabled, only the small arrow icons are permanently visible. The line is only displayed temporarily when you touch the arrow.

9 Mask Testing

9.1 About Mask Testing

Masks are used to determine whether the signal remains within specified limits, e.g. to uncover signal anomalies or test compliance and stability of digital signals. The limits are specified as "mask", which is laid over the input signal in the display. Thus you can easily detect where the signal violates the mask.

Mask testing with R&S RTE has only a minor impact on the acquisition rate, thus mask violations are detected very fast and reliably.

With R&S RTE, you can define own masks easily. Specific actions can be executed when mask violations occur. For error analysis, you can stop the acquisition on a failed test and use the history view to look at the previous waveforms.

Mask test

A mask test consists of:

- Mask definition
- Waveform to be tested
- Fail criteria for test
- Actions to be taken on violation or successful completion

Mask Definition

A mask can be created in several ways:

- The individual mask points are defined, either on the touch screen or as numerical values. This mask type is called *user mask*.
  For details, see Chapter 9.2.2.1, "Mask Definition: User Mask", on page 357.
- The mask is derived from an existing waveform. This mask type is called *waveform mask*.
  For details, see Chapter 9.2.2.2, "Mask Definition: Waveform Mask", on page 360.

Fail Criteria for Testing

The fail criteria for a mask test is set by two parameters: "Fail condition" and "Violation tolerance". Fail condition defines if sample hits or the number of acquisitions with sample hits are considered. Violation tolerance sets the number of tolerable sample hits or acquisition hits. A test has failed if the number of sample hits or acquisition hits exceeds the limit of violation tolerance hits.

See also: "Fail condition, Violation tolerance" on page 356.

9.1.1 Results of a Mask Test

The result box of a mask test shows the following test results:

Acq. completed
Number of tested acquisitions.

Remote command:
`MTESt:RESult:COUNt:WAVeforms?` on page 1099

Acq. remaining
Remaining acquisitions until "Average count / Nx Single count" is reached.

The value is useful if you test a specified number of acquisitions with action "Stop acquisition" on violation, or if the acquisition has been stopped manually before the required number of acquisitions has been acquired.

See also: Chapter 9.3.4, "Running a Mask Test", on page 373.

Remote command:
`MTESt:RESult:COUNt:REMaining?` on page 1100

State
Shows if the test has been completed. The state is set to "Finished" when "Nx Single count" acquisitions are tested and the number of "Acq. remaining" is 0. as long as the number of tested acquisitions is less the "Nx Single count" number, the state is "Running".

If you run the acquisition with RUN CONT, or the number of played history acquisitions exceeds "Nx Single count", the mask testing is perfomed according to fail criteria settings independently of the test state. The testing is not stopped when the state is set to "Finished".

Remote command:
`MTESt:RESult:STATe?` on page 1099

Sample hits
Number of samples that hit the mask.

Remote command:
`MTESt:RESult:COUNt:FAILures?` on page 1100

Acquisition hits
Number of acquisitions that contained at least one sample hit.

Remote command:
`MTESt:RESult:COUNt:FWAVeforms?` on page 1100

Fail rate
Ratio of acquisition hits to the number of tested acquisitions.

Remote command:
`MTESt:RESult:FRATe?` on page 1101

Test result
A test has failed if the number of sample hits or acquisition hits exceeds the limit of "Violation tolerance" hits.

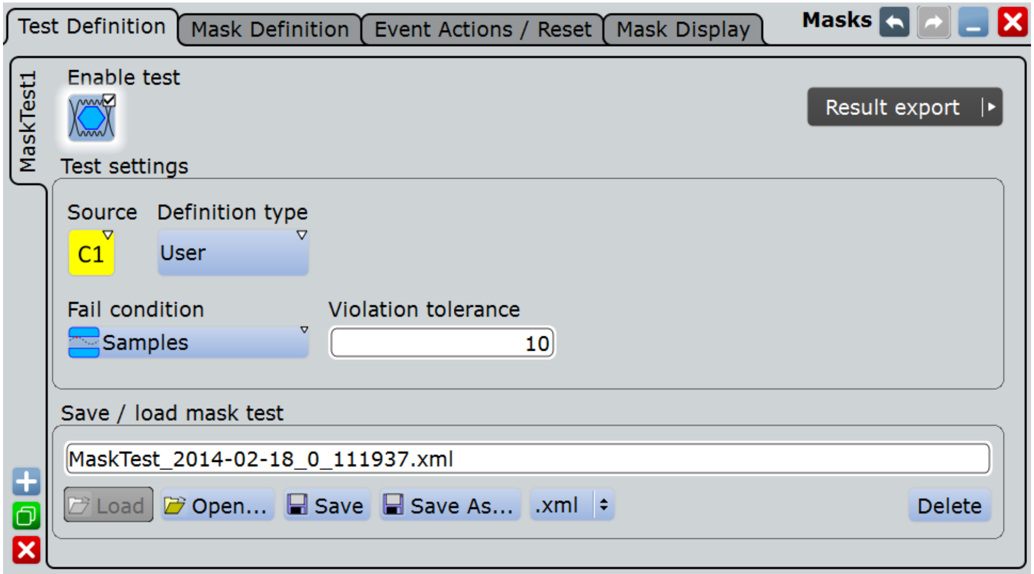
Remote command:
`MTESt:RESult[:RESult]?` on page 1099

9.2 Mask Test Settings

9.2.1 Test Definition

Access: MASKS > "Test Definition"

The "Test Definition" tab provides all settings for the mask test itself: the waveform to be tested, pass/fail conditions, and saving/loading the mask definition.



The content of the "Test Definition" tab depends on the selected definition type: "User" or "Waveform". If "Waveform" is selected, the main mask settings can be set directly on the "Test Definition" tab. For a description of these settings, see Chapter 9.2.2.2, "Mask Definition: Waveform Mask", on page 360.

Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

Remote commands:

`MTESt:ADD` on page 1086

`MTESt:REMove` on page 1086

Enable test
Activates and deactivates the mask test. If the acquisition is running, the test starts immediately. Otherwise, the test starts when acquisition is started.

The testing is stopped when acquisition is stopped, or if a stop action is configured with Stop acq..

Closing the result box also disables the mask test.

Remote command:
`MTESt[:STATe]` on page 1086

Source
Selects the waveform to be tested against the mask. All channel waveforms can be tested.

Remote command:
`MTESt:SOURce` on page 1087

Definition type
Sets the method of mask definition.

"User"	The mask is created manually by tapping the mask points on the touch screen and/or by entering the numerical x- and y-values of the mask points.
"Waveform"	The mask is created from an existing waveform. The waveform builds the upper and lower limit line of the mask, and the limits are moved and stretched. The result is a tolerance tube around the waveform that is used as mask.

Remote command:
`MTESt:CTYPe` on page 1088

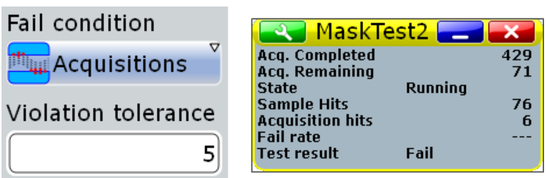
Fail condition, Violation tolerance
The fail criteria for a mask test is set by two parameters: "Fail condition" and "Violation tolerance".

"Fail condition" defines the kind of hits to be considered for test evaluation:
- "Samples": Considers the number of samples that hit the mask.
- "Acquisitions": Considers the number of acquisitions that contain at least one sample hit. How many samples hit the mask in that acquisition is not relevant.

"Violation tolerance" sets the number of tolerable sample hits or acquisition hits.

A test has failed if the number of sample hits or acquisition hits exceeds the limit of violation tolerance hits.

Example:



The example test has failed when the sixth acquisition violated the mask.

Remote command:
`MTESt:CONDition` on page 1087
`MTESt:TOLerance` on page 1087

Save / load mask test
Provides all functions to store and recall a mask test. The mask definition, defined actions and fail conditions are stored in an R&S RTE-specific xml file.

"Load, Save"	Recalls or stores the specified file.
"Open, Save As"	Opens a dialog box where you can select the directory the file name. See also: Chapter 11.1.7, "File Selection Dialog", on page 408.
"Delete"	Opens a dialog box where you can select the file to be deleted.

Remote command:
`MTESt:FILE:NAME` on page 1088
`MTESt:FILE:SAVE` on page 1088
`MTESt:FILE:OPEN` on page 1088
`MTESt:FILE:DELete` on page 1089

9.2.2 Mask Definition

Access: MASKS > "Mask Definition"

With mask definition, you define the shape of the mask - the form and position of its limit lines. The content of the "Mask Definition" tab depends on the selected "Definition type": "User" or "Waveform".

The "Definition type" is a common setting on the top of the tab, see "Definition type" on page 356.

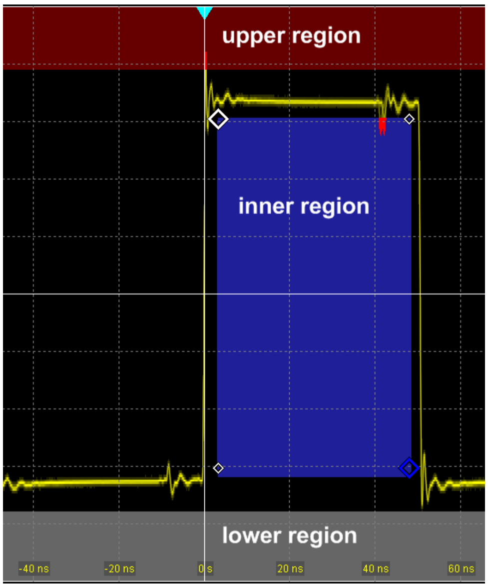
Below, you find the specific settings:

9.2.2.1 Mask Definition: User Mask

Access: MASKS > "Mask Definition" > "Definition type" = "User"

A user mask is defined by entering the time and voltage values for all corner points of the mask segments. A user mask has at least one segment. Complex masks can have up to 16 segments.

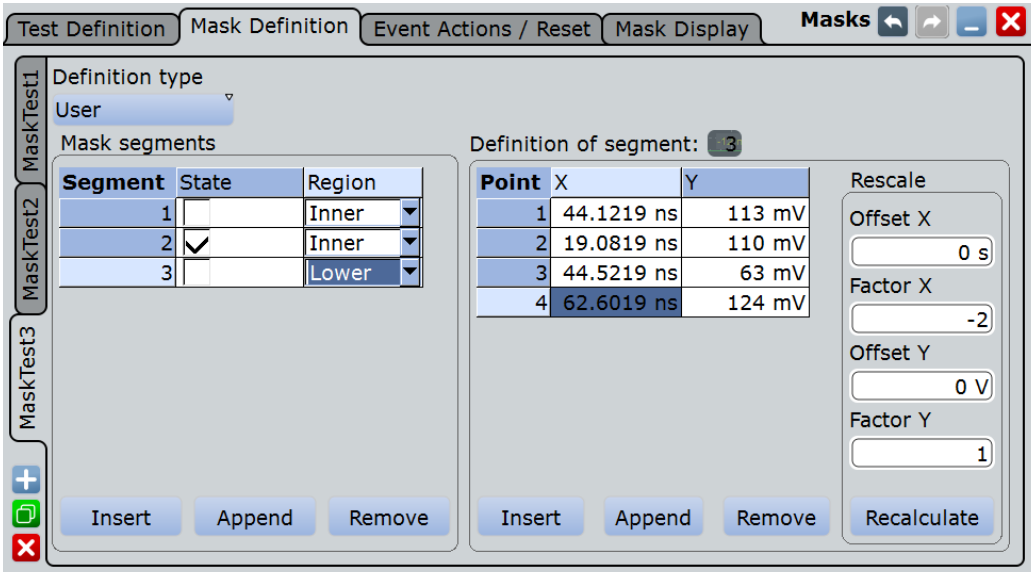
An inner segment is an area defined by three or more points. Upper and lower segments limit the signal on top and bottom of the screen. They are defined by a line, the region above or below the line is set automatically as mask segment.



Alternatively, you can set the corner points on the touch screen and adjust the values in the "Mask Definition" tab.

To save the mask, select the "Test Definition" tab and save the mask test.

Settings overview:



Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

Mask segments

Defines the number and state of mask segments for the selected mask test. Here you can:

- Insert a new segment before the selected segment.

- Append a new segment at the end of the list.
- Remove the selected mask segment from the list.
- Select the region that builds the mask.
  – Inner region: the segment points form a closed geometrical shape, which is the mask segment.
  – Upper region: the segment points are connected to a line, the display area above this line is the mask segment.
  – Lower region: the segment points are connected to a line, the display area below this line is the mask segment.
- Enable and disable the mask segments individually. Disabled segments are not considered by running tests.

Remote command:
`MTESt:SEGMent:STATe` on page 1089
`MTESt:SEGMent:ADD` on page 1090
`MTESt:SEGMent:REMove` on page 1090
`MTESt:SEGMent:INSert` on page 1090
`MTESt:SEGMent:REGion` on page 1090
`MTESt:SEGMent:COUNt?` on page 1090

Definition of segment
The number of the selected segment is shown above the table. In the definition table, the individual points of the selected mask segment are listed with exact horizontal and vertical numerical coordinates. Here you can:

- Insert a new point before the selected point.
- Append a new point at the end of the list.
- Remove the selected point from the list.
- Change the x- and y-values of each point. To scale or move the complete segment, use offset and factor values, see Rescale.

Remote command:
`MTESt:SEGMent:POINt:ADD` on page 1091
`MTESt:SEGMent:POINt:REMove` on page 1091
`MTESt:SEGMent:POINt:INSert` on page 1091
`MTESt:SEGMent:POINt:X` on page 1092
`MTESt:SEGMent:POINt:Y` on page 1092
`MTESt:SEGMent:POINt:COUNt?` on page 1092

Rescale
You can rescale and move mask segments by numerical input of factors and offsets. The values change the selected mask segment and take effect on "Recalculate".

Offset X ← Rescale
Moves the mask segment horizontally. The specified offset is added to the x-values of all points of the selected mask segment.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:XOFFset` on page 1093

Factor X ← Rescale
Stretches or compresses the selected mask segment in horizontal direction. The x-values of all points of the selected mask segment are multiplied with this factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:XFACtor` on page 1093

Offset Y ← Rescale
Moves the mask segment vertically. The specified offset is added to the y-values of all points of the selected mask segment.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:YOFFset` on page 1094

Factor Y ← Rescale
Stretches or compresses the selected mask segment in vertical direction. The y-values of all points of the selected mask segment are multiplied with this factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:YFACtor` on page 1093

Recalculate ← Rescale
Multiplies and adds the given x- and y-factors and offsets to the coordinates of all points of the selected mask segment.

Remote command:
`MTESt:SEGMent:RESCale:RECalculate` on page 1093

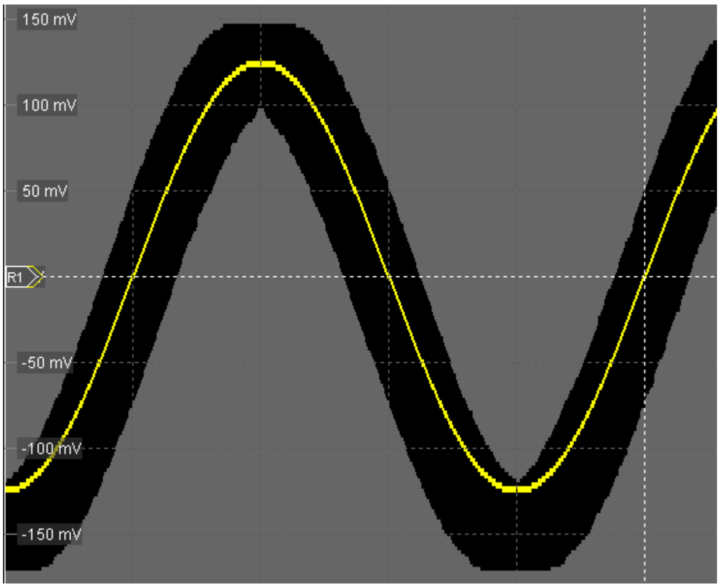
9.2.2.2 Mask Definition: Waveform Mask

Access: MASKS > "Mask Definition" > "Definition type" = "Waveform"

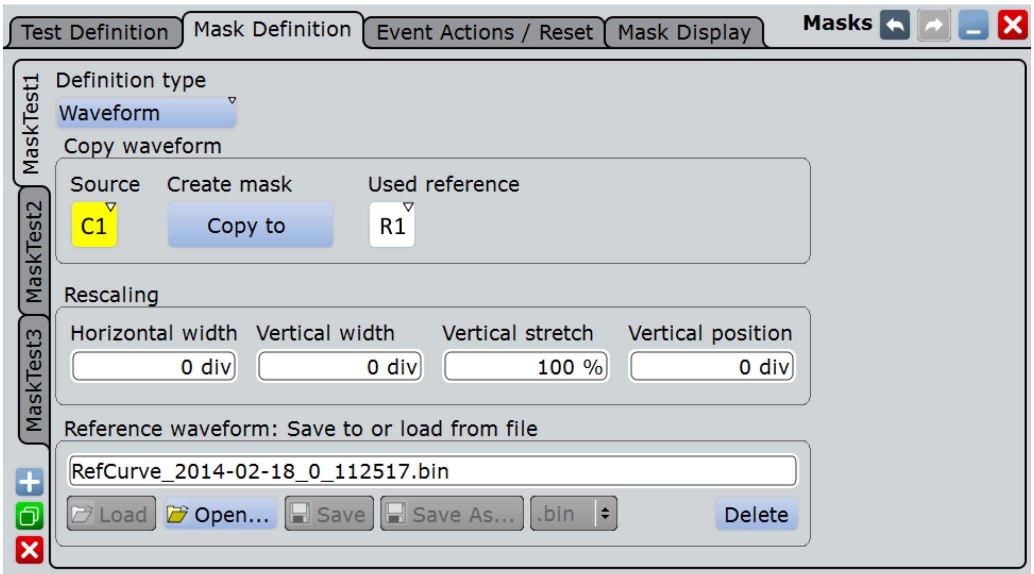
A waveform mask is created from an existing waveform. The waveform builds the upper and lower limit line of the mask, and the limits are moved and stretched. The result is a tolerance tube around the waveform that is used as mask.

During mask testing using a waveform mask, the record length is limited to 1 MSample.

The source for a waveform mask is a reference waveform. The reference waveform can be defined before mask definition, or loaded from a file, or it is created from the waveform to be tested.



Settings overview:



Common settings:

- "Definition type" on page 356
- "Source" on page 356
- "Arithmetic" on page 157

Create mask

Creates the upper and lower mask limit from the selected reference waveform. If the reference waveform was not defined before, it is created automatically from the mask test "Source" waveform which is selected in the "Test Defintion" tab.

Remote command:

`MTESt:WFMLupdate` on page 1095

Used reference
Sets the reference waveform from which the mask is created.

The reference waveform can be created before with "Reference Waveform Setup", or loaded from a file in the lower part of the dialog box. If the reference waveform was not defined before mask definition, it is created automatically from the mask test "Source" waveform.

Remote command:
`MTESt:REFWfm` on page 1094

Horizontal width
Sets the width of the mask in horizontal direction. The specified number of divisions is added to the positive x-values and subtracted from the negative x-values of the mask limits in relation to the source waveform of the mask. The overall mask width is twice the specified horizontal width.

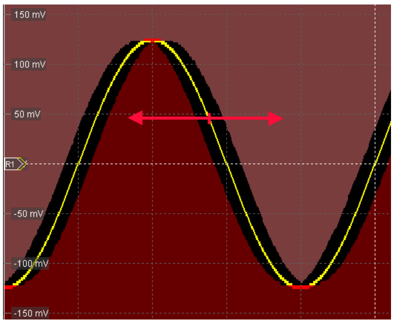


Figure 9-1: Waveform mask with horizontal width = 0.2 div

Remote command:
`MTESt:WFMRescale:XWIDth` on page 1095

Vertical width
Sets the width of the waveform mask in vertical direction. The specified number of divisions is added to the y-values of the upper mask limit and subtracted from the y-values of the lower mask limit. Thus, the upper half of the mask is pulled upwards, the lower half is pulled down, and the overall height of the mask is twice the vertical width.

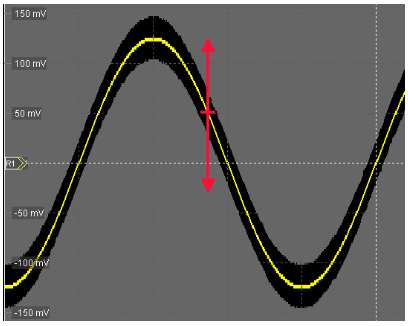


Figure 9-2: Waveform mask with vertical width = 0.5 div

Remote command:
`MTESt:WFMRescale:YWIDth` on page 1095

Vertical stretch
Sets the vertical scaling to stretch the mask in y-direction. The scaling axis is the horizontal line through the lowest value of the lower mask limit. Values > 100% stretch the mask, and values < 100% compress it.

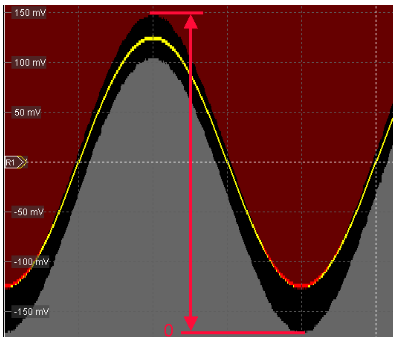


Figure 9-3: Waveform mask with vertical width = 0.5 div, vertical position = -0.5 div, vertical stretch = 110%

Remote command:
`MTESt:WFMRescale:YSTRetch` on page 1096

Vertical position
Moves the mask vertically within the display.

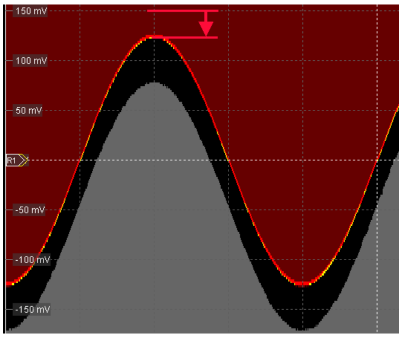


Figure 9-4: Waveform mask with vertical width = 0.5 div and vertical position = -0.5 div

Remote command:
`MTESt:WFMRescale:YPOSition` on page 1096

Reference waveform: save to or load from file
Loads the waveform from the selected file to the "Reference" and creates the mask immediately.

See also: "Save to or load from file" on page 243.

9.2.3 Event Actions /Reset

Access: MASKS > "Event Actions /Reset "

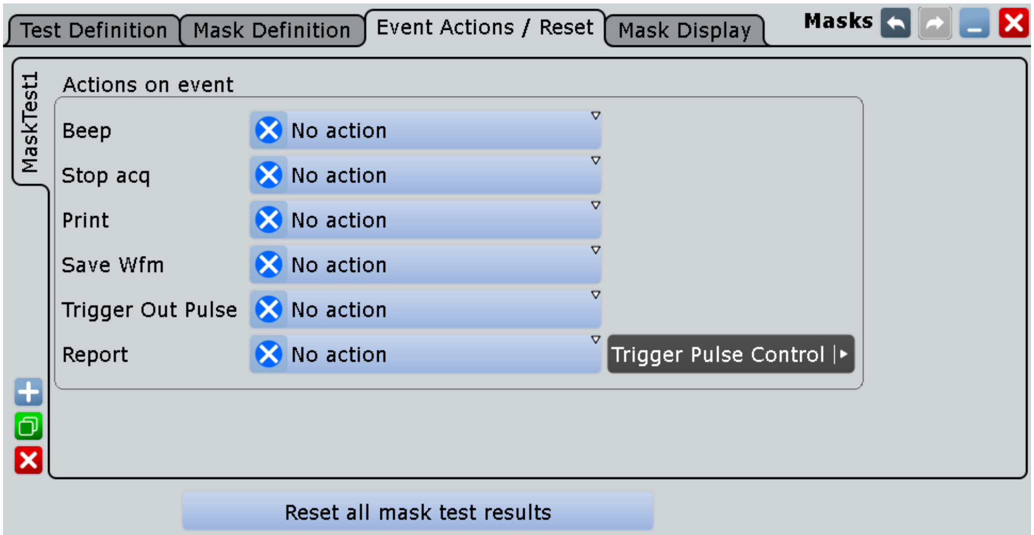
The settings in this tab define what happens when the mask test has failed or when it has passed successfully. Furthermore, you can reset all totals and results in the "Mask Test" result boxes.

Most actions can be initiated either on failure or on success:

- On violation
  The action is initiated as soon as the fail criteria is fulfilled.
- On successful completion
  The action is initated when the RUN N× SINGLE acquisition has finished and the fail citeria is not fulfilled - the fail condition and violation tolerance limit have not been reached.

There are two usual test practices:

- Testing a defined number of waveforms against the mask and initiate an action when the acquisition cycle has been completed without failure:
  – Set the number of acquistions to be tested: "Average count (N-single count)"
  – Start RUN N× SINGLE
- Testing a continuous acquisition or a defined number of waveforms against the mask and initiate an action as soon as the fail criteria is fulfilled



Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

Beep
Generates a beep sound.

Remote command:
`MTESt:ONViolation:BEEP` on page 1096

Stop acq.
Stops the waveform acquisition on mask violation.

Remote command:
`MTESt:ONViolation:STOP` on page 1097

Print
Prints a screenshot including the mask test results to the printer defined in the "Print" dialog box (see Printer).

Remote command:
`MTESt:ONViolation:PRINt` on page 1097

Report
Creates and saves a report using the settings defined in "File" menu > "Report Setup".

Remote command:
`MTESt:ONViolation:REPort` on page 1098

Save Wfm
Saves the failed waveform as a reference waveform to the file specified in FILE > "Save/Recall" > "Waveform".

Remote command:
`MTESt:ONViolation:SAVewaveform` on page 1097

Trigger Out Pulse
Creates a pulse on the EXT TRIGGER OUT connector on mask violation or successful completion of the test cycle. The minimum time difference between two trigger out pulses is 30 ms because the instrument detects mask violation at display update. Events with a higher frequency are not captured completely.

If this event is enabled and the mask test is running, the trigger control option "Enable trigger out" is disabled. Thus, the trigger out pulse is provided only on mask test result but not when a trigger occurs. The pulse is provided always with the minimum delay of 800 ns, the "Delay" cannot be set.

Remote command:
`MTESt:ONViolation:TRIGgerout` on page 1098

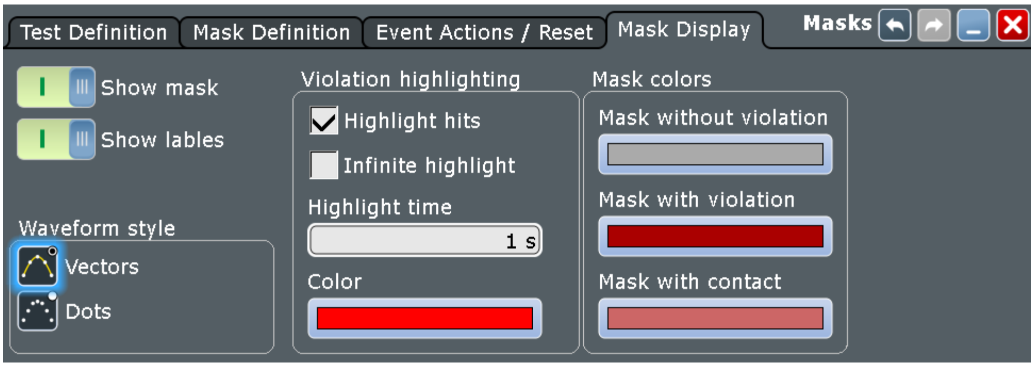
Reset
Clears all totals and results in all "Mask Test" result boxes.

Remote command:
`MTESt:RST` on page 1086

9.2.4 Mask Display

Access: MASKS > "Mask Display"

The "Mask Display" tab contains all settings for mask and hit display.



Show mask

Switches the display of all mask segments on or off.

Show labels

Switches the display of the mask test name on or off.

To change the name of the mask test, open the "Test Definition" tab, double-tap the mask test subtab and enter the new mask test name.

Remote command:

`MTESt:LABel` on page 1098

`MTESt:REName` on page 1098

Waveform style

See: "Style" on page 118.

Highlight hits

If selected, the mask hits are highlighted on the screen. You can define the color and the time of the hit display.

Infinite highlight

If selected, the mask hits are highlighted for an unlimited period of time.

Highlight time

Sets the time how long the mask hits are highlighted.

Color

Sets the color of samples that violated the mask.

Mask without violation

Sets the color of masks segments that were not hit.

Mask with violation

Sets the color of mask segments the signal has entered into.

Mask with contact

Sets the color of masks segments that were touched at the border. In this case, the resolution is not sufficient to detect if the mask was really hit or not. Zoom into the concerned area to see the actual result.

9.3 Working with Masks

This chapter explains step-by-step how mask tests are setup and preformed. For the explanation of the individual settings, see Chapter 9.2, "Mask Test Settings", on page 355.

The usage of masks tests is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Mask Test".

9.3.1 Setting Up User Masks

9.3.1.1 Creating User Masks

There are two ways to create a new mask:

- Graphical way by tapping the mask points on the touchscreen,
- Numerical entry of the x- and y-values of the mask points.

You can combine both methods. For example, at first you enter the mask quickly on the touchscreen, and then modify the point coordinates with precise values.

To create a mask graphically on the touch screen

1. Tap the "Masks" icon on the toolbar.

2. Tap the corner points of the mask segment on the touch screen.

   Tip: To create an exact rectangle, draw the diagonal of the rectangle on the screen.

3. To finish the segment and the mask definition, double-tap the last point.

   Note: Tapping any icon on the toolbar finishes the mask definition.

4. Tap outside the mask to deselect the mask segment.

You can also enter only two points to create a line. When you finish the mask segment by double-tapping the second point, the display region above or below the line is defined as mask. If the line is in the upper half of the display, the region above the line becomes the mask (upper region). If the line is in the lower half, the region below the line is taken (lower region).

To create a mask numerically in the dialog box

The settings mentioned here are described in detail in Chapter 9.2.2.1, "Mask Definition: User Mask", on page 357.

1. Press the MASKS key on the front panel.
2. Select the "Mask Definition" tab.
3. Create a new mask test:
    a) Tap the "+"-icon in the lower left corner.
    b) Enter a name for the new mask test.

    A new, empty tab for the mask test appears.
4. Check the horizontal and vertical units and adjust them, if necessary.
5. In the "Mask segments" area, tap "Insert" to create a new mask segment.
6. Set the corner points of the mask segment:
    a) In the "Definition of segment" area, tap "Insert".
    Point 1 appears.
    b) Tap the X-cell and enter the X-value of the point.
    c) Tap the Y-cell and enter the Y-value of the point.
    d) To insert the next point:
        - Tap "Insert" to add a point before the selected point.
        - Tap "Append" to add a point at the end of the list.
    e) Set the X- and Y-values for this point.
    f) Repeat the last two steps until all points are defined.

9.3.1.2 Modifying User Masks

To change an existing mask definition, you can also use the graphical method on the touch screen, or the numerical way, or combine both.

With the graphical method, you can:

- Move, add, and delete segments
- Move and delete points

Adding points to an existing segment graphically is not possible.

With the numerical method, in the "Mask Definition" tab, you have all modification possibilities. You can delete and add points and segments, change the coordinates, and also stretch a segment, or move it by adding an offset.

To add a mask segment on the touch screen

1. Tap a mask segment of the mask test that you want to complement.
2. Tap the "Masks" icon on the toolbar.

3. Tap the corner points of the new mask segment on the touch screen.
4. To finish the segment and mask definition, double-tap the last point, or tap the "Select" icon on the toolbar.

To delete a mask segment on the touch screen

1. On the toolbar, tap the "Delete" icon.

2. Tap the mask segment to be deleted.

To delete a point on the touch screen

1. Tap the mask segment from which you want to delete a point.

   The selected segment is now in definition mode, shown with blue color.
2. On the toolbar, tap the "Delete" icon.

3. Tap the point to be deleted.

To move a segment on the touch screen

1. Drag&drop the segment to the new position.
2. Tap outside the mask to deselect the mask segment.

To move a point on the touch screen

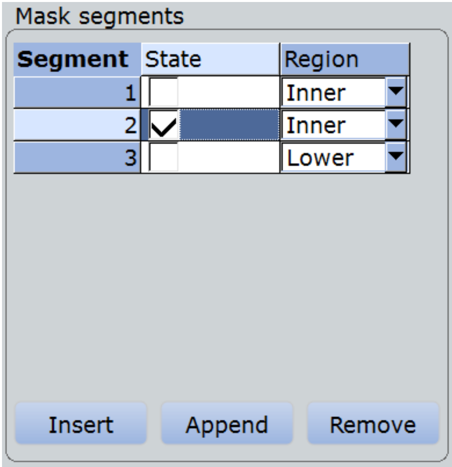
1. Tap the mask segment to be changed.
2. Drag&drop the point to the new position.
3. Tap outside the mask to deselect the mask segment.

To change the mask definition numerically

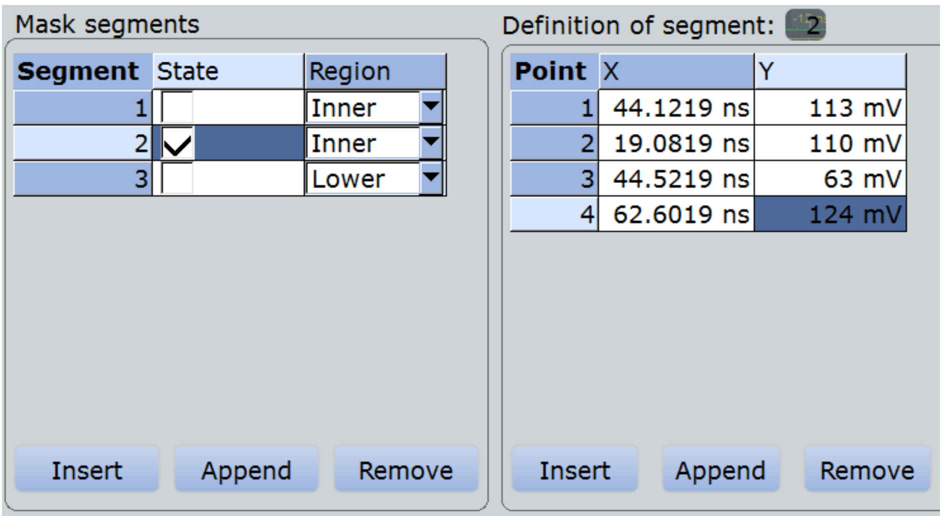
The settings mentioned here are described in detail in Chapter 9.2.2.1, "Mask Definition: User Mask", on page 357.

1. Press the MASKS key on the front panel.
2. Select the "Mask Definition" tab.
3. On the left, select the mask test for which you want to change the mask definition.

4. To add or delete a mask segment, tap the segment's row in the "Mask segments" table and tap the required button below:
   - "Insert": to add a new segment before the selected segment.
   - "Append": to add a new segment at the end of the list.
   - "Remove": to delete the selected mask segment from the list.



5. To add, delete, or move a point of a segment:
   a) Select the segment in the "Mask segments" table.
   b) Select the point in the "Definition of segment" table.
   c) To add or delete the selected point, use the buttons below the table.
      - "Insert": to add a new point before the selected point.
      - "Append": to add a new point at the end of the list.
      - "Remove": to delete the selected point from the list.
   d) To move the selected point, change the X- and Y-values.



To rescale and move a mask segment

The settings mentioned here are described in detail in Chapter 9.2.2.1, "Mask Definition: User Mask", on page 357.

1. Press the MASKS key on the front panel.
2. Select the "Mask Definition" tab.
3. On the left, select the mask test for which you want to change the mask definition.
4. Select the required segment in the "Mask segments" table.
5. To stretch or compress the selected mask segment, enter the "X-Factor" for horizontal scaling and the "Y-Factor" for vertical scaling. The x-values and y-values of all points are multiplied with the corresponding factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.
6. To move the selected mask segment, enter the "X-Offset" for horizontal direction and the "Y-Offset" for vertical direction. The specified offset is added to the corresponding values of all points.
7. Tap "Recalculate" to perform the scaling and/or move.

9.3.2 Setting Up a Mask Test

In addition to the mask definition, the mask test contains further settings:

- the waveform to be tested
- the criteria for a failed test
- the actions to be taken if a test has failed or has been completed successfully

1. Press the MASKS key on the front panel.
2. Select the "Test Definition" tab.
3. Select the "Source" to be tested.
4. Set the conditions for a failed test:
   a) Fail condition: select if sample hits or the number of acquisitions with sample hits are considered.
   b) Violation tolerance: number of tolerable sample hits or acquisition hits.

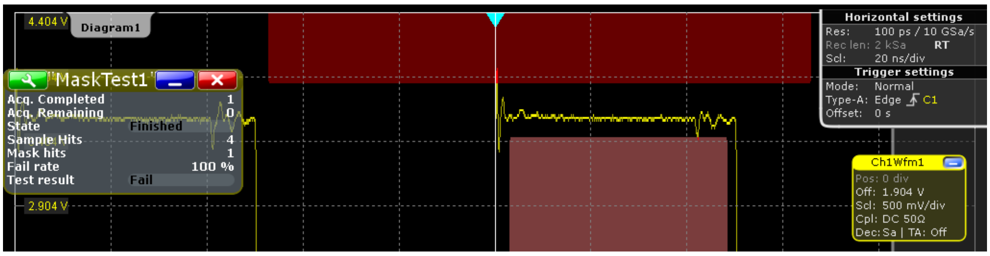
   A test has failed if the number of sample hits or acquisition hits exceeds the limit of violation tolerance hits.
5. Select the "Event Actions / Reset" tab.
6. For each action, select when the action will be executed:
   - "On violation" if the mask test has failed
   - "On successful completion"

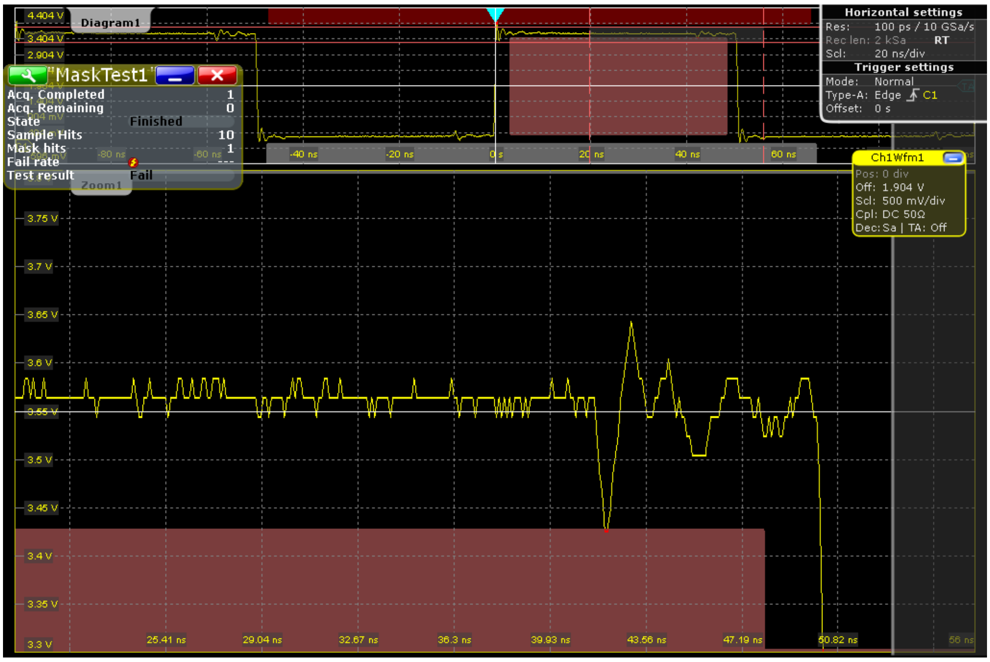
9.3.3 Configuring the Mask and Hit Display

The display of masks and mask violation is the same for all mask tests.

The settings mentioned here are described in detail in Chapter 9.2.4, "Mask Display", on page 365.

1. Press the MASKS key on the front panel.
2. Select the "Mask Display" tab.
3. Select "Show mask" to display the masks of all enabled mask tests on the screen.
4. Define how the sample hits are displayed:
   a) Select "Highlight hits" to display the sample hits.
   b) Set the "Highlight time" or "Infinite highlight".
   Set the "Color" of the sample hits.
5. Define the color of the masks segments depending on the violation state:
   - Mask without violation
   - Mask with violation
   - Mask with contact: This color shows that the edge of the mask segment was touched. In this case, the resolution is not sufficient to detect if the mask was really hit or not. Zoom into the concerned area to see the correct result.





9.3.4 Running a Mask Test

Before you can start a mask test, make sure that the mask setup is complete:

- The mask is defined, see Chapter 9.3.1.1, "Creating User Masks", on page 367 and Chapter 9.3.1.2, "Modifying User Masks", on page 368.
- The mask test is defined, see Chapter 9.3.2, "Setting Up a Mask Test", on page 371
- The mask display is configured, see Chapter 9.3.3, "Configuring the Mask and Hit Display", on page 372.

You can perform continuous testing or test a specified number of acquisitions.

1. Press the MASKS key on the front panel.
2. Select the "Test Definition" tab.
3. Select "Enable test".

   If the acquisition is running, the test starts immediately.
4. If the acquisition is not running, press RUN CONT.

   The tests starts and runs until you stop the acquisition or the stop action is executed if defined.
5. To test a specified number of acquisitions:
   a) Press the ACQUISITION key.
   b) Set the "Average count" to the number of acquisitions.
   See also:"Acquisition/average count" on page 157
   c) Press RUN N× SINGLE.

Note: If you run the acquisition with RUN CONT, the state of the mask test is set to "Finished" when this number of acquisitions has been captured but the mask testing continues until the acquisition will be stopped.

9.3.5 Saving and Loading Masks

Mask test definitions remain on the instrument until they are changed or deleted, or PRESET is performed. If you want to keep a mask test, you can save and reload them.

To save a mask

1. Press the MASKS key on the front panel.
2. Select the "Test Definition" tab.
3. To save the mask file in the current directory, change the file name if needed, and tap "Save".
   You can use the automatic file name generation, see Chapter 11.1.6, "Autonaming", on page 406.
4. To select the directory and enter the file name, tap "Save As".

To load a mask

1. To load the specified mask file, tap "Load."
2. To load the mask from a different file, tap "Open". Select the file from the file selection dialog box.

9.3.6 Mask Testing on History Acquisitions

In the same way as for running acquisitions, you can set up and perform the mask testing also on history waveforms.

The requirements for mask testing on history waveforms are also the same:
- The mask is defined, see Chapter 9.3.1.1, "Creating User Masks", on page 367 and Chapter 9.3.1.2, "Modifying User Masks", on page 368.
- The mask test is defined, see Chapter 9.3.2, "Setting Up a Mask Test", on page 371
- The mask display is configured, see Chapter 9.3.3, "Configuring the Mask and Hit Display", on page 372.

1. Perform and finish the acquisition.
2. Press HISTORY.
3. In the quick-access "History" dialog box, tap "Play".

   The mask testing is performed on the complete history memory, starting with the oldest acquisition. The state of the mask test is set to "Finished" when "Nx Single count" acquisitions are tested.

For details on history, see Chapter 6.4, "History", on page 258.

10 Search Functions

Search functions allow you to detect and analyze specific events in the acquired data quickly and simply. You can search in various waveforms for several events at once. The search area can be limited by a gate.

The events that can be searched for are basically the same events you can trigger on. Thus, the search parameters are defined in the same way as the trigger conditions. The results are displayed in a result box and optionally shown in a zoom window.

10.1 Overview: Search Definition and Results

10.1.1 Search Definition

You can define up to 4 different searches and let them run simultaneously. For each search, you define the criteria, the parameters of each criterion, the gate, and the result display.

The instrument keeps the settings until the next preset. If you save a user-defined preset, the search settings are included in the preset.

Each search is configured in a separate tab and contains:

- *Search control*
  If you enable a search and run an acquisition, the search is performed continuously on the acquired data until acquisition is stopped.
  If acquisition is stopped and you enable a search, the data of the last acquisition is searched.
  Enabling the search zoom window disables the search, stops a running acquisition, and displays the search results of the last acquisition in the zoom window.
- *Source*
  Waveform that is searched for one or more events. You can search in analog and digital signals, math or reference waveforms, and tracks. Furthermore, search in decoded data of serial buses is possible.
- *Search criteria and parameters*
  Various search criteria are available, depending on the source. Most parameters known from trigger event definition can also be configured as search conditions. Unlike triggering, you can configure several event types to be searched for simultaneously.
  If the source is an FFT spectrum, you can perform a frequency marker search by using the cursor measurement and defining the peak excursion. See Chapter 7.1.3.3, "Peak Search Tab", on page 276.
- *Search gate*
  Searches can be performed on the entire waveform, or only a on defined area (gate). The gate can be coupled to an existing zoom.
  Gating is not available for searches on digital signals and serial buses.

- *Result presentation*
  For each search, you define how the search results are displayed: in a result table and/or in a search zoom window.
- *Noise rejection*
  Hysteresis for the selected source is defined for each search separately, in absolute or relative values.
  Noise rejection is not available for searches on serial buses.

Remote commands:
- SEARch:ADD on page 1101
- SEARch:REMove on page 1102

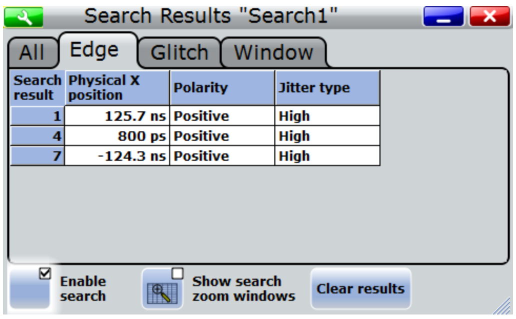
10.1.2 Search Results

The results are displayed in a "Search Results" box and optionally in a zoom window.

Search Results box

The results of each search are tabulated in a "Search Results" box.

If you search for several event types in parallel, the results are presented in several tabs - one for each search event and one for the combined results. Each tab contains a table with the position and, if available, further parameters for each result. The tables row can be sorted, and you can define a maximum number of table entries in the "Result Presentation" dialog box. As with all result boxes, you can minimize it, display it like a diagram, and define the default position.



The instrument displays the search results of the last acquisition.

Remote commands for result query:
- SEARch:RESult[:ALL]? on page 1136

Search zoom windows

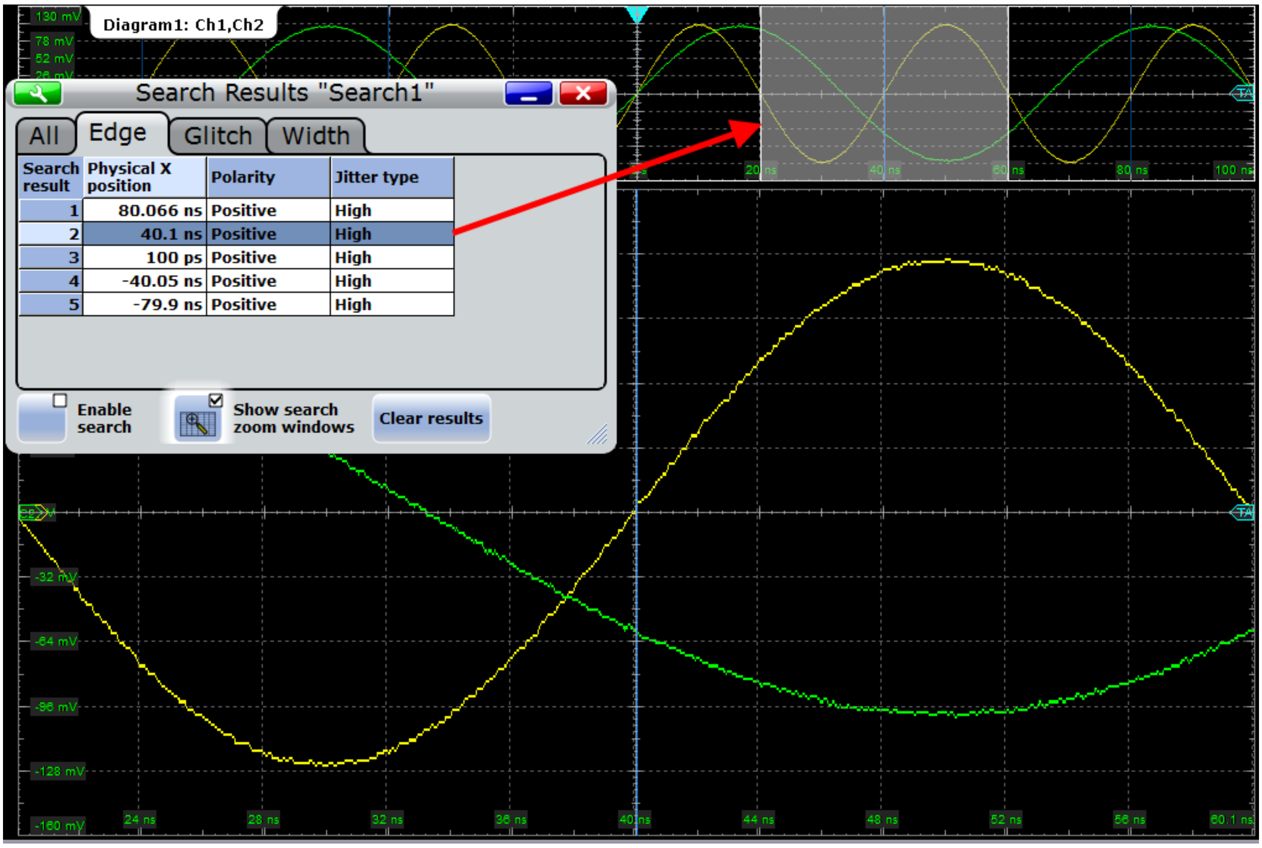
Search zoom windows allow you to analyze the search results in more detail. By default, the zoom is displayed for the selected search result. The zoom area is indicated in the diagram that displays the source waveform of the search.

Enabling the search zoom window disables the search, stops a running acquisition, and displays the search results of the last acquisition in the zoom window.

Navigating search results

If a search zoom window has been opened, it shows the first result that was found.

► To display the zoom of a specific search result, tap the result line in the result table to set the zoom to this event.

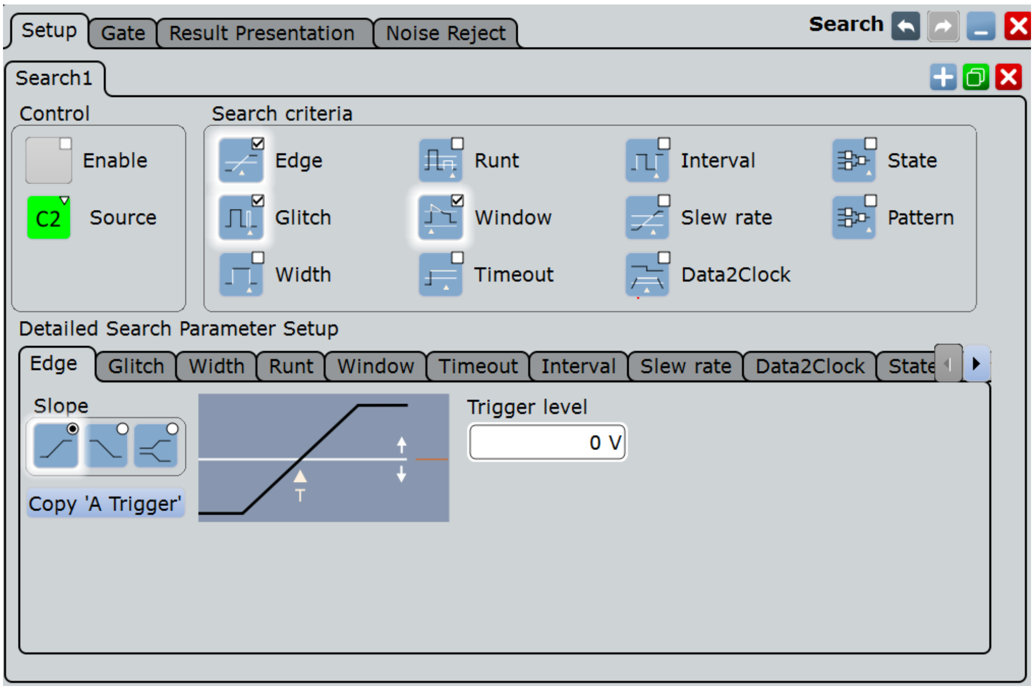


The zoom area in the source diagram moves to the selected result and the zoom is displayed.

You can change the size and the position of the search zoom area in the same way as a usual zoom. If you move the zoom area in the source diagram, the nearest search result is marked in the results table. See also: Chapter 6.1.1, "Methods of Zooming", on page 227.

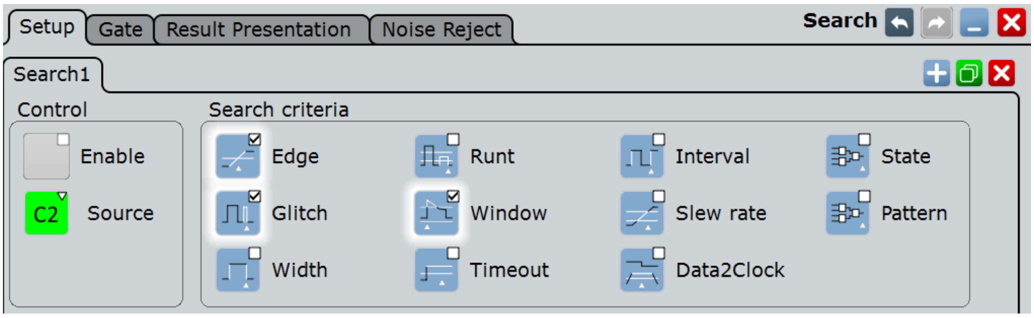
10.2 Search Setup

The search setup includes the source selection, the selection of search events (criteria), event-specific search conditions, and search control.



10.2.1 Search Criteria

Access: SEARCH > "Setup" tab



Enable

If you enable a search and run an acquisition, the search is performed continuously on the acquired data until acquisition is stopped.

If acquisition is stopped and you enable a search, the data of the last acquisition is searched.

Remote command:
SEARch:ONLine on page 1102
SEARch:ALL on page 1103

Source

Defines the waveform to be searched. The source can be any analog and digital input signal, math or reference waveform, or track. While the instrument triggers only on real input signals, it can search also calculated and restored waveforms.

If the source is an FFT spectrum, you can perform a frequency marker search by using the cursor measurement and defining the peak excursion. See Chapter 7.1.3.3, "Peak Search Tab", on page 276.

For some serial protocol options, search on a serial bus is available. For details, see the relevant chapters of the "Protocol Analysis" chapter.

Depending on the selected source, different search criteria are available.

Remote command:
`SEARch:SOURce` on page 1102

Edge, Glitch, Width, Runt, Window, Timeout, Interval, Slew rate, Data2Clock, State, Pattern
Search criterias for analog and digital input signals, math andreference waveforms, and tracks. For search on digital channels, only edge, width, timeout and Data2Clock searches are available.

Tap the icon to include or exclude the search criteria in the next search. You can enable several event types for simultaneous search.

Remote command:
`SEARch:TRIGger:EDGE[:STATe]` on page 1104
`SEARch:TRIGger:GLITch[:STATe]` on page 1104
`SEARch:TRIGger:WIDTh[:STATe]` on page 1104
`SEARch:TRIGger:RUNT[:STATe]` on page 1104
`SEARch:TRIGger:WINDow[:STATe]` on page 1104
`SEARch:TRIGger:TIMeout[:STATe]` on page 1104
`SEARch:TRIGger:INTerval[:STATe]` on page 1104
`SEARch:TRIGger:SLEWrate[:STATe]` on page 1104
`SEARch:TRIGger:DATatoclock[:STATe]` on page 1104
`SEARch:TRIGger:STATe[:STATe]` on page 1104
`SEARch:TRIGger:PATTern[:STATe]` on page 1104

10.2.2 Search Parameters

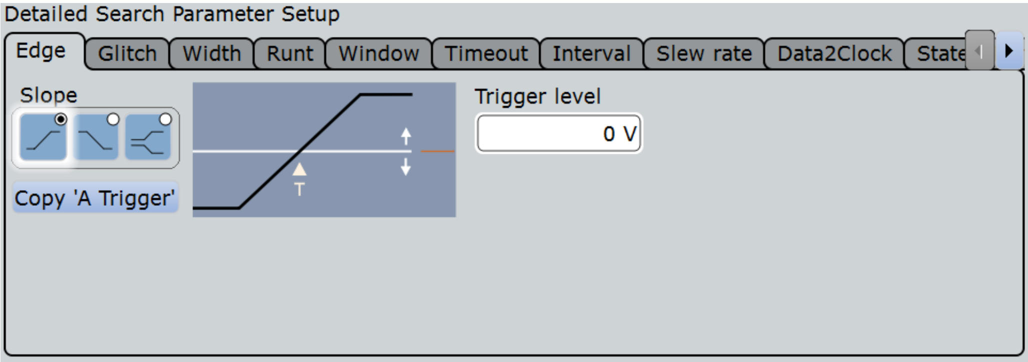
Most parameters available for trigger event definition can also be configured as search conditions. Each event type is defined in a separate subtab.

If the source is a spectrum, the instrument performs a frequency marker search.

For serial protocol options, search on a serial bus is available. These searches have protocol-specific search criteria. For details, see the relevant chapters of the "Protocol Analysis" chapter.

10.2.2.1 Edge

The edge search works the same way as the edge trigger.



Slope

Sets the edge typ: rising edge ("Positive"), falling edge ("Negative"), or both.

Remote command:

`SEARch:TRIGger:EDGE:SLOPe` on page 1105

Trigger level

Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:

`SEARch:TRIGger:LEVel[:VALue]` on page 1104

Copy 'A Trigger'

Copies the trigger type-specific settings from the A-trigger configuration to the search settings. The source itself is not copied.

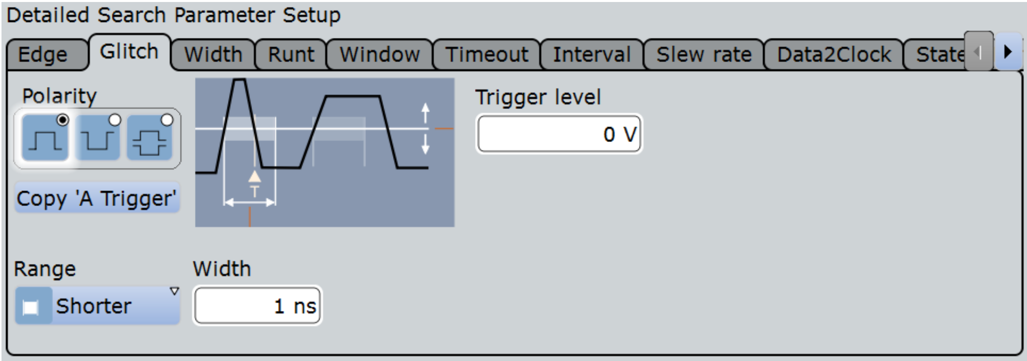
Remote command:

`SEARch:TRIGger:EDGE:ACOPy` on page 1105
`SEARch:TRIGger:GLITch:ACOPy` on page 1105
`SEARch:TRIGger:WINDow:ACOPy` on page 1105
`SEARch:TRIGger:WIDTh:ACOPy` on page 1105
`SEARch:TRIGger:RUNT:ACOPy` on page 1105
`SEARch:TRIGger:WINDow:ACOPy` on page 1105
`SEARch:TRIGger:TIMeout:ACOPy` on page 1105
`SEARch:TRIGger:INTerval:ACOPy` on page 1105
`SEARch:TRIGger:SLEWrate:ACOPy` on page 1105
`SEARch:TRIGger:DATatoclock:ACOPy` on page 1105
`SEARch:TRIGger:STATe:ACOPy` on page 1105
`SEARch:TRIGger:PATTern:ACOPy` on page 1105

10.2.2.2 Glitch

The glitch search works the same way as the glitch trigger. To apply the trigger settings to search, tap Copy 'A Trigger'.

The glitch search is not available if the search source is a digital channel.



Polarity, Range, Width

See trigger settings:
- "Range" on page 197
- "Width" on page 197
- "Polarity" on page 197

Remote command:
`SEARch:TRIGger:GLITch:POLarity` on page 1106
`SEARch:TRIGger:GLITch:RANGe` on page 1106
`SEARch:TRIGger:GLITch:WIDTh` on page 1106

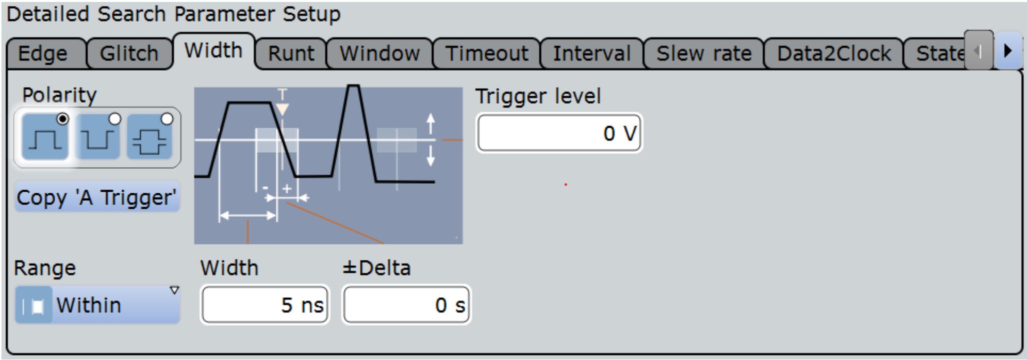
Trigger level

Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1104

10.2.2.3 Width

The width search works the same way as the width trigger. To apply the trigger settings to search, tap Copy 'A Trigger'.



Polarity, Range, Width, ±Delta

See trigger settings:

- "Polarity" on page 198
  While the width trigger can only analyze positive *or* negative polarity, searching for a width is also possible for both polarities at the same time ("Either").
- "Range" on page 198
- "Width" on page 199
- "±Delta" on page 199

Remote command:

`SEARch:TRIGger:WIDTh:POLarity` on page 1114
`SEARch:TRIGger:WIDTh:RANGe` on page 1114
`SEARch:TRIGger:WIDTh:WIDTh` on page 1115
`SEARch:TRIGger:WIDTh:DELTa` on page 1113

Trigger level

Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

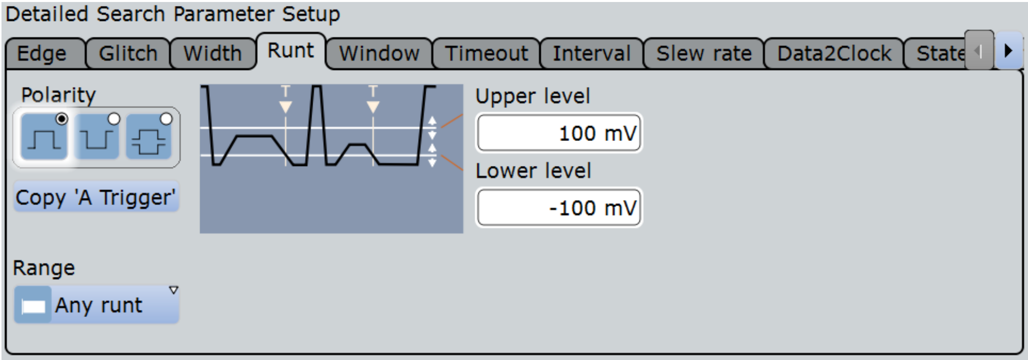
Remote command:

`SEARch:TRIGger:LEVel[:VALue]` on page 1104

10.2.2.4 Runt

The runt search settings are the same as the runt trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.

The runt search is not available if the search source is a digital channel.



Polarity, Range, Runt width, ±Delta

Time limit for the runt, see trigger settings:

- "Polarity" on page 197
- "Range" on page 200
- "Runt width" on page 200
- "±Delta" on page 200

Remote command:

`SEARch:TRIGger:RUNT:POLarity` on page 1109
`SEARch:TRIGger:RUNT:RANGe` on page 1109
`SEARch:TRIGger:RUNT:WIDTh` on page 1110
`SEARch:TRIGger:RUNT:DELTa` on page 1108

Upper level, Lower level

Set the upper and lower voltage thresholds. The amplitude of a runt crosses the first threshold twice in succession without crossing the second one.

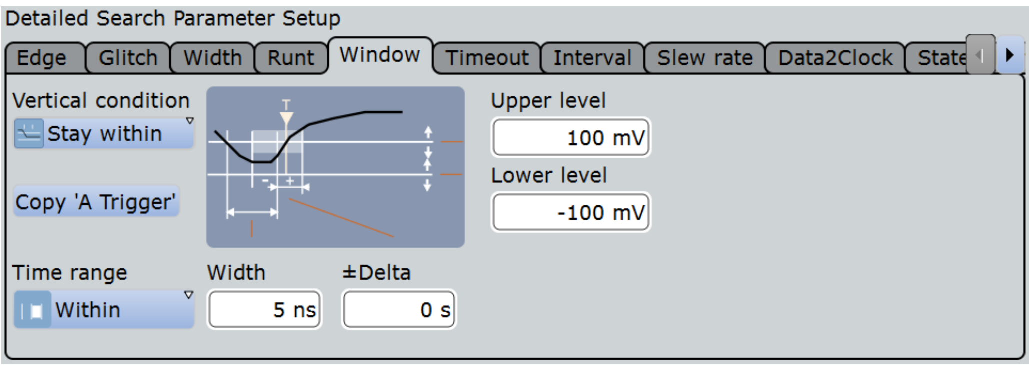
Remote command:

`SEARch:TRIGger:LEVel:RUNT:UPPer` on page 1110
`SEARch:TRIGger:LEVel:RUNT:LOWer` on page 1110

10.2.2.5 Window

The window search settings are the same as the window trigger settings. This search type is not available if the search source is a digital channel.To apply the trigger settings to search, tap Copy 'A Trigger'.

The window search is not available if the search source is a digital channel.



Vertical condition
Defines the run of the signal relative to the window, see "Vertical condition" on page 201.

Remote command:
SEARch:TRIGger:WINDow:RANGe on page 1115

Time condition, Width, ±Delta
Set the time limit for the vertical condition, see
- "Time condition" on page 202
- "Width" on page 202
- "±Delta" on page 202

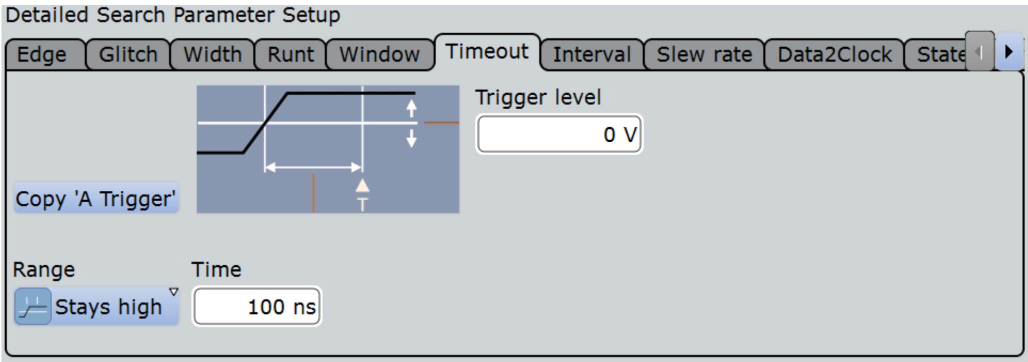
Remote command:
SEARch:TRIGger:WINDow:TIMerange on page 1116
SEARch:TRIGger:WINDow:WIDTh on page 1117
SEARch:TRIGger:WINDow:DELTa on page 1115

Upper level, Lower level
Set the upper and lower voltage thresholds. The amplitude of a runt crosses the first threshold twice in succession without crossing the second one.

Remote command:
SEARch:TRIGger:LEVel:WINDow:UPPer on page 1117
SEARch:TRIGger:LEVel:WINDow:LOWer on page 1117

10.2.2.6 Timeout

The timeout search settings are the same as the timeout trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.



Range, Time
Set the timeout condition, see
- "Range" on page 203
- "Time" on page 203

Remote command:
SEARch:TRIGger:TIMeout:RANGe on page 1113
SEARch:TRIGger:TIMeout:TIME on page 1113

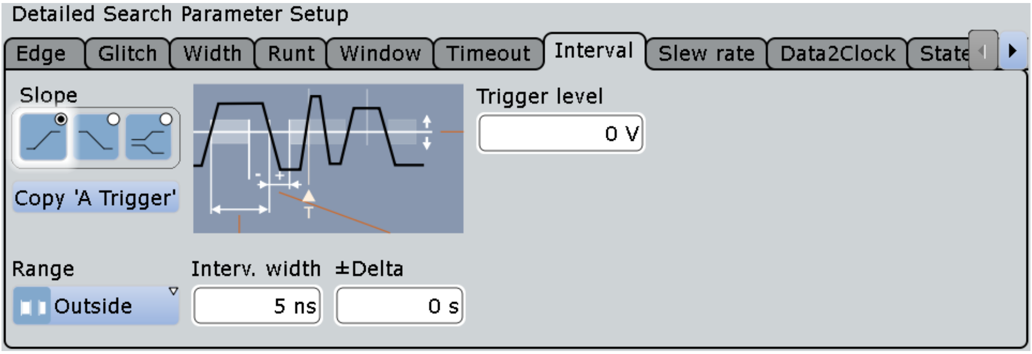
Trigger level
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1104

10.2.2.7 Interval

The interval search settings are the same as the interval trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.

The interval search is not available if the search source is a digital channel.



Slope, Range, Interv. width, ±Delta
Set the interval condition, see
- "Slope" on page 203
  While the interval trigger can only analyze rising or falling edges, searching for a width is possible for both edges at the same time ("Either").
- "Range" on page 204
- "Interv. width" on page 204
- "±Delta" on page 204

Remote command:
`SEARch:TRIGger:INTerval:SLOPe` on page 1107
`SEARch:TRIGger:INTerval:RANGe` on page 1107
`SEARch:TRIGger:INTerval:WIDTh` on page 1108
`SEARch:TRIGger:INTerval:DELTa` on page 1107

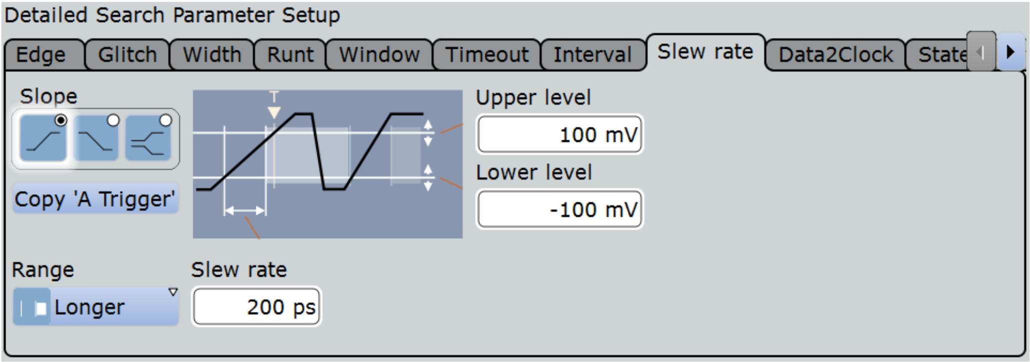
Trigger level
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1104

10.2.2.8 Slew Rate

The slew rate search settings are the same as the slew rate trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.

The slew rate search is not available if the search source is a digital channel.



Polarity, Range, Slew rate, ±Delta

- "Slope" on page 195
- "Range" on page 205
- "Slew rate" on page 206
- "±Delta" on page 206

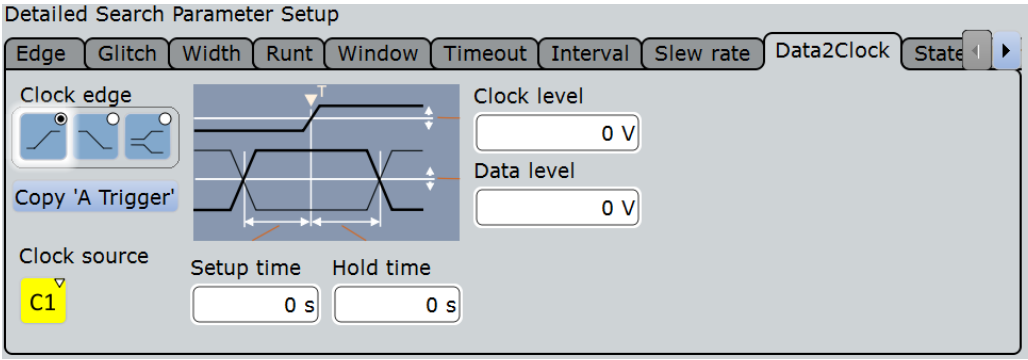
Remote command:
SEARch:TRIGger:SLEWrate:SLOPe on page 1111
SEARch:TRIGger:SLEWrate:RANGe on page 1111
SEARch:TRIGger:SLEWrate:TIME on page 1112
SEARch:TRIGger:SLEWrate:DELTa on page 1111

Upper level, Lower level
Set the upper and lower voltage thresholds. When the signal crosses a level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:
SEARch:TRIGger:LEVel:TRANsition:UPPer on page 1112
SEARch:TRIGger:LEVel:TRANsition:LOWer on page 1112

10.2.2.9 Data2Clock

The Data2Clock search settings are the same as the Data2Clock trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.



Clock source, Clock edge, Clock level

Set the clock settings. Both "Clock level" and "Clock edge" define the starting point for calculation of the setup and hold time.

Remote command:
SEARch:TRIGger:DATatoclock:CSOurce on page 1118
SEARch:TRIGger:DATatoclock:CEDGe on page 1118
SEARch:TRIGger:DATatoclock:CLEVel on page 1118

Data level

Sets the voltage level for the data signal. At this level, the setup and hold time is measured.

Remote command:
SEARch:TRIGger:LEVel[:VALue] on page 1104

Setup time, Hold time

Sets the minimum time **before** (Setup) and **after** (Hold) the clock edge while the data signal must stay steady above or below the data level.

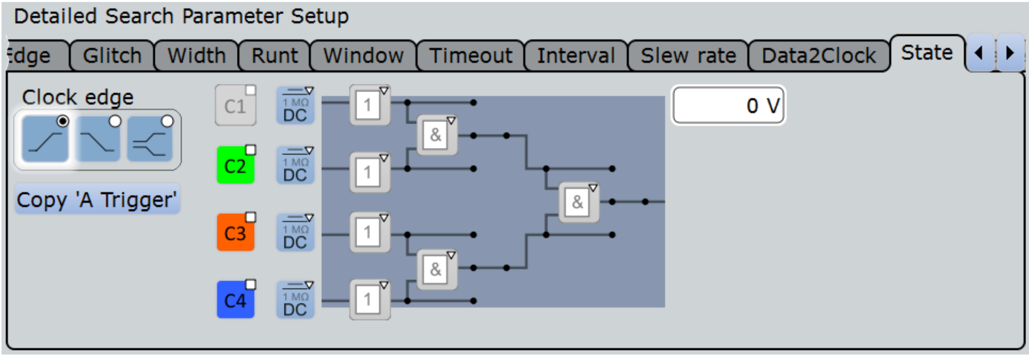
See also: "Setup time" on page 207 and "Hold time" on page 207.

Remote command:
SEARch:TRIGger:DATatoclock:STIMe on page 1119
SEARch:TRIGger:DATatoclock:HTIMe on page 1118

10.2.2.10 State

The state search is a qualified edge search. The state search is only available for analog channel sources (Ch1 to Ch4).

Note: The logic combination of CH1 and CH3 is different from the trigger settings. Thus, "Copy 'A' Trigger" does not work.



Clock source, Clock edge

Define the clock settings. The clock signal is the waveform to be searched.

Remote command:

SEARch:TRIGger:STATe:CSOurce on page 1124

SEARch:TRIGger:STATe:CEDGe on page 1124

SEARch:TRIGger:STATe:CLEVel on page 1125

State pattern

State settings are similar to the state trigger, but the logic combination of CH1 and CH3 is different. See also "Pattern" on page 208.

Remote command:

SEARch:TRIGger:STATe:A[:ENABle] on page 1125

SEARch:TRIGger:STATe:A:LOGic on page 1126

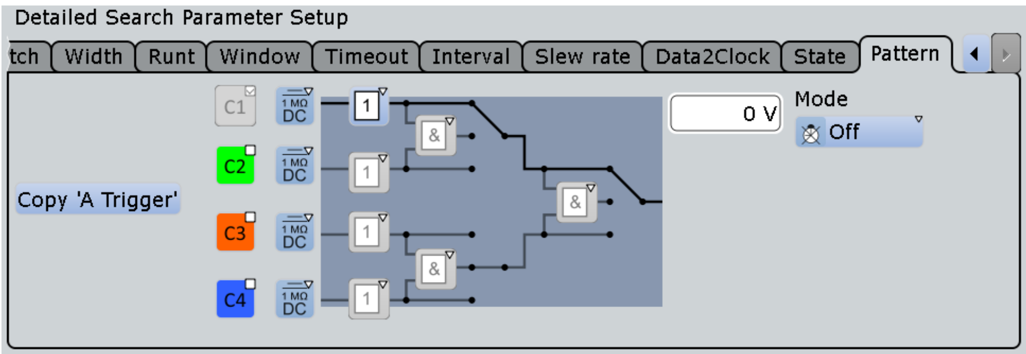
SEARch:TRIGger:STATe:AB:LOGic on page 1126

SEARch:TRIGger:STATe:ABCD:LOGic on page 1126

10.2.2.11 Pattern

The pattern search combines a logical combination of the input channels with a timing condition. The pattern search is only available for analog channel sources (Ch1 to Ch4).

Note: The logic combination of CH1 and CH3 is different from the trigger settings. Thus, "Copy 'A' Trigger" does not work.



Pattern
Pattern search settings are similar to the pattern trigger, but the logic combination of CH1 and CH3 is different. See also "Pattern" on page 208. .

Remote command:
`SEARch:TRIGger:PATTern:A[:ENABle]` on page 1120
`SEARch:TRIGger:PATTern:A:LOGic` on page 1120
`SEARch:TRIGger:PATTern:AB:LOGic` on page 1121
`SEARch:TRIGger:PATTern:ABCD:LOGic` on page 1121

Timing condition: Mode, Range, Time, Width, ±Delta
Additional time limitation to the pattern, see "Additional settings: Timing" on page 210

Remote command:
`SEARch:TRIGger:PATTern:MODE` on page 1121
`SEARch:TRIGger:PATTern:TIMeout:MODE` on page 1122
`SEARch:TRIGger:PATTern:TIMeout[:TIME]` on page 1122
`SEARch:TRIGger:PATTern:WIDTh:RANGe` on page 1123
`SEARch:TRIGger:PATTern:WIDTh[:WIDTh]` on page 1123
`SEARch:TRIGger:PATTern:WIDTh:DELTa` on page 1123

10.2.3 Frequency Marker Search

When you start a search on a spectrum, a frequency marker search is performed to detect peaks in a spectrum. You can define which peaks the instrument will find by defining the noise reject settings.

Threshold
See "Threshold" on page 276.

Peak excursion
See "Peak excursion" on page 276.

10.2.4 Configuring the Search Setup

There are two ways to create a search:

- Creating a simple default search using the toolbar icon. This method is not available for search on serial buses.
- Setting up a search using the dialog box.

To perform a simple search

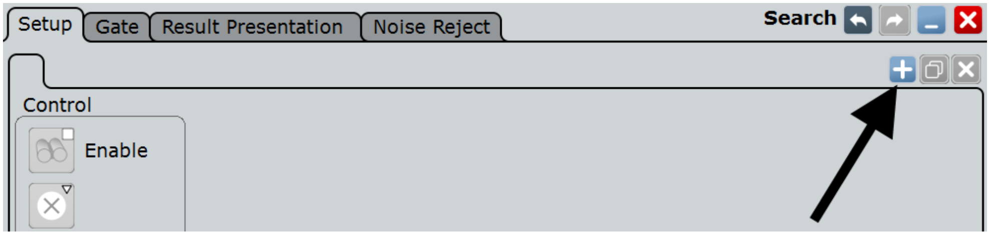
1. If more than one waveform is in the diagram, select the waveform to be searched by tapping it in the diagram.
2. Select the "Search" icon on the toolbar.

3. Tap the diagram with the waveform to be searched, or drag a rectangle on the diagram to define the search area.

   The default edge search is configured as "Search<x>" and performed. The "Search Results" box is displayed.

To create a user-defined search

1. Press the SEARCH key.
2. There are two ways to create a search:
   - If you want to create a new, unconfigured search, tap the "Add" icon.

   - If you want to create a new search based on an existing one, tap the "Copy" icon.

3. Enter a name for the search using the on-screen keyboard.

To configure a user-defined search

1. Select the "Setup" tab and the search you want to configure.
2. Select the "Source" on which you want to perform the search.
3. Select the events to be included in the search.
4. Define the settings of the first search event.
   To use the same conditions as defined in the trigger configuration of the A-event, tap "Copy 'A-Trigger". The selected trigger settings are applied to the search settings.
5. Repeat the previous steps to define further events for the same search.
6. To perform the search only on a part of the waveform, configure the gate in the "Gate" tab as described in Chapter 10.3.2, "Defining the Search Gate", on page 393.
7. To filter out noise from the search results, configure noise rejection as described in Chapter 10.5.2, "Defining Noise Rejection for Searches", on page 398.

   Note: A-event copy, gating and noise reject are not available for search on serial buses.

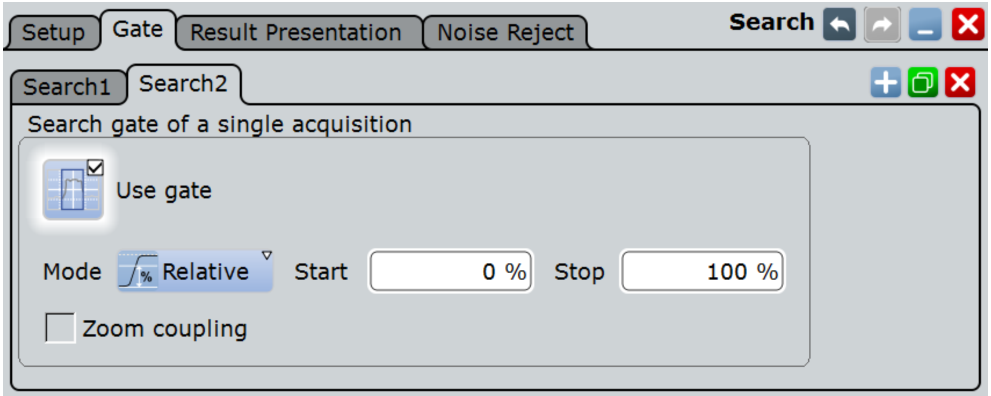
10.3 Search Gate

The gate defines the search area within the source waveform. You can use absolute or relative values to define the gate, or couple it to a previously defined zoom area.

10.3.1 Gate Settings

The search gate settings are identical to those for gate areas for measurements or FFT analysis.

Gating is not available if the search source is a digital channel or a serial bus.



Use Gate
Enables the gate settings and shows the gate. Search is only performed on the defined gate area of the source waveform.

Remote command:
`SEARch:GATE[:STATe]` on page 1127

Mode
Defines whether the gate settings are configured using absolute or relative values.

"Absolute" The gate is defined by absolute start and stop values.

"Relative" The gate's start and stop values are defined by a percentage of the value range.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:MODE` on page 1077
`MEASurement<m>:GATE:MODE` on page 1057
`SEARch:GATE:MODE` on page 1128

(Relative) Start
Defines the starting value for the gate.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt` on page 1077
`CALCulate:MATH<m>:FFT:GATE:RELative:STARt` on page 1077
`MEASurement<m>:GATE:ABSolute:STARt` on page 1057

MEASurement<m>:GATE:RELative:STARt on page 1057
SEARch:GATE:ABSolute:STARt on page 1128
SEARch:GATE:RELative:STARt on page 1128

(Relative) Stop
Defines the end value for the gate.

Remote command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP on page 1077
CALCulate:MATH<m>:FFT:GATE:RELative:STOP on page 1078
MEASurement<m>:GATE:ABSolute:STOP on page 1057
MEASurement<m>:GATE:RELative:STOP on page 1057
SEARch:GATE:ABSolute:STOP on page 1128
SEARch:GATE:RELative:STOP on page 1129

Zoom coupling
Zoom coupling is available if a zoom is defined. As long as "Zoom coupling" is enabled, the gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.

If several zoom diagrams are defined, select the zoom diagram to be used for gating. The "Start" and "Stop" values of the gate are adjusted accordingly.

Zoom coupling can be set for measurement gates, FFT gates, and search gates.

Remote command:
CALCulate:MATH<m>:FFT:GATE:ZCOupling on page 1078
MEASurement<m>:GATE:ZCOupling on page 1059
MEASurement<m>:GATE:ZDIagram on page 1059
SEARch:GATE:ZCOupling on page 1129
SEARch:GATE:ZDIagram on page 1129

10.3.2 Defining the Search Gate

If you create a search using the "Search" toolbar icon, you can directly define the gate by dragging a rectangle on the diagram. Otherwise, you define the gate in the "Gate" tab of the "Search" dialog box.

1. Press the SEARCH key and select the "Gate" tab.
2. Select the search for which you want to define the gate.
3. Use one of the following methods:
   - Set the absolute or relative "Mode" and enter the start and stop values of the gate area.
   - If a zoom area has already been defined for the waveform, couple the gate area to the zoom area by selecting the "Zoom coupling" option. If several zoom diagrams are defined, select the zoom diagram to be used for gating.
4. Tap "Use gate" to enable the gate.

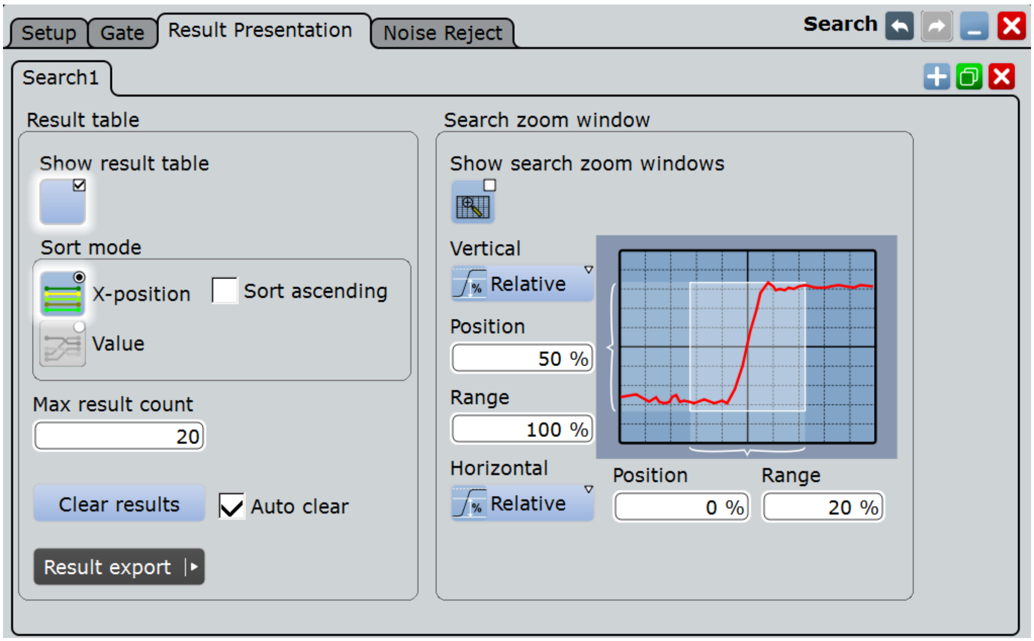
5. Optionally, tap "Show gate" to display the gate area in the diagram.

10.4 Result Presentation

Search results are displayed in a table in the "Search Results" box. In addition, a zoom window for a selected search result can be displayed so that you can analyze the result in more detail.

10.4.1 Result Presentation Settings

The following settings configure the layout of the result table in the "Search Results" box and the size and position of the search zoom window. The result tables can be sorted by x-position or value. You can define a maximum number of table entries.



Result table

These settings refer to the search result table.

Show result table ← Result table

Displays or hides the search result table.

Remote command:

`SEARch:RESult:SHOW` on page 1135

Sort mode ← Result table

Sorts the search results by x-value position or value of the result.

Remote command:

`SEARch:RESult:SORT[:MODE]` on page 1136

Sort ascending ← Result table

By default, the results are listed in descending order, i.e. the largest value at the top. To change the sorting direction, enable "Sort ascending".

Remote command:

`SEARch:RESult:SORT:ASCending` on page 1135

Max result count

Defines the maximum number of entries in the search result table.

Remote command:

`SEARch:RESult:LIMit` on page 1135

Search zoom window

The search zoom window allows you to analyze the search results in more detail.

You can change the size and the position of the search zoom area in the same way as a usual zoom. If you move the zoom area in the source diagram, the nearest search result is marked in the results table. See also: Chapter 6.1.1, "Methods of Zooming", on page 227

The search zoom area is marked in the waveform diagram. You can change the color of the area with: "Display" menu > "Diagram layout" > "Search result gate symbol color" on page 123.

Show search zoom windows ← Search zoom window

If enabled, a zoom window is displayed for the currently selected search result. The zoom area is indicated in the diagram that displays the source waveform of the search.

Remote command:

`SEARch:RESDiagram:SHOW` on page 1133

Vertical ← Search zoom window

Defines whether absolute or relative values are used to specify the y-axis values.

Remote command:

`LAYout:ZOOM:VERTical:MODE` on page 991

`SEARch:RESDiagram:VERT:MODE` on page 1134

Position / Relative position (vertical) ← Search zoom window

Defines the y-value of the centerpoint of the zoom area.

Remote command:

`LAYout:ZOOM:VERTical:ABSolute:POSition` on page 991

`LAYout:ZOOM:VERTical:RELative:POSition` on page 992

`SEARch:RESDiagram:VERT:ABSolute:POSition` on page 1133

`SEARch:RESDiagram:VERT:RELative:POSition` on page 1134

Range / Relative Range (vertical) ← Search zoom window

Defines the height of the zoom area.

Remote command:

`LAYout:ZOOM:VERTical:RELative:SPAN` on page 992

`LAYout:ZOOM:VERTical:ABSolute:SPAN` on page 991

SEARch:RESDiagram:VERT:ABSolute:SPAN on page 1134
SEARch:RESDiagram:VERT:RELative:SPAN on page 1134

Horizontal ← Search zoom window
Defines whether absolute or relative values are used to specify the x-axis values.

Remote command:
LAYout:ZOOM:HORZ:MODE on page 988
SEARch:RESDiagram:HORZ:MODE on page 1132

Position / Relative position (horizontal) ← Search zoom window
Defines the x-value of the centerpoint of the zoom area.

Remote command:
LAYout:ZOOM:HORZ:ABSolute:POSition on page 988
LAYout:ZOOM:HORZ:RELative:POSition on page 989
SEARch:RESDiagram:HORZ:ABSolute:POSition on page 1132
SEARch:RESDiagram:HORZ:RELative:POSition on page 1133

Range / Relative Range (horizontal) ← Search zoom window
Defines the width of the zoom area.

Remote command:
LAYout:ZOOM:HORZ:ABSolute:SPAN on page 988
LAYout:ZOOM:HORZ:RELative:SPAN on page 990
SEARch:RESDiagram:HORZ:ABSolute:SPAN on page 1132
SEARch:RESDiagram:HORZ:RELative:SPAN on page 1133

10.4.2 Configuring the Search Results Presentation

Initially, the "Search Results" box is displayed in front of the other diagrams or as result icon on the signal bar, depending on the default setting in the "Diagram Layout" tab. Alternatively, you can display it in its own area on the screen, like any other diagram.

For details, see "Displaying Results" in the "Getting Started" manual.

To configure the result tables

1. Press the SEARCH key to open the "Search" dialog box.
2. Select the tab for the search you want to configure.
3. Select the "Result Presentation" tab.
4. Select "Show result table" to display the "Search Results" box.
5. Select the sort mode of the result table.
6. By default, the results are listed in descending order, i.e. the largest value at the top. To change the sorting direction, enable "Sort ascending".
7. Define a maximum number of results to be displayed in the result table in the "Max result count" field.

To display search zoom windows

1. In the "Search Results" box, select "Show search zoom windows".

   This stops a running search and a running acquisition.
   The zoom area is indicated in the diagram that displays the source waveform of the search. The zoom window is displayed for the first result that was found.

2. If you need to adjust the search zoom area, you can drag the area or their edges on the screen. You can also enter the limits of the search zoom window in the "Search > Results Presentation" tab.
   Be aware, that the zoom window size is valid for all results of a search definition, so if you change the settings drastically for one result, they may not be correct for the next search result you switch to.

   See also:
   - Chapter 6.1.3, "Zooming for Details", on page 233
   - "Navigating search results" on page 378

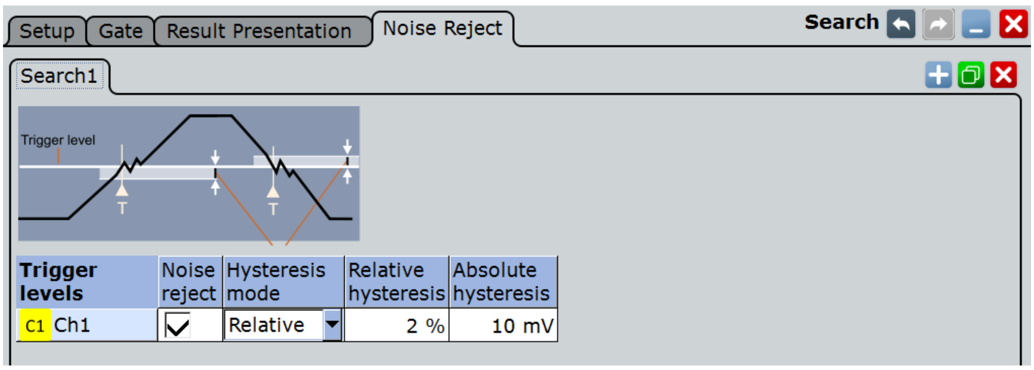
10.5 Noise Reject

Noise rejection for searches is very similar to noise rejection for triggers. You can reject noise by setting a hysteresis in order to avoid finding events caused by noise oscillation around the trigger level.

10.5.1 Noise Reject Settings

You can select the hysteresis mode and value for each analog and digital input channel, math and reference waveform.

The noise reject settings are similar to those for triggers, see also Chapter 5.5, "Noise Reject", on page 218.



Noise reject
If enabled, the hysteresis is considered for the search.

Remote command:
`SEARch:TRIGger:LEVel:NOISe[:STATe]` on page 1131

Hysteresis mode
Defines whether values absolute or relative to the vertical scaling are used.

Remote command:
SEARch:TRIGger:LEVel:NOISe:MODE on page 1130

Relative / Absolute hysteresis
Defines a range in absolute or relative values around the search level. If the signal jitters inside this range and crosses the level, no search event is detected.

Absolute hysteresis values are adapted when the relative hysteresis is changed , and vice versa.

If you change the vertical scaling, either the relative or the absolute value is adjusted automatically.

Remote command:
SEARch:TRIGger:LEVel:NOISe:ABSolute on page 1130
SEARch:TRIGger:LEVel:NOISe:RELative on page 1131

10.5.2 Defining Noise Rejection for Searches

1. Press the SEARCH key to open the "Search" dialog box.
2. Select the "Noise reject" tab.
3. Select the tab for the search you want to configure.
4. Define the absolute or relative hysteresis. If you change one value, the other is automatically calculated.

11 Data and File Management

This chapter describes how to manage instrument settings, and measurement results like waveform data, numeric results and screenshots.

The FILE key provides functions for saving and restoring data on the instrument. A naming pattern is available and can be adjusted to simplify a clear data storage.

The effect of the PRINT key can be configured to save or print screenshots or reports.

11.1 Instrument Settings

In order to repeat measurements at different times or perform similar measurements with different test data, it is useful to save the used instrument settings and load them again later. Furthermore, it can be helpful to refer to the instrument settings of a particular measurement when analyzing the results. Therefore, you can easily save the instrument settings of a measurement. In addition to the measurement-related settings, user-specific display settings can also be saved and loaded.

The R&S RTE provides three types of saving and restoring settings.

- **Savesets** contain the complete instrument and measurement configuration except for user-specific display settings.
- **User preferences** contain user-specific display settings like diagram layout, toolbar, intensity and transparency settings.
- **User-defined presets** contain the complete instrument setup including display settings, except for transparency and intensity. These settings can be restored by pressing the PRESET key.

Access: FILE key > "Save/Recall" tab

11.1.1 Savesets

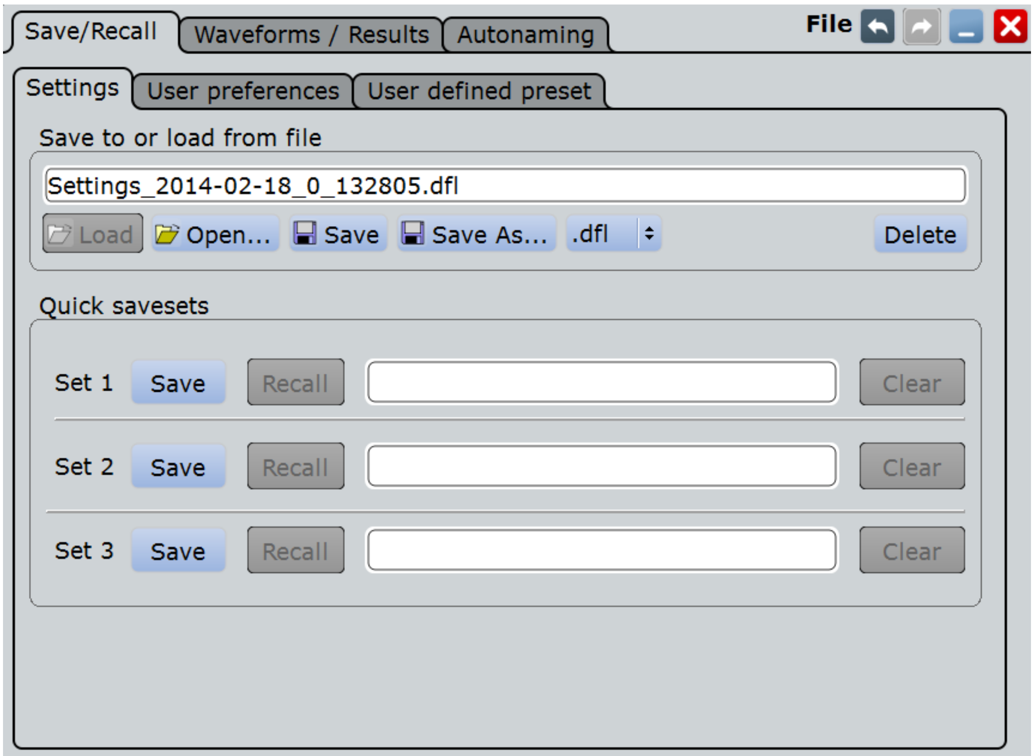
Savesets contain the complete instrument and measurement configuration icluding a screenshot of the current display, but except for user-specific display settings stored as user preferences. You can save an unlimited number of setting files.

To load a saveset quickly, you can use the "Load saveset" function on the toolbar. A graphical preview helps you to find the required settings file.

If you often need to store the instrument settings, you can add the "Save settings" icon to the toolbar and use the icon to store the saveset file.

For the most frequently used measurements, store the settings in "Quick savesets" and recall them very quickly. Up to 3 quick savesets can be used. They are stored automatically, the name and storage place are fixed.

11.1.1.1 Settings



Save to or load from file
Enter the file name to load or to save the setting data to, and select the file format with the format button on the right. Double-tap the file name to open the file selection dialog box. See also: Chapter 11.1.7, "File Selection Dialog", on page 408.

By default, saveset file names have the prefix "Settings_".

"Load"	Loads the specified file.
"Open"	Opens a file selection dialog box and loads the selected file.
"Save"	Saves the data to the selected file.
"Save As..."	Opens the file selection dialog box and saves the data to the selected file.
".dfl/.xml"	Selects the file format.
"Delete"	Deletes the selected file.

Remote command:
MMEMory:SAV on page 1143
MMEMory:RCL on page 1143

Quick savesets

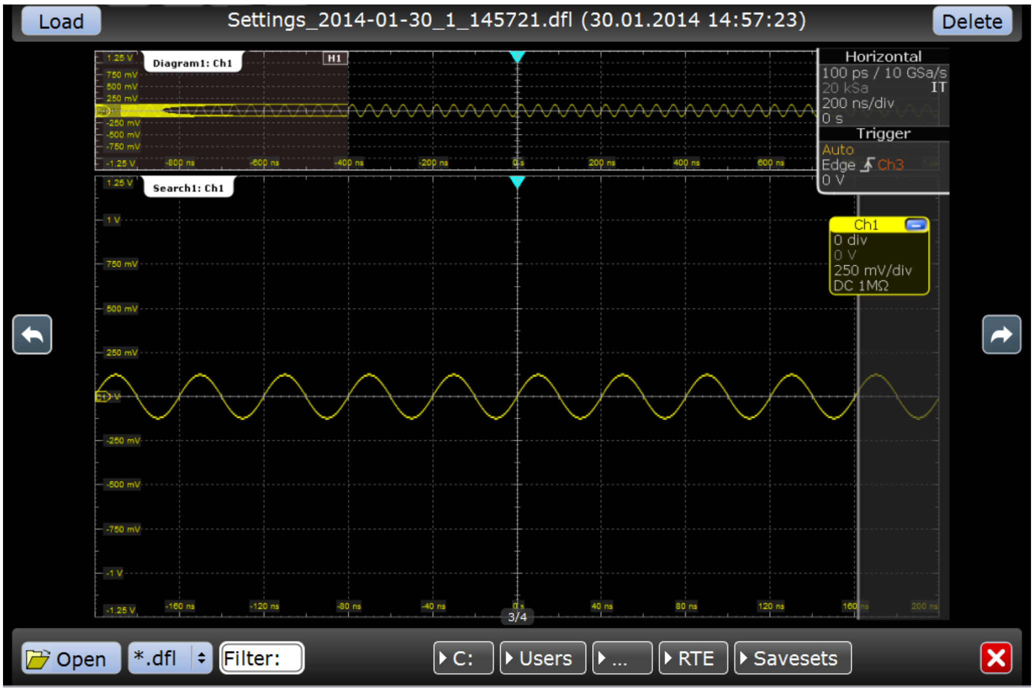
A saveset stores the current measurement and instrument settings at the touch of a button, and reloads them in the same way. Three savesets are available for the most frequently used measurements.

Savesets are stored automatically with standard names, so it is useful to describe the settings in a comment.

"Save"	Saves the current measurement and instrument settings to one of the three savesets.
"Recall"	Loads the instrument settings from one of the three savesets.
"Comment"	Double-tap the edit field to describe the settings saved in the selected saveset.
"Clear"	Deletes the selected saveset.

11.1.1.2 Load Saveset Function

The "Load saveset" function is available on the toolbar. Here, a graphical preview helps you to find the required settings file.



1. On the toolbar, tap the "Load saveset" icon.

A window opens and shows the screenshot of the first measurement configuration that is stored in the default `Saveset` directory.

2. Find the required saveset file:
   - Tap the "Next" icon on the rigth or the "Previous" icon on the left to scroll the savesets of the directory.

     The file name is shown on the top, and the screenshot helps to identify the settings.
   - Select the file format: `*.dfl` or `*.xml`.
   - If the saveset was stored in another directory, use the path buttons at the bottom or tap "Open" to open the required directory.
3. Tap "Load" in the upper left corner to recall the settings of the selected file.

11.1.1.3 Saving and Loading Settings

Settings can be stored in a file with user-defined name and location, or in a quick saveset. The settings in a saveset can be saved and retrieved very quickly at the touch of a button, so savesets are ideal for frequently used measurements.

For details on save/recall instrument settings and associated remote commands, see Chapter 11.1.1, "Savesets", on page 399.

To save instrument settings in a quick saveset

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.
4. For one of the three available quick savesets, enter a comment in the "Quick savesets" area to identify the configuration.
5. Tap the corresponding "Save" button

   The current instrument settings are saved in the selected quick saveset.

To load instrument settings from a quick saveset

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.

4. Tap the required "Recall" button in the "Quick savesets" area.

   The saved settings are loaded to the R&S RTE.

To save settings to a saveset file

Alternatively, you can add the "Save settings" icon to the toolbar and use the icon to store the saveset file to the folder and file specified in the "Settings" tab. See also Chapter 2.4.5.2, "Configuring the Toolbar", on page 92.

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.
4. Tap "Save" to save the settings to the specified file.
   Tap "Save As" to save the settings to a different file. Select the file and directory from the file selection dialog box.

   The current settings are saved to the selected file.

To load settings from a saveset file

Alternatively, you can use the "Load saveset" function on the toolbar, see Chapter 11.1.1.2, "Load Saveset Function", on page 401.

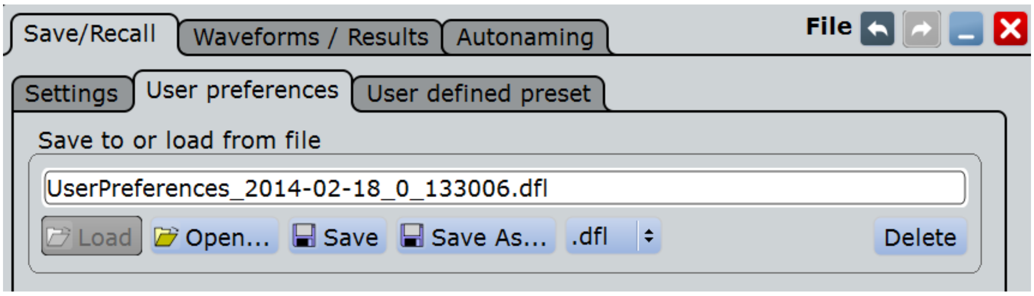
1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.
4. Tap "Load" to load the settings from the specified file.
   Tap "Open" to navigate to a different file. Select the file from the file selection dialog box and tap "Select".

   The saved settings are loaded to the R&S RTE.

11.1.2 User Preferences

User preferences contain user-specific display settings like diagram layout, toolbar, intensity and transparency settings. By default, these file names have the prefix "User-Preferences_".

User preferences are saved and loaded in the same way as saveset files but on the User preferences tab. See also: "To save settings to a saveset file" on page 403 and "To load settings from a saveset file" on page 403.



Save to or load from file
The file name to load or to save the data to.

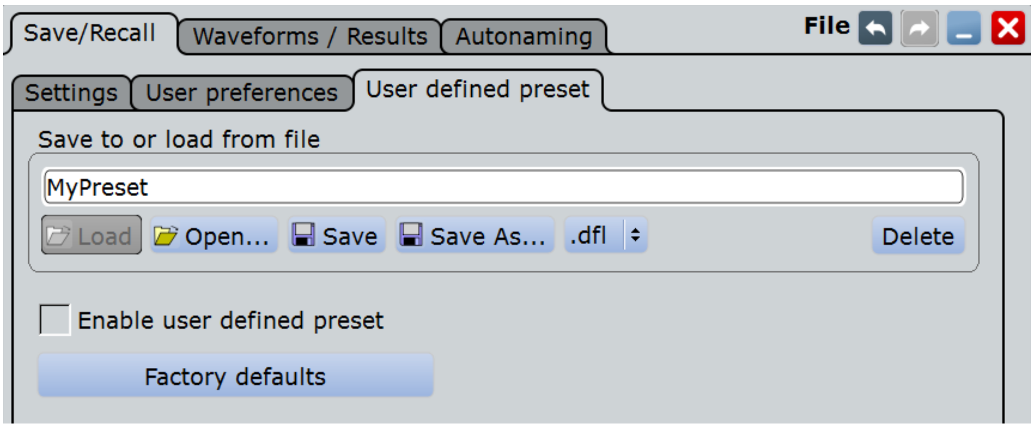
By default, user preference file names have the prefix "UserPreferences_".

For details, see the Save to or load from file function in the "Settings" tab.

11.1.3 User-defined Preset

A user-defined preset contains the complete instrument setup including display settings, except for transparency and intensity. You can save the current configuration to a preset file, and load a previously saved preset file. You can then specify that these settings are to be applied with the PRESET key.

11.1.4 User-defined Preset - Settings



Save to or load from file
The file name with extension `.dfl` to load or to save the settings to.

For details, see the Save to or load from file function in the "Settings" tab.

Enable user-defined preset
If enabled, the settings from the selected preset file are restored when the PRESET key is pressed.

If disabled, PRESET sets the instrument to the factory defaults.

Factory defaults
Resets the instrument to the factory default settings, to the initial state. Factory settings comprise all instrument settings, including display, intensity and transparency settings. After laoading factory defaults, perform a self-aligment to synchronize the signal data ("File" menu > "Selfalignment").

Remote command:
`SYSTem:PRESet` on page 891

11.1.5 Restoring Settings

When you have changed many different settings on the instrument and are no longer sure which settings are causing which effect in the measurement, you may want to restore the default settings and start anew. The following methods are available:

- Saving instrument settings to a user-defined preset and restoring the instrument settings to user-defined default values
- Restoring all settings on the R&S RTE to the factory-defined values
- Restoring settings from a file (see "To load settings from a saveset file" on page 403)

For details on save/recall instrument settings and associated remote commands, see Chapter 11.1.1, "Savesets", on page 399.

To save a user-defined preset

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "User-defined Preset" tab.
4. Enter a name for the preset file and select the file format.
5. Tap Save.

   Note: If you want to store the file in another directory than the default one, select "Save As". See also: Chapter 11.1.7, "File Selection Dialog", on page 408

To restore the instrument settings to user-defined default values

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "User-defined Preset" tab.
4. Tap "Open" and select the preset file that contains the required settings.

   The instrument settings are restored to values that are stored in the file.
5. To use these settings as presest values, select "Enable user-defined preset".
6. Press the PRESET key.

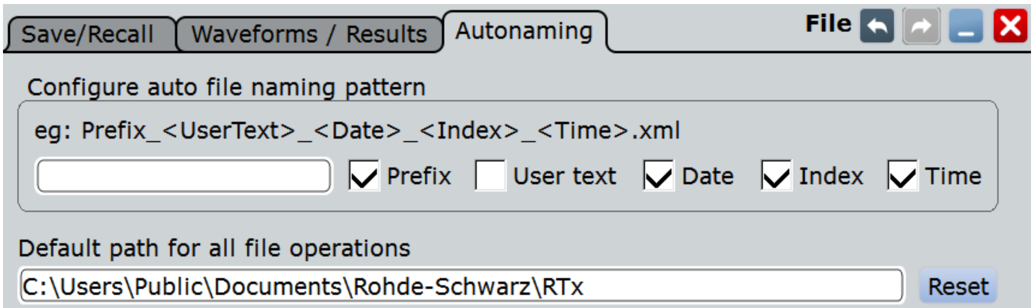
To restore all settings to the factory defaults

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "User-defined Preset" tab.
4. Tap the "Factory defaults" button.

   All settings on the R&S RTE are reset to their factory-defined values. As long as no user-defined preset file is loaded and Enable user defined preset is disabled, the PRESET key also resets the instrument settings to factory defaults.

11.1.6 Autonaming

In this tab you can define the pattern for automatic file name generation. This name is used as the default file name. The default path is the storage location for all saved files and their subdirectories.



11.1.6.1 Autonaming Settings

Prefix

If enabled, inserts the default prefix in the file name. The prefix indicates the type of data that is saved, for example, Histogram, RefCurve, Settings.

Remote command:
`MMEMory:AUTonaming:PREFix` on page 1144

Text input

User-defined text to be inserted after the prefix.

Remote command:
`MMEMory:AUTonaming:TEXT` on page 1145

User text (enable)

If enabled, inserts the specified user text after the prefix.

Remote command:
`MMEMory:AUTonaming:USERtext` on page 1144

Date
If enabled, inserts the current date.

Remote command:
`MMEMory:AUTonaming:DATE` on page 1144

Index
If enabled, inserts an index.

Remote command:
`MMEMory:AUTonaming:INDex` on page 1145

Time
If enabled, inserts the current time.

Remote command:
`MMEMory:AUTonaming:TIME` on page 1145

Default path for all file operations
Defines the default path displayed in the file selection dialog box for loading and storing operations.

Remote command:
`MMEMory:AUTonaming:DEFaultpath` on page 1145

Reset
Resets the default file path.

Remote command:
`MMEMory:AUTonaming:RESPath` on page 1145
`MMEMory:AUTonaming:RESall` on page 1145

11.1.6.2 Defining Default File Paths and Names

When a save or load operation is performed, a default file name and path is provided. You can configure which path is used and how the file name is generated. In the file selection dialog box you can change the folder and name as desired.

To define the default file path

1. Press the FILE key.
2. Select the "Autonaming" tab.
3. Double-tap the "Default path for all file operations" field.

   The directory selection dialog box is opened.
4. Select the folder in which the data is to be stored by default.
5. To restore the factory-set default path, tap "Reset" next to the path field.

To define the automatic file name pattern

The automatic file name pattern can consist of the following elements:

<Prefix>_<UserText>_<Date>_<Index>_<Time>

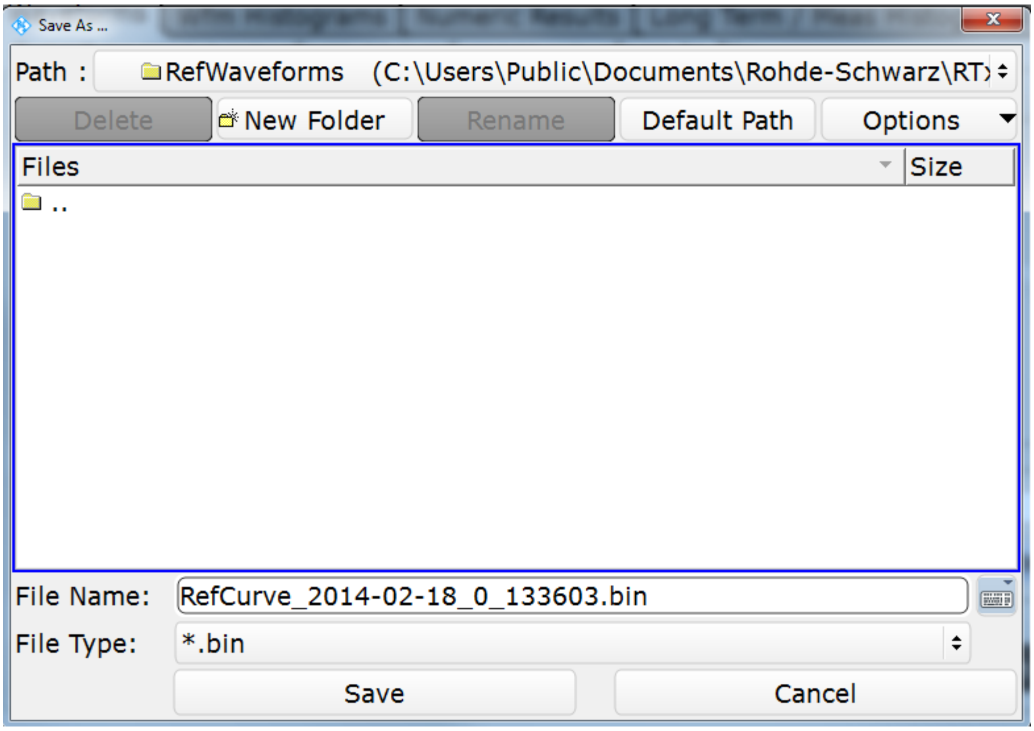
The prefix depends on the data type to be stored and cannot be changed by the user. The other elements can be enabled or disabled as required.

1. Press the FILE key.
2. Select the "Autonaming" tab.
3. To insert a user-defined text after the prefix, enter the text in the edit field. and enable "User text".
4. If you want to exclude the prefix, current date, time or an index (serial number), disable the corresponding option.

   The specified elements are used to generate the default file name for the next storage operation.

11.1.7 File Selection Dialog

The file selection dialog provides a file explorer from which you can select a file to load or to save data to.



Path

Tap the path to change the current folder. The default folder is defined in "Default path for all file operations" on page 407.

You can save the data in a local folder on the instrument, to an external storage device (usually a USB flash drive), or to an folder on a connected network drive. The path list provides all available drives and folders.

Delete
Deletes the selected file

New Folder
Creates a new subfolder in the current folder.

Rename
Opens an online keyboard to enter a new name for the selected file or folder.

Options
Opens a menu with view and delete options.

"Size" Shows the a column with the file sizes.

"Last modified" Show a column with the date and time of the last modification of the file.

"Multi-selection for delete"
Enables mult-selection. Tap the files you want delete, and then tap the "Delete" button.

"Select all files for delete"
Selects all files in the current folder. Tap the "Delete" button to remove the files.

File Name
The file name to be loaded or stored to. Double-tap the file name to open the file selection dialog and select a different file name, or enter the file name directly using the online keyboard.

The default file name for new files is defined in the "Autonaming" tab, see Chapter 11.1.6, "Autonaming", on page 406.

Online keyboard
Opens an online keyboard to enter the file name. Tap the ENTER key to close the keyboard.

File Type
The file extension of the file to be loaded or stored to.

Select
Selects the specified file for the open or save operation and closes the dialog box.

Cancel
Closes the dialog box without selecting a file.

11.2 Waveforms and Results

You can export various data to file: waveform data, histograms, and measurement results.

11.2.1 Waveform Export Files

Waveforms can be stored in XML, CSV, or BIN format.

Reloading waveforms: Restrictions

In order to reload waveform data as a reference waveform, it must be stored in BIN format.

If multiple acquisitions of one waveform are exported (Data logging or Multiple waveforms), only the first acquisition can be reloaded.

If the signal is a spectrum, reloading is only possible for waveforms with "Magnitude unit" = Linear. Waveforms with logarithmic unit cannot be reloaded.

Data of all waveforms is saved in two files. One file contains the waveform data values and is indicated by `*Wfm.*` in the file name. The second file contains the header data, for example, time scale, vertical scale, vertical and horizontal positions, interpolation mode and much more. Header data is required to restore the waveform from data, or to analyze the data values of the data file.

11.2.1.1 Header Files

The header files of XML and BIN waveform files are written in XML format. The header files of CSV waveform files are written in CSV format. You can open the header files and use their information for data analysis.

CSV header files only contain the property names and values, one property per row.

```
Resolution:1e-010:
RecordLength:1000:
```

XML header files contain more information than CSV header files. The additional information is required to reload the stored waveforms with their correct settings.

```
<Prop Avail="0" ValueKey="" Name="Resolution" Value="1e-010" UserValue="0"
Step="1e-011" Default="0" Min="0" Max="1e+026" StepDefault="1e-011"
StepFactor="10" Resolution="0" UnitId="55" UnitName="s" UnitPowerProduct=""
BitGroupSize="0" Format="0"></Prop>

<Prop Avail="0" ValueKey="" Name="RecordLength" Value="1000" UserValue="1000"
Step="1" Default="1000" Min="0" Max="4294967295" StepDefault="1" StepFactor="10"
Resolution="1" UnitId="93" UnitName="Sa" UnitPowerProduct="" BitGroupSize="0"
Format="0"></Prop>
```

Header files contain the following properties:

Table 11-1: Header file properties

Value	Description
General	
FirmwareVersion	Firmware version that is installed on the R&S RTE (last entry in the header file)
Source	Name of the exported waveform
Resolution	Time between two samples *Resolution = 1 / Sample Rate*
SignalResolution	Time between two samples in this waveform. The value can differ from Resolution if the source is, for example, a spectrum, a bus signal, a correlation or a measurement. The value is determined automatically considering the waveform parameters and their dependencies. If the signal is a spectrum, the value indicates the frequency range of FFT bins.
EnhancementMode	Method to increase the sample rate if the required sample rate is higher than the ADC sample rate.
InterpolationMode	Interpolation method. The value is relevant when the enhancement mode is interpolated time.
DecimationMode	Method to reduce the number of data samples to achieve the required sample rate
DecimationFactor	Factor to the number of data samples to achieve the required sample rate *Decimation factor = ADC sample rate / Sample rate*
TraceArithmetics	Off, Envelope, or Average
InterleavedTraceCount	Number of y-values saved at each sampling time. The value is usually 1. The value is 2, if min and max values are saved for each sample, for example, for envelope waveforms.
SignalFormat	Format of the data values: ● FLOAT: floating point numbers, general export format ● INT (8 Bit): Integer 8 bit, used for "Raw (ADC sample)" data export. ● INT (16 Bit): Integer 16 bit, used for "Raw (ADC sample)" data export in high definition mode (option R&S RTE-K17).
Timestamp	Absolute time of the waveform recording
ByteOrder	Endianess, only relevant for raw data export in high definition mode (SignalFormat = INT (16 Bit)). ● LSB first: little endian, least significant byte first ● MSB first: big endian, most significant byte first
NumericFormat	Number format of bus values and digital channel data (bit pattern format)
Record length	
RecordLength	Number of samples in a waveform record of one acquisition
HWRecordLength	Equivalent to the RecordLength

Value	Description
SignalRecordLength	Number of required samples in the waveform. The value can differ from RecordLength and HWRecordLength if the source is, for example, a spectrum, a bus signal, a correlation or a measurement. The value is determined automatically considering the waveform parameters and their dependencies. If the signal is a spectrum, the value indicates the number of FFT bins.
SignalHardwareRecordLength	Number of samples actually available in this waveform, including the number of required samples in the waveform and the additional samples needed for further computation
LeadingSettlingSamples	Number of additional samples before the beginning of waveform samples. These additional samples are needed for further computation, for example, for filters.
Horizontal system	
TimeScale	Horizontal scale in seconds per division
HorizontalDivisionCount	Number of horizontal divisions
RescaleCenterTime	Horizontal position, the time distance between the reference point and the zero point of the diagram
RescaleCenterPoint	Position of the reference point in % of the screen
ReferencePoint	Position of the zero point in % of the screen
TriggerOffset	Time distance from the trigger point to the zero point of the diagram
XStart	Horizontal start value of the waveform (time or frequency) *)
XStop	Horizontal stop value of the waveform (time or frequency)
HardwareXStart	Actual horizontal start value of data, including the settling time for further computation *)
HardwareXStop	Actual horizontal stop value of data, including the settling time for further computation
	*) If the waveform is a spectrum, the XStart and HardwareXStart values may be slightly smaller than the specified start frequency, or even get negative. The spectrum is centered on the center frequency, and the frequency range covered by one spectral bin is given by the SignalResolution. Hence, the spectral bin in the center of the spectrum always covers the range [CenterFrequency; CenterFrequency + SignalResolution[. As a result, the range covered by the first spectral bin in the spectrum may reach further than the start frequency specified by the user. It is ensured that the specified start frequency is included in the frequency range.
Vertical system In case of multi channel export, the values of channel1 are delivered, no matter if channel 1 is exported or not.	
VerticalScale	Vertical scale of the waveform in Volts per division, or other unit / division
VerticalDivisionCount	Number of vertical divisions
VerticalPosition	Vertical position of the waveform in divisions
VerticalOffset	Vertical offset of the waveform in Volts, or other unit

Value	Description
NofQuantisationLevels	Theoretical number of quantization levels in the signal. This value depends on the waveform format (8 bit, 16 bit, …). In case of a math waveform, it depends on the quantization levels of the operands and on the operator type.
BaseYStart	Vertical start value of the waveform
BaseYStop	Vertical stop value of the waveform
Multi channel export The header files contain strings like this: `MultiChannelVerticalOffset: 4:1.63:1.96:0:0:1e-005:0:-1e+026:1e+026:1e-005:10:0:V:`. Only the first 5 values and the unit at the end of the string are relevant for data analysis. All other values are for internal use and not explained here. Examples are in csv format.	
MultiChannelExport	Indication whether multiple channels are exported simultaneously: On | Off
MultiChannelExportState	Number of channels and export status of the individual channels, for example, 4:On:Off:On:On...: channels 1, 3 and 4 are exported.
MultiChannelVerticalOffset	Number of channels and vertical offset of the individual channels, for example, 4:0:0:0.02:0...: channel 3 has an offset of 20 mV.
MultiChannelVerticalPosition	Number of channels and vertical position of the individual channels, for example, 4:0:0:0:2...: the position of channel 4 is 2 divisions.
MultiChannelVerticalScale	Number of channels and vertical scale of the individual channels, for example, 4:0.05:0:0.03:0.04...: scale of channel is 50 mV/div, channel 3 has 30 mV/div and channel 4 has 40 mV/div.
MultiChannelBaseYStart	Number of channels and minimum value of the vertical range for each individual channel, for example, 4:-0.25:0:-0.13:-0.28...
MultiChannelBaseYStop	Number of channels and maximum value of the vertical range for each individual channel, for example, 4:0.25:0:0.17:0.12...: The range of channel 1 is -250 mV to 250 mV. The range of channel 3 is -130 mV to 170 mV. The range of channel 4 is -280 mV to 120 mV.
History	
TimestampState	State of the timestamps export. If on, the timestamps of each history waveform is written to the waveform data file.
Math waveform	
BaseUnit	Base unit of a mathematic waveform, for example, linear unit
ViewUnit	User-selected unit of a mathematic waveform, for example, logarithmic unit for a spectrum. The value is only valid if the exported waveform is a math waveform.
ViewUnitRelative	Indication of a relative unit. It is true if the math waveform has the ViewUnit "dB", for example. The value is only valid if the exported waveform is a math waveform.
ViewReferenceLevel	Reference level for a relative unit. The value is only valid if the exported waveform is a math waveform, and the unit is relative.
FFT	
CenterFreq	Center frequency of the spectrum

Value	Description
FreqSpan	Frequency span of the spectrum
FrequencyStart	Start frequency of the spectrum
FrequencyStop	Stop frequency of the spectrum
WindowType	Window used for the spectrum computation
ResolutionBW	Resolution bandwidth of the spectrum
AdjustedResolutionBW	Actual resolution bandwidth of a spectrum waveform. The value is only valid if the exported waveform is a spectrum.
GateRBWCoupling	Indication whether the record length or the resolution bandwidth is a constant for the spectrum computation
Parameters for power calculation	
Impedance	Impedance used for power calculation
NoiseBandwidth	Noise bandwidth of a spectrum waveform, required for power calculation. The value is only valid if the exported waveform is a spectrum.
Parameters for internal use	
SourceType	Source qualifier
TraceType	Waveform qualifier
ValueType	
TOADone	
BaseUnitRelative	Base unit indication
UseInterSampleTriggerOffset	
ISO_TRG SC_POST SC_TRG	

11.2.1.2 Waveform Data Files

The waveform data files - indicated by `*Wfm.*` in the file name - contain the actual waveform data. Usually only Y-values - mostly voltage values - are written subsequently. If the signal is a spectrum, the data of the last frame is written.

If the waveform consists of minimum and maximum values, two Y-values per sample are written, and the property `InterleavedTraceCount` in the header file is >1. This applies to envelope waveforms, for example.

The option "Interleaved X/Y" allows you to include horizontal values into the file.

if multi-channel export is enabled, the Y-values of the selected channels are written in interleaved order.

- One channel, single acquisition export
  – Normal waveform:
    Y_0; Y_1; Y_2; Y_3; ...

  - Envelope waveform:
    $Ymin_0$; $Ymax_0$; $Ymin_1$; $Ymax_1$; $Ymin_2$; $Ymax_2$; $Ymin_3$; $Ymax_3$; ...
  - Normal waveform, interleaved x/y data:
    X_0; Y_0; X_1; Y_1; X_2; Y_2; X_3; Y_3; ...
  - Envelope waveform, interleaved x/y data:
    X_0;$Ymin_0$; $Ymax_0$; X_1; $Ymin_1$; $Ymax_1$; X_2; $Ymin_2$; $Ymax_2$; X_3; $Ymin_3$; $Ymax_3$; ...
- Multi-channel, single acquisition export
  In the example, two channels are exported.
  - Normal waveforms:
    $YCh1_0$; $YCh2_0$; $YCh1_1$; $YCh2_1$; $YCh1_2$; $YCh2_2$; $YCh1_3$; $YCh2_3$; ...
  - Envelope waveforms, channel 1 and channel 2 are envelopes:
    $YCh1min_0$; $YCh1max_0$; $YCh2min_0$; $YCh2max_0$; $Ymin_1$; $Ymax_1$; $YCh2min_1$; $YCh2max_1$; $Ymin_2$; $Ymax_2$; $YCh2min_2$; $YCh2max_2$; $Ymin_3$; $Ymax_3$; $YCh2min_3$; $YCh2max_3$; ...
  - Normal waveforms, interleaved x/y data:
    X_0; $YCh1_0$; $YCh2_0$; X_1; $YCh1_1$; $YCh2_1$; X_2; $YCh1_2$; $YCh2_2$; X_3; $YCh1_3$; $YCh2_3$; ...
  - Envelope waveform and normal waveform, interleaved x/y data:
    X_0;$YCh1min_0$; $YCh1max_0$; $YCh2_0$; X_1; $YCh1min_1$; $YCh1max_1$; $YCh2_1$; X_2; $YCh1min_2$; $YCh1max_2$; $YCh2_2$; X_3; $YCh1min_3$; $YCh1max_3$; $YCh2_3$; ...

In XML and CSV waveform value files, the data of each sample is grouped. The example shows the values of two samples for two waveforms and interleaved x/y data. The first waveform is an envelope, the second one is a normal waveform.

In CSV files, the data values for a given sampling time is written in one row.

```
-1.96e-008    -0.0079051387    -0.0059288535    -0.1027668
-1.95e-008    -0.0098814229    -0.0079051387    -0.10474309
```

In XML format, an empty line marks the beginning of the next sample.

```
<Data>-1.96e-008</Data>
<Data>-0.0079051387 </Data>
<Data>-0.0059288535 </Data>
<Data>-0.1027668 </Data>

<Data>-1.95e-008</Data>
<Data>-0.0098814229 </Data>
<Data>-0.0079051387 </Data>
<Data>-0.1027668 </Data>
```

If multiple acquisitions (Data logging / Multiple waveforms) are exported, the first acquisition is written in the same way as with single acquisition export. The following acquisitions are appended in the same way. If the signal is a spectrum, the last frame of each acquisition is saved.

Before and after the waveform data, the instrument writes some leading and trailing settling samples. They ensure that all measurements can be performed on the reloaded waveform that could be performed on the original waveform. The number of leading settling samples is provided in the header file.

11.2.1.3 Number of Samples in the Export File

In this section, a sample is defined as one or more values acquired at a given sampling time. The number of samples for one channel and acquisition is given in the header file by the property `SignalHardwareRecordLength`. This number includes the number of required samples in the waveform and additional samples at the beginning (leading samples) and the end of the file (trailing samples).

The number of additional samples is:

No of additional samples = SignalHardwareRecordLength - SignalRecordLength

The number of leading additional samples is given in the header file: `LeadingSettlingSamples`.

The number of trailing additional samples is:

No of trailing additional samples = No of additional samples - LeadingSettlingSamples
= SignalHardwareRecordLength - SignalRecordLength - LeadingSettlingSamples

If the waveform has more than one Y-value per sample (e.g. envelope), the property `InterleavedTraceCount` is > 1, and the number of values in the file for this waveform is:

*No of values per waveform = InterleavedTraceCount * SignalHardwareRecordLength*

If multiple acquisitions are exported, the total number of values in the file is:

*No of values = InterleavedTraceCount * SignalHardwareRecordLength * No of exported acquisitions*

If "Interleaved x/y"is enabled, one horizontal value is added per sample. The total number of values in the file is:

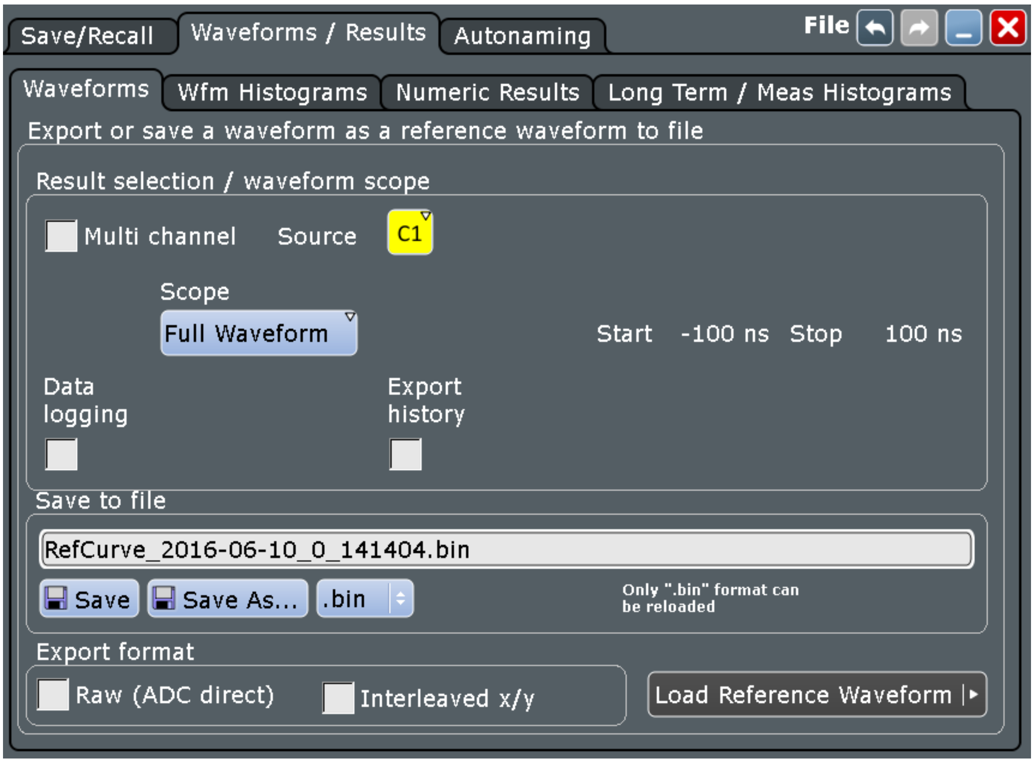
*No of values = (1+ InterleavedTraceCount) * SignalHardwareRecordLength * No of exported acquisitions*

MSO option R&S RTE-B1:

If the data of digital channels is stored in BIN format, one bit is written for each sample. 8 data samples are written in one byte (data word). For example, 100 MSa are written into a 12.5 MByte BIN file. After reading the file, you have to extract the samples from the data words.

11.2.2 Waveforms - Export Settings

In this tab, the storage settings for waveform data are defined.



See also: Chapter 11.2.6, "Saving and Loading Waveform Data", on page 427.

Source

Selects the waveform to be exported if "Multichannel export" is disabled. Active wave-forms of input channels, math signals and reference waveforms are available for export.

If the MSO option R&S RTE-B1 is installed, you can save also digital channels and parallel buses..

Remote command:
`EXPort:WAVeform:SOURce` on page 1146

Multi-channel export

Enables or disables the export of multiple input channels. If enabled, you can export the data of selected input channels (Selected sources) into one file.

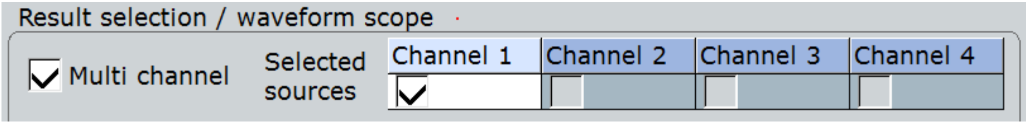
If disabled, you can export one Source waveform.

You can reload exported muliple channels if they are stored in BIN format. The import asks you to assign each stored waveform to a reference waveform.

Remote command:
`EXPort:WAVeform:MULTichannel` on page 1146

Selected sources

Select the channels to be included in data export if "Multichannel export" is enabled. Waveform1 of up to four input channels can be saved into one file.



Remote command:
CHANnel<m>:EXPortstate on page 1147

Scope

Defines the part of the waveform record that has to be stored.

"Full wave-form" Saves the complete waveform record.

"Zoom" Saves the data included in the zoom area if at least one zoom is defined for the source waveform. The start and stop values of the area are shown. If several zooms are defined, select the "Zoom" to be used for export.

"Cursor" Saves the data between the cursor lines if at least one cursor measurement is defined for the source waveform. The start and stop values of the area between the cursor lines are shown. If several cursor sets are defined, select the "Cursor set" to be used for export.

"Gate" Saves the data included in the measurement gate if a gated measurement is defined for the source waveform. Select the "Measurement" for which the required gate is defined. The start and stop values of the gate are shown.

"Manual" Saves the data between user-defined "Start" and "Stop" values.

Remote command:
EXPort:WAVeform:SCOPe on page 1148
EXPort:WAVeform:STARt on page 1148
EXPort:WAVeform:STOP on page 1149
EXPort:WAVeform:ZOOM on page 1149
EXPort:WAVeform:CURSorset on page 1149
EXPort:WAVeform:MEAS on page 1149

Data logging / Multiple Wfms

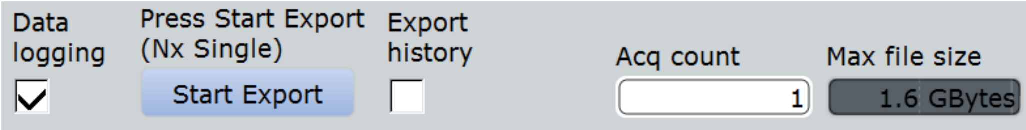
The "Data logging / Multiple Wfms" setting enables the export of subsequent acquisitions of the selected waveforms. If "Export history" is disabled, the setting is named "Data logging", and it exports the data of a running Nx Single acquisition. If "Export history" is enabled, the setting is named "Multiple Wfms", and it exports the history waveform data to file.

If multiple acquisitions of one waveform are exported into a BIN file, the first acquisition can be reloaded as reference waveform.

"Data logging" enables the export of all waveforms of an Nx Single acquisition into one file. The waveform records are written in historical order one after the other, either the complete records or the sections as defined in "Scope". Set the number of acquisitions to be acquired and stored with "Acq. count". The maximum amount of data that can be written is shown in "Max. file size".

Enabling "Data logging" stops a running acquisition. To start the logging, tap Start Export or press RUN N× SINGLE.

Pressing "Run cont" disables data logging.



If "Export history" is enabled, the option "Multiple Wfms" allows you to save several or all history waveforms. Define the part of the history to be exported using "Start acq" and "Stop acq".

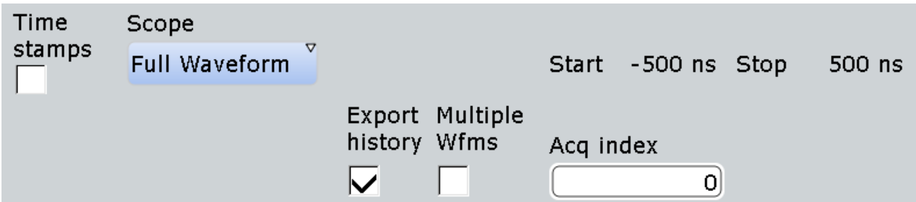
Remote command:
`EXPort:WAVeform:DLOGging` on page 1150

Start Export
Starts an Nx Single acquisition series and simultaneously saves the waveform data to a file if data logging is enabled.

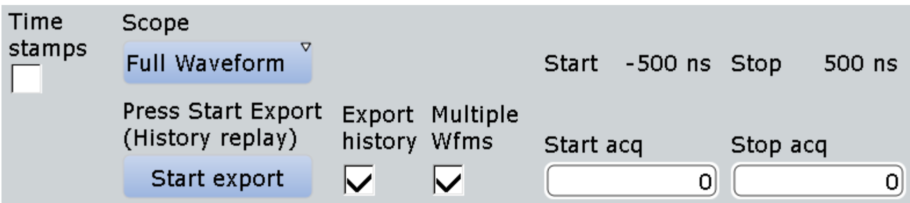
If "Export history" is enabled, the button starts the history replay and simultaneously saves the history waveforms.

Remote command:
`RUNSingle` on page 909 (Nx Single acquisition)
`CHANnel<m>[:WAVeform<n>]:HISTory:PLAY` on page 1007 (History export)

Export history
Enables the history mode and the export of history waveforms to file. The setting is also available in the "History" dialog box under the designation"Show history".



To save one waveform from the history, enter the number of the required acquisition in "Acq index", and tap "Save".



To save several subsequent history waveforms, enable "Multiple Wfms" and define the range of the waveforms to be saved using "Start acq" and "Stop acq". These range settings are also available in the "History" dialog box. Start the history replay and simultaneous saving with "Start Export".

Remote command:
CHANnel<m>[:WAVeform<n>]:HISTory[:STATe] on page 1005
CHANnel<m>[:WAVeform<n>]:HISTory:STARt on page 1006
CHANnel<m>[:WAVeform<n>]:HISTory:STOP on page 1006

Timestamps

If enabled, the relative timestamps of all history waveforms are written into the waveform data file at the beginning of each waveform record.

Remote command:
EXPort:WAVeform:TIMestamps on page 1151

Save to file

Enter the file name to save the waveform to. Double-tap the file name to open the file selection dialog box.

By default, the file name has the prefix "RefCurves_". You can define a pattern for automatic naming in the "Autonaming" tab.

"Save"	Saves the waveform as a reference waveform in the selected file.
"Save As..."	Opens the file selection dialog box and saves the waveform to the selected file. See also Chapter 11.1.7, "File Selection Dialog", on page 408
".bin/.xml/.csv"	Selects the file format. Note that reference waveforms can be loaded from `.bin` files only. See also: Chapter 11.2.1, "Waveform Export Files", on page 410.

Remote command:
EXPort:WAVeform:NAME on page 1147
EXPort:WAVeform:SAVE on page 1148

Interleaved x/y

Includes horizontal values in the export data (time or frequency values, depending on the waveform). X and Y-values are written alternately to the file. If disabled, only Y-values - mostly voltage values - are written.

Interleaved x/y data cannot be exported as raw values, the "Raw (ADC direct)" option is not available.

The setting is not available for the export of digital channel data.

Remote command:
EXPort:WAVeform:INCXvalues on page 1151

Raw (ADC direct)

Enables the export of data in the raw sample format of the ADC. The data format is integer 8 bit (signed 8 bit binary format). This format reduces the file size (1 Byte/sample instead of 4 Bytes/sample in binary files) but decreases the precision of the values.

If the high definition mode is active (option R&S RTE-K17), the data format is integer 16 bit, except for peak detect decimation (8 bit). See "Export" on page 166.

Only y-values are exported, the "Interleaved x/y" option is not available.

Currently, the setting is not available for the export of digital channel data.

Data conversion:

To convert INT8 or INT16 data to physical quantities, e.g. voltages, use the following formulas:

*ConversionFactor = VerticalScale * VerticalDivisionCount / NofQuantisationLevels*

*PhysicalQuantity = (Value_ADC * ConversionFactor) + VerticalOffset*

The raw values are written in the `*.Wfm.*` file, all other values can be found in the corresponding header file.

	INT8	INT16, HD mode
VerticalScale	0.05	0.05
NofQuantisationLevels	253	253 * 256
VerticalDivisionCount	10	10
Value_ADC	-61	-61
ConversionFactor	0.05 * 10 / 253 = 0,00197628	0.05 * 10 / (253 * 256) = 0,0000771986
Voltage	(-61 * 0,00197628) + 0 = -120,5 mV	(-61 * 0,0000771986) + 0 = -4,7091146 mV

Remote command:
`EXPort:WAVeform:RAW` on page 1151

Byte order
Sets the endianess for INT16 data:
- LSB first: little endian, least significant byte first
- MSB first: big endian, most significant byte first

Remote command:
`FORMat:BORDer` on page 888

11.2.3 Waveform Histograms

Access: FILE > "Waveforms/Results > Wfm Histograms"

The waveform histogram export saves data in two files. The `*.Wfm.*` file contains 256 or 512 absolute or relative histogram values. The other file is the header file.

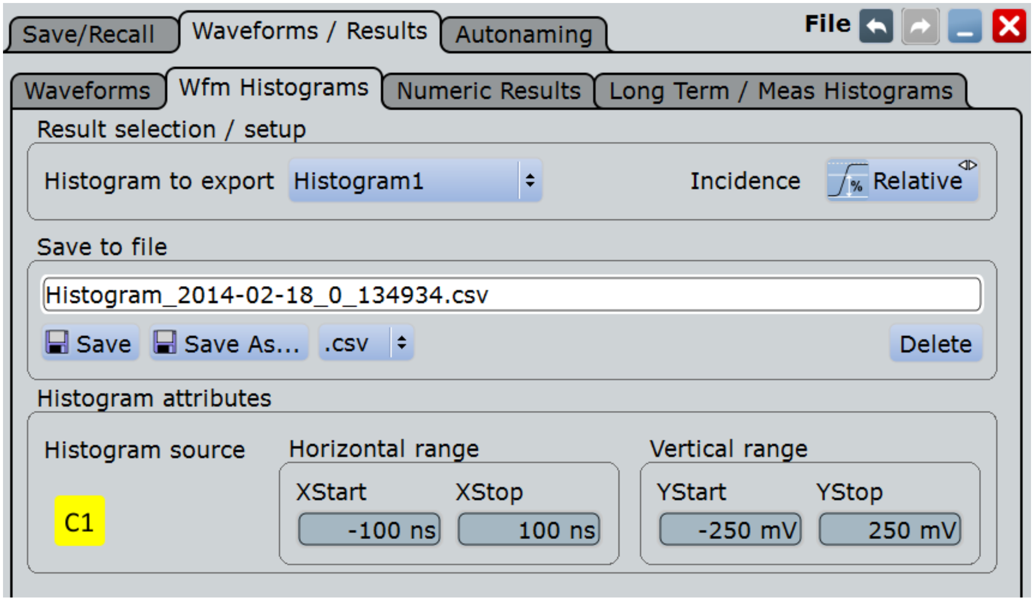
Contents of the header file:
- Source waveform of the histogram
- Histogram mode: vertical or horizontal
- Incidence of exported values: absolute or relative
- Histogram range: XStart, XStop, YStart, YStop
- Name of the exported histogram

Data conversion:

Using the header data, you can calculate the waveform value to which a histogram value belongs:

*YValue = (YStop - YStart) / HistogramValuesCount * HistogramValueNumber + YStart*

YStart	-0.25 V
YStop	0.25 V
HistogramValuesCount	256 (total number of written rows in an CSV file)
HistogramValueNumber	68 (number of the row in an CSV file)
Y-Value	(0.25 - (-0.25)) / 256 * 68 - 0.25 = -0.11719 V



Histogram to export
Selects the histogram to be exported. All active waveform histograms are shown in the list.

Measurement histograms can also be exported, see Chapter 11.2.5, "Long Term / Meas Histograms", on page 425.

Remote command:
`EXPort:HISTogram:SELect` on page 1152

Incidence
Sets the mode of exported histogram data: relative or absolute count of values. If relative values are exported, the sum of all values is 1, and and the count of each value is set in relation to the sum.

Remote command:
`EXPort:HISTogram:INCidence` on page 1152

Save to file
Enter the file name to save the waveform histogram to. Double-tap the file name to open the file selection dialog box.

By default, the file name has the prefix "Histogram_". You can define a pattern for automatic naming in the "Autonaming" tab. The default directory is:

`C:\Users\Public\Documents\Rohde-Schwarz\RTE\Histograms`

"Save" Saves the histogram data in the selected file.

"Save As..." Opens the file selection dialog box and saves the histogram data to the selected file. See also Chapter 11.1.7, "File Selection Dialog", on page 408

".bin/.xml/.csv" Selects the file format.

Remote command:
`EXPort:HISTogram:NAME` on page 1153
`EXPort:HISTogram:SAVE` on page 1153
`EXPort:HISTogram:DATA?` on page 1153

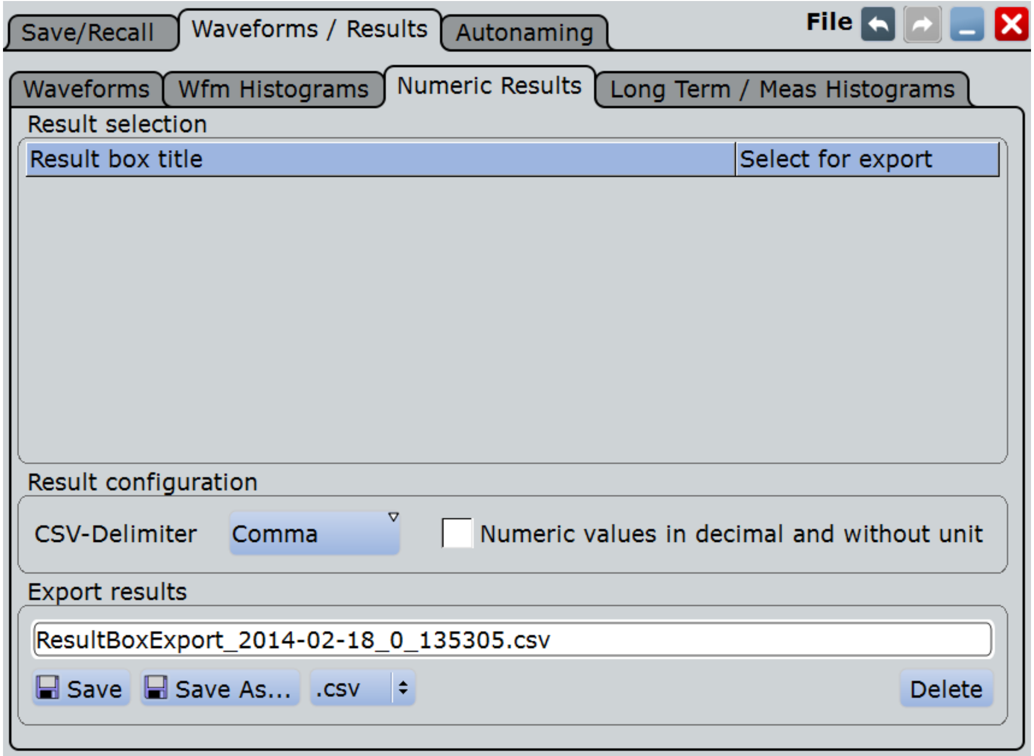
Histogram source, Horizontal range, Vertical range
Show the source and the limits of the histogram area for information. The ranges are set in the "Histogram" dialog box ("Meas" menu > "Histogram"). See also: Chapter 7.2.8.2, "Histogram Setup", on page 313.

11.2.4 Numeric Results

In this tab, you can select the result boxes to be saved, and define the storage settings.

Access: FILE > "Waveforms/Results > Numeric Results"

Access to the tab is also available in all tabs where measurement and analysis settings are defined, for example, in the "Measurements Setup", "Cursors Setup", and "Masks Test Definition" tabs: Simply tap the "Result Export" button.



Result selection
The table lists all result boxes that are currently open, including minimized boxes and docked boxes. Select the results that you want to save to file. All results are written into one file.

Note: If the result box is minimized, only the columns shown on the result icon are saved (2 columns). Statistical results are not shown on the minimized results icon, and they are not saved.

CSV-Delimiter
Selects the value delimiter that is used to convert the values in columns. For MS Excel, the semicolon is recommended to be used.

Numeric values without unit
By default, numeric result values are written with their unit to the file. If the option is ennabled, the values are saved with more decimal places.

Export results
Enter the file name to save the results to. Double-tap the file name to open the file selection dialog box.

By default, the file name has the prefix "ResultBoxExport_". You can define a pattern for automatic naming in the "Autonaming" tab.

"Save"	Saves the selected results to the indicated file.
"Save As..."	Opens the file selection dialog box and saves the selected results to the selected file. See also Chapter 11.1.7, "File Selection Dialog", on page 408

".csv/.html" — Selects the file format.

- CSV: Comma-Separated Values.
  You can select the value delimiter with "CSV-Delimiter" to ensure that the file can be read by the analyzing software. The decimal separator is the point.
  Tipp for using MS Excel: It is recommended that you use the semicolon as csv delimiter. When you open the file with MS Excel, use "File > Open" and follow the wizard to set the separators correctly, or set the separator settings with "Tools > Options > International".
- HTML: Results are saved as web page for display in a browser.

11.2.5 Long Term / Meas Histograms

Access: FILE > "Waveforms / Results > Long Term / Meas Histograms"

You can export the data of long term measurements and the measurement histogram data to file .

The measurement export saves results in two files. The `*.Wfm.*` file contains data values, and the other file is the header file.

The header file contains:

- Source waveform of the measurement
- Measurement scale
- Export type = Histogram or Long term
- Exported measurement
- Histogram range: XStart, XStop, YStart, YStop
  The range is only relevant for export type = histogram. The measurement axis is the X-axis, which can be a horizontal or vertical axis depending on the histogram mode.

Long term measurements: The `*.Wfm.*` file contains one value or value set for each long term measurement point. The maximum number of points is defined in the "Horizontal scaling" dialog box.

- If statistics are disabled, the current result of the main measurement is written - one double value per long term point.
- If statistics are enabled, seven values for each long term point are saved:
  – Current value of the long term point
  – Upper peak
  – Lower peak
  – Average
  – Standard deviation
  – Event count per point: number of measurement results that creates one long term point
  – Waveform count per point: number of waveforms included in one long term point.

Measurement histogram: The `*.Wfm.*` file contains 1000 absolute or relative histogram values.

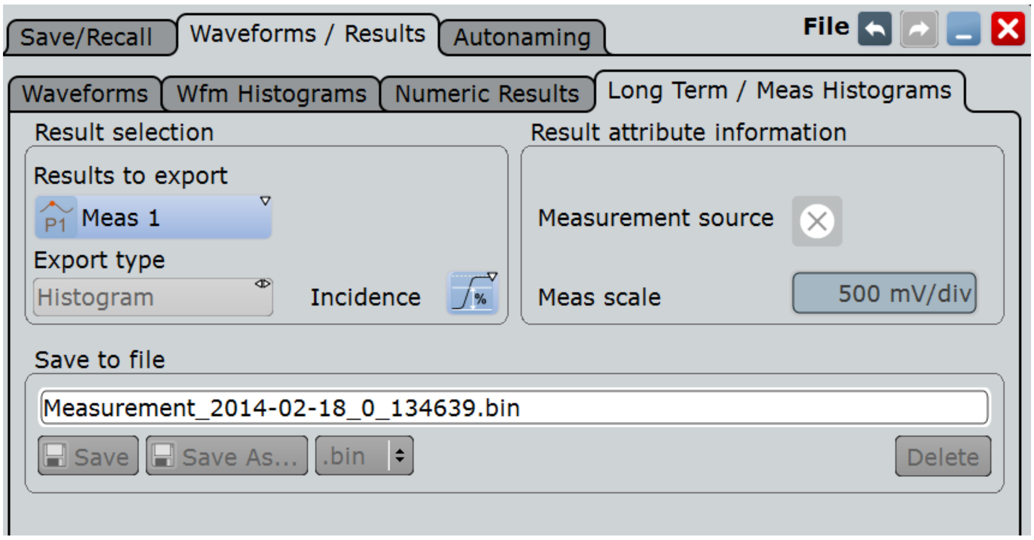
Data conversion of measurement histogram data:

Using the header data, you can calculate the measurement value to which a histogram value belongs:

*MeasValue = (XStop - XStart) / 1000 * HistogramValueNumber + XStart*

Example: The 273rd histogram value is 0.491749. That means, the relative frequency of the measurement value 0.1246 V is 0.491749.

XStart	0.07 V
XStop	0.27 V
HistogramValueNumber	273 (number of the row in an CSV file)
MeasValue	(0.27 - 0.07) / 1000 * 273 + 0.07 = 0.1246 V



Results to export
Selects the measurement to be exported.

Remote command:
`EXPort:MEASurement:SELect` on page 1153

Export type
You can export the result data of the long term measurement, or the measurement histogram. To export the data, the required type must be enabled in "Measurements > Long Term/Track": "Long term Enable" or "Histogram Enable".

Remote command:
`EXPort:MEASurement:TYPE` on page 1154

Incidence

Sets the mode of exported histogram data: relative or absolute count of values. If relative values are exported, the sum of all values is 1, and and the count of each value is set in relation to the sum.

Remote command:
`EXPort:HISTogram:INCidence` on page 1152

Measurement source, Meas scale

Show the measurement settings source and scale for information.

Save to file

Enter the file name to save the measurement data to. Double-tap the file name to open the file selection dialog box.

By default, the file name has the prefix "Measurement_". You can define a pattern for automatic naming in the "Autonaming" tab. the default directory is:

`C:\Users\Public\Documents\Rohde-Schwarz\RTE\Measurements`

"Save"	Saves the measurement data in the selected file.
"Save As..."	Opens the file selection dialog box and saves the measurement data to the selected file. See also Chapter 11.1.7, "File Selection Dialog", on page 408
".bin/.xml/.csv"	Selects the file format.

Remote command:
`EXPort:HISTogram:NAME` on page 1153
`EXPort:MEASurement:SAVE` on page 1154
`EXPort:MEASurement:DATA?` on page 1155

11.2.6 Saving and Loading Waveform Data

You can save the data of a channel, math or reference waveform to an `.xml`, `.csv`, or `.bin` file. The data export of several channels into one file is also possible. Files in `.bin` format can be reloaded to the R&S RTE as reference waveforms.

Instead of a complete waveform, you can also save a part of it, limited by a previously defined zoom, cursor lines, measurement gate or user-defined time values.

To save waveform data quickly, you can add the "Save Waveform" icon to the toolbar and use it for saving. The icon does not work for saving actions that are started with "Start export" (data logging and multiple history waveforms). .

It is also possible to save history data to file. Furthermore, you can save a "live record" of a running RUN Nx SINGLE acquisition to one data file.

For details on waveform save/recall settings, see Chapter 11.2.2, "Waveforms - Export Settings", on page 416.

The following procedures are described:

- "To save a waveform or a part of a waveform to a file" on page 428
- "To save a waveform using the toolbar icon" on page 428

- "To export waveform data of a running acquisition" on page 428
- "To save the history data" on page 263
- "To load a reference waveform" on page 241
"To save a reference waveform" on page 240

To save a waveform or a part of a waveform to a file

1. Press the FILE key.
2. Tap the "Waveforms/Results" tab.
3. Tap the "Waveforms" sub-tab.
4. Select the waveform(s) to be saved:
   - To save one waveform, tap the "Source" icon and select the waveform.
   - To save data of several channels, enable "Multi channel" and select the channels.
5. In the "Scope" list, select the part of the waveform record to be saved. Zoom, cursor and gate segments require the according setup for the selected waveform before saving. For "Manual", enter the "Start" and "Stop" time of the section.
6. Check the file name under "Save to file" and change it if needed. Usually, autonaming is used.
7. Check the file format and the "Export format" settings and change them if needed.
8. Tap "Save" to save the waveform data to the specified file.
   Tap "Save As" to save the waveform data to a different file or file type. Select the file from the file selection dialog box.

To save a waveform using the toolbar icon

1. Add the "Save Waveform" icon to the toolbar, see Chapter 2.4.5.2, "Configuring the Toolbar", on page 92.
2. Set the scope, export format, and other parameters in FILE > "Waveforms / Results" > "Waveforms".
3. If necessary, adjust the autonaming pattern and the storage path in FILE > "Autonaming".
4. To save the waveform data:
   a) Tap the "Save Waveform" icon on the toolbar.

   b) Tap the waveform to be saved.
   If you tap the diagram background, the data of the focused waveform is saved.

To export waveform data of a running acquisition

1. Select the waveform(s) to be saved and the scope as described in "To save a waveform or a part of a waveform to a file" on page 428, step 1 to 5.

2. If you want to save only a section of each waveform, set the "Scope".
3. Enable "Data logging".
4. Enter the number of acquisitions to be acquired and saved in "Acq count".
5. Check the file name under "Save to file" and change it, if needed. Usually, auto-naming is used.
6. Tap "Start Export" to start the acquisition and to save the acquired waveform data to the specified file.

To load waveform data as a reference waveform

In order to re-load waveform data from a previous measurement, the waveform must have been stored as a reference waveform in a BIN file before.

The procedure is described in "To load a reference waveform" on page 241

11.3 Screenshots

To store the graphical results of the measurement, you can either print the current display on a printer or save an image to a file. The instrument saves or prints a screenshot of the graphic area. To document current settings, the open dialog box can be included in the screenshot.

The "Save Screenshot" toolbar icon saves the current display to a file according to the settings in "File" menu > "Print setup". See also Chapter 2.4.5.2, "Configuring the Toolbar", on page 92.

You can configure the PRINT key to save or print screenshots by a single keypress. See also Chapter 3.3.2, "Hardkeys: Function Assignment", on page 113.

If you want to save all user data (for example screenshots, waveform data, settings...) to a USB flash drive, change the default path of the user data directory: FILE > "Auto-naming" tab > "Default path for all file operations" > tap the USB flash drive symbol in the file explorer.

Meta information in screenshots

The meta data of the screenshot also contains instrument information. In PNG and JPEG files, meta information is saved as EXIF information and can be read, for example, using the ExifTool.

Example:

Reading meta information using the ExifTool

Command: `# exif C:\Screenshot_2016-07-14_0_110551.png`

Result:

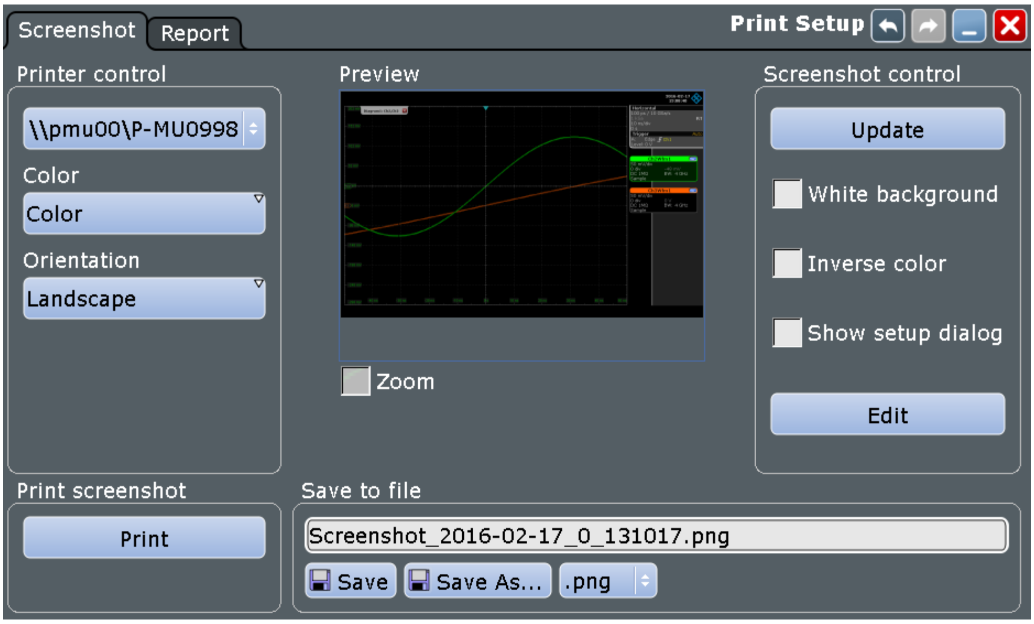
```
ExifTool Version Number          : 10.20
File Name                        : Screenshot_2016-07-14_0_110551.png
Directory                        : C:/
File Size                        : 37 kB
File Modification Date/Time      : 2016:07:14 11:05:51+02:00
File Access Date/Time            : 2016:07:14 11:05:51+02:00
File Creation Date/Time          : 2016:07:14 11:05:51+02:00
...
Instrument Firmware Version      : 3.30.0.46
Instrument Material Number       : 1329.7002k44
Instrument Serial Number         : 123456
Image Size                       : 1280x800
Megapixels                       : 1.0
```

11.3.1 Screenshot Settings

Access: "File" menu > "Print setup"

In the "Screenshot" dialog box, you configure the image to be printed, saved, or included in a report. You select the printer and the storage location for screenshot files. In addition, you can edit the image before saving or printing, and include an open dialog box in the image. The image is created when you open the dialog box, and can be updated at any time.

You can print and save the image in the "Screenshot" dialog box. To save screenshots quickly, use the "Save Screenshot" toolbar icon, or configure and use the PRINT key.



Printer

Selects a configured printer to print screenshots and reports. You can use a local printer or a network printer. The instrument firmware uses the Windows printer configuration, no additional printer setup is required. To make a printer available for R&S RTE, add and configure it in the Windows operating system: "Devices and Printers"

Depending on the printer driver, printing to a file is also possible. By default, the "RS Printer" drivers for JPG, PDF, PNG, and TIFF files are installed. To configure the name and storage location of the printed files, open the Windows printer configuration window (see above) and select "File > Printing Preferences > Save" for the required driver.

Remote command:
`SYSTem:COMMunicate:PRINter:SELect<1..2>` on page 1160

Color

Defines the color mode for printing. The setting affects the output on a printer and also the printing to a file using the "RS Printer" drivers for JPG, PDF, PNG, and TIFF files.

"Black and white"	Black and white output
"Color"	Color output

Remote command:
`HCOPy:DEVice<m>:COLor` on page 1157

Orientation
Toggles the page orientation between "Landscape" and "Portrait."

Remote command:
`HCOPy:PAGE:ORIentation<1..2>` on page 1157

Print
Prints the current image together with saved editing changes on the selected Printer.

If the printer is configured to print to a file, "Print" is an alternative of "Save image to file".

Remote command:
`HCOPy:DESTination<1..2>` on page 1156
`HCOPy:IMMediate<m>[:DUM]` on page 1158
`HCOPy:IMMediate<m>:NEXT` on page 1159

Preview
Shows a preview of the screenshot. The image is created when the dialog box opens.

Zoom ← Preview
Enlarges the preview display and adds scrollbars to zoom into specific areas of the print image. Zooming does not affect the original display.

Update
Updates the preview of the screenshot with the current display view, e.g. after changes to the settings have been made, or an additional channel has been activated.

White background
Inverts the background color. So you can print waveforms with normal waveform colors on white background.

Remote command:
`HCOPy:WBKG` on page 1158

Inverse color
Inverts the colors of the output, i.e. a dark waveform is printed on a white background.

Remote command:
`HCOPy:DEVice<m>:INVerse` on page 1157

Show setup dialog
If you want to save dialog boxes in screenshots, enable "Show setup dialog". The currently open dialog box is included in the screenshot. Use the PRINT key to print or save the display.

Remote command:
`HCOPy:SSD` on page 1158

Edit
Opens the screenshot in the Paint application. Edit the image as necessary. You can store the file using "Save as" or print the file from Paint. Alternatively, save the file and close the Paint application to return to the "Print Setup" dialog, then print or save the edited image. The changes are not shown in the preview.

Save to file
Defines the filename to which screenshot is saved. By default, the filename has the prefix "Screenshot_". Double-tap the filename to open the file selection dialog box.

If you want to save all user data (for example screenshots, waveform data, settings...) to a USB flash drive, change the default path of the user data directory: FILE > "Auto-naming" tab > "Default path for all file operations" > tap the USB flash drive symbol in the file explorer.

"Save"	Saves the current screenshot to the specified file.
"Save As..."	Opens the file selection dialog box. Here you can adjust the target directory and the file name and save the current screenshot to the file. The symbols of important target folders are listed on the left of the file explorer.
"Delete"	Opens the file selection dialog box and deletes the selected file.

Remote command:
`HCOPy:DEVice<m>:LANGuage` on page 1156
`HCOPy:DESTination<1..2>` on page 1156
`MMEMory:NAME` on page 1156
`HCOPy:IMMediate<m>[:DUM]` on page 1158
`HCOPy:IMMediate<m>:NEXT` on page 1159
`MMEMory:DELete` on page 1141

11.3.2 Printing Screenshots

You can configure the format and colors used for printing, and edit the image.

1. Open the "File" menu and select "Print setup". You can use a local printer or a network printer. Depending on the printer driver, printing to a file is also possible. See also "Printer" on page 431.
2. Tap the printer selection box and select the printer.
3. Tap the "Color" selection box to configure black and white or color images.
4. Tap the "Orientation" selection box and select the paper format.
5. To enhance the images for print on white paper, enable "White background" or "Inverse color".

6. If the current display is likely to have changed since you have opened the "Print Setup" dialog box (e.g. due to a running measurement), tap "Update image".
   The screenshot is updated.
7. To zoom into the screenshot, enable the "Zoom" option beneath the preview area.
   The image is enlarged and scrollbars are displayed to scroll through the image.
8. To edit the image in an external application and process it further from there, tap "Edit image".
9. To print the image to the selected printer, tap "Print".

11.3.3 Configuring and Saving Screenshots

You can edit the image, invert all colors, and set the background color. A preview of the current image is shown for reference.

1. Open the "File" menu and select "Print setup".
2. To enhance the images for later print on white paper, enable "White background" or "Inverse color". If you print this image later on a monochrome printer, you get a grayscaled picture. The contrast of the resulting gray lines depends on waveform colors and the used printer.
3. Select the file format: png, jpg, or another one.
4. By default, screenshots are saved in the `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\ScreenShots` directory. To change the directory, tap "Save As" and configure the path. The symbols of important target folders are listed on the left of the file explorer.
5. Tap "Save".
   The file is saved and the dialog box closes.
6. Check if the screenshot was saved to the desired directory.
7. To save further screenshots, use one of the following ways:
   - Configure the PRINT key. Press the key to save a screenshot. See also Chapter 3.3, "Frontpanel Setup", on page 112.
   - Add the "Save Screenshot" icon to the toolbar. Tap the icon to save an image. See also Chapter 2.4.5.2, "Configuring the Toolbar", on page 92.
   - In the "Print setup" dialog box, tap "Save" to save the image to the specified file.
   - To save the image with a dedicated filename or to another directory, open the "Print setup" dialog box and tap "Save As". Select the path, enter a filename, and tap "Save".

Printing on a black-and-white printer

- If you use the "White background" or "Inverse color" settings and save the image to a file, you get a grayscaled picture. The contrast of the resulting gray lines on the printout depends on waveform colors and the used printer.
- To get a monochrome image, set the "Color = Black and white" and tap "Print" to start the direct printout or the print to file. See also "Printer" on page 431.

11.4 Reports

Reports document the current measurement and test results. The report contains general information, current vertical and horizontal settings, trigger settings, active channels and all current results except for zoom and search results. A screenshot is also included.

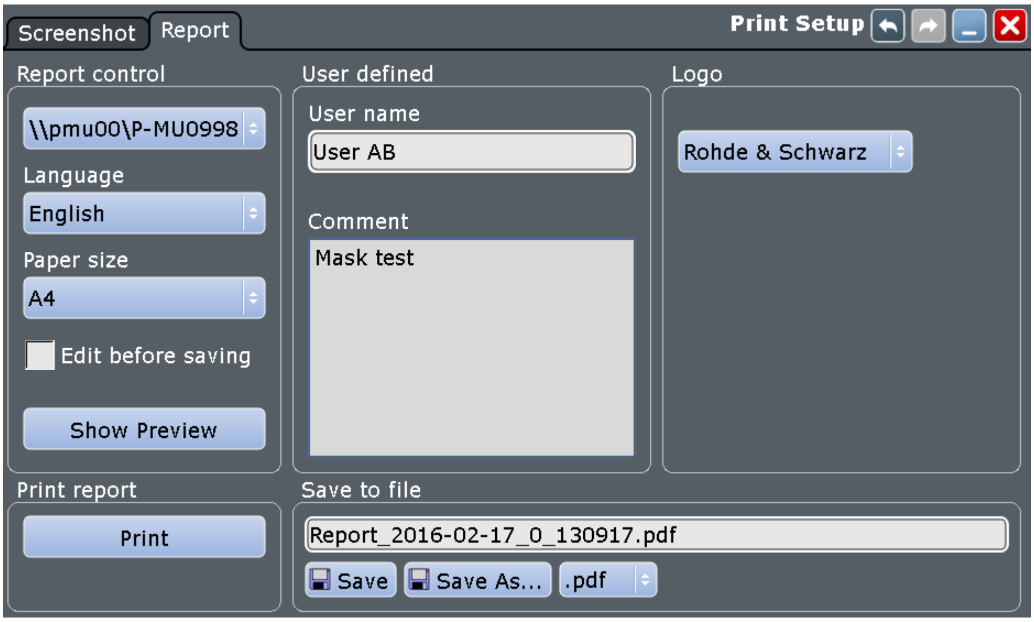
The report is configured in the "Report" tab, the screenshot is configured in the "Screenshot" tab.

You can create the report manually, or automatically on defined events:

- Press the PRINT key. Before, configure the key to create or print reports, see Chapter 3.3, "Frontpanel Setup", on page 112
- Tap the "Create report" toolbar icon.
  Before, add the icon to the toolbar, see also Chapter 2.4.5.2, "Configuring the Toolbar", on page 92.
- Action on micro button, available on active Rohde & Schwarz probes
- Action on trigger
- Event action at mask testing

11.4.1 Report Settings

Access: "File" menu > "Report Setup"



Printer
See "Printer" on page 431.

Language
Selects the language to be used in the report. Available languages are listed in the data sheet.

Remote command:
`REPort:LANGuage` on page 1160

Paper size
Selects the paper size: A4 or US Letter.

Remote command:
`REPort:PAPersize` on page 1160

Edit before saving
Enable to edit the report info when you save reports using the PRINT key. When you press the key, a dialog box opens where you can change the user name and the comment.

Show Preview
Opens the current report in PDF format.

User name / Comment
Enter information that appears in the general information section at the beginning of the report.

Remote command:
`REPort:USER` on page 1161
`REPort:COMMent` on page 1161

Logo

By default, the Rohde & Schwarz logo is shown in the header of the report pages. You can switch the logo off, or select your logo to be shown. A preview of the selected log file is shown.

Remote command:
`REPort:LOGType` on page 1160
`REPort:LOGO` on page 1161

Print

Starts the printout to the configured printer.

Save to file

Select the file format and define the filename of the report file. By default, the filename has the prefix "Report_".

Double-tap the filename to open the file selection dialog box.

"pdf/doc/html"	Selects the report format.
"Save"	Saves the current report to the specified file.
"Save As..."	Opens the file selection dialog box and saves the report to the selected file.

Remote command:
`REPort:FILE:NAME` on page 1161
`REPort:FILE:SAVE` on page 1161

12 Protocol Analysis

Using the serial protocol options for the R&S RTE, you can analyze various serial protocols.

12.1 Basics of Protocol Analysis

Before you can analyze a serial signal, the bus has to be configured according to the protocol and specifics of the signal. The configuration contains:

- Assignment of the data and clock lines to the input channels
- Logical thresholds
- Protocol-specific settings

Serial data can be analyzed in several ways:

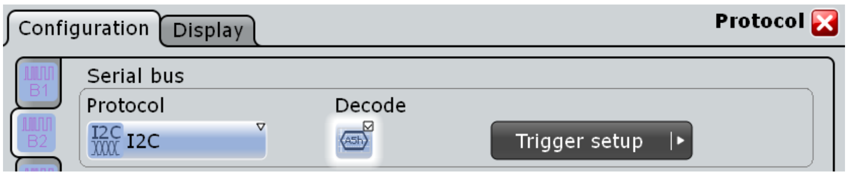
- Triggering: You can trigger on various events that are typical for the selected protocol type, for example, on start and stop of messages, on specific addresses, or on specified data patterns in the message.
  Triggering on a trigger event sequence is not supported, and holdoff settings are not available.
- Protocol decoding: The digitized signal data is displayed on the screen together with the decoded content of the messages in readable form, and the decode results are listed in a table.
- Search on decoded signal data: For most serial protocols, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can be combined, and you get the results for the complete acquisition cycle.

12.1.1 Configuration - General Settings

For all protocols, configuration starts with the selection of the serial bus and the protocol. The "Trigger Setup" button leads directly to the trigger configuration.

Protocol-specific configuration settings are described in the protocol chapters:

- I²C: Chapter 12.2.2, "I²C Configuration", on page 448
- SPI: Chapter 12.3.2, "SPI Configuration", on page 465
- UART: Chapter 12.4.2, "UART Configuration", on page 477
- CAN and CAN FD: Chapter 12.5.1, "CAN and CAN-FD Configuration", on page 485
- LIN: Chapter 12.6.2, "LIN Configuration", on page 524
- FlexRay: Chapter 12.7.1, "FlexRay Configuration", on page 536
- Audio: Chapter 12.8.2, "Audio Signal Configuration", on page 555
- MIL-1553: Chapter 12.9.2, "MIL-STD-1553 Configuration", on page 577
- ARINC 429: Chapter 12.10.2, "ARINC 429 Configuration", on page 596
- Ethernet: Chapter 12.11.2, "Ethernet Configuration", on page 609
- SENT: Chapter 12.12.2, "SENT Configuration", on page 627
- Custom: Manchester / NRZ: Chapter 12.13.2, "Custom: Manchester / NRZ Configuration", on page 659
- MDIO: Chapter 12.14.2, "MDIO Configuration", on page 688
- USB: Chapter 12.15.2, "USB Configuration", on page 708
- SpaceWire: Chapter 12.16.2, "SpaceWire Configuration", on page 737



Make sure that the tab of the correct serial bus is selected on the left side.

Protocol
Defines protocol type of the bus for bus configuration and trigger settings.

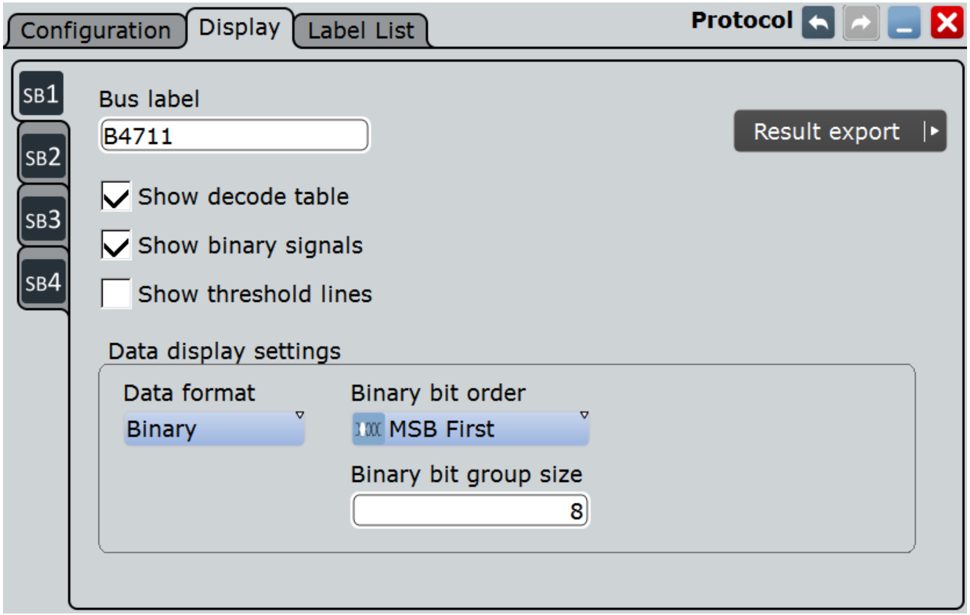
Remote command:
`BUS<m>:TYPE` on page 1162

Decode
Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Remote command:
`BUS<m>[:STATe]` on page 1163

12.1.2 Display

For all protocols, you can select to display the decoded signal as a table and to show the binary signal on the screen. Optionally, you can assign a label to the bus.



Bus label

Defines a label to be displayed with the bus.

Remote command:

BUS<m>:LABel on page 1163

Show decode table

Opens a table with decoded data of the serial signal. The function requires the option for the analyzed protocol.

The decode results are protocol-specific. They are described in the related chapters:

- I²C: Chapter 12.2.5, "I²C Decode Results ", on page 456
- SPI: Chapter 12.3.4, "SPI Decode Results ", on page 471
- UART: Chapter 12.4.4, "UART Decode Results ", on page 482
- LIN: Chapter 12.6.5, "LIN Decode Results", on page 530
- CAN: Chapter 12.5.4, "CAN and CAN FD Decode Results", on page 504
- Audio signals: Chapter 12.8.4, "Audio Decode Results", on page 564
- FlexRay: Chapter 12.7.4, "FlexRay Decode Results", on page 546
- MIL-1553: Chapter 12.9.5, "MIL-STD-1553 Decode Results", on page 587
- ARINC 429: Chapter 12.10.5, "ARINC 429 Decode Results", on page 602
- Ethernet: Chapter 12.11.3, "Ethernet Decode Results", on page 614
- SENT: Chapter 12.12.5, "SENT Decode Results", on page 647
- MDIO: Chapter 12.14.5, "MDIO Decode Results", on page 695
- USB: Chapter 12.15.4, "USB Decode Results", on page 722
- SpaceWire: Chapter 12.16.4, "SpaceWire Decode Results", on page 743

Remote command:

BUS<m>:RESult on page 1164

Show binary signals
For each configured line, the binary signal is displayed additionally to the decoded signal.

Show threshold lines
If selected, the threshold levels are displayed in the diagram.

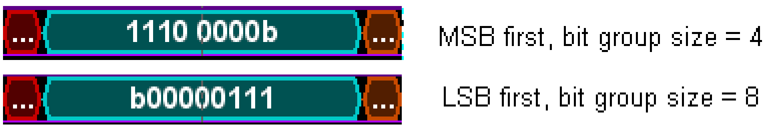
Data format
Sets the data format for decoded data values of the selected bus in the "Decode results" box and in the combs of the decoded signal.

Remote command:
`BUS<m>:FORMat` on page 1164

Binary bit order
Select MSB or LSB to define the data bit order in the combs of the decoded signal. The setting is only available for the binary data format, and only for protocols sending data LSB first (UART, SPI, LIN, Audio, ARINC429).

If the "Binary bit order" is LSB, you can read the bits of an LSB first signal in LSB first order in the combs while the results table displays the correct values MSB first.

Binary bit group size
Sets the number of bits that forms a bit group in the comb display of the selected bus. The setting is only available for the binary data format, and only for protocols sending data LSB first (UART, SPI, LIN, Audio, ARINC429).



12.1.3 Label Lists

For all protocols using ID or address identification, it is possible to create label lists containing addresses or IDs, a symbolic name for each node (symbolic label), and some protocol-specific information. You can load label lists, and activate its usage for decoding. As a result, an additional "Label" column appears in the "Decode results" table, containing the symbolic label. The frame captions of the decoded signal show the symbolic label instead of the ID or address values so it is easy to identify the messages of the different bus nodes.

Available file formats are PTT, CSV, DBC (CAN only), and XML (FIBEX files, FlexRay only).

12.1.3.1 Content and Format of the PTT File

Label lists are stored as PTT (protocol translation table) files. The PTT file format is an extension of the CSV format (comma separated values). You can edit it with standard editors, for example, with MS Excel or a text editor.

The PTT file has three types of lines:

- Comment lines begin with a hash character #. A hash character at any other position in the line is treated like a standard character.
- Command lines begin with a commercial at character @. An @ character at any other position in the line is treated like a standard character.
- Standard lines are the lines that not qualify as comment or command lines. They build the core of the label list.

Command lines

Command lines define the version of the PTT file and the protocol name:

- @FILE_VERSION: must appear exactly once in the file
- @PROTOCOL_NAME: must appear at least once in the file. Thus, one file can contain several label lists for different protocols.

```
# --- Start of PTT file
@FILE_VERSION  = 1.0
@PROTOCOL_NAME = i2c
[... Label list for I2C]
@PROTOCOL_NAME = can
[... Label list for CAN]
# --- End of PTT file
```

Standard lines

Standard lines define the contents of the label list. The rules for standard lines follow the csv convention, they are:

- Values are separated by commas
- Space characters following a delimiter are ignored
- Values with a special character (comma, newline, or double quote) must be enclosed in double quotes
- Text in double quotes must be escaped by double quote characters

The format of the numeric value is indicated by a suffix. The following formats are supported:

Format	Suffix	Example
Decimal	<empty> d	`106, DeviceName` `106d, DeviceName`
Hexadecimal	h	`6Ah, DeviceName` or prefix: `0x6A, DeviceName`
Octal	o	`152o, DeviceName`
Binary	b	`01101010b, DeviceName`

The maximum supported word size for (unsigned) integers is 64 bits.

```
# --- Start of PTT file
@FILE_VERSION  = 1.0
```

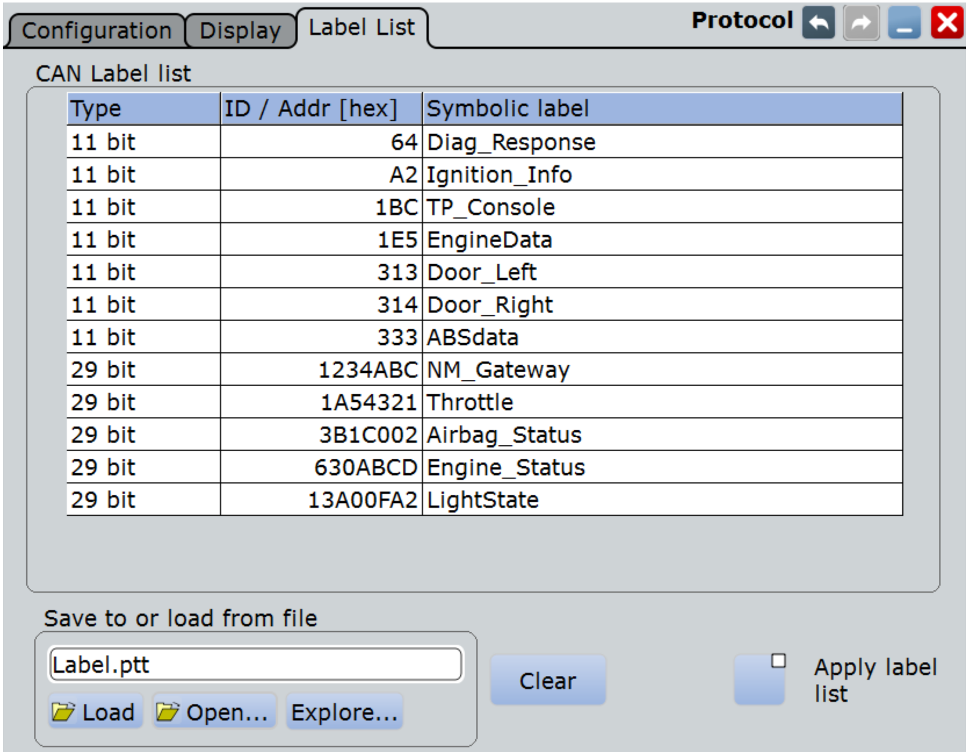
```
@PROTOCOL_NAME = i2c
#    Following two lines are equal:
7,01h,Temperature
7,01h, Temperature
#    A comma must be enclosed in double quotes:
7,01h,"Temperature, Pressure, and Volume"
#    A double quote must also be enclosed in double quotes:
7,7Fh,"Highspeed ""Master"" 01"
#    Following lines yield the same result:
7d,0x11,Pressure
7h,11h,Pressure
0x7,17d,Pressure
7,17,Pressure
```

Label lists are protocol-specific. Their contents are described in the corresponding protocol chapters:

- Chapter 12.2.4, "I²C Label List", on page 455
- Chapter 12.5.3, "CAN / CAN FD Label List", on page 502
- Chapter 12.6.4, "LIN Label List", on page 529
- Chapter 12.7.3, "FlexRay Label List", on page 544
- Chapter 12.10.4, "ARINC 429 Label List", on page 602
- Chapter 12.9.4, "MIL-STD-1553 Label List", on page 586

12.1.3.2 Label List - General Settings

In the "Label List" tab, you can load, read and activate label list files.



The common settings for all protocols are:

Save to or load from file
Selects and loads a label list file. Available file formats are PTT, CSV, DBC (CAN only), and XML (FIBEX files, FlexRay only).

Label lists are protocol-specific. Their contents are described in the corresponding protocol chapters:

- Chapter 12.2.4, "I²C Label List", on page 455
- Chapter 12.5.3, "CAN / CAN FD Label List", on page 502
- Chapter 12.6.4, "LIN Label List", on page 529
- Chapter 12.7.3, "FlexRay Label List", on page 544
- Chapter 12.10.4, "ARINC 429 Label List", on page 602
- Chapter 12.9.4, "MIL-STD-1553 Label List", on page 586

Remote command:
`BUS<m>:NEWList` on page 1165

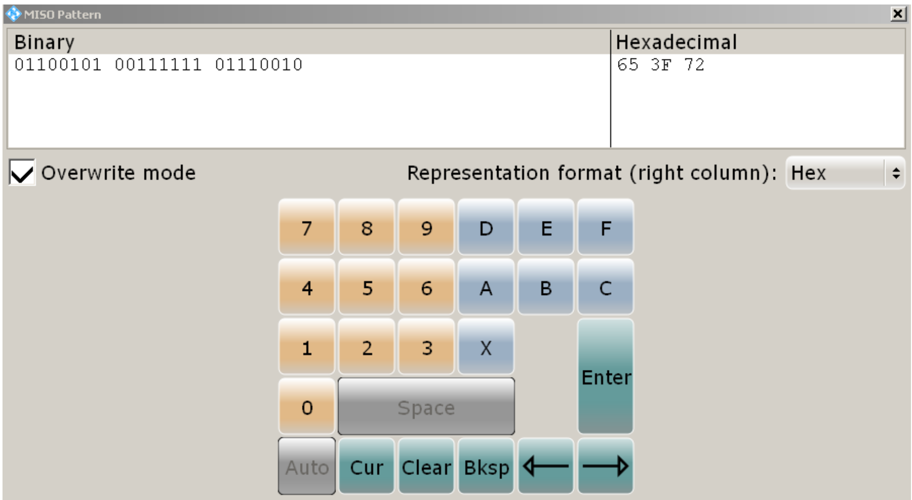
Clear
Deletes the label list from the instrument.

Apply label list
Activates the label list to be used for decoding. The "Label" appear in the "Decode results" table and in the frame captions of the decoded signal.

Remote command:
`BUS<m>:SYMBols` on page 1165

12.1.4 Bit Pattern Editor

If you want to enter a specified address or data pattern, the bit pattern editor helps you to enter the pattern in various formats - decimal, hexadecimal, octal, binary and ASCII.



The editor displays the pattern in two columns. The left column always shows binary data. For the right column, you can select the format, the default depends on the data specifics. You can edit data in the left or right column. The keypad adapts itself to the column format, only keys appropriate to the format are enabled.

The data is grouped and converted in bit groups. The size of a bit group depends on the address or data specifics and is set by the instrument. Groups are automatically separated by blanks. The maximum size of a bit group is 64 bit, the most common group size is 1 byte.

"Overwrite mode": If disabled, the data behind the new digit is shifted to the right. Bit groups are rearranged automatically.

Format-specific information:

- Unsigned: Decimal data format without sign. It is available for I²C, SPI, UART, CAN, LIN and FlexRay protocols. If you enter a decimal number that is too large for the defined bit group, the number is truncated and a message appears. X (don't care) in the decimal column sets all binary digits of the bit group to X.
- Signed: Signed decimal format, available for audio protocols. The first bit represents the sign. You can use the 2's complement or 1's complement format.
- Binary: 0, 1 and X (dont care) are allowed.
- Hex: most common format in the right column.
- Octal: Each digit represents 3 bit.
- ASCII: In the ASCII column, "X" is the character X. The binary X (don't care) is not allowed. If an X is included in the binary value in the left column, the ASCII columns displays "§" to indicate that the value is not defined.

Where applicable, frequently used values are provided in a "Predefined values" list below the pattern table, for example, reserved end words of data packets in the UART protocol.

12.2 I²C (Option R&S RTE-K1)

The Inter-Integrated Circuit is a simple, low-bandwidth, low-speed protocol used for communication between on-board devices.

12.2.1 The I²C Protocol

This chapter provides an overview of protocol characteristics, data format, address types and trigger possibilities. For detailed information, read the "I2C-bus specification and user manual" available on the NXP manuals web page at http://www.nxp.com/.

I²C characteristics

Main characteristics of I²C are:

- Two-wire design: serial clock (SCL) and serial data (SDA) lines
- Master-slave communication: the master generates the clock and addresses the slaves. Slaves receive the address and the clock. Both master and slaves can transmit and receive data.
- Addressing scheme: each slave device is addressable by a unique address. Multiple slave devices can be linked together and can be addressed by the same master.
- Read/write bit: specifies if the master will read (=1) or write (=0) the data.
- Acknowledge: takes place after every byte. The receiver of the address or data sends the acknowledge bit to the transmitter.

The R&S RTE supports all operating speed modes: high-speed, fast mode plus, fast mode, and standard mode.

Data transfer

The format of a simple I²C message (frame) with 7 bit addressing consists of the following parts:

- Start condition: a falling slope on SDA while SCL is high
- 7-bit address of the slave device that either will be written to or read from
- R/W bit: specifies if the data will be written to or read from the slave
- ACKnowledge bits: is issued by the receiver of the previous byte if the transfer was successful
  Exception: At read access, the master terminates the data transmission with a NACK bit after the last byte.
- Data: a number of data bytes with an ACK bit after every byte

- Stop condition: a rising slope on SDA while SCL is high

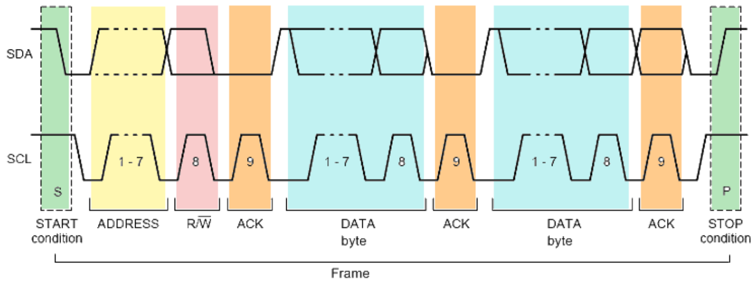


Figure 12-1: I2C write access with 7-bit address

Address types: 7-bit and 10-bit

Slave addresses can be 7 or 10 bits long. A 7-bit address requires one byte, 7 bits for the address followed by the R/W bit.

A 10-bit address for write access requires two bytes: the first byte starts with the reserved sequence 11110, followed by the two MSB of the address and the write bit. The second byte contains the remaining 8 LSB of the address. The slave acknowledges each address byte.

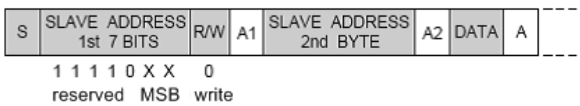


Figure 12-2: 10-bit address, write access

A 10-bit address for read access requires three bytes. The first two bytes are identical to the write access address. The third byte repeats the address bits of the first byte and sets the read bit.

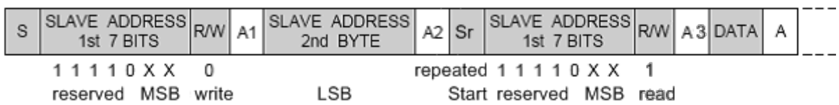


Figure 12-3: 10-bit address, read access

Trigger

The R&S RTE can trigger on various parts of I²C messages. The data and clock lines must be connected to the input channels, triggering on math and reference waveforms is not possible.

You can trigger on:

- Start or stop condition
- Repeated start condition
- Transfer direction (read or write)
- Bytes with missing acknowledge bit
- Specific slave address or address range

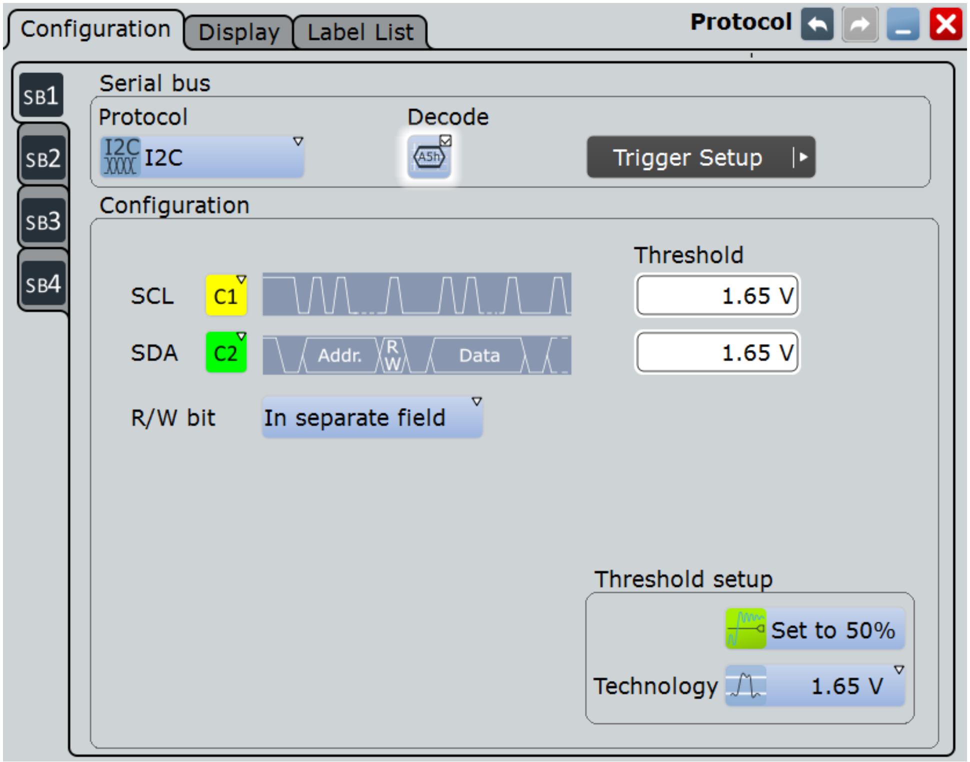
- Specific data pattern in the message

12.2.2 I²C Configuration

12.2.2.1 I²C Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *I2C*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

SDA, SCL

Set the waveforms of the data line (SDA) and clock line (SCL).

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Alternatively, digital channels can be used if MSO option R&S RTE-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
BUS<m>:I2C:SDA:SOURce on page 1168
BUS<m>:I2C:SCL:SOURce on page 1167

Threshold
Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high (1 or true for the boolean logic). Otherwise, the signal state is considered low (0 or false) if the signal value is below the threshold.

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
BUS<m>:I2C:SCL:THReshold on page 1168
BUS<m>:I2C:SDA:THReshold on page 1168
BUS<m>:I2C:TECHnology on page 1169
BUS<m>:SETReflevels on page 1163

R/W bit
Defines if the R/W bit is considered separately or as part of the address. The setting affects the Address setup of the trigger conditions.

Remote command:
BUS<m>:I2C:RWBit on page 1169

12.2.2.2 Configuring I²C Protocol

The configuration of the I²C is simple - assign the two lines to input channels, and set the thresholds.

For details on configuration settings, see Chapter 12.2.2, "I²C Configuration", on page 448.

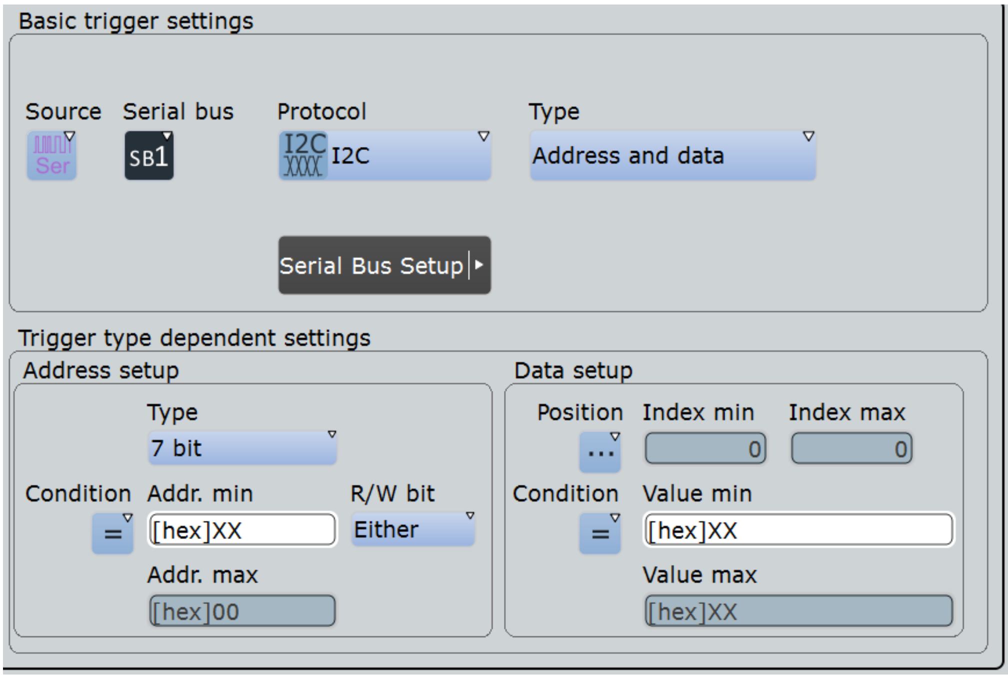
1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.

4. Tap the "Protocol" button and select the protocol: "I2C".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "SDA" button, and select the waveform of the data line.
7. Tap the "SCL" button, and select the waveform of the clock line.
8. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fileds.
9. Enable "Decode", if available.

12.2.3 I²C Trigger

12.2.3.1 I²C Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = I2C"



Make sure that:
- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Serial bus

Selects the serial bus to be triggered on. Make sure to select the correct bus before you enter the settings.

To trigger on a serial bus, the signals sources must be channel signals. If the data or clock source is a math or reference waveform, you cannot trigger on that bus.

Remote command:
`TRIGger<m>:SOURce:SBSelect` on page 1166

Protocol

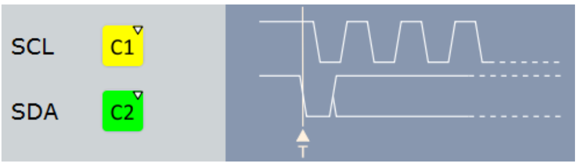
Defines protocol type of the bus for bus configuration and trigger settings.

Remote command:
`BUS<m>:TYPE` on page 1162

Trigger type

Selects the trigger type for I²C analysis.

"Start" Sets the trigger to the start of the message. The start condition is a falling edge on SDA while SCL is high. The trigger instant is the falling edge of the SDA line.
You can change the SDA and SCL lines here if necessary.



"Repeated start" Sets the trigger to a repeated start - when the start condition occurs without previous stop condition. Repeated start conditions occur when a master exchanges multiple messages with a slave without releasing the bus.

"Stop" — Sets the trigger to the end of the message. The stop condition is a rising slope on SDA while SCL is high.

"No Ack (Missing Ack)" — Missing acknowledge bit: the instrument triggers if the data line remains HIGH during the clock pulse following a transmitted byte.
You can also localize specific missing acknowledge bits by setting the No Ack conditions.

"Address" — Sets the trigger to one specific address condition or a combination of address conditions. The trigger time is the falling clock edge of the acknowledge bit after the address.

- Address type
- Specified address or address range
- Read/Write bit

Description of trigger type specific settings: "Address setup" on page 453.

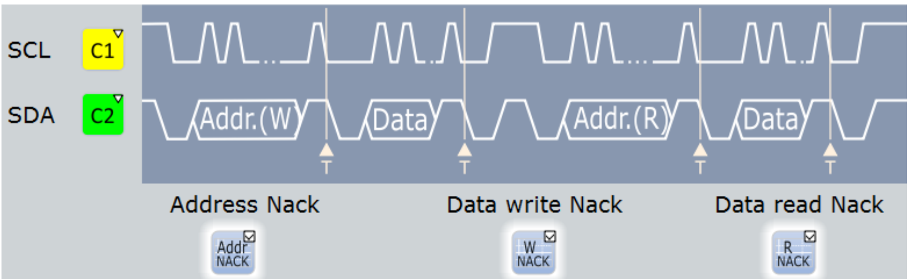
"Address OR" — Triggers on one to four address conditions.
Description of trigger type specific settings: "Address OR conditions" on page 454.

"Address and data" — Sets the trigger to a combination of address and data condition. The address conditions are the same as for the "Address" trigger type, see "Address setup" on page 453 and "Data setup" on page 454.

Remote command:
`TRIGger<m>:I2C:MODE` on page 1170

No Ack conditions

Selects which missing acknowledge bits is detected if the trigger type is set to "Missing Ack".



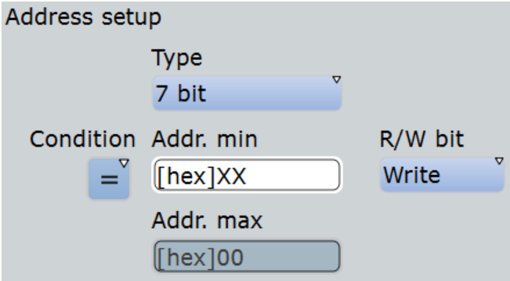
"Address Nack" — No slave recognizes the address.

"Data write Nack" — The addressed slave does not accept the data.

"Data read Nack" — Marks the end of the read process when the master reads data from the slave. This Nack is sent according to the protocol definition, it is not an error.

Remote command:
TRIGger<m>:I2C:ADNack on page 1171
TRIGger<m>:I2C:DWNack on page 1172
TRIGger<m>:I2C:DRNack on page 1172

Address setup
Specifies the address conditions:



Type ← Address setup
Sets the address length to be triggered on: 7 bit, 7+1 bit, or 10 bit. Available settings depend on the R/W bit setting of the bus configuration.

For "7 bit" and "10 bit", enter the address bits in the Addr. min / Addr. max field, and use the "R/W bit" on page 454 field to select the transfer direction.

For "7+1 bit", enter the seven address bits and also the R/W bit in the "Address" field.

If the trigger type is "Address + data", you can set the address type "Any" to trigger on data only, regardless of the address.

Remote command:
TRIGger<m>:I2C:AMODe on page 1172

Addr. min / Addr. max ← Address setup
Defines the bit pattern of the slave device address. The length of the entry is adjusted to the selected address type. In binary format, use the following characters: 1; 0; or X (any bit). The use of X is restricted to the "Address operator"s "Equal" and "Not equal".

The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

Depending on the Condition, a specific address or an address range must be defined.

To trigger on any address, set the "Address operator" to "Equal" and enter *X* for each address bit.

Remote command:
TRIGger<m>:I2C:ADDRess on page 1173
TRIGger<m>:I2C:ADDTo on page 1173

Condition ← Address setup
Sets the operator to set a specific address ("Equal" or "Not equal") or an address range. The address values are set with Addr. min / Addr. max.

Remote command:
TRIGger<m>:I2C:ACONdition on page 1172

R/W bit ← Address setup
Toggles the trigger condition between Read and Write access of the master. Select "Either" if the transfer direction is not relevant for the trigger condition.

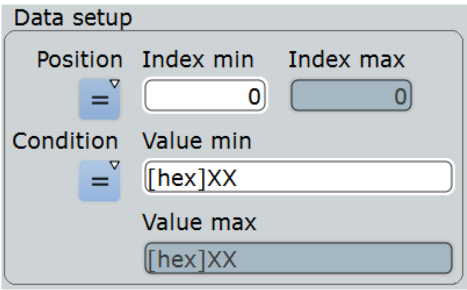
Remote command:
TRIGger<m>:I2C:ACCess on page 1171

Address OR conditions
Triggers on one to four address conditions. For each condition to be used, select "Monitor".

Each condition requires an exact address. The definition of address ranges is not possible here. X (don't care) can be used.

Remote command:
TRIGger<m>:I2C:ADOR<n>:ENABle on page 1173
TRIGger<m>:I2C:ADOR<n>:ADRType on page 1173
TRIGger<m>:I2C:ADOR<n>[:VALue] on page 1174
TRIGger<m>:I2C:ADOR<n>:RWBit on page 1174

Data setup
Specifies the data conditions:



Position ← Data setup
Operator for the data position within a frame. You can define an exact position, or a position range. Select "Any", if the position of the required pattern is not relevant.

Remote command:
TRIGger<m>:I2C:DPOPerator on page 1174

Index min, Index max ← Data setup
Sets the number of data bytes to be skipped after the address. The index 0 is associated with the first data byte. If the Position defines a range, the first and the last byte of interest are defined.

Remote command:
TRIGger<m>:I2C:DPOSition on page 1174
TRIGger<m>:I2C:DPTO on page 1175

Condition ← Data setup
Selects the operator for the "Data" pattern: "Equal", "Not equal", or a range definition.

Remote command:
TRIGger<m>:I2C:DCONdition on page 1175

Value min / Value max ← Data setup
Specifies the data bit pattern. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

The instrument ensures that the max value is always ≥ the min value, and X bits (don't care) are at the same position in both values.

The bit pattern editor helps you to enter the pattern, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

Remote command:
`TRIGger<m>:I2C:DMIN` on page 1175
`TRIGger<m>:I2C:DMAX` on page 1175

12.2.3.2 Triggering on I²C Signals

Prerequesites: A I²C bus is configured, see Chapter 12.2.2.2, "Configuring I²C Protocol", on page 449.

1. Press the TRIGGER key.
   If the "Protocol Configuration" dialog box is open, you can tap the "Trigger Setup" button.
2. Tap the "Source" button and select the "Serial bus" trigger source.
3. Select the serial bus that is set to I²C.
4. Select the "Trigger type".
5. For more complex trigger types, enter the address and/or data conditions: address, acknowledge bits, R/W bit, and data pattern.
   For details, see Chapter 12.2.3, "I²C Trigger", on page 450

12.2.4 I²C Label List

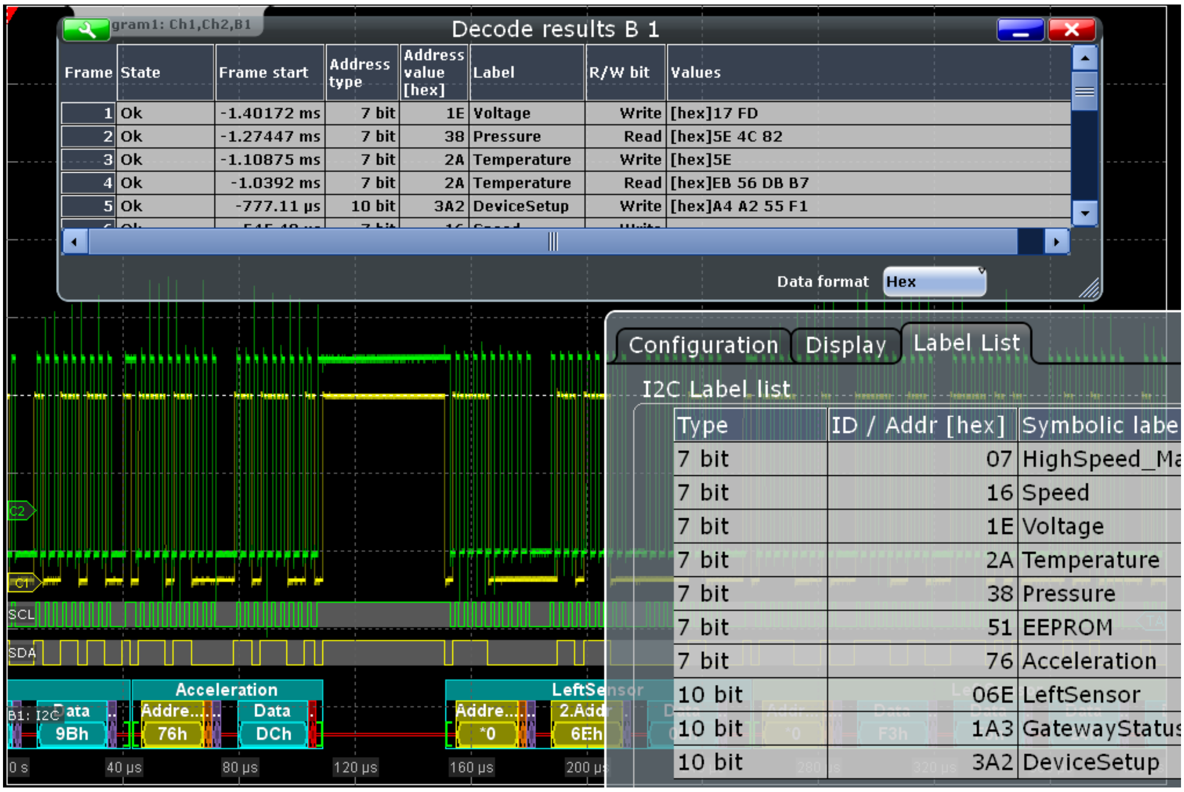
Label lists are protocol-specific. An I²C label file contains three values for each address:

- "Type": address type, 7-bit or 10-bit long
- "ID / Addr": hexadecimal address value
- "Symbolic label": name of the address, specifiing its function in the bus network.

Example: I²C PTT file

```
# ----------------------------------------------------------------------------
@FILE_VERSION  = 1.00
@PROTOCOL_NAME = i2c
# ---------------------------------------------------------------------------
# Labels for I2C protocol
#   Column order: Identifier type, Identifier value, Label
# ---------------------------------------------------------------------------
7,1Eh,Voltage
7,38h,Pressure
```

```
7,2Ah,Temperature
7,16h,Speed
7,76h,Acceleration
7,07h,HighSpeed_Master_0x3
7,51h,EEPROM
10,3A2h,DeviceSetup
10,1A3h,GatewayStatus
10,06Eh,LeftSensor
# ---------------------------------------------------------------------------
```



For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 441.

Remote command:

- BUS<m>:I2C:FRAMe<n>:SYMBol? on page 1181

12.2.5 I²C Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

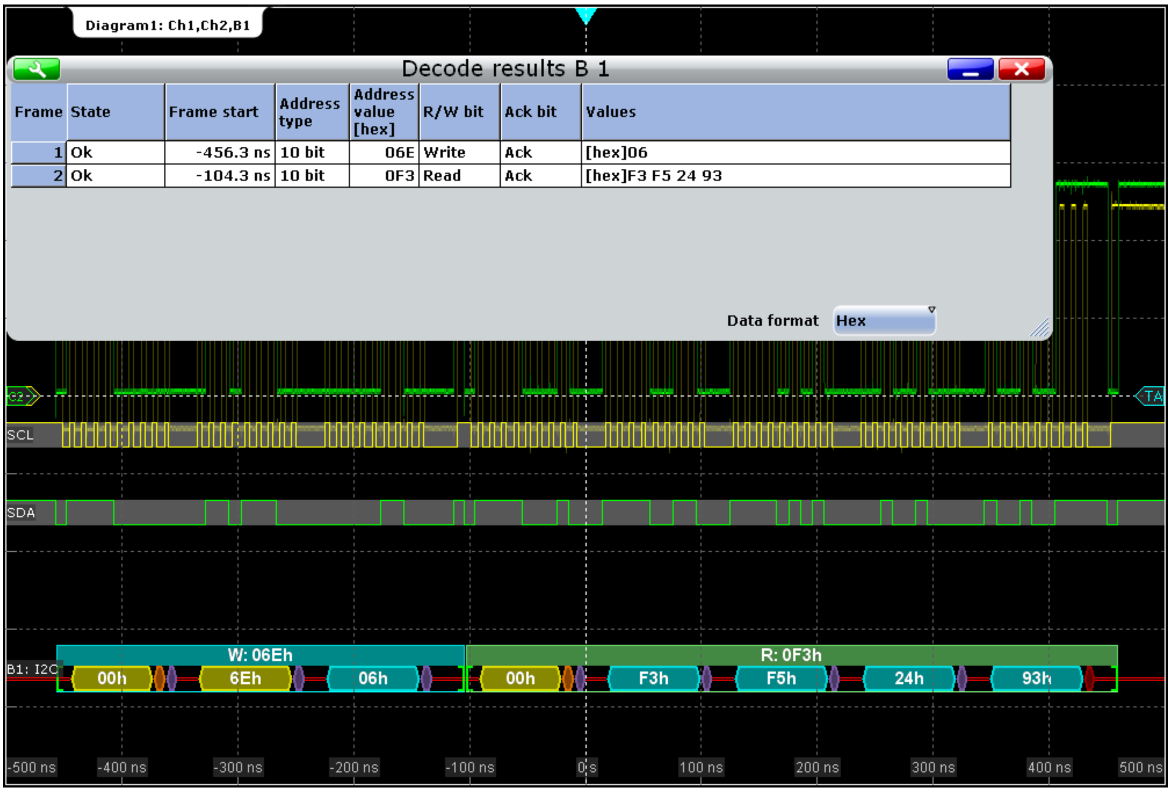


Figure 12-4: Decoded and binary I2C signal, and decode results

green brackets [...]	= start and end of frame
blue frame header	= write frame ok, with transfer direction and address value
green frame header	= read frame ok, with transfer direction and address value
yellow	= address
blue	= correct data
light orange	= R/W bit
purple	= acknowledge bit
red	= No ack (missing acknowledge bit)

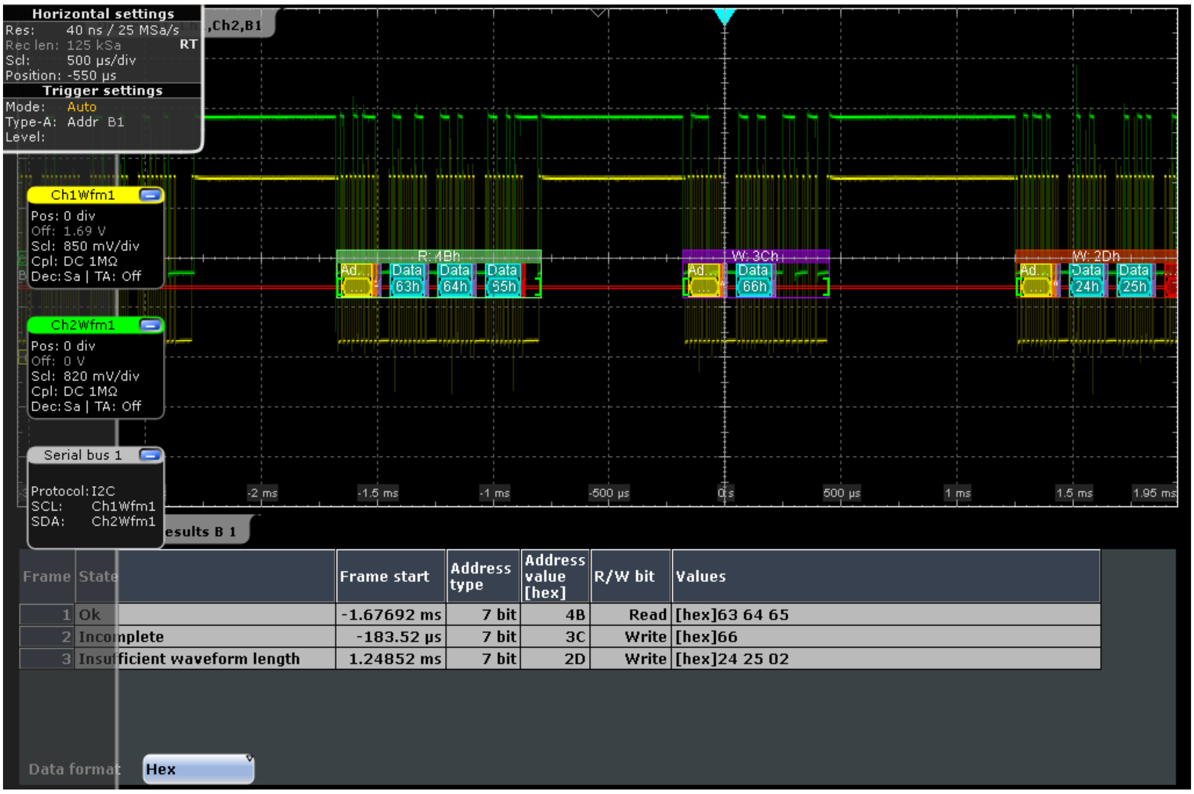


Figure 12-5: Decoded I2C signal with incomplete data, and decode results

magenta frame header	= incomplete frame, missing bits in data words
dark orange frame header	= insufficient frame (end of acquisition before decoding has been completed), with transfer direction and address value
red	= insufficient data word (end of acquisition before end of word)

The "Decode results" box shows the detailed decoded data for each data frame.

Table 12-1: Content of the "Decode results" table

Column	Description
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Frame start	Time of frame start
Address type	Address length, 7 bit or 10 bit
Address value (hex)	Hexadecimal value of the address
R/W bit	Value of the R/W bit
Ack bit	Value of the address acknowledge bit
Values	Value of all data bytes of the frame. The data format is selected below the table.

Example:

The signal in Figure 12-4 shows a write access followed by a read access, both with 10bit address. The decoded data shows a No Ack bit at the end of the read data. This No Ack bit is sent according to the protocol definition and is not an error. Thus, the decode results in the table indicate "Ack" for the second frame.

Remote commands:
- `BUS<m>:I2C:FRAMe<n>:DATA?` on page 1176
- `BUS<m>:I2C:FCOunt?` on page 1177
- `BUS<m>:I2C:FRAMe<n>:AACCess?` on page 1177
- `BUS<m>:I2C:FRAMe<n>:ACCess?` on page 1177
- `BUS<m>:I2C:FRAMe<n>:ACOMplete?` on page 1177
- `BUS<m>:I2C:FRAMe<n>:ADBStart?` on page 1178
- `BUS<m>:I2C:FRAMe<n>:ADDRess?` on page 1178
- `BUS<m>:I2C:FRAMe<n>:ADEVice?` on page 1178
- `BUS<m>:I2C:FRAMe<n>:AMODe?` on page 1179
- `BUS<m>:I2C:FRAMe<n>:ASTart?` on page 1179
- `BUS<m>:I2C:FRAMe<n>:RWBStart?` on page 1180
- `BUS<m>:I2C:FRAMe<n>:STATus?` on page 1180
- `BUS<m>:I2C:FRAMe<n>:STARt?` on page 1181
- `BUS<m>:I2C:FRAMe<n>:STOP?` on page 1181
- `BUS<m>:I2C:FRAMe<n>:BCOunt?` on page 1182
- `BUS<m>:I2C:FRAMe<n>:BYTE<o>:ACCess?` on page 1182
- `BUS<m>:I2C:FRAMe<n>:BYTE<o>:ACKStart?` on page 1182
- `BUS<m>:I2C:FRAMe<n>:BYTE<o>:COMPlete?` on page 1183
- `BUS<m>:I2C:FRAMe<n>:BYTE<o>:STARt?` on page 1183
- `BUS<m>:I2C:FRAMe<n>:BYTE<o>:VALue?` on page 1184

12.2.6 Search on Decoded I²C Data

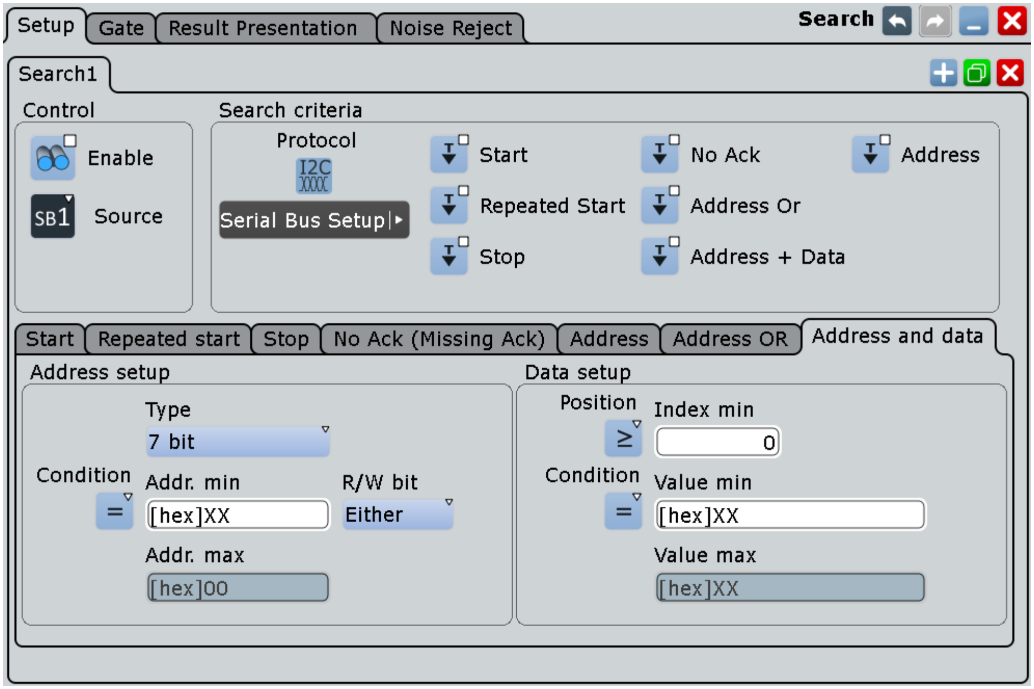
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 376.

12.2.6.1 I²C Search Setup

Access: SEARCH > "Setup" tab



Search criteria

Enable the events to be searched for. Unlike triggering, where you can trigger only on one defined event, you can search for various different events in one search.

"Start" Searches for the start of the message. The start condition is a falling edge on SDA while SCL is high. The event is the falling edge of the SDA line.
You can change the SDA and SCL lines here if necessary.

"Repeated start" Searches for a start condition without previous stop condition. Repeated start conditions occur when a master exchanges multiple messages with a slave without releasing the bus.

"Stop" Searches for the end of the message. The stop condition is a rising slope on SDA while SCL is high.

"No ACK (Missing ACK)" Searches for a missing acknowledge bit: an event is found if the data line remains HIGH during the clock pulse following a transmitted byte.
For details, see "No Ack conditions" on page 452.

"Address" Searches for one specific address condition or a combination of address conditions. The event is the falling edge of the acknowledge bit after the address.

"Address OR" Searches for one to four address conditions.
See "Address OR conditions" on page 454.

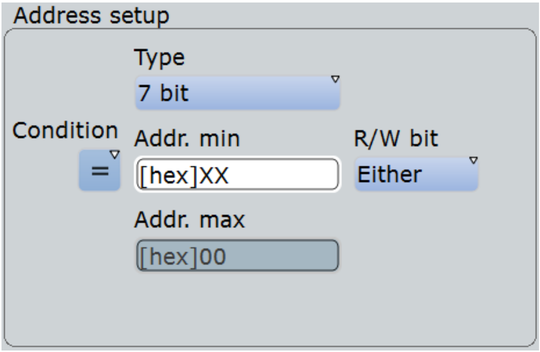
"Address and data" Searches for a combination of address and data conditions.

Remote command:
`SEARch:TRIGger:I2C:SCONdition` on page 1185
`SEARch:TRIGger:I2C:RCONdition` on page 1185
`SEARch:TRIGger:I2C:STCNdition` on page 1185

SEARch:TRIGger:I2C:NACKnowledge on page 1185
SEARch:TRIGger:I2C:SADDress on page 1186
SEARch:TRIGger:I2C:ADOR on page 1186
SEARch:TRIGger:I2C:ADData on page 1186

Address setup: Condition, Type, Addr. min, Addr. max, R/W bit
The address setup consists of the condition, type, R/W bit and one or two address patterns.

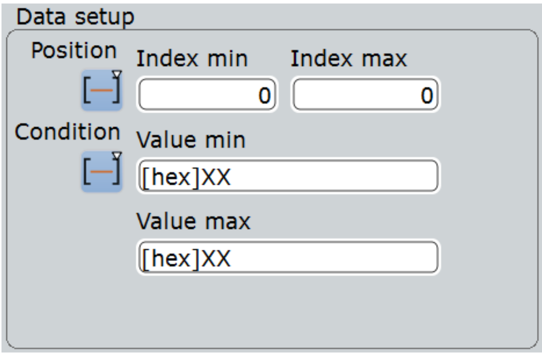
The address setup settings are the same as in the I2C trigger setup, see "Address setup" on page 453.



Remote command:
SEARch:TRIGger:I2C:ACONdition on page 1187
SEARch:TRIGger:I2C:ADDRess on page 1188
SEARch:TRIGger:I2C:ADDTo on page 1188
SEARch:TRIGger:I2C:AMODe on page 1187
SEARch:TRIGger:I2C:ACCess on page 1188

Data setup: Condition, Position, Index min, Index max, Value min, Value max
The data setup consists of the condition, position, and one or two index/value patterns.

The data setup settings are the same as in the I2C trigger setup, see "Data setup" on page 454.



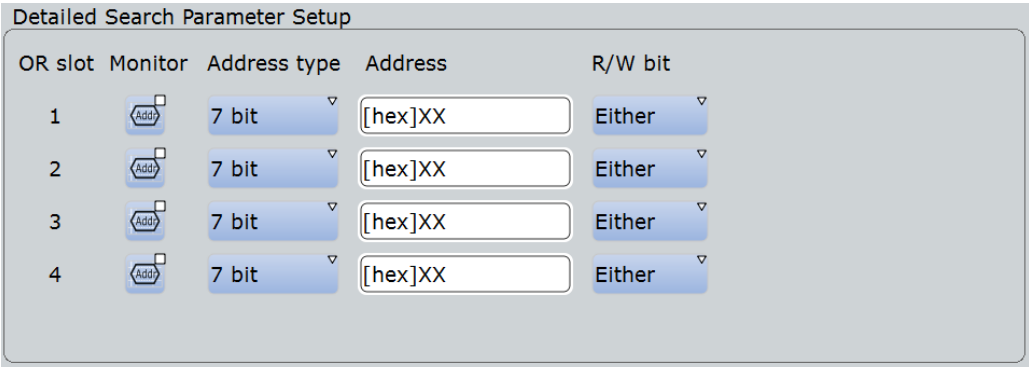
Remote command:
SEARch:TRIGger:I2C:DPOPerator on page 1190
SEARch:TRIGger:I2C:DPOSition on page 1190
SEARch:TRIGger:I2C:DPTO on page 1191
SEARch:TRIGger:I2C:DCONdition on page 1191

SEARch:TRIGger:I2C:DMIN on page 1191
SEARch:TRIGger:I2C:DMAX on page 1192

Address OR setup: Monitor, Address type, Address, R/W bit

The address OR setup consists of the monitor, address type, address and a R/W bit.

The address OR setup settings are the same as in the I2C trigger setup, see "Address OR conditions" on page 454.

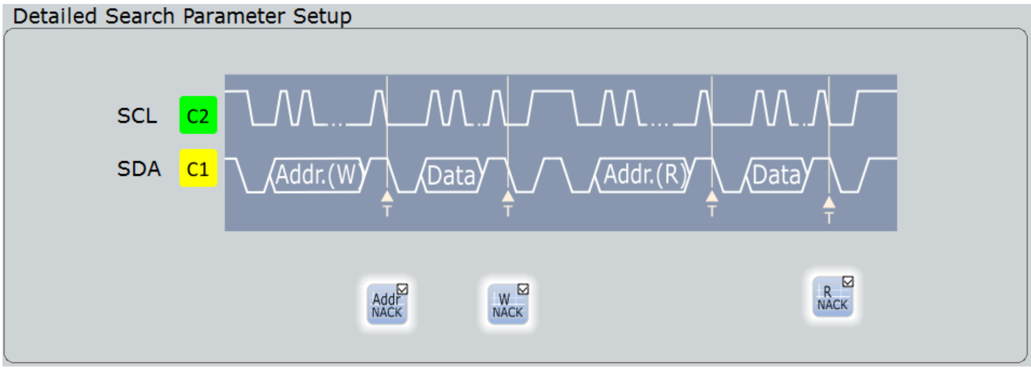


Remote command:
SEARch:TRIGger:I2C:ADDO<m>:ENABle on page 1188
SEARch:TRIGger:I2C:ADDO<m>:ADRType on page 1189
SEARch:TRIGger:I2C:ADDO<m>[:VALue] on page 1189
SEARch:TRIGger:I2C:ADDO<m>:RWBit on page 1190

No ACK setup: Addr/W/R NACK

The no ACK setup consists of the Addr/W/R NACK.

The no ACK setup settings are the same as in the I2C trigger setup, see "No Ack conditions" on page 452.



Remote command:
SEARch:TRIGger:I2C:DRNack on page 1192
SEARch:TRIGger:I2C:DWNack on page 1192
SEARch:TRIGger:I2C:NACKnowledge on page 1185

12.2.6.2 I²C Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394

The columns in the serach result table are the same as in the decoding table, see Chapter 12.2.5, "I²C Decode Results ", on page 456.

Remote commands:

- SEARch:RESult:I2C:FCOunt? on page 1193
- SEARch:RESult:I2C:FRAMe<m>:STATus? on page 1193
- SEARch:RESult:I2C:FRAMe<m>:STARt? on page 1194
- SEARch:RESult:I2C:FRAMe<m>:STOP? on page 1194
- SEARch:RESult:I2C:FRAMe<m>:SYMBol? on page 1197
- SEARch:RESult:I2C:FRAMe<m>:DATA? on page 1197
- SEARch:RESult:I2C:FRAMe<m>:ADDRess? on page 1195
- SEARch:RESult:I2C:FRAMe<m>:AACCess? on page 1194
- SEARch:RESult:I2C:FRAMe<m>:ACCess? on page 1195
- SEARch:RESult:I2C:FRAMe<m>:ACOMplete? on page 1195
- SEARch:RESult:I2C:FRAMe<m>:ADBStart? on page 1195
- SEARch:RESult:I2C:FRAMe<m>:ADEVice? on page 1196
- SEARch:RESult:I2C:FRAMe<m>:AMODe? on page 1196
- SEARch:RESult:I2C:FRAMe<m>:ASTart? on page 1196
- SEARch:RESult:I2C:FRAMe<m>:BCOunt? on page 1197
- SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACCess? on page 1197
- SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACKStart? on page 1198
- SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:COMPlete? on page 1198
- SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:STARt? on page 1198
- SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:VALue? on page 1199

12.3 SPI Bus (Option R&S RTE-K1)

12.3.1 The SPI Protocol

A 4-channel instrument is required for full support of the SPI protocol.

The Serial Peripheral Interface SPI is used for communication with slow peripheral devices, in particular, for transmission of data streams.

Main characteristics of SPI are:

- Master-slave communication
- No device addressing; The slave is accessed by a chip select, or slave select line.
- No acknowledgement mechanism to confirm receipt of data
- Duplex capability

Most SPI buses have four lines, two data and two control lines:

- Clock line to all slaves (SCLK)
- Slave Select or Chip Select line (SS or CS)
- Master data output, slave data input (MOSI or SDI)
- Master data input, slave data output (MISO or SDO)

When the master generates a clock and selects a slave device, data may be transferred in either or both directions simultaneously.

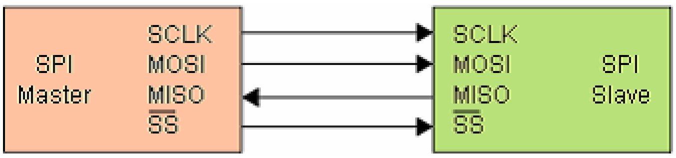


Figure 12-6: Simple configuration of SPI bus

The data bits of a message are grouped by following criteria:

- A word contains a number of successive bits. The word length is defined in the protocol configuration.
- A frame contains a number of successive words, at least one word.

For SPI buses, the R&S RTE provides the following trigger possibilities:

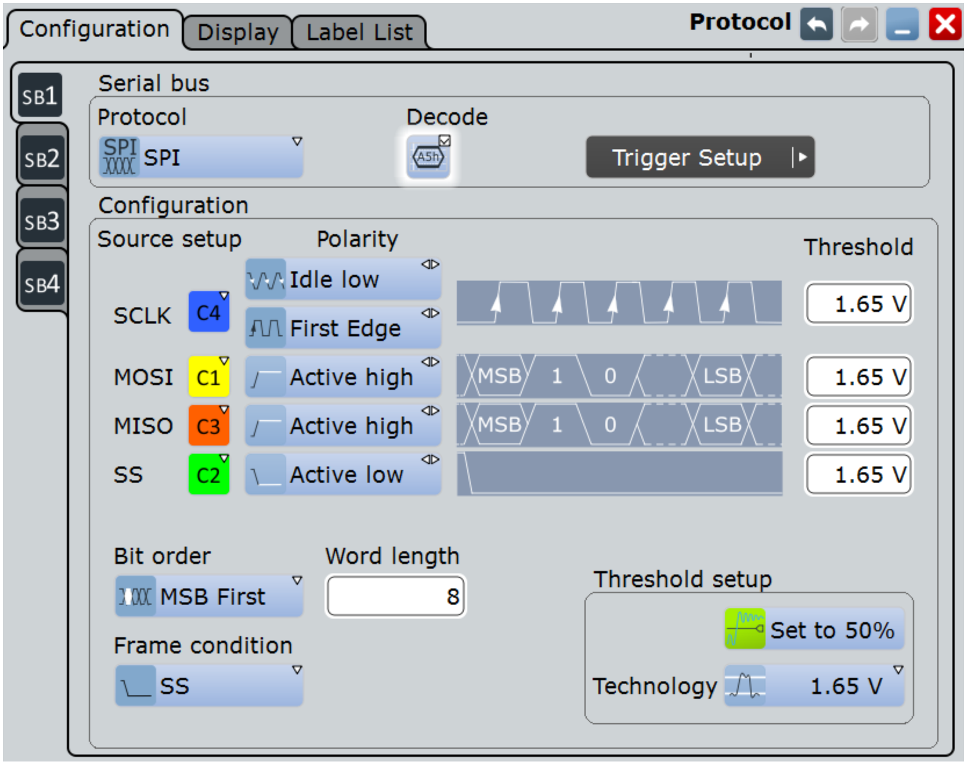
- On frame start
- On a serial pattern at a specified position

12.3.2 SPI Configuration

12.3.2.1 SPI Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *SPI*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

SCLK
Defines the settings for the clock line.

SCLK source ← SCLK
Sets the input channel of the clock line. Analog channels, math waveforms, and reference waveforms can be used for decoding.

Alternatively, digital channels can be used if MSO option R&S RTE-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:SPI:SCLK:SOURce` on page 1200

Polarity ← SCLK
Two settings define the clock mode: the clock polarity and the clock phase. Together, they determine the edges of the clock signal on which the data are driven and sampled. A master/slave pair must use the same parameter pair values to communicate.

The clock polarity is "Idle low" (idle = 0) or "Idle high" (idle = 1).

The clock phase defines the slope. It selects if data is stored with the rising or falling slope of the clock. The slope marks the begin of a new bit.

SS, MISO, MOSI
Configures the Slave Select, MISO and MOSI lines.

Source ← SS, MISO, MOSI
Sets the input channel of the selected line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Alternatively, digital channels can be used if MSO option R&S RTE-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:SPI:SSELect:SOURce` on page 1201
`BUS<m>:SPI:MISO:SOURce` on page 1201
`BUS<m>:SPI:MOSI:SOURce` on page 1202

Polarity ← SS, MISO, MOSI
Selects whether transmitted data or the slave select signal is high active (high = 1) or low active (low = 1).

Remote command:
`BUS<m>:SPI:SSELect:POLarity` on page 1201
`BUS<m>:SPI:MISO:POLarity` on page 1202
`BUS<m>:SPI:MOSI:POLarity` on page 1202

Threshold
Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold. The interpretation of HIGH and LOW is defined by the Polarity.

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"

Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
BUS<m>:SPI:SCLK:THReshold on page 1203
BUS<m>:SPI:MISO:THReshold on page 1203
BUS<m>:SPI:MOSI:THReshold on page 1203
BUS<m>:SPI:SSELect:THReshold on page 1203
BUS<m>:SPI:TECHnology on page 1203
BUS<m>:SETReflevels on page 1163

Bit order
Defines if the data of the messages starts with msb (most significant bit) or lsb (least significant bit). The display of the decoded signal considers this setting, results are displayed in the specified order.

Remote command:
BUS<m>:SPI:BORDer on page 1200

Word length
Sets the number of bits in a word. The maximum length is 32 bit.

Remote command:
BUS<m>:SPI:WSIZe on page 1200

Frame condition
Defines the start of a frame. A frame contains a number of successive words, at least one word.

"SS" Start and end of the frame is defined by the active state of the slave select signal.

"CLK timeout" Defines a timeout on the clock line SCLK as limiter between two frames. The timeout condition is used for SPI connections without an SS line. Enter the minimum clock idle time in the field.

Remote command:
BUS<m>:SPI:FRCondition on page 1204

Timeout
Sets the minimum clock idle time if a timeout on the clock line SCLK is used as limiter between two frames.

See also: "Frame condition" on page 467.

Remote command:
BUS<m>:SPI:TIMeout on page 1204

12.3.2.2 Configuring SPI Signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

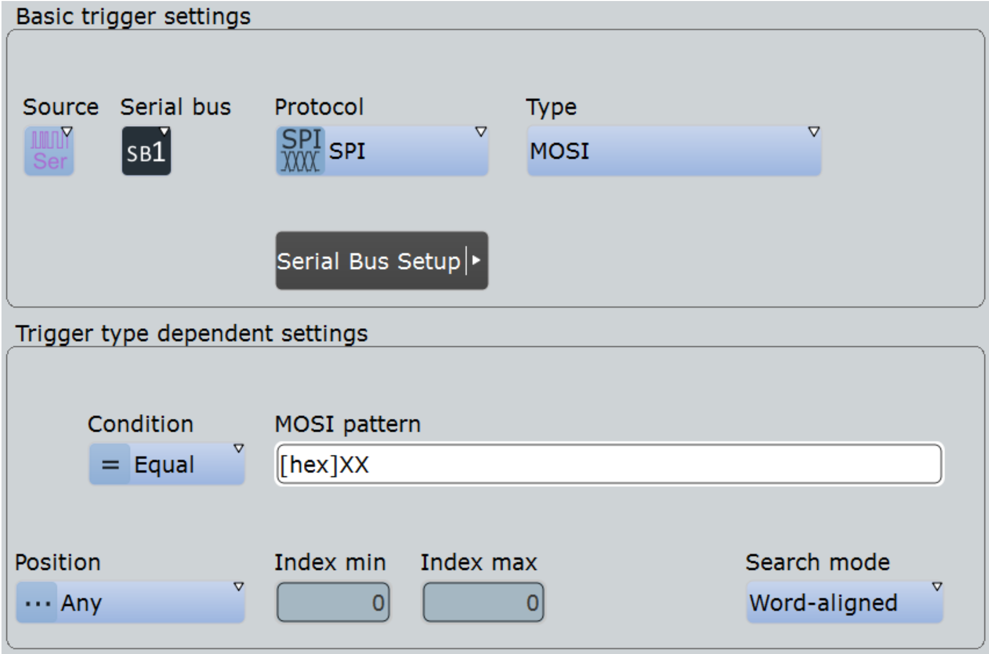
For details on configuration settings, see Chapter 12.3.2, "SPI Configuration", on page 465.

1. Press the PROTOCOL key on the front panel.
2. At the left hand-side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "SPI".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Tap the "SCLK Source" button, and select the waveform of the clock line.
7. Set the polarity (clock mode) for SCLK.
8. For each of the available SS, MISO and MOSI lines, assign the waveform and define the polarity (active state) of the line.
9. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fileds.
10. Set the "Bit order", "Word length", and "Frame condition" according to your signal.

12.3.3 SPI Trigger

12.3.3.1 SPI Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = SPI"



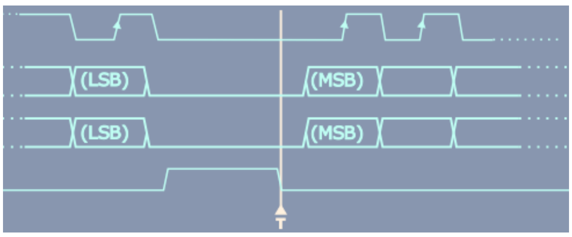
Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

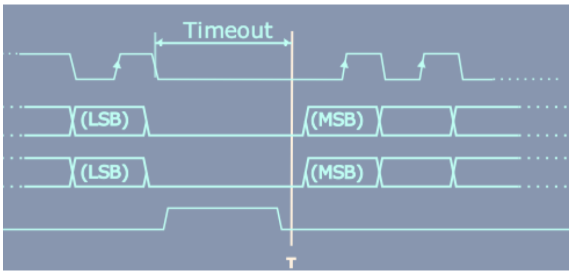
Trigger type

Selects the trigger type for SPI analysis.

"Frame start (SS)" Trigger on the start of the frame when the slave select signal SS changes to the active state. This trigger type is available if Frame condition is set to "SS".



"Frame start (Timeout)" Triggers on the start of the frame when the clock idle time exceeds the "Timeout" time. This trigger type is available if Frame condition is set to "CLK timeout".



"MOSI" Sets the trigger to a specified data pattern expected on the MOSI line.
See: "MOSI and MISO data conditions" on page 470.

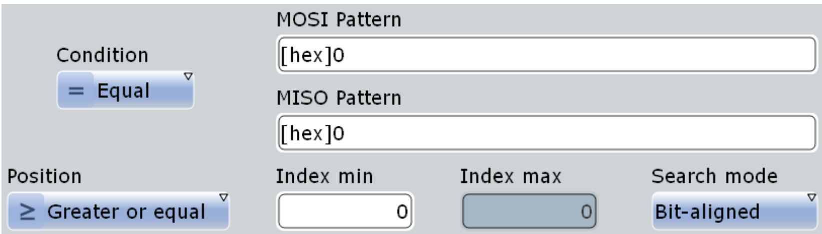
"MISO" Sets the trigger to a specified data pattern expected on the MISO line.
See: "MOSI and MISO data conditions" on page 470.

"MOSI/MISO" Sets the trigger to specified data patterns expected on the MOSI and MISO lines.

Remote command:
`TRIGger<m>:SPI:MODE` on page 1205

MOSI and MISO data conditions

The trigger on MOSI and MISO patterns is defined in the same way:



Condition ← MOSI and MISO data conditions

Selects the operator for the "Data" pattern: "Equal" or "Not equal".

Remote command:
`TRIGger<m>:SPI:FCONdition` on page 1206

MOSI pattern, MISO pattern ← MOSI and MISO data conditions

Specifies the data pattern to be found on the MOSI or MISO line, respectively. Enter the words in msb first bit order. The maximum pattern length is 256 bit if one pattern is defined. If both MOSI and MISO patterns are used, the maximum pattern length of each pattern is 128 bit. The starting point of the pattern is defined by Index min, Index max and Search mode.

The bit pattern editor helps you to enter the pattern, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

Remote command:
TRIGger<m>:SPI:MOSipattern on page 1207
TRIGger<m>:SPI:MISopattern on page 1206

Position ← MOSI and MISO data conditions
Operator for the data position. You can defined an exact position, a position range, or let the position undefined ("Any").

Remote command:
TRIGger<m>:SPI:DPOPerator on page 1205

Index min, Index max ← MOSI and MISO data conditions
The effect of data positioning depends on the Search mode. It sets the number of bits or words before the first word of interest. These offset bits/words are skipped. If the position operator defines a range, the first and the last bit/word of interest are defined. The index 0 is associated with the first data bit or word.

Remote command:
TRIGger<m>:SPI:DPOSition on page 1206
TRIGger<m>:SPI:DPTO on page 1206

Search mode ← MOSI and MISO data conditions
Defines how the specified data pattern is searched:

"Word-aligned" The pattern is matched only at word boundaries.

"Bit-aligned" Bit-by-bit: the pattern can start at any position in the message.

Remote command:
TRIGger<m>:SPI:PALignment on page 1205

12.3.3.2 Triggering on SPI

Prerequesites: A bus is configured for the SPI signal to be analyzed.

1. Press the TRIGGER key.
2. Tap the "Source" button and select the "Serial" trigger source.
3. Select the serial bus that is set to SPI.
4. Select the "Trigger type".
5. For more complex trigger types, enter the data pattern conditions
   For details, see Chapter 12.3.3, "SPI Trigger", on page 468

12.3.4 SPI Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The decoding process considers the "Bit order" configuration setting of the signal and displays the the binary result MSB first. Binary values in the combs of the decoded signal also consider the "Binary bit order" setting in the "Display" tab. Thus, you can read the bits of an LSB first signal in LSB first order in the combs while the results table displays the correct values MSB first.

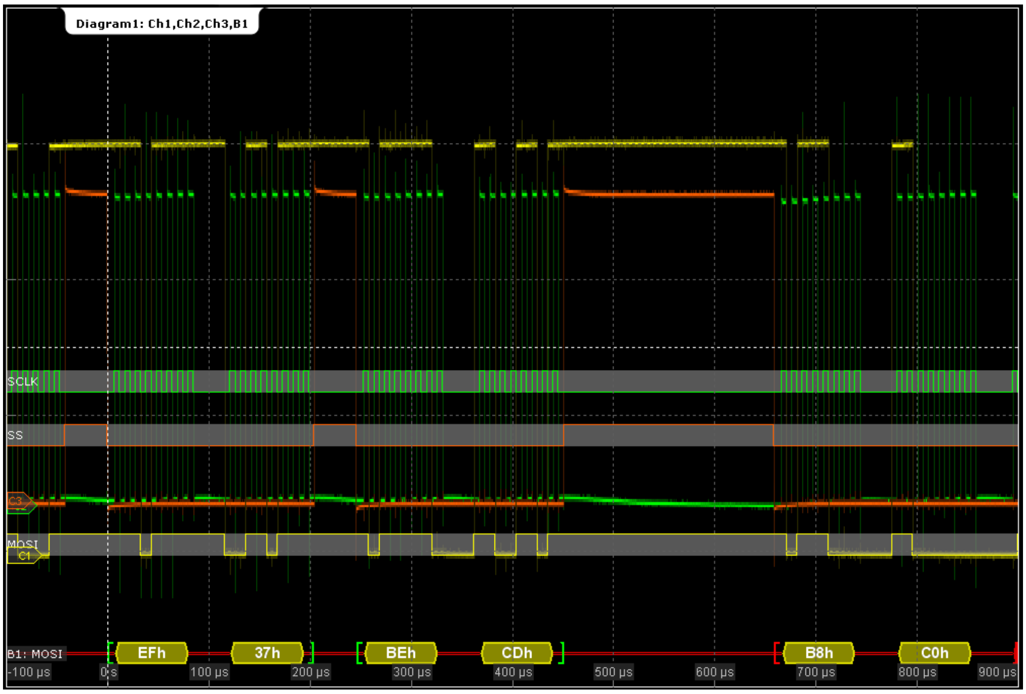


Figure 12-7: Decoded and binary SPI signal with SCLK, MOSI, and SS line

green brackets [...] = start and end of complete frame
red brackets [...] = start and end of incomplete frame
yellow = word
red = error

The "Decode results" box shows the detailed decoded data for each data frame.

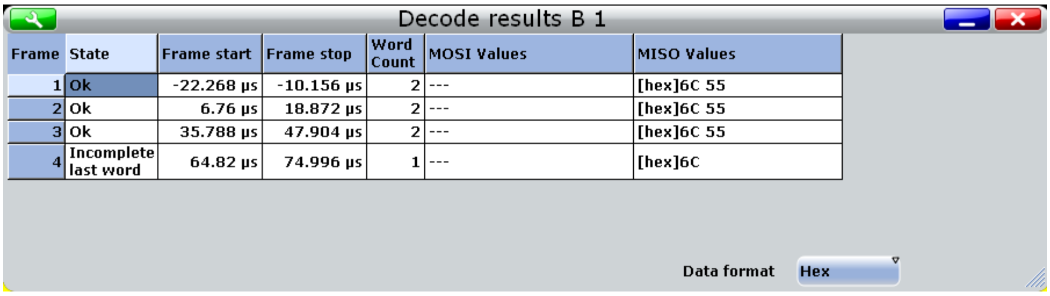


Figure 12-8: Decode results

Table 12-2: Content of the "Decode results" table

Column	Description
State	Overall state of the frame
Frame start , Frame stop	Times of frame start and frame end
Word count	Number of words in the frame
MOSI values	Value of the MOSI data words. The data format is selected below the table.
MISO values	Value of the MISO data words. The data format is selected below the table.

Example:

In the figure above, the first three frames contain two words each. The fourth frame is incomplete, only one word of the frame was recognized

Remote commands:

- `BUS<m>:SPI:FRAMe<n>:DATA?` on page 1207
- `BUS<m>:SPI:FCOunt?` on page 1208
- `BUS<m>:SPI:FRAMe<n>:STATus?` on page 1208
- `BUS<m>:SPI:FRAMe<n>:STARt?` on page 1208
- `BUS<m>:SPI:FRAMe<n>:STOP?` on page 1209
- `BUS<m>:SPI:FRAMe<n>:WCOunt?` on page 1209
- `BUS<m>:SPI:FRAMe<n>:WORD<o>:STARt?` on page 1209
- `BUS<m>:SPI:FRAMe<n>:WORD<o>:STOP?` on page 1210
- `BUS<m>:SPI:FRAMe<n>:WORD<o>:MISO?` on page 1210
- `BUS<m>:SPI:FRAMe<n>:WORD<o>:MOSI?` on page 1211

12.3.5 Search on Decoded SPI Data

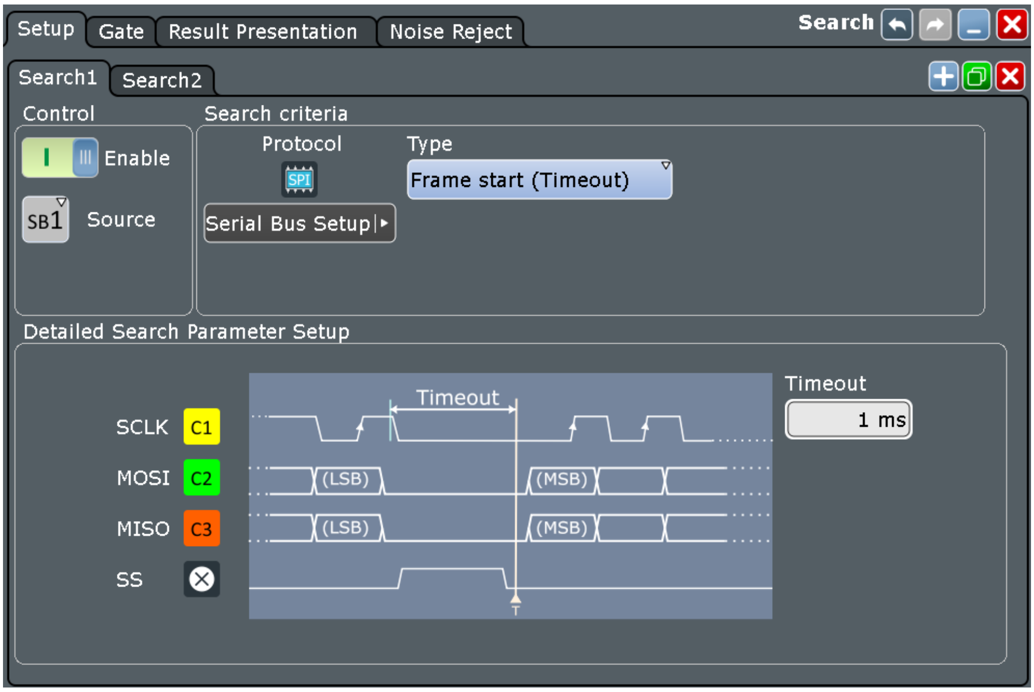
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 376.

12.3.5.1 SPI Search Setup

Access: SEARCH > "Setup" tab



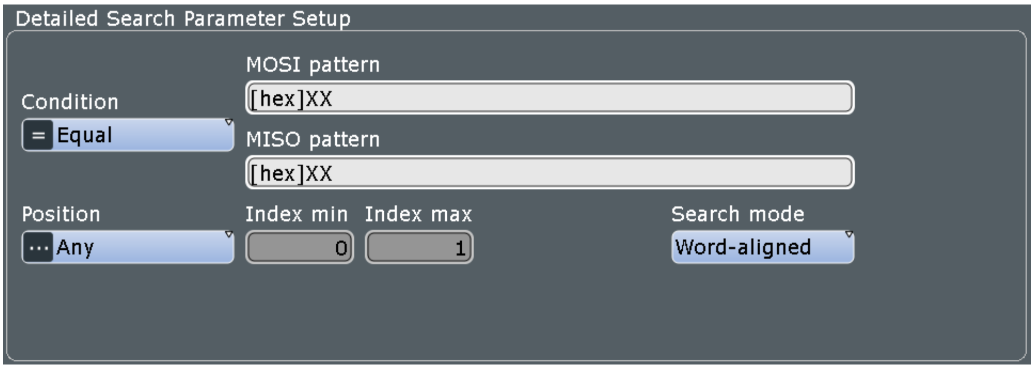
Type
Sets the event to be searched for.

"Frame start (SS)"	Searches for the start of the frame when slave select signal SS changes to the active state. This type is available if the slave select line is configured in the bus setup, and the frame condition is "SS".
"Frame start (Timeout)"	Searches for the start of the frame when the clock idle time exceeds the timeout. This trigger type is available if frame condition is set to "CLK timeout".
"MOSI"	Searches for a specified data pattern expected on the MOSI line.
"MISO"	Searches for a specified data pattern expected on the MISO line.
"MOSI / MISO"	Searches for specified data patterns expected on the MOSI and MISO lines.

Remote command:
`SEARch:TRIGger:SPI:MODE` on page 1211

MOSI and MISO data search
The MOSI and MISO setup consists of the condition, position, MOSI pattern, MISO pattern, search mode (word-aligned, bit-aligned) and one or two index patterns.

The MOSI and MISO setup settings are the same as in the SPI trigger setup. For details, see "MOSI and MISO data conditions" on page 470.



Remote command:
`SEARch:TRIGger:SPI:FCONdition` on page 1212
`SEARch:TRIGger:SPI:MISopattern` on page 1212
`SEARch:TRIGger:SPI:MOSipattern` on page 1212
`SEARch:TRIGger:SPI:DPOPerator` on page 1213
`SEARch:TRIGger:SPI:DPOSition` on page 1213
`SEARch:TRIGger:SPI:DPTO` on page 1213
`SEARch:TRIGger:SPI:PALignment` on page 1214

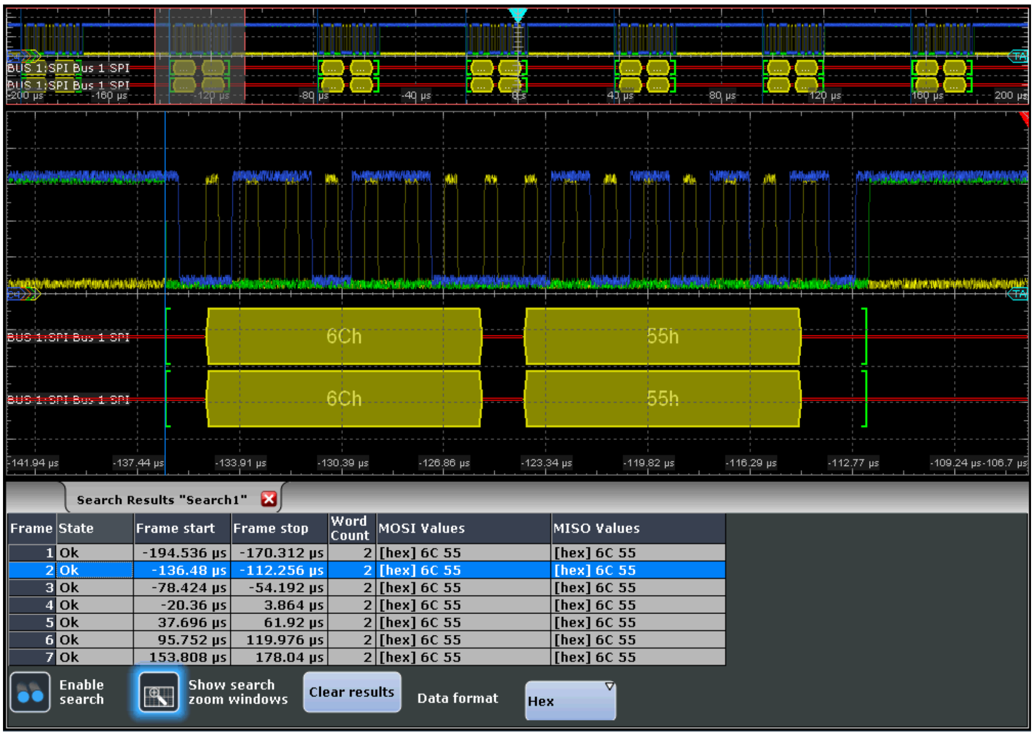
12.3.5.2 SPI Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394



Remote commands are listed in Chapter 16.17.4.5, "SPI Search Results", on page 1214.

12.4 UART / RS232 (Option R&S RTE-K2)

12.4.1 The UART / RS232 Interface

The Universal Asynchronous Receiver/Transmitter UART converts a word of data into serial data, and vice versa. It is the base of many serial protocols like of RS-232. The UART uses only one line, or two lines for transmitter and receiver.

Data transfer

The data is transmitted in words, also referred to as symbols or characters. Each word consists of a start bit, several data bits, an optional parity bit, and one or more stop bits. Several words can form a package, or frame. The end of a package is marked with a reserved word or by a pause between two words.

Start	Data0	Data1	Data2	Data3	Data4	[Data5]	[Data6]	[Data7]	[Data8]	[Parity]	Stop

Figure 12-9: Bit order in a UART word (symbol)

- The start bit is a logic 0.
- The stop bits and the idle state are always logic 1.

The UART protocol has no clock for synchronization. The receiver synchronizes by means of the start and stop bits, and the bit rate that must be known to the receiver.

Trigger

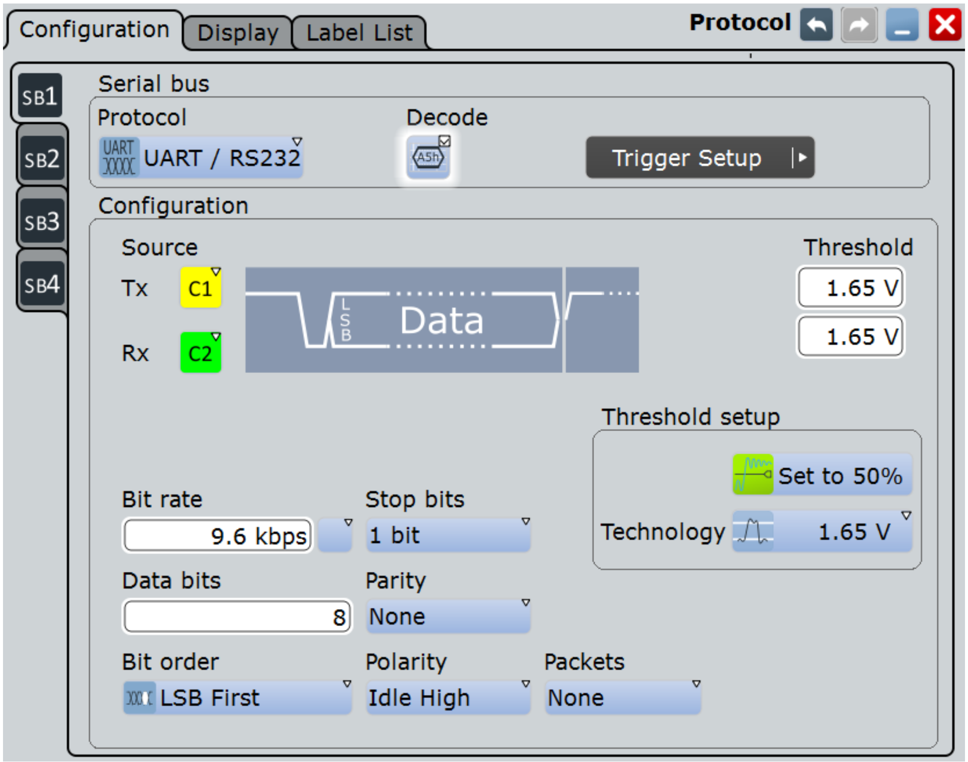
The R&S RTE can trigger on specified parts of UART serial signals:

- Start bit
- Packet start
- Parity errors, and breaks
- Stop errors
- A serial pattern at any or a specified position

12.4.2 UART Configuration

Access: PROTOCOL > "Configuration" tab > "Protocol" = *UART / RS232*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Source: Tx, Rx
Select the input channels for the transmitter and receiver signals.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Alternatively, digital channels can be used if MSO option R&S RTE-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:UART:TX:SOURce` on page 1219
`BUS<m>:UART:RX:SOURce` on page 1218

Threshold
Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold. The interpretation of HIGH and LOW is defined by the Polarity.

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:UART:RX:THReshold` on page 1219
`BUS<m>:UART:TX:THReshold` on page 1219
`BUS<m>:UART:TECHnology` on page 1220
`BUS<m>:SETReflevels` on page 1163

Polarity
Defines the logic levels of the bus. The idle state corresponds to a logic 1. the start bit to a logic 0. "Idle high" (high=1) is used, for example, for control signals, while "Idle low" (low=1) is defined for data lines (RS-232).

Remote command:
`BUS<m>:UART:POLarity` on page 1221

Bit rate
Sets the number of transmitted bits per second. To select a bit rate from list of predefined values, tap the icon beside the "Bit rate" field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

Remote command:
`BUS<m>:UART:BITRate` on page 1220
`BUS<m>:UART:BAUDrate` on page 1220

Data bits
Sets the number of data bits of a word in a range from 5 to 8 bits.

Remote command:
`BUS<m>:UART:SSIZe` on page 1222

Bit order
Defines if a word starts with msb (most significant bit) or lsb (least significant bit). The display of the decoded signal considers this setting, results are displayed in the specified order.

Stop bits
Sets the number of stop bits: 1 or 1.5 or 2 stop bits are possible.

Remote command:
`BUS<m>:UART:SBIT` on page 1221

Parity
Defines the optional parity bit that is used for error detection.

"None" No parity bit is used.

"Odd" The parity bit is set to "1" if the number of data bits set to "1" is even.

"Even" The parity bit is set to "1" if the number of data bits set to "1" is odd.

"Mark" The parity bit is always a logic 1.

"Space" The parity bit is always a logic 0.

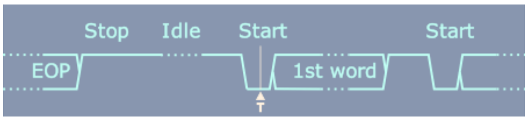
"Don't care" The parity is ignored.

Remote command:
`BUS<m>:UART:PARity` on page 1221

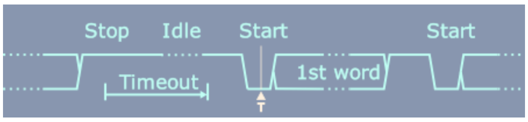
Packets
Allows to define packets of several words in the data stream.

"None" Packets are not considered.

"End word" Defines a pattern as end condition of a packet, for example, a reserved word like CR or LF. The bit pattern editor provides frequently used values in the "Predefined values" list below the pattern table.
A new packet starts with the first start bit after the defined end pattern.



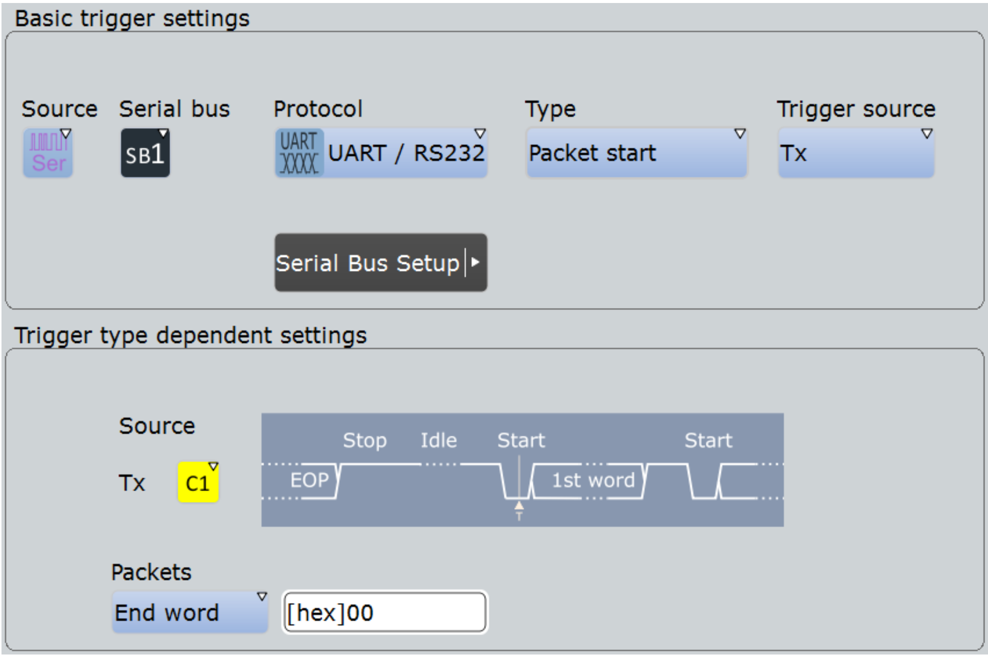
"Timeout" Defines a timeout between a stop bit and the next start bit. Enter the minimum time that marks the end of a packet.
A new packet starts with the first start bit after the timeout.



Remote command:
`BUS<m>:UART:PACKets` on page 1222
`BUS<m>:UART:TOUT` on page 1222
`BUS<m>:UART:EWORd` on page 1223

12.4.3 UART Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = UART / RS232"



Make sure that:
- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Type

Selects the trigger type for UART analysis.

"Start bit" Triggers on a start bit. The start bit is the first low bit after a stop bit.

"Packet start" Triggers on the begin of a data packet. The frame start is configured with "Packets" on page 479.

"Data" Trigger on a serial pattern at a defined position in the data packet. The pattern can include several subsequent symbols (data frames). See "Data conditions" on page 481.

"Parity error" Triggers on a parity error indicating a transmission error. This trigger type is only available if a parity is configured for the UART bus.

"Break condition" Triggers if a start bit is not followed by a stop bit, the data line remains at logic 0 for longer than a UART word.

"Stop error" Triggers if the stop bit is a logic 0.

Remote command:

`TRIGger<m>:UART:TYPE` on page 1224

Trigger source

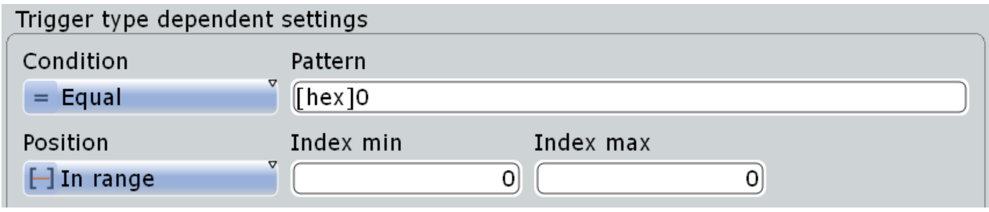
Selects the transmitter or receiver line as trigger source.

Remote command:

`TRIGger<m>:UART:SOURce` on page 1224

Data conditions

Specify the data conditions if the trigger type is set to "Data".



Condition ← Data conditions

Selects the operator for the "Data" pattern: "Equal" or "Not equal".

Remote command:

`TRIGger<m>:UART:FCONdition` on page 1225

Pattern ← Data conditions

Specifies the data pattern to be found on the specified trigger source, in binary or hex format. Enter the words in msb first bit order. The starting point of the pattern is defined by Position and Index min, Index max.

The bit pattern editor helps you to enter the pattern, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

Remote command:

`TRIGger<m>:UART:DATA` on page 1225

Position ← Data conditions

Operator for the data position. You can define an exact position, or a position range.

The setting is available if packet detection is enabled in the protocol configuration.

Remote command:
`TRIGger<m>:UART:DPOPerator` on page 1224

Index min, Index max ← Data conditions
Sets the number of words before the first word of interest. These offset words are ignored. If the Position defines a range, the first and the last word of interest are defined.

The setting is available if packet detection is enabled in the protocol configuration.

Remote command:
`TRIGger<m>:UART:DPOSition` on page 1225
`TRIGger<m>:UART:DPTO` on page 1225

12.4.4 UART Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The decoding process considers the "Bit order" configuration setting of the signal and displays the the binary result MSB first. Binary values in the combs of the decoded signal also consider the "Binary bit order" setting in the "Display" tab. Thus, you can read the bits of an LSB first signal in LSB first order in the combs while the results table displays the correct values MSB first.

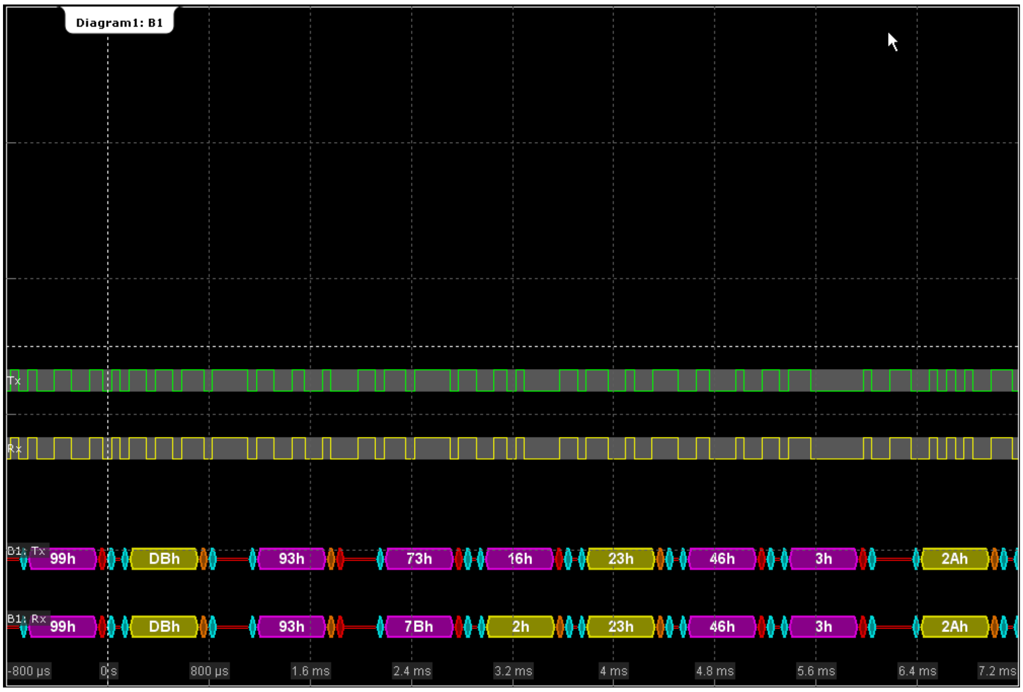


Figure 12-10: Decoded and binary UART signal

blue = start and stop bits if ok
red = start error, stop error, parity error
orange = parity bit if ok
yellow = word ok
magenta = word contains error

The "Decode results" box shows the detailed decoded data for each word.

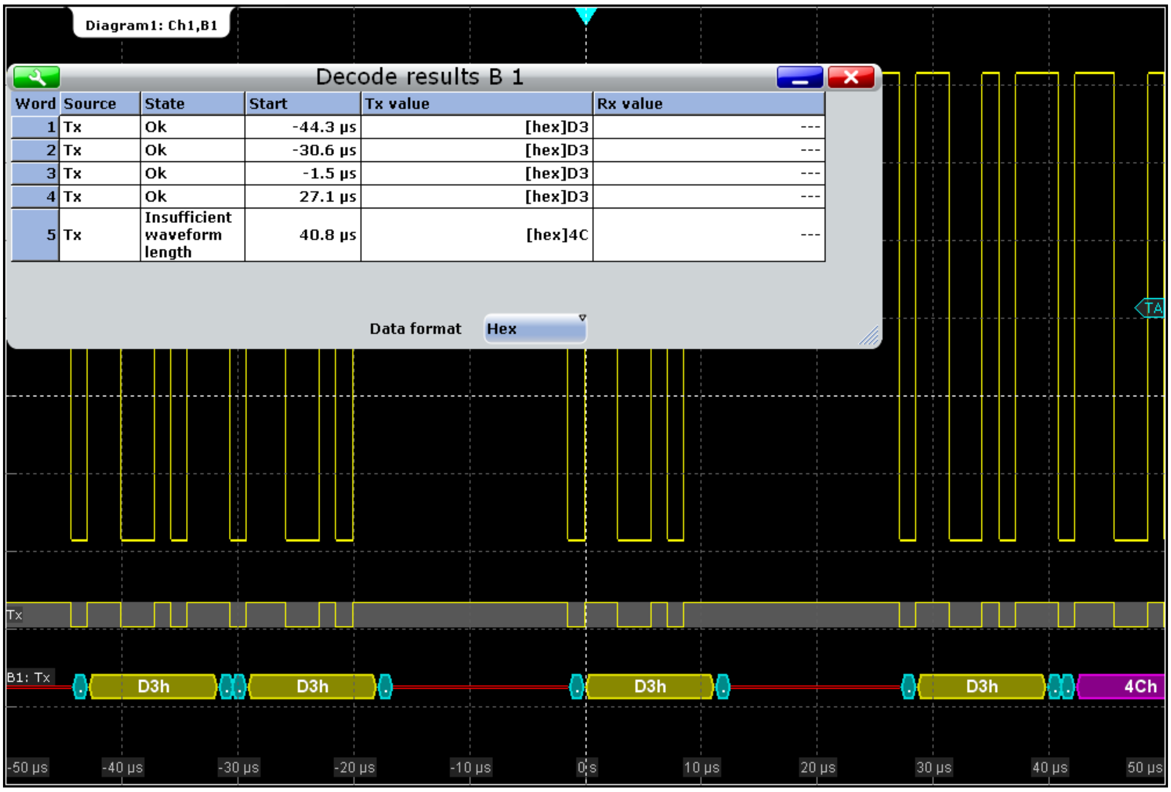


Figure 12-11: Decode results of the UART signal

Table 12-3: Content of the "Decode results" table

Column	Description
Source	Line, Tx or Rx
State	Decoding state of the word. "Insuffcient waveform length" indicates that the word is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of the word start (start bit)
Tx value	Value of the Tx word. The data format is selected below the table.
Rx value	Value of the Rx word. The data format is selected below the table.

Remote commands:

- `BUS<m>:UART:WORD<n>:COUNt?` on page 1226
- `BUS<m>:UART:WORD<n>:SOURce?` on page 1226
- `BUS<m>:UART:WORD<n>:STATe?` on page 1227
- `BUS<m>:UART:WORD<n>:STARt?` on page 1227
- `BUS<m>:UART:WORD<n>:TXValue?` on page 1226
- `BUS<m>:UART:WORD<n>:RXValue?` on page 1226

12.5 CAN and CAN FD (Options R&S RTE-K3 and -K9)

CAN is the Controller Area Network, a bus system designed by Bosch for use within automotive network architecture, for example, for brake, power train and engine management. Today, it is also used in many other systems, for example, in industrial machines, aerospace, subsea, merchant marine etc..

More than 20 years after the invention of CAN, communication needs have increased, and CAN has reached it's bandwidth limits in some application fields. Therefore, Bosch specified an improved CAN protocol with flexible data rate - CAN FD. It introduces a higher bit rate in the data phase up to 15 Mbit/s and an extended data field from up to 64 bytes.

The R&S RTE provides decoding, triggering and searching CAN and CAN FD signals with following options:

- CAN: option R&S RTE-K3
- CAN FD: option R&S RTE-K9, requires CAN option R&S RTE-K3

12.5.1 CAN and CAN-FD Configuration

Access: PROTOCOL key > "Configuration" tab > "Protocol" = "CAN" or "CAN/CAN-FD"

Make sure that the tab of the correct serial bus is selected on the left side.

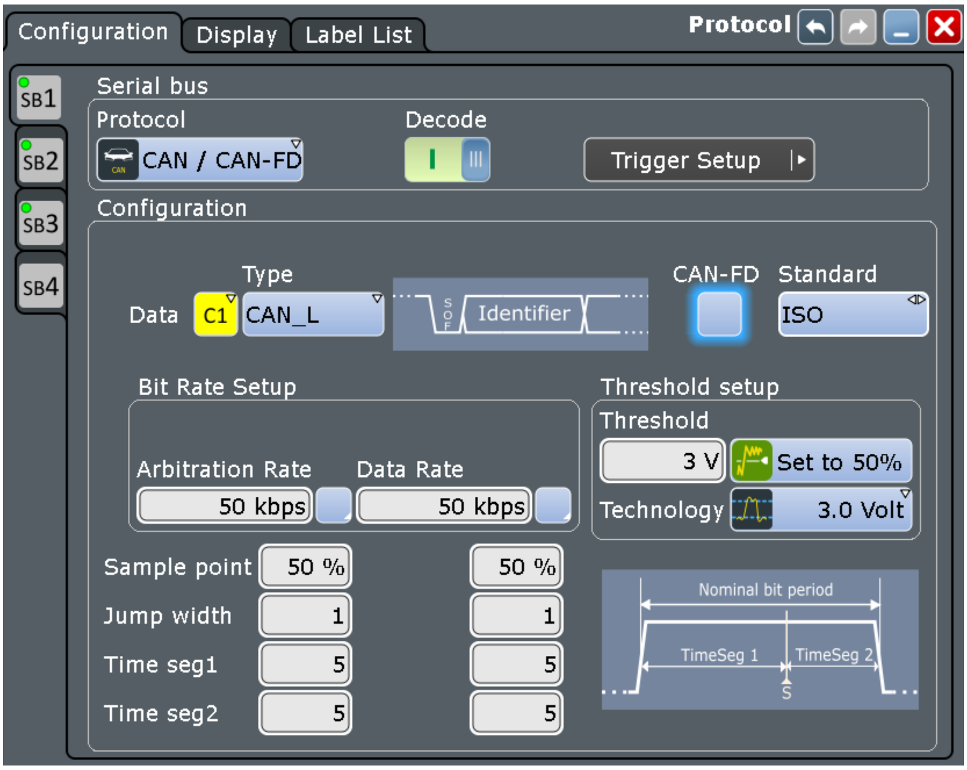


Figure 12-12: Configuration for CAN FD

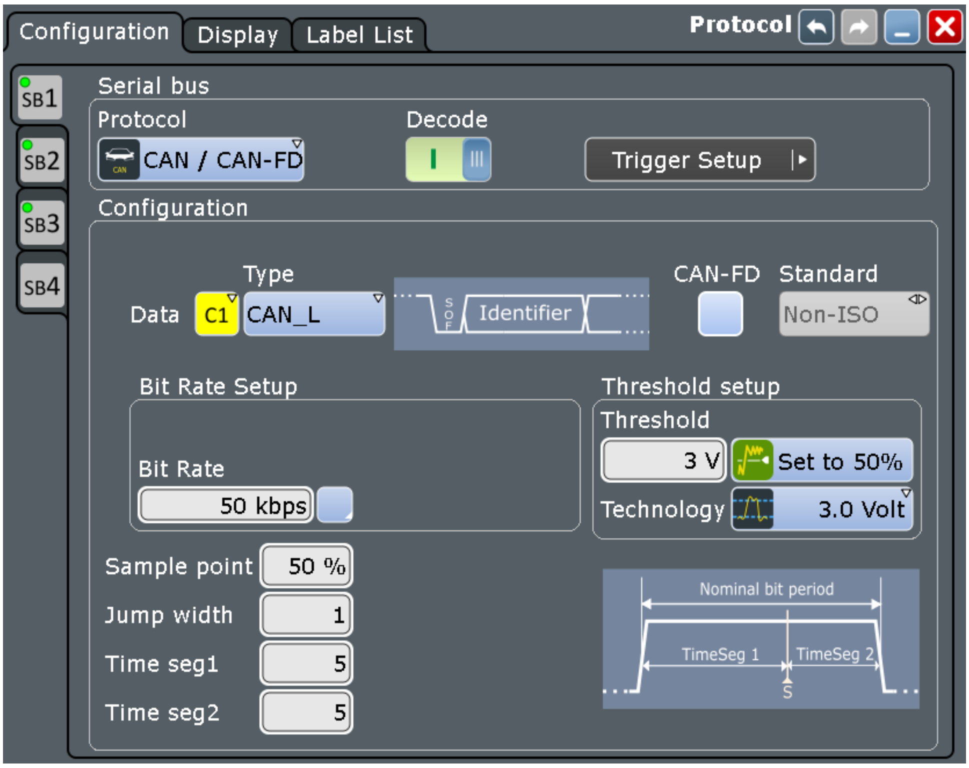


Figure 12-13: Configuration for CAN

See also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Data

Sets the source of the selected data line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTE-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

A math waveform can be used, for example, if you probe on CAN-High and CAN-Low using two single-ended probes, and the difference between high and low is calculated and displayed using a math waveform.

Remote command:
`BUS<m>:CAN:DATA:SOURce` on page 1228

Type

Selects the CAN-High or CAN-Low line. CAN uses both lines for differential signal transmission.

If you measure with a differential probe, connect the probe to both CAN-H and CAN-L lines, and select the data "Type" = *CAN-H*.

If you use a single-ended probe, connect the probe to either CAN_L or CAN_H, and select the data type accordingly.

Remote command:
`BUS<m>:CAN:TYPE` on page 1228

CAN-FD

Enables the CAN FD protocol configuration and displays additional CAN FD parameters.

The setting is available in CAN FD option R&S RTE-K9.

Remote command:
`BUS<m>:CAN:FDATa:ENABle` on page 1230
`BUS<m>:CAN:FDATa:FRAMe<n>:STANdard?` on page 1242

Standard

Only available for CAN FD buses.

"Non-ISO"	Signals are decoded according to the the Bosch CAN FD protocol.
"ISO"	Signals are decoded according to the the ISO CAN FD protocol. This protocol has an additional stuff count field before the CRC sequence.

Remote command:
`BUS<m>:CAN:FDATa:PSTandard` on page 1229

Threshold

Sets the threshold value for digitization of the signal. If the signal value on the line is higher than the threshold, the signal state is high (1 or true for the boolean logic). Otherwise, the signal state is considered low (0 or false).

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:CAN:DATA:THReshold` on page 1229
`BUS<m>:CAN:TECHnology` on page 1229
`BUS<m>:SETReflevels` on page 1163

Bit rate (CAN) / Arbitration rate (CAN FD)
For CAN buses, the "Bit rate" sets the number of transmitted bits per second.

For CAN FD buses, this parameter is called "Arbitration rate" and sets the bit rate of the arbitration phase.

The maximum value of this rate is 1 Mbit/s. The bit rate is uniform and fixed for a given CAN or CAN FD bus.

To select a bit rate from the list of predefined values, tap the button beside the field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

Remote command:
`BUS<m>:CAN:BITRate` on page 1230

Data rate
The setting is available in CAN FD option R&S RTE-K9.

Sets the bit rate of the data phase. The data rate can be equal or higher than the arbitration rate; and it is uniform and fixed for a given CAN FD bus.

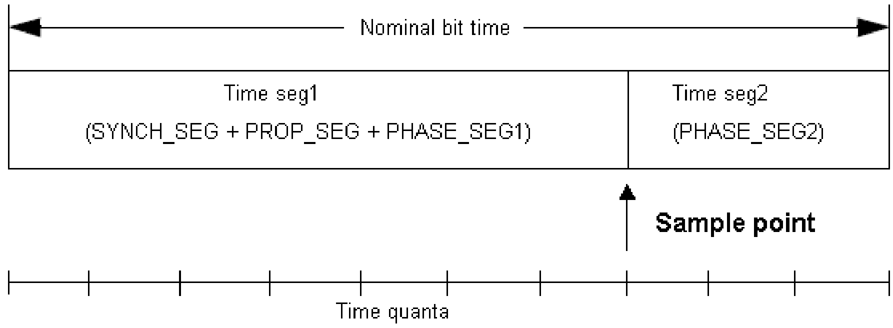
To select a data rate from the list of predefined values, tap the button beside the field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

Remote command:
`BUS<m>:CAN:FDATa:DBITrate` on page 1231

Synchronization: Sample point, Time segments, Jump width
The CAN bus interface uses an asynchronous transmission scheme. The standard specifies a set of rules to resynchronize the local clock of a CAN node to the message.

The sample point divides the nominal bit period into two distinct time segments. The length of the time segments is defined in time quanta according to network and node conditions during CAN development.

For CAN FD signals, you can define the sysnchronization settings separately for the arbitration phase and data phase.



To specify the bit timing, enter either "Time seg1" and "Time seg2", or directly the "Sample point". Additionally, set the "Jump width".

"Time seg1, Time seg2"
Set the number of time quanta before the sample point (Time seg1) and after the sample point (Time seg2). The "Sample point" percentage value is adjusted accordingly.
Time seg1 comprises the segments Synch_seg, Prop_seg, and Phase_seg1 which are specified in the CAN standard. Time seg2 matches Phase_seg2 from the standard.
The maximum sum of Time seg1 and Time seg2 is 25.

"Sample point"
Sets the position of the sample point within the bit in percent ot the nominal bit time.
The time quanta values "Time seg1, Time seg2" are adjusted accordingly.

"Jump width"
Time segment1 may be lengthened or time segment2 may be shortened due to resynchronization. Resynchronization corrects the phase error of an edge caused by the drift of the oscillators. The jump width defines the maximum number of time quanta for phase correction.
The maximum value of the jump width is 4, or *Time seg1 - Time seg2* if this difference is lower than 4.

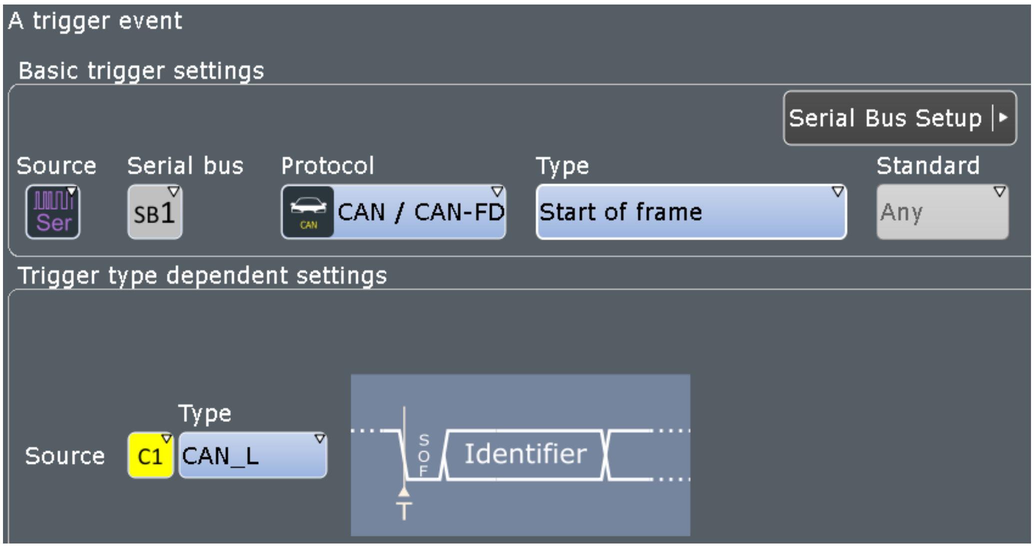
Remote command:
`BUS<m>:CAN:T1Segment` on page 1231
`BUS<m>:CAN:T2Segment` on page 1232
`BUS<m>:CAN:SAMPlepoint` on page 1231
`BUS<m>:CAN:JWIDth` on page 1232
`BUS<m>:CAN:FDATa:T1Segment` on page 1232
`BUS<m>:CAN:FDATa:T2Segment` on page 1233
`BUS<m>:CAN:FDATa:SAMPlepoint` on page 1232
`BUS<m>:CAN:FDATa:JWIDth` on page 1233

12.5.2 CAN / CAN FD Trigger

The R&S RTE can trigger on various events in a CAN or CAN FD frame. Trigger conditions include start of frame, frame ID, data pattern, or error conditions.

12.5.2.1 Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = CAN or CAN / CAN FD"



Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Serial bus
Selects the serial bus to be triggered on. Make sure to select the correct bus before you enter the settings.

To trigger on a serial bus, the signals sources must be channel signals. If the data or clock source is a math or reference waveform, you cannot trigger on that bus.

Remote command:
`TRIGger<m>:SOURce:SBSelect` on page 1166

Protocol
Defines protocol type of the bus for bus configuration and trigger settings.

Remote command:
`BUS<m>:TYPE` on page 1162

Trigger type
Selects the trigger type for CAN analysis.

"Start of frame" Triggers on the first edge of the dominant SOF bit (synchronization bit).

"Frame type"	Triggers on a specified frame type (data, remote, error, or overload). For data and remote frames, also the identifier format is considered. For details, see: ● "Frame type" on page 491 ● "ID type" on page 492
"Identifier"	Sets the trigger to a specific message identifier or an identifier range. See "Identifier setup: Condition, Identifier min, Identifier max" on page 492.
"Identifier + Data"	Sets the trigger to a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern. The identifier conditions are the same as for the "Identifier" trigger type, see "Identifier setup: Condition, Identifier min, Identifier max" on page 492. Data conditions are set with "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 494.
"Error condition"	Identifies various errors in the frame, see "Error conditions" on page 496.
"Symbolic"	The "Symbolic" trigger type is available if a DBC label list file is loaded and applied. It allows you to trigger on a specific data message, or a signal and its value that appears inside the message, see Chapter 12.5.6.1, "Symbolic Trigger", on page 516.

Remote command:
`TRIGger<m>:CAN:TYPE` on page 1234

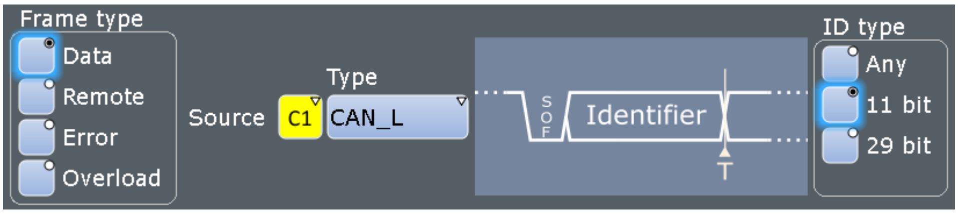
Standard
Selects the CAN standard: "CAN", "CAN FD", or "Any".

The setting is available in CAN FD option R&S RTE-K9.

Use "Any" to trigger on either CAN or CAN-FD frame. In this case, the trigger configuration provides all possible settings, for CAN as well as for CAN FD.

Remote command:
`TRIGger<m>:CAN:FDATa:STANdard` on page 1234

Frame type
CAN has four frame types which can be used as trigger condition.



For data and remote frames, the identifier format has to be set with ID type.

"Data"	The data frame is the only frame for actual data transmission.

"Remote" Remote frames are only available in the CAN protocol.
The remote frame initiates the transmission of data by another node.
The frame format is the same as of data frames but without the data field.

"Error" When a node recognizes an error, it cancels transmission by sending an error frame.
The instrument triggers seven bit periods after the end of the error flag that is marked by a dominant-recessive edge.
The ID type is irrelevant for error frames.

"Overload" When a node needs a delay between data and/or remote frames, it sends and overload frame.
The instrument triggers seven bit periods after the end of the overload flag that is marked by a dominant-recessive edge.
The ID type is irrelevant for overload frames.

Remote command:
`TRIGger<m>:CAN:FTYPe` on page 1235

ID type
Selects the length of the identifier:

"11 bit" Identifier length of the CAN base frame format. The instrument triggers on the sample point of the IDE bit (identifier extension flag).

"29 bit" Identifier length of the CAN extended frame format. The instrument triggers on the sample point of the RTR bit.

"Any" The ID type and ID pattern are not relevant for the trigger condition.
If the trigger type is "Identifier", the instrument triggers on any identifier in the specified frame type.
If the trigger type is "Identifier + Data", set the "ID type" to "Any" if you want to trigger only on data.

Remote command:
`TRIGger<m>:CAN:ITYPe` on page 1235

Identifier setup: Condition, Identifier min, Identifier max
The identifier setup consists mainly of the condition and one or two identifier patterns. Additionally, ID type and frame type may qualify the identifier.

The trigger point depends on the ID type.

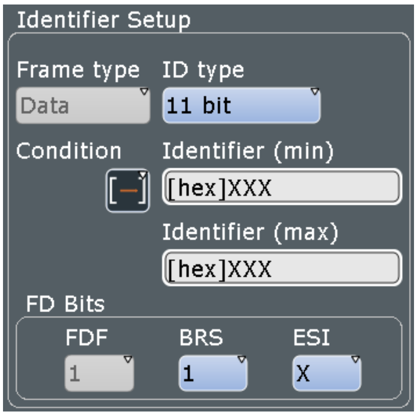


Figure 12-14: Identifier setup for CAN FD

"Frame type" Data frames and remote frames contain an identifier. Select the frame type to be triggered on, or select "Any" if the frame type is not relevant.
In CAN FD, only "Data" frames are available.

"ID type" See: "ID type" on page 492.

"Condition" Defines the operator to set a specific identifier ("Equal" or "Not equal") or an identifier range.

"Identifier min" Defines the bit pattern of the message identifier. In binary format, use the following characters: 1; 0; or X (any bit). The use of X is restricted to the conditions "Equal" and "Not equal".
The length of the bit patterns is restricted to the selected "ID type".
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"Identifier max" The second identifier pattern is required to specify a range with conditions "In range" and "Out of range".

"FD bits" See: "FD bits" on page 493.

Remote command:
`TRIGger<m>:CAN:ICONdition` on page 1235
`TRIGger<m>:CAN:IMIN` on page 1236
`TRIGger<m>:CAN:IMAX` on page 1236

FD bits

For standard settings "CAN FD" and "Any", you can trigger on CAN FD-specific bits.

"FDF" The bit determines whether a frame is CAN or CAN-FD. It corresponds to the EDL bit (extended data length), which only exists in CAN FD format. If you do not know if the signal is CAN or CAN FD, you can use this bit to identify the format: FDF = 1 is CAN FD, and FDF = 0 is CAN. Set "X" if the format is not relevant.

"BRS" is the bit rate switch bit. Value 1 means that the bit rate switches from the "Arbitration rate" to the faster "Data rate".

"ESI" is the error state indicator. Set "X" if the bit is not relevant.

Remote command:
`TRIGger<m>:CAN:FDATa:FDF` on page 1236
`TRIGger<m>:CAN:FDATa:BRS` on page 1236
`TRIGger<m>:CAN:FDATa:ESI` on page 1237

Data setup: DLC, NDB, Transfer, Condition, Data min, Data max
The data setup consists of the transfer direction, the number of bytes, the condition, and one or two data patterns.

To trigger only on data, set the "ID type" of the identifier setup to "Any".

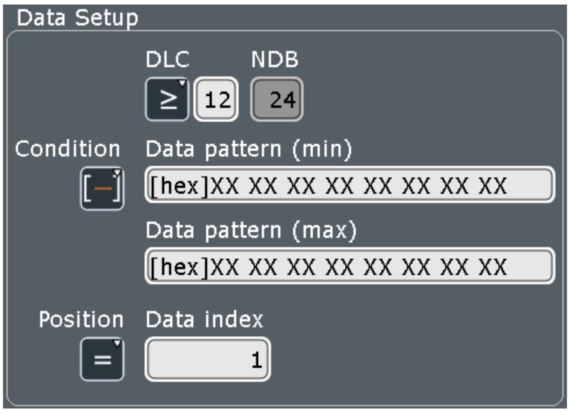


Figure 12-15: Data setup for CAN FD

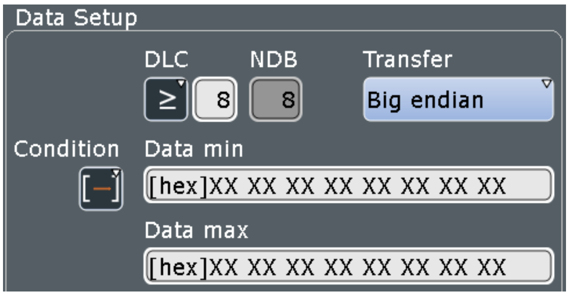


Figure 12-16: Data setup for CAN

"Transfer" CAN only:

Sets the byte order (endianness) of the data transfer. With "Big endian", the data is analyzed and evaluated in the order of reception. With "Little endian", the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

"DLC, NDB" "DLC" sets the Data Length Code, which defines the number of data bytes to be found.
"NDB" shows the number of data bytes that is set by the DLC. DLC and NDB are different in CAN FD for DLCs > 8.
CAN:

For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set.
Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*. With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*.
CAN FD:
The data field can have up to 64 bytes, the DLC is defined in the standard. For example, DLC = 9 defines that the data field has 12 bytes, and DLC = 15 sets a 64 byte data field.

"Condition" Sets the operator to set a specific data pattern ("Equal" or "Not equal") or a data range.

"Data min" Defines the data pattern. The pattern length is adjusted to the DLC setting (and vice versa). Enter the pattern MSB first and with big endian byte order.
In binary format, use the following characters: 1; 0; or X (any bit). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"Data max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:CAN:BORDer` on page 1238
`TRIGger<m>:CAN:DCONdition` on page 1237
`TRIGger<m>:CAN:DMIN` on page 1237
`TRIGger<m>:CAN:DMAX` on page 1237
`TRIGger<m>:CAN:DLCCondition` on page 1238
`TRIGger<m>:CAN:DLC` on page 1238
`TRIGger<m>:CAN:NDBYtes?` on page 1238

Data position
The data position sets the location in the data field where the instrument looks for the specified data pattern.

The setting is available in CAN FD option R&S RTE-K9.

The position can be defined if the data field of the frame is longer than 8 bytes - if DLC ≥9.

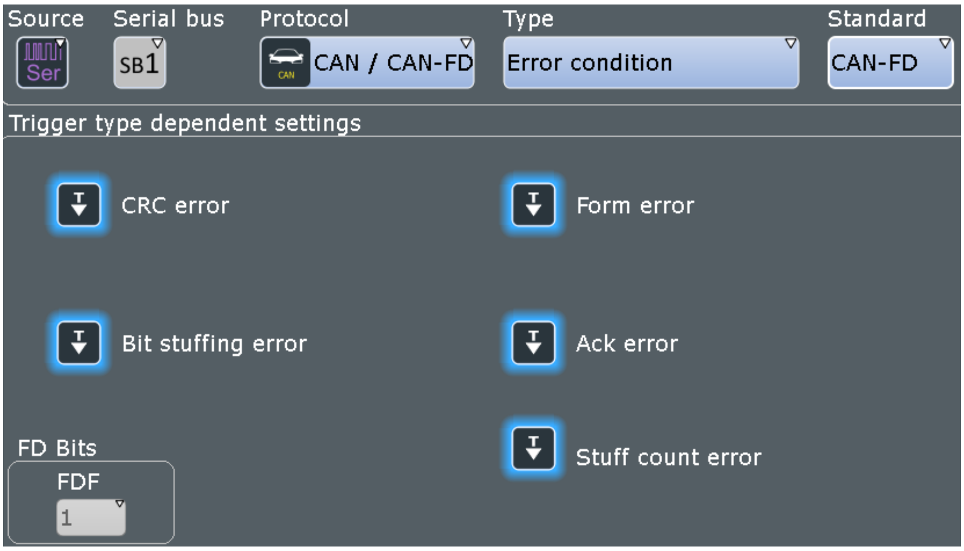
"Position" Sets the operator to define an exact position ("Equal") or a data range.
Use "Any", if the data position is not relevant for the trigger condition.

"Data index (min)"	Defines the number of the first data byte at which the data pattern may start.
"Data index (max)"	Sets the number of the last byte at which the required data pattern may start if the "Position" operator is "In range".

Remote command:
`TRIGger<m>:CAN:FDATa:DPOPerator` on page 1239
`TRIGger<m>:CAN:FDATa:DPOSition` on page 1239
`TRIGger<m>:CAN:FDATa:DPTO` on page 1239

Error conditions

If a CAN detects an error, it transmits an error flag at the next bit. The R&S RTE detects errors in the message and triggers on these errors even if no CAN node sends an error flag.



- CRC error
  CAN uses the Cyclic Redundancy Check, which is a complex checksum calculation method. The transmitter calculates the CRC and sends the result in the CRC sequence. The receiver calculates the CRC in the same way. A CRC error occurs when the calculated result differs from the received value in the CRC sequence.
- Bit stuffing error
  The frame segments Start Of Frame, Arbitration Field, Control Field, Data Field and CRC Sequence are coded by the bit stuffing method. The transmitter automatically inserts a complementary bit into the bit stream when it detects five consecutive bits of identical value in the bit stream to be transmitted. A stuff error occurs when the 6th consecutive equal bit level in the mentioned fields is detected.
- Form error
  A form error occurs when a fixed-form bit field contains one or more illegal bits.
- Ack error
  An acknowledgement error occurs when the transmitter does not receive an acknowledgment - a dominant bit during the Ack Slot.
- Stuff count error

A stuff count error occurs if th received stuff count value does not match the value calculated from the own stuff bit count. Only relevant for CAN FD signals in ISO standard.

Remote command:
`TRIGger<m>:CAN:CRCerror` on page 1240
`TRIGger<m>:CAN:BITSterror` on page 1240
`TRIGger<m>:CAN:FORMerror` on page 1240
`TRIGger<m>:CAN:ACKerror` on page 1240
`TRIGger<m>:CAN:FDATa:SCERror` on page 1241

12.5.2.2 Triggering on CAN FD Data

The "Identifier + Data" trigger type supports triggering on data bytes of specific value at specific location in the data field of a frame. The "Data Pattern" field provides 8 data bytes to define the data pattern. For data fields longer than 8 byte, you can define the position where the specified pattern starts.

The following examples demonstrate how the data pattern and data position are defined.

To set up the trigger

1. Set the basic trigger events:
   a) Select the source: "Serial bus".
   b) Select the serial bus.
   c) Select the protocol: "CAN/CAN FD".
   d) Select the trigger type: "Identifier + Data".
   e) Select the standard:"CAN FD" or "Any".
2. In this example, the identifier does not matter. Set the "ID type = Any".
3. Define the data setup as described in the examples.

Example: Triggering on the second data byte

The CAN FD frame has 2 or more data bytes, where the value of the second data byte should be E7.

- Set "DLC ≥ 2".
- Set the data pattern: "= XX E7".

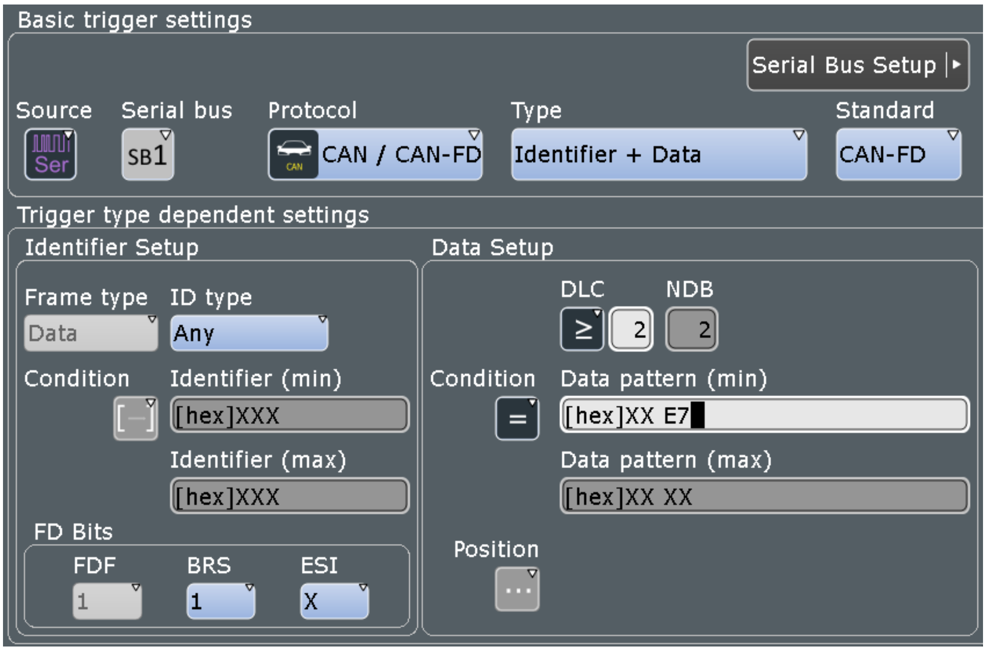
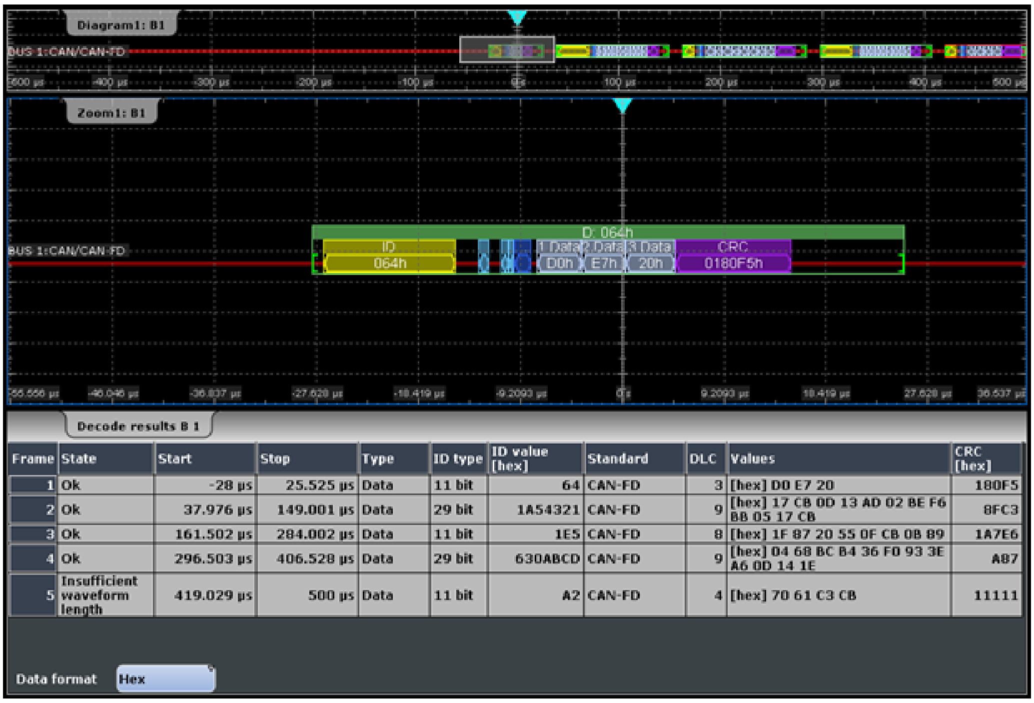


Figure 12-17: Trigger setup to trigger on the 2nd data byte with value = E7



Frame	State	Start	Stop	Type	ID type	ID value [hex]	Standard	DLC	Values	CRC [hex]
1	Ok	-28 µs	25.525 µs	Data	11 bit	64	CAN-FD	3	[hex] D0 E7 20	180F5
2	Ok	37.976 µs	149.001 µs	Data	29 bit	1A54321	CAN-FD	9	[hex] 17 CB 0D 13 AD 02 8E F6 8B 05 17 CB	8FC3
3	Ok	161.502 µs	284.002 µs	Data	11 bit	1E5	CAN-FD	8	[hex] 1F 87 20 55 0F CB 08 89	1A7E6
4	Ok	296.503 µs	406.528 µs	Data	29 bit	630ABCD	CAN-FD	9	[hex] 04 68 BC B4 36 F0 93 3E A6 0D 14 1E	A87
5	Insufficient waveform length	419.029 µs	500 µs	Data	11 bit	A2	CAN-FD	4	[hex] 70 61 C3 CB	11111

Figure 12-18: Data type trigger on 2nd data byte with value = E7

Example: Triggering on the seventh or later data byte

The CAN FD frame has 12 or more data bytes, where the value of the seventh or later data byte should be 17.

- Set "DLC ≥ 9".
- Set the data pattern: "= XX XX XX XX XX XX 17 XX".

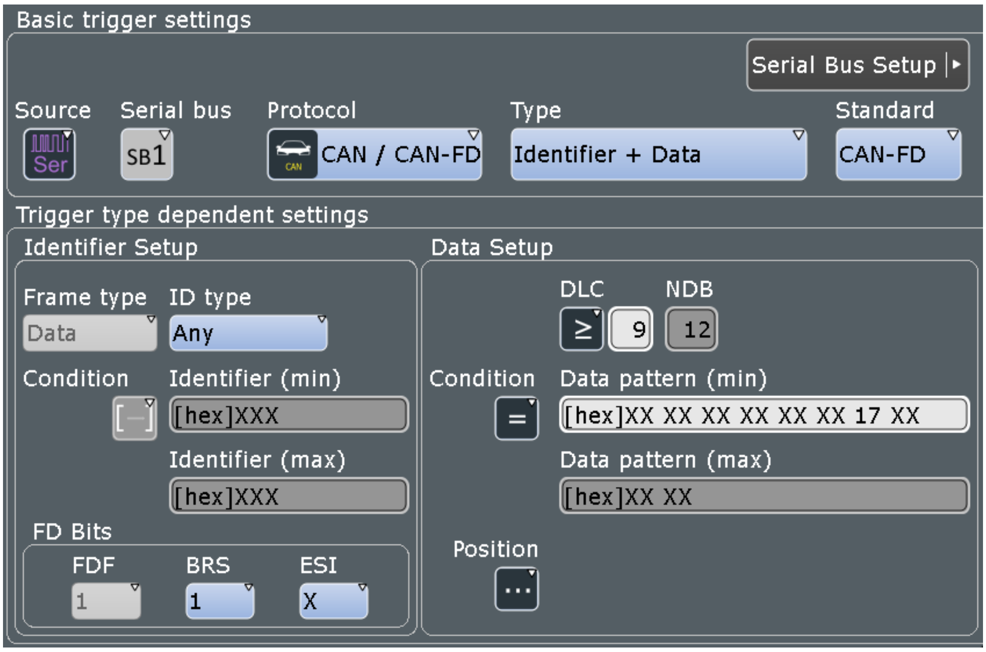


Figure 12-19: Trigger setup to trigger on the 7th or later data byte with value = 17

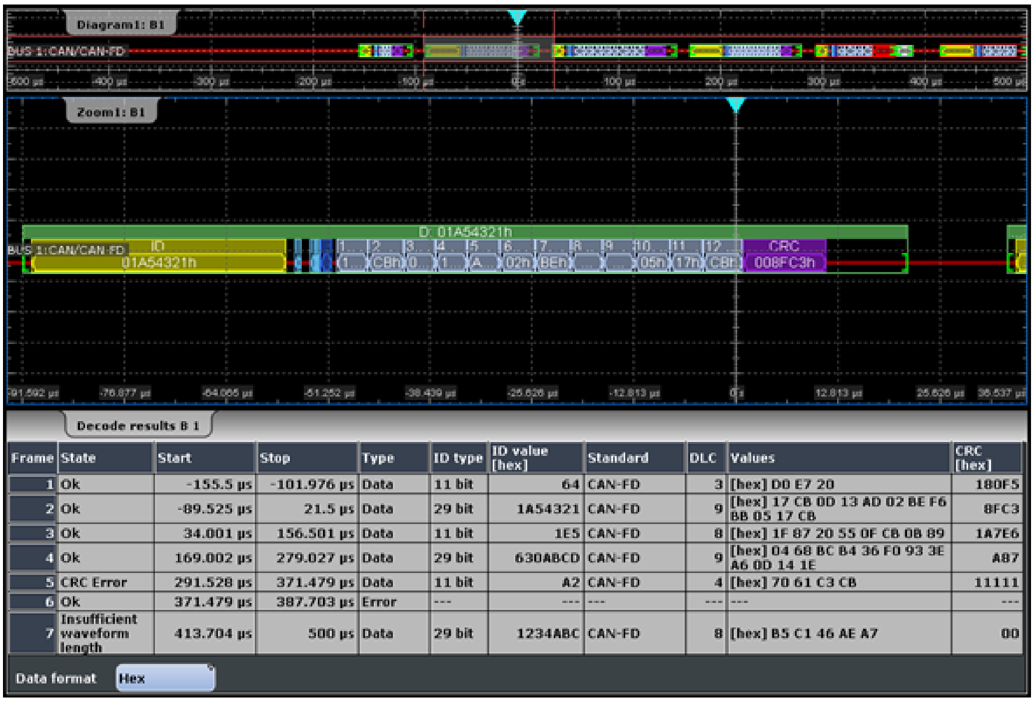


Figure 12-20: Data type trigger on data byte with the 7th or later byte value = 17

Example: Triggering on a data byte at a given position

The CAN FD frame has 12 or more data bytes. the trigger is set at the 8th data byte starting at the 4th data byte or later, with data byte value = 17.

- Set "DLC ≥ 9".
- Set the data pattern: "= XX XX XX XX XX XX XX 17 ".
- Set the position of the data pattern: "In range", "4" to "12".

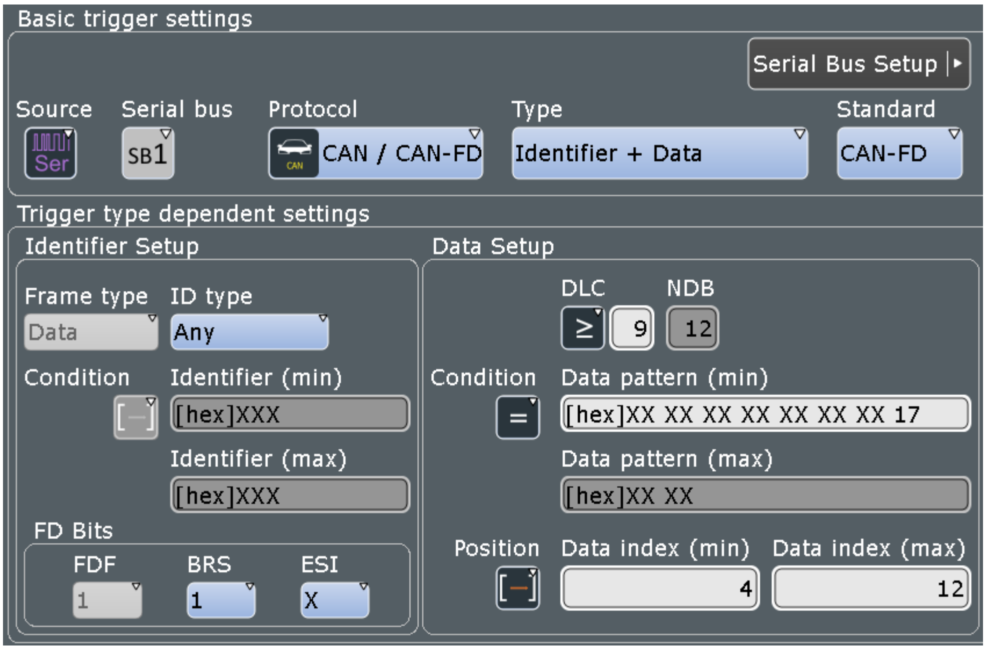


Figure 12-21: Trigger setup to trigger on data byte with value = 17 at 11th data byte location

The instrument skips the first 3 data bytes and starts comparing the data pattern with the 4th data byte. So, the byte with value 17 can be found between the 11th and the 19th data byte.

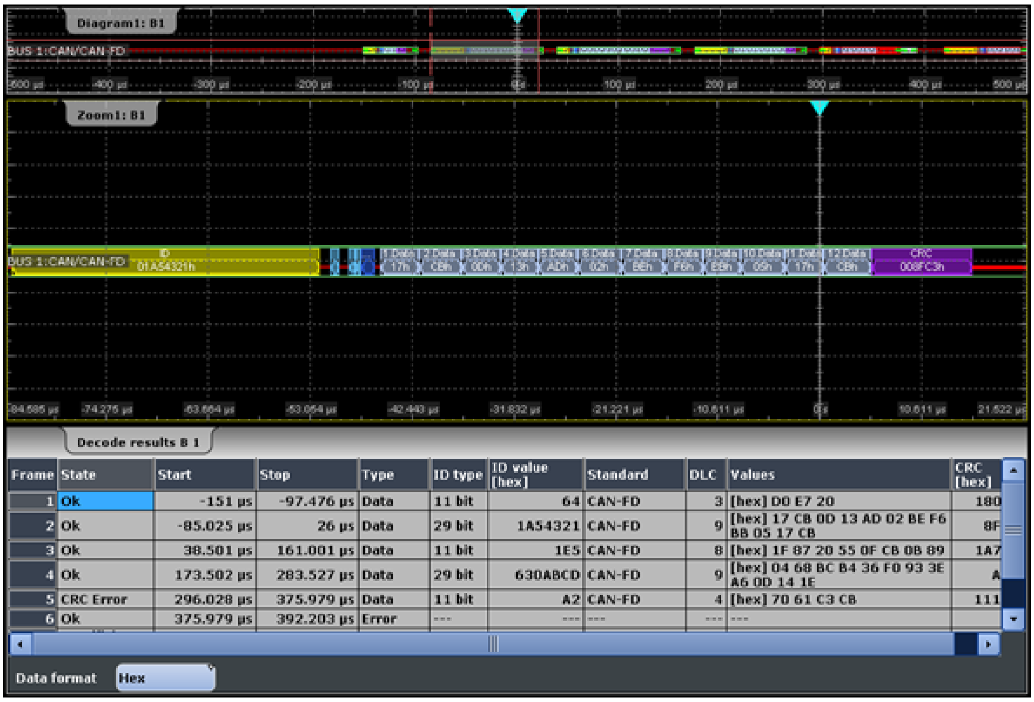


Figure 12-22: Data type trigger on data byte with value = 17 at 11th data byte location

12.5.3 CAN / CAN FD Label List

Label list files (symbolic data files) for CAN and CAN FD protocols are available in PTT and CSV file formats, similar to other serial protocols. In addititION, the R&S RTE can read and apply DBC files to the decoded signal and provides settings for symbolic triggering and symbolic search.

Note: In the following, CAN means both protocols: CAN, and CAN FD.

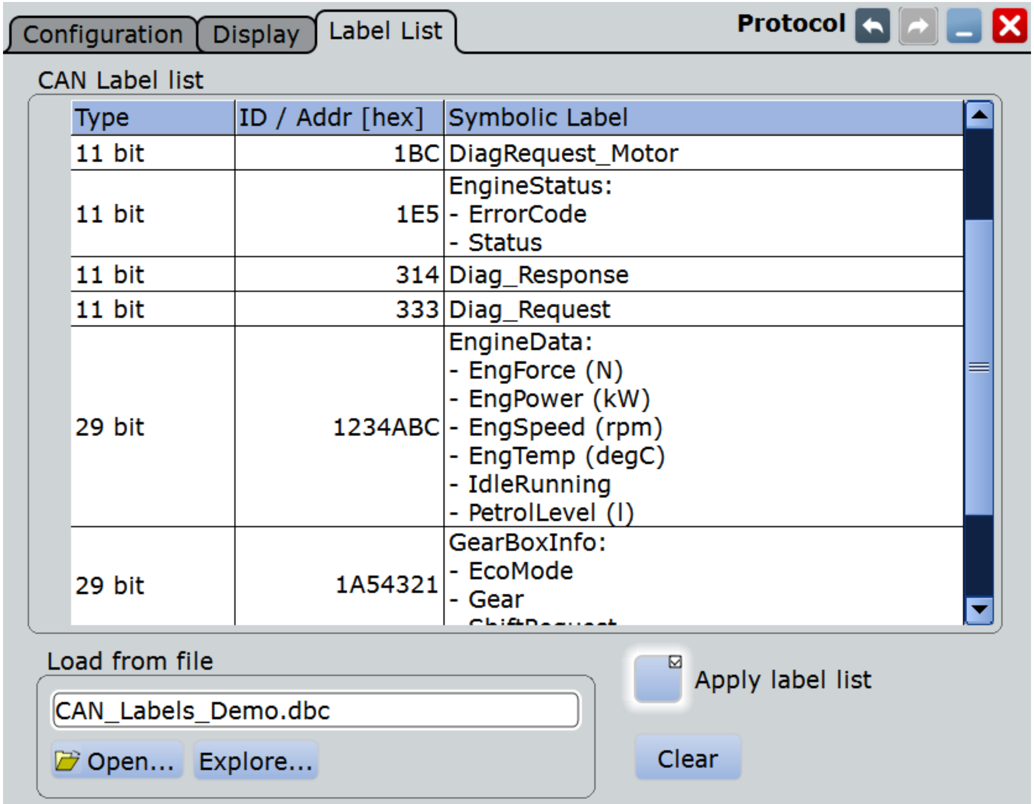
12.5.3.1 DBC files for CAN / CAN FD

Industry-standard DBC files contain more information than PTT and CSV files and translate the abstract decode results to human language. For each frame, the frame ID and the symbolic name of the ID are given; the frames are also called messages in CAN. The data of a CAN message can consist of several "signals". The DBC file provides the label, unit, start bit, length and other indicators for each signal. For state-encoded signals, the meaning of the states is given.

In the demo example, the message "EngineData" has the decimal ID 2,166,573,756 and consists of 8 data bytes. These 8 bytes are defined as 6 signals. The first one, "PetrolLevel", starts at bit #24, has a length of 8 bit, and the unit is liter. The signal "IdleRunning" is state-encoded. It has only one bit. The binary value 0 means "Running", and the binary value 1 means "Idle".

Example: CAN DBC file section

```
BO_ 2166573756 EngineData: 8 Engine
 SG_ PetrolLevel : 24|8@1+ (1,0) [0|255] "l" ...
 SG_ EngPower : 48|16@1+ (0.01,0) [0|350] "kW" ...
 SG_ EngForce : 32|10@1+ (1,0) [0|1000] "N" ...
 SG_ IdleRunning : 23|1@1+ (1,0) [0|1] "" ...
 SG_ EngTemp : 16|7@1+ (2,-50) [-50|150] "degC" ....
 SG_ EngSpeed : 0|13@1+ (1,0) [0|8000] "rpm" ...
....
 VAL_ 2166573756 IdleRunning 0 "Running" 1 "Idle" ;
```



The usage of DBC files is described in Chapter 12.5.6, "Symbolic Trigger, Decode and Search", on page 516.

12.5.3.2 PTT and CSV Files for CAN / CAN FD

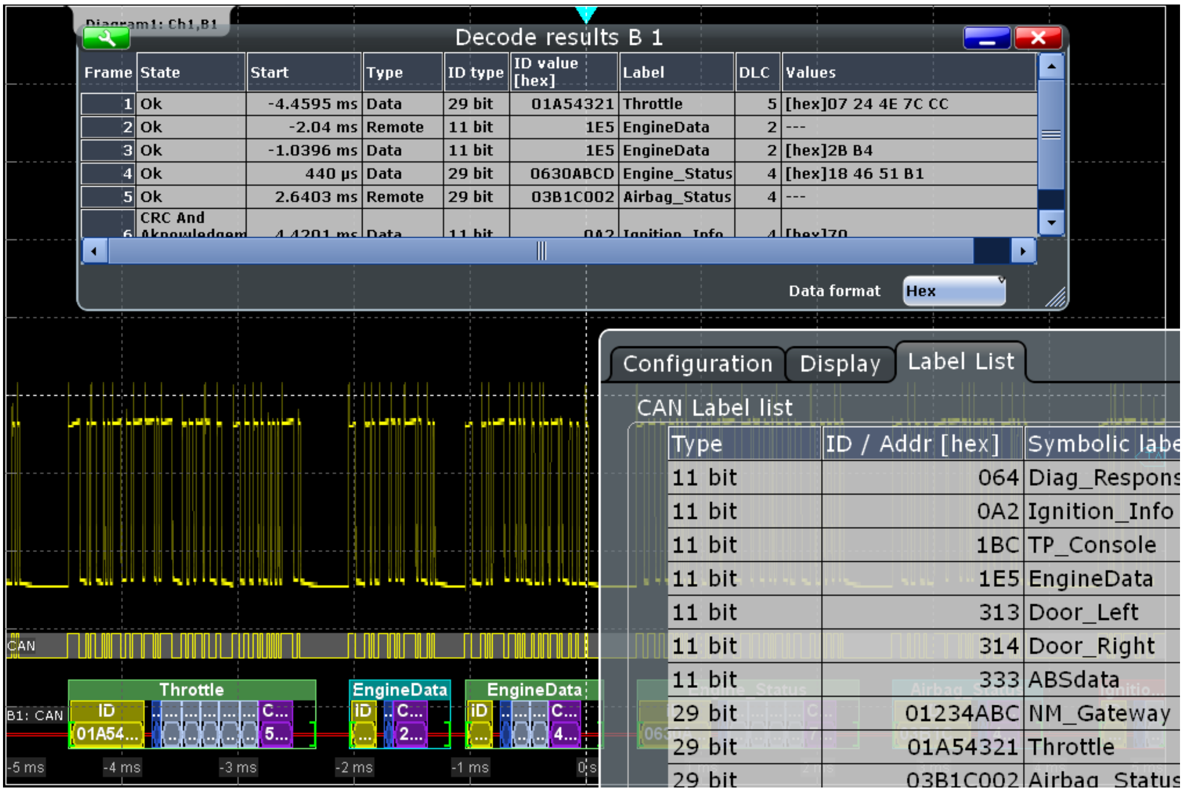
PTT files are protocol-specific. A PTT label file for CAN protocols contains three values for each identifier:

- "Type": identifier type, 11-bit or 29-bit long
- "ID / Addr": hexadecimal identifier value
- "Symbolic label": symbolic name of the identifier, specifying its function in the bus network.

Example: CAN PTT file

```
# ----------------------------------------------------------------------------
@FILE_VERSION  = 1.00
@PROTOCOL_NAME = can
# ---------------------------------------------------------------------------
# Labels for CAN protocol
#   Column order: Identifier type, Identifier value, Label
# ---------------------------------------------------------------------------
11,064h,Diag_Response
11,1E5h,EngineData
11,0A2h,Ignition_Info
11,1BCh,TP_Console
```

```
11,333h,ABSdata
11,313h,Door_Left
11,314h,Door_Right
29,01A54321h,Throttle
29,13A00FA2h,LightState
29,0630ABCDh,Engine_Status
29,03B1C002h,Airbag_Status
29,01234ABCh,NM_Gateway
# ---------------------------------------------------------------------------
```



For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 441.

Remote command:

- BUS<m>:CAN:FRAMe<n>:SYMBol? on page 1244

12.5.4 CAN and CAN FD Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

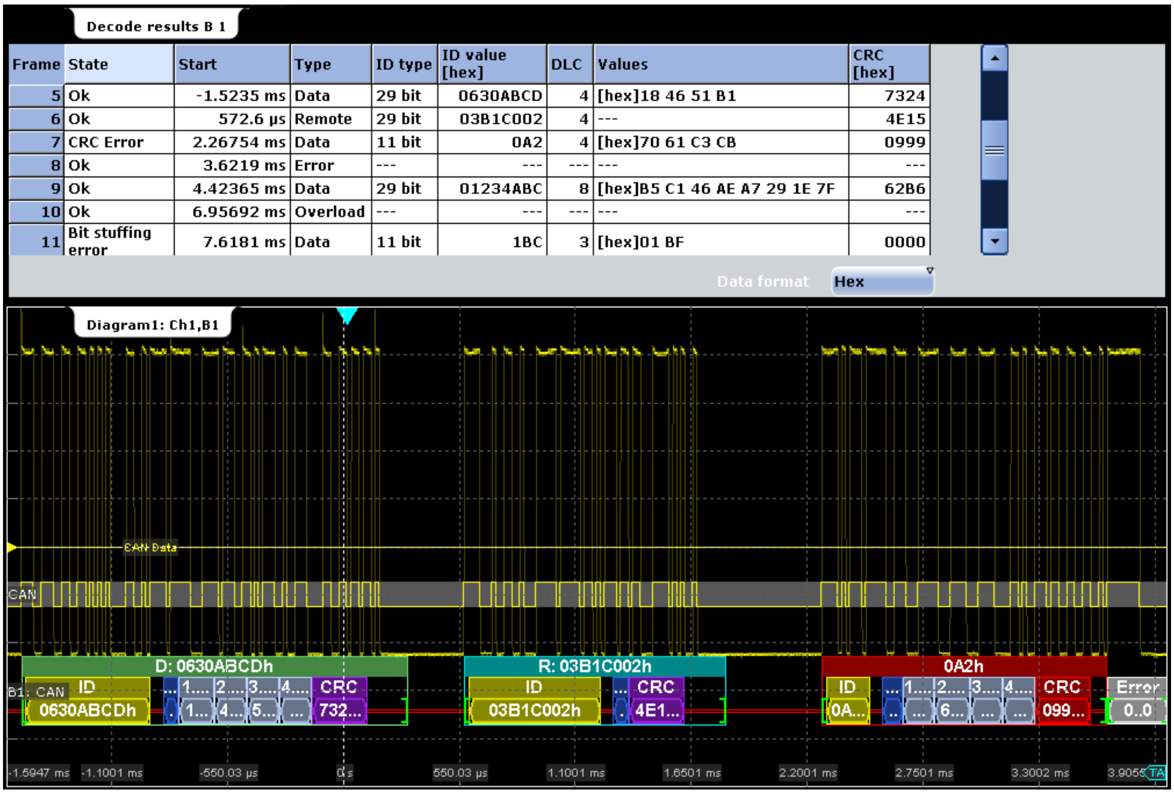
1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The binary results of data bytes are displayed MSB first.

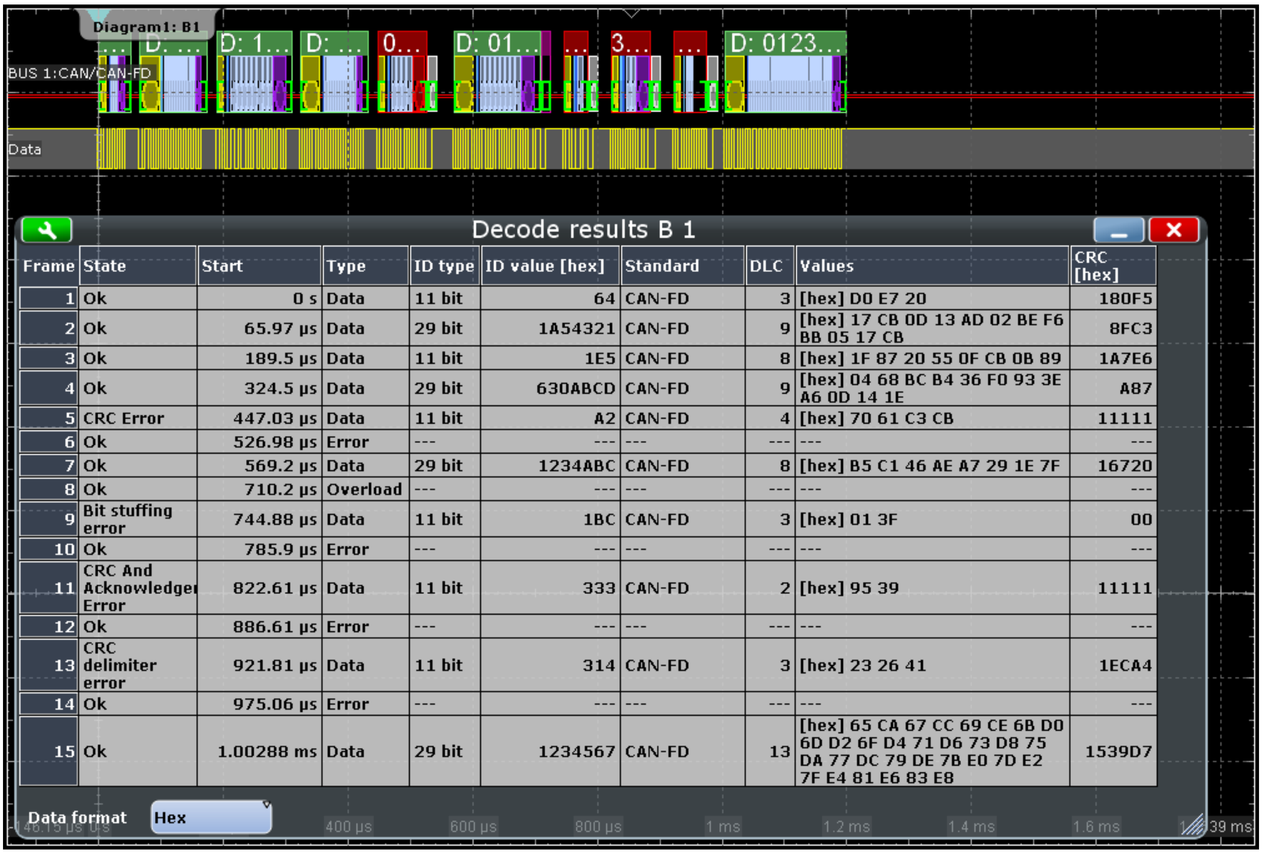
For CAN protocol, the endianness setting ("Transfer") is a trigger setting and not considered for decoding.



Frame	State	Start	Type	ID type	ID value [hex]	DLC	Values	CRC [hex]
5	Ok	-1.5235 ms	Data	29 bit	0630ABCD	4	[hex]18 46 51 B1	7324
6	Ok	572.6 µs	Remote	29 bit	03B1C002	4	---	4E15
7	CRC Error	2.26754 ms	Data	11 bit	0A2	4	[hex]70 61 C3 CB	0999
8	Ok	3.6219 ms	Error	---	---	---	---	---
9	Ok	4.42365 ms	Data	29 bit	01234ABC	8	[hex]B5 C1 46 AE A7 29 1E 7F	62B6
10	Ok	6.95692 ms	Overload	---	---	---	---	---
11	Bit stuffing error	7.6181 ms	Data	11 bit	1BC	3	[hex]01 BF	0000

Figure 12-23: Decoded and binary CAN signal, and decode results

green brackets [...]	= Start and end of frame
green frame header	= Data frame, ok
cyan frame header	= Remote frame, ok
magenta frame header	= Overload frame, ok
red frame header	= Frame contains an error
no frame header	= Error frame
yellow	= Identifier
blue	= DLC
gray-blue	= data
purple	= CRC (checksum)
gray	= Error frame
red	= Error occured



Frame	State	Start	Type	ID type	ID value [hex]	Standard	DLC	Values	CRC [hex]
1	Ok	0 s	Data	11 bit	64	CAN-FD	3	[hex] D0 E7 20	180F5
2	Ok	65.97 µs	Data	29 bit	1A54321	CAN-FD	9	[hex] 17 CB 0D 13 AD 02 BE F6 BB 05 17 CB	8FC3
3	Ok	189.5 µs	Data	11 bit	1E5	CAN-FD	8	[hex] 1F 87 20 55 0F CB 0B 89	1A7E6
4	Ok	324.5 µs	Data	29 bit	630ABCD	CAN-FD	9	[hex] 04 68 BC B4 36 F0 93 3E A6 0D 14 1E	A87
5	CRC Error	447.03 µs	Data	11 bit	A2	CAN-FD	4	[hex] 70 61 C3 CB	11111
6	Ok	526.98 µs	Error	---	---	---	---	---	---
7	Ok	569.2 µs	Data	29 bit	1234ABC	CAN-FD	8	[hex] B5 C1 46 AE A7 29 1E 7F	16720
8	Ok	710.2 µs	Overload	---	---	---	---	---	---
9	Bit stuffing error	744.88 µs	Data	11 bit	1BC	CAN-FD	3	[hex] 01 3F	00
10	Ok	785.9 µs	Error	---	---	---	---	---	---
11	CRC And Acknowledger Error	822.61 µs	Data	11 bit	333	CAN-FD	2	[hex] 95 39	11111
12	Ok	886.61 µs	Error	---	---	---	---	---	---
13	CRC delimiter error	921.81 µs	Data	11 bit	314	CAN-FD	3	[hex] 23 26 41	1ECA4
14	Ok	975.06 µs	Error	---	---	---	---	---	---
15	Ok	1.00288 ms	Data	29 bit	1234567	CAN-FD	13	[hex] 65 CA 67 CC 69 CE 6B D0 6D D2 6F D4 71 D6 73 D8 75 DA 77 DC 79 DE 7B E0 7D E2 7F E4 81 E6 83 E8	1539D7

Figure 12-24: Decoded CAN FD signal with data type = CAN_L, arbitration rate = 1 Mbps and data rate = 2 Mbps

You can also load and apply industry-standard DBC files. The symbolic names from the file are applied to the display of the decoded data, see Chapter 12.5.6.2, "Symbolic Decode Waveform", on page 518.

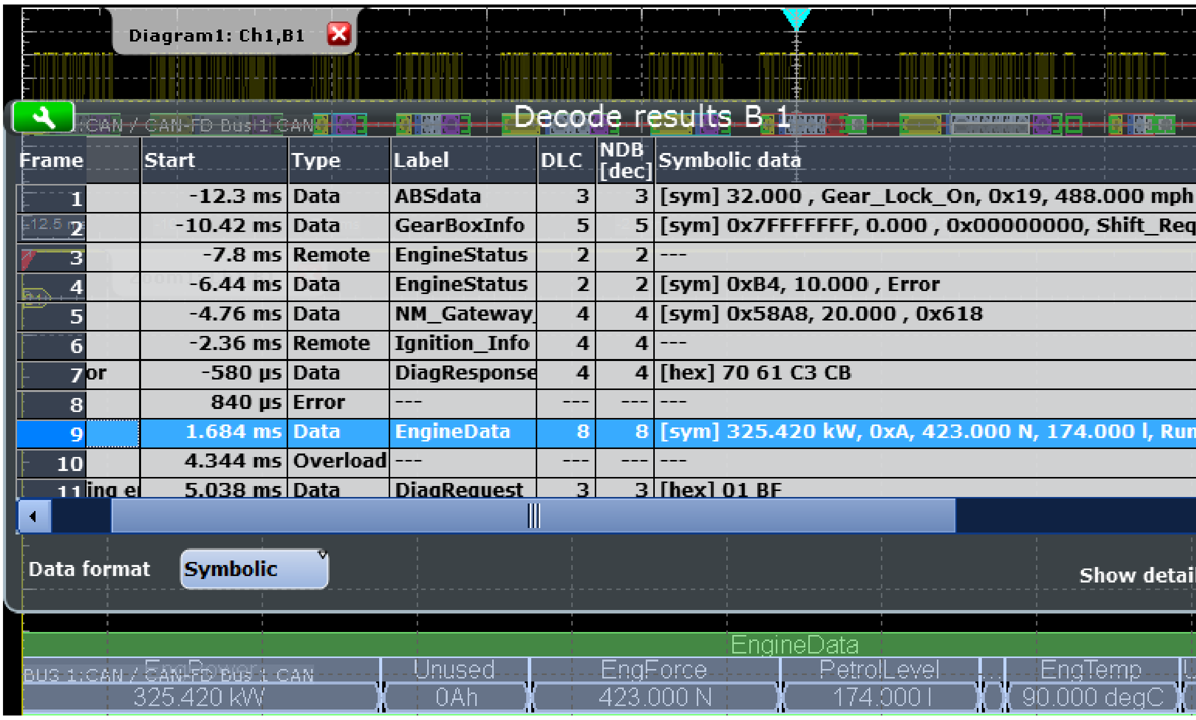


Figure 12-25: Decoded CAN signal with applied DBC file and "Symbolic" data in the result table

Table 12-4: Content of the "Decode results" table

Column	Description
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of frame start
Type	Frame type: Data, Remote, Error, or Overload
ID type	11 bit standard format or 29 bit extended format
ID value (hex)	Identifier value, hexadecimal value
Standard	Frame format, CAN or CAN FD. Only available in CAN FD option R&S RTE-K9.
DLC	Data length code, coded number of data bytes
NDB	Actual number of data bytes
Values	Value of the data frame. The data format is selected below the table. Remote frames do not transmit data, therefore "- - -" is displayed.
Symbolic data	Values of the individual signals that are part of a message. The column is shown instead of the "Values" column, if a DBC file is loaded and the "Data format" is "Symbolic".
SC (dec)	Stuff count value, decimal value. Only available for CAN FD ISO signals, option R&S RTE-K9.

Column	Description
CRC (hex)	Value of the Cyclic Redundance Check (checksum), hexadecimal value
Form error cause	Reason of a form error if a form error occurred

Remote commands:
- `BUS<m>:CAN:FCOunt?` on page 1241
- `BUS<m>:CAN:FRAMe<n>:STATus?` on page 1242
- `BUS<m>:CAN:FRAMe<n>:FERCause?` on page 1248
- `BUS<m>:CAN:FRAMe<n>:DATA?` on page 1245
- `BUS<m>:CAN:FRAMe<n>:STARt?` on page 1243
- `BUS<m>:CAN:FRAMe<n>:STOP?` on page 1243
- `BUS<m>:CAN:FRAMe<n>:TYPE?` on page 1244
- `BUS<m>:CAN:FRAMe<n>:ACKState?` on page 1245
- `BUS<m>:CAN:FRAMe<n>:ACKValue?` on page 1245
- `BUS<m>:CAN:FRAMe<n>:BSEPosition?` on page 1247
- `BUS<m>:CAN:FRAMe<n>:BYTE<o>:STATe?` on page 1248
- `BUS<m>:CAN:FRAMe<n>:BYTE<o>:VALue?` on page 1249
- `BUS<m>:CAN:FRAMe<n>:CSSTate?` on page 1245
- `BUS<m>:CAN:FRAMe<n>:CSValue?` on page 1246
- `BUS<m>:CAN:FRAMe<n>:DLCState?` on page 1245
- `BUS<m>:CAN:FRAMe<n>:DLCValue?` on page 1246
- `BUS<m>:CAN:FRAMe<n>:IDSTate?` on page 1245
- `BUS<m>:CAN:FRAMe<n>:IDTYpe?` on page 1247
- `BUS<m>:CAN:FRAMe<n>:IDValue?` on page 1247
- `BUS<m>:CAN:FDATa:FRAMe<n>:SCValue?` on page 1248

12.5.5 Search on Decoded CAN or CAN FD Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

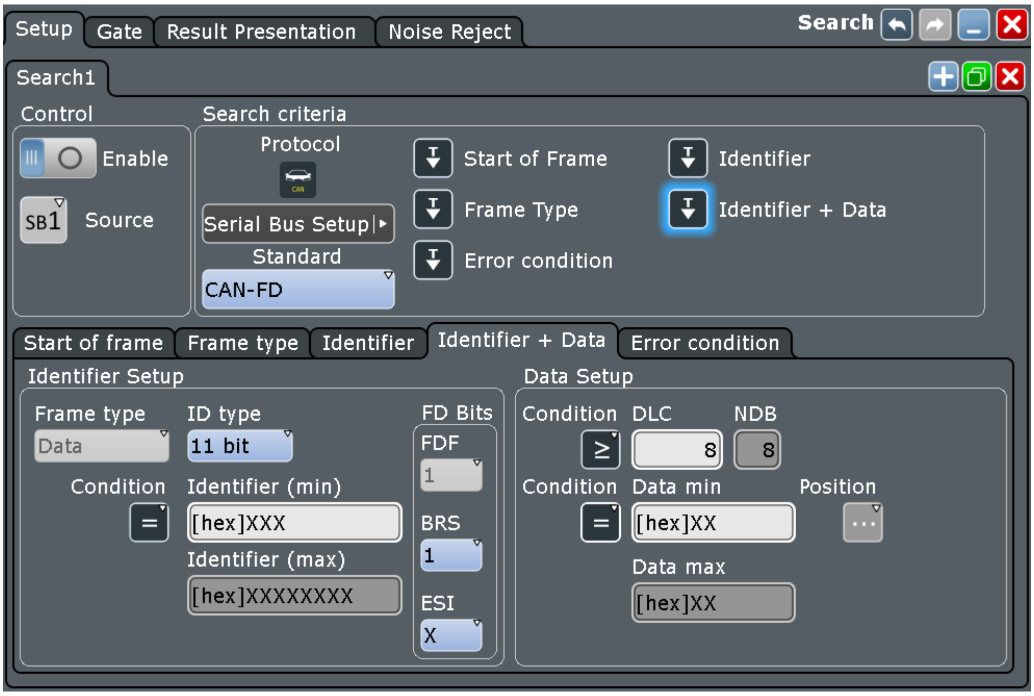
Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 376.

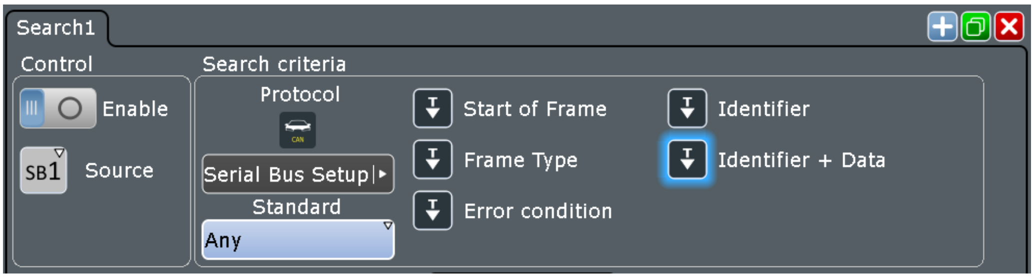
12.5.5.1 Search Settings

Access: SEARCH > "Setup" tab



Search Criteria
Sets one criterion or an AND-combination of criteria to be searched for. If more than one criterion is selected, all criteria must be fulfilled by a frame for it to be shown in the search results.

If a DBC label list file is applied, an additional criterion "Symbolic" is provided, see Chapter 12.5.6.3, "Symbolic Search", on page 519.



"Start of frame" Searches for the first edge of the dominant SOF bit (synchronization bit).

"Frame type" Searches for a specified frame type (data, remote, error, or overload). For data and remote frames, also the identifier format is considered.

For details, see:
- "Frame type" on page 510
- "ID type" on page 511

"Identifier" Searches for a specific message identifier or an identifier range.
See "Identifier setup: Condition, Identifier min, Identifier max" on page 511.

"Identifier + Data"
Searches for a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern.
The identifier conditions are the same as for the "Identifier" search criteria, see "Identifier setup: Condition, Identifier min, Identifier max" on page 511. Data conditions are set with "Data setup: DLC, NDB, Condition, Data min, Data max" on page 512.

"Error condition"
Identifies various errors in the frame, see "Error conditions" on page 496.

"Symbolic" The "Symbolic" search criteria is available if a DBC label list file is loaded and applied. It allows you to search for specific data messages, or a signal and its value that appears inside the message.
Symbolic search is an alternative to the other search criteria, you can either search for symbolic values or for an AND-combination of the other 5 criteria.
For details, see Chapter 12.5.6.3, "Symbolic Search", on page 519.

Remote command:
`SEARch:TRIGger:CAN[:SSOFrame]` on page 1250
`SEARch:TRIGger:CAN:SFTYpe` on page 1250
`SEARch:TRIGger:CAN:SFIDentifier` on page 1251
`SEARch:TRIGger:CAN:SIDData` on page 1251
`SEARch:TRIGger:CAN:SERRor` on page 1251
`SEARch:TRIGger:CAN:SSYMbolic` on page 1268

Standard
Selects the CAN standard: "CAN", "CAN FD", or "Any".

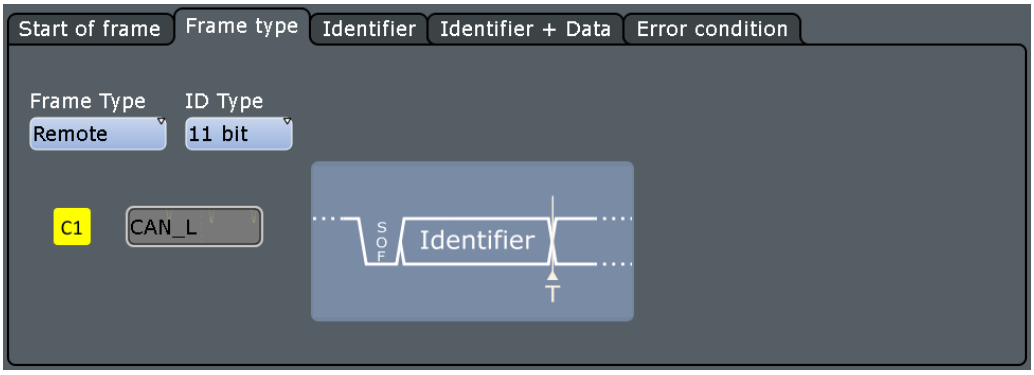
The setting is available in CAN FD option R&S RTE-K9.

Use "Any" to search for both CAN and CAN-FD frames. In this case, the search configuration provides all possible settings, for CAN as well as for CAN FD.

Remote command:
`SEARch:TRIGger:CAN:FDATa:STANdard` on page 1251

Frame type
Selects the frame type.

Remote frames are only available in the CAN protocol.



The frame types are the same as in the CAN trigger setup, see "Frame type" on page 491.

Remote command:
`SEARch:TRIGger:CAN:FTYPe` on page 1252

ID type

Selects the length of the identifier.

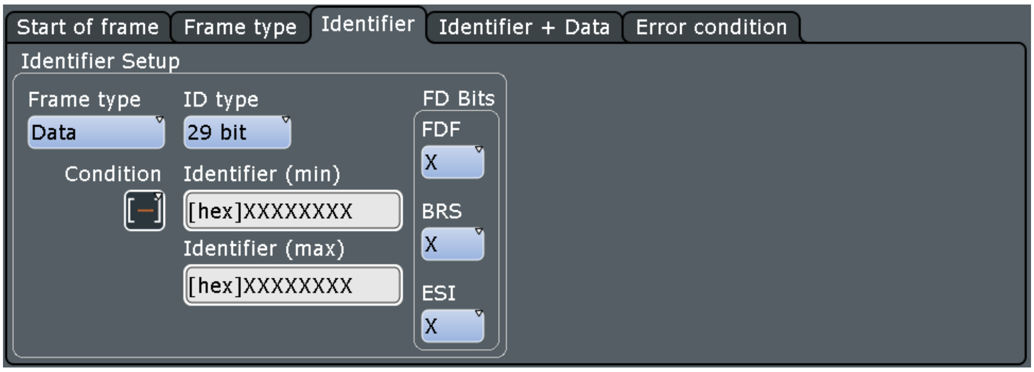
"11 bit"	Identifier length of the CAN base frame format. The instrument triggers on the sample point of the IDE bit.
"29 bit"	Identifier length of the CAN extended frame format. The instrument triggers on the sample point of the RTR bit.
"Any"	The ID type is not relevant. If the trigger type is "Identifier + Data", set the "ID type" to "Any" if you want to search only for data.

Remote command:
`SEARch:TRIGger:CAN:ITYPe` on page 1252

Identifier setup: Condition, Identifier min, Identifier max

The identifier setup consists mainly of the condition and one or two identifier patterns. Additionally, ID type and frame type may qualify the identifier.

The identifier setup settings are the same as in the CAN trigger setup, see "Identifier setup: Condition, Identifier min, Identifier max" on page 492.



FD bits: see "FD bits" on page 512.

Remote command:
`SEARch:TRIGger:CAN:ICONdition` on page 1252
`SEARch:TRIGger:CAN:IMIN` on page 1253
`SEARch:TRIGger:CAN:IMAX` on page 1253

FD bits
For standard settings "CAN FD" and "Any", you can search for CAN FD-specific bits.

For details, see "FD bits" on page 493.

The setting is available in CAN FD option R&S RTE-K9.

Remote command:
`SEARch:TRIGger:CAN:FDATa[:FDF]` on page 1257
`SEARch:TRIGger:CAN:FDATa:BRS` on page 1258
`SEARch:TRIGger:CAN:FDATa:ESI` on page 1258

Data setup: DLC, NDB, Condition, Data min, Data max
The data setup consists of the number of bytes, the condition, and one or two data patterns.

The data setup settings are the same as in the CAN trigger setup, see "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 494.

The data condition setting is also used for symbolic signal search, see Chapter 12.5.6.3, "Symbolic Search", on page 519.

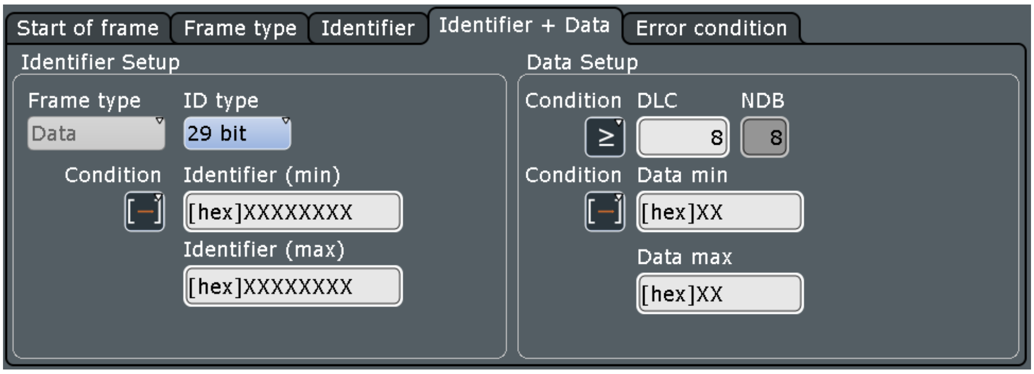


Figure 12-26: Identifier + Data search setup for CAN signals

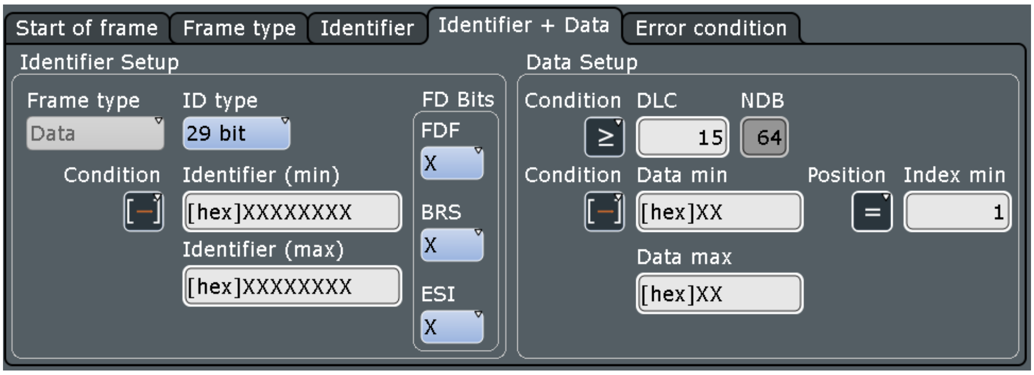


Figure 12-27: Identifier + Data search setup for CAN FD signals

Remote command:
SEARch:TRIGger:CAN:DCONdition on page 1253
SEARch:TRIGger:CAN:DMIN on page 1253
SEARch:TRIGger:CAN:DMAX on page 1254
SEARch:TRIGger:CAN:DLCCondition on page 1254
SEARch:TRIGger:CAN:DLC on page 1254
SEARch:RESult:CAN:FRAMe<m>:NDBYtes? on page 1255

Data position

The data position sets the location in the data field where the instrument looks for the specified data pattern.

The setting is available in CAN FD option R&S RTE-K9.

The position can be defined if the data field of the frame is longer than 8 bytes - if DLC ≥9.

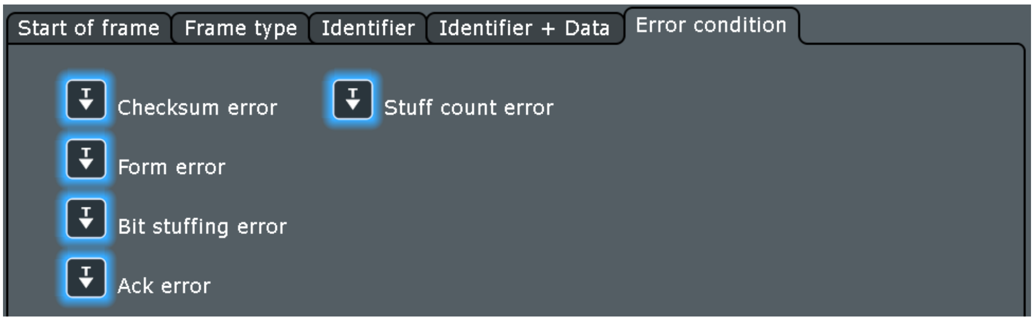
For details, see "Data position" on page 495.

Remote command:
SEARch:TRIGger:CAN:FDATa:DPOPerator on page 1255
SEARch:TRIGger:CAN:FDATa:DPOSition on page 1255
SEARch:TRIGger:CAN:FDATa:DPTO on page 1256

Error Condition

Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the CAN trigger setup, see "Error conditions" on page 496.



Remote command:
SEARch:TRIGger:CAN:CRCerror on page 1257
SEARch:TRIGger:CAN:BITSterror on page 1256
SEARch:TRIGger:CAN:FORMerror on page 1257
SEARch:TRIGger:CAN:ACKerror on page 1256
SEARch:TRIGger:CAN:FDATa:SCERror on page 1257

12.5.5.2 Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394

Remote commands:

- `SEARch:RESult:CAN:FCOunt?` on page 1259
- `SEARch:RESult:CAN:FRAMe<m>:STATus?` on page 1264
- `SEARch:RESult:CAN:FRAMe<m>:FERCause?` on page 1262
- `SEARch:RESult:CAN:FRAMe<m>:ACKState?` on page 1259
- `SEARch:RESult:CAN:FRAMe<m>:ACKValue?` on page 1260
- `SEARch:RESult:CAN:FRAMe<m>:BSEPosition?` on page 1260
- `SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:STATe?` on page 1260
- `SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:VALue?` on page 1260
- `SEARch:RESult:CAN:FRAMe<m>:CSSTate?` on page 1261
- `SEARch:RESult:CAN:FRAMe<m>:CSValue?` on page 1261
- `SEARch:RESult:CAN:FRAMe<m>:DATA?` on page 1261
- `SEARch:RESult:CAN:FRAMe<m>:DLCState?` on page 1261
- `SEARch:RESult:CAN:FRAMe<m>:DLCValue?` on page 1262
- `SEARch:RESult:CAN:FRAMe<m>:IDSTate?` on page 1262
- `SEARch:RESult:CAN:FRAMe<m>:IDTYpe?` on page 1263
- `SEARch:RESult:CAN:FRAMe<m>:IDValue?` on page 1263
- `SEARch:RESult:CAN:FDATa:FRAMe<m>:STANdard?` on page 1264
- `SEARch:RESult:CAN:FRAMe<m>:STARt?` on page 1264
- `SEARch:RESult:CAN:FRAMe<m>:STOP?` on page 1264
- `SEARch:RESult:CAN:FRAMe<m>:SYMBol?` on page 1265
- `SEARch:RESult:CAN:FRAMe<m>:TYPE?` on page 1265

12.5.5.3 Searching CAN FD Data

The "Identifier + Data" search supports the search for data bytes of specific value at a specific location in the data field of a frame. The "Data Pattern" field provides 8 data bytes to define the pattern. For data fields longer than 8 byte, you can define the position where the specified pattern starts.

The following example demonstrates how the data pattern and data position is defined.

To set up the search

1. Set the "Source", the signal to be searched: "SerBus". Select the bus that is configured for CAN FD.

2. Set the search criteria:
   a) Select the standard: "CAN FD".
   b) Select the search type: "Identifier + Data".
3. In this example, the identifier does not matter. Set the "ID type = Any".
4. Define the data setup as described in the example.

Example: Searching for a specific byte anywhere in the frame

The CAN FD frame has 8 or more data bytes, containing at least one data byte with value = CB anywhere in the data field.

- Set "DLC ≥ 8".
- Set the data pattern: "= CB".

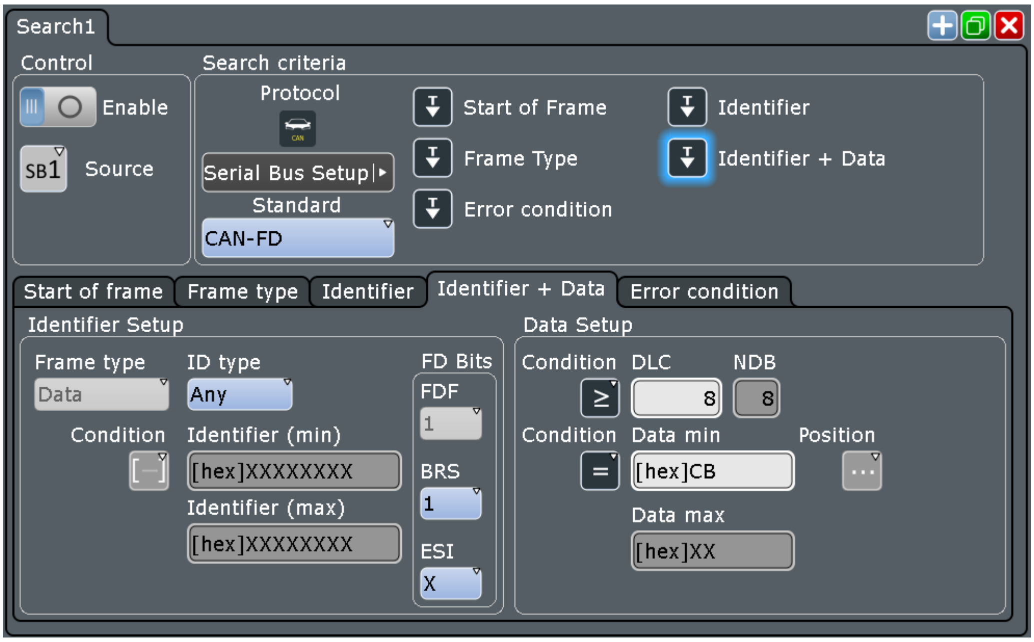


Figure 12-28: Search setup to find all data bytes with value = CB

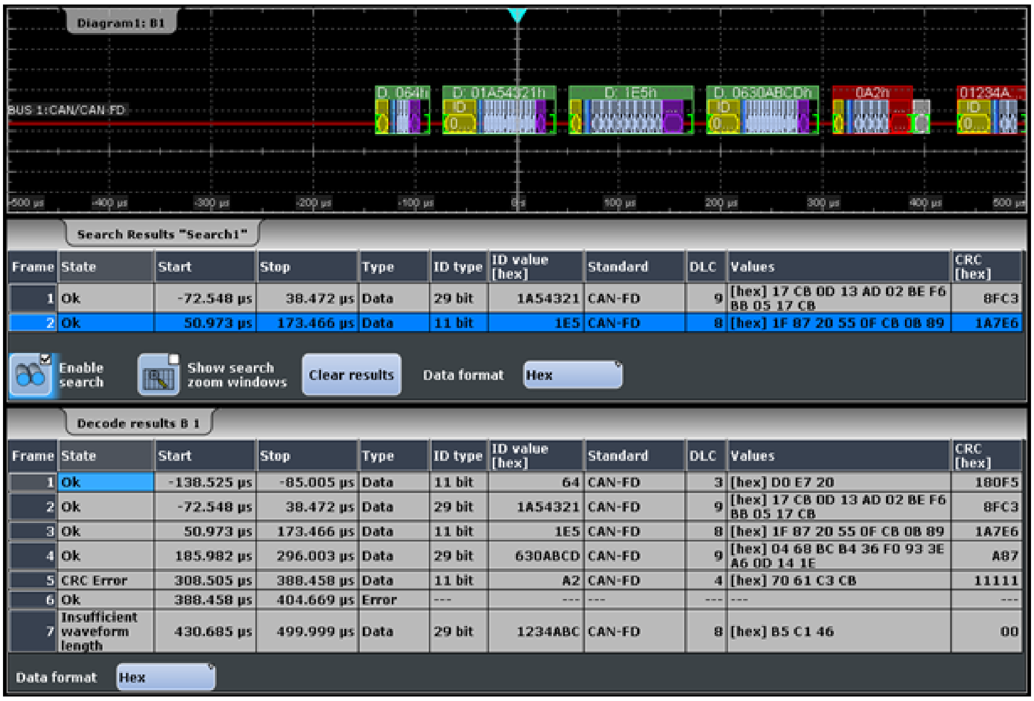


Figure 12-29: Search result

12.5.6 Symbolic Trigger, Decode and Search

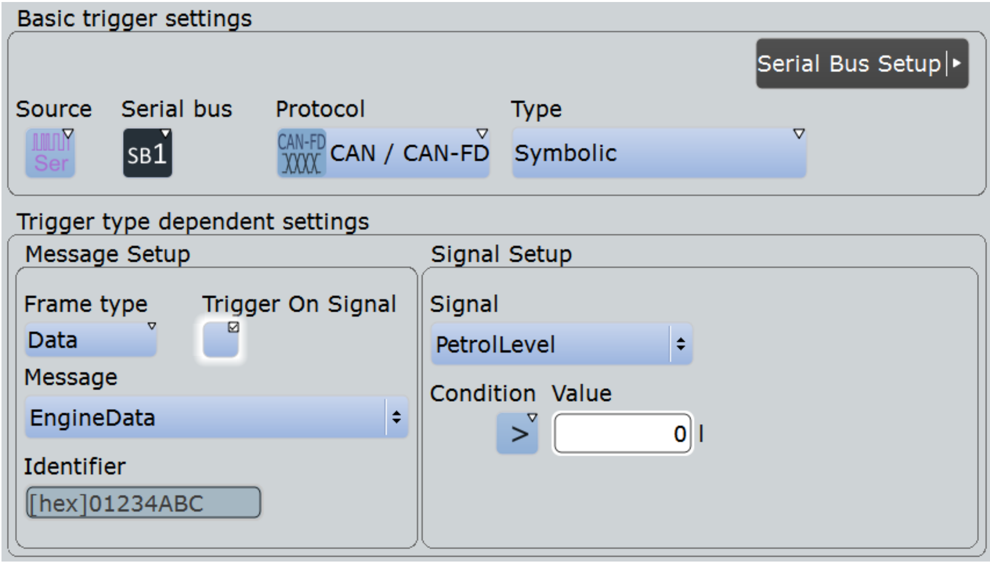
The R&S RTE can read and apply industry-standard DBC files to the decoded signal and provides settings for symbolic triggering and symbolic search.

For a description of DBC files, see Chapter 12.5.3.1, "DBC files for CAN / CAN FD", on page 502.

12.5.6.1 Symbolic Trigger

The "Symbolic" trigger type is available if a DBC label list file is loaded and applied, see Chapter 12.5.3, "CAN / CAN FD Label List", on page 502. It allows you to trigger on a specific data message, or a signal and its value that appears inside the message.

Access: TRIGGER > "Source" = "Serial Bus" and "Protocol" = "CAN" or "CAN / CAN FD" > "Type" = "Symbolic"



The "Frame type" is automatically set to "Data", and the "Identifier" is shown for information.

Specific settings for the symbolic trigger are:

Message
Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

Remote command:
`TRIGger<m>:CAN:SYMBolic:MSGValue` on page 1266

Trigger on signal
Enables the trigger on a specific signal value that is part of the selected message.

Remote command:
`TRIGger<m>:CAN:SYMBolic:TSIGnals` on page 1266

Signal
Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

Remote command:
`TRIGger<m>:CAN:SYMBolic:SIGValue` on page 1266

Condition
Sets the operator to set a specific data pattern or symbolic value ("Equal" or "Not equal") or a data range.

Remote command:
`TRIGger<m>:CAN:DCONdition` on page 1237

Value, Value min
Defines the data pattern or selects a symbolic data value.

Remote command:
`TRIGger<m>:CAN:SYMBolic:DMIN` on page 1267
`TRIGger<m>:CAN:SYMBolic:SGEValue` on page 1267

Value max
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:CAN:SYMBolic:DMAX` on page 1266

12.5.6.2 Symbolic Decode Waveform

If a DBC file is applied, the symbolic names from the file are applied to the display of the decoded data. The result table lists the signal values and units in the "Symbolic Data" column, and the comb display shows the signal names in addition to the signal values and units.

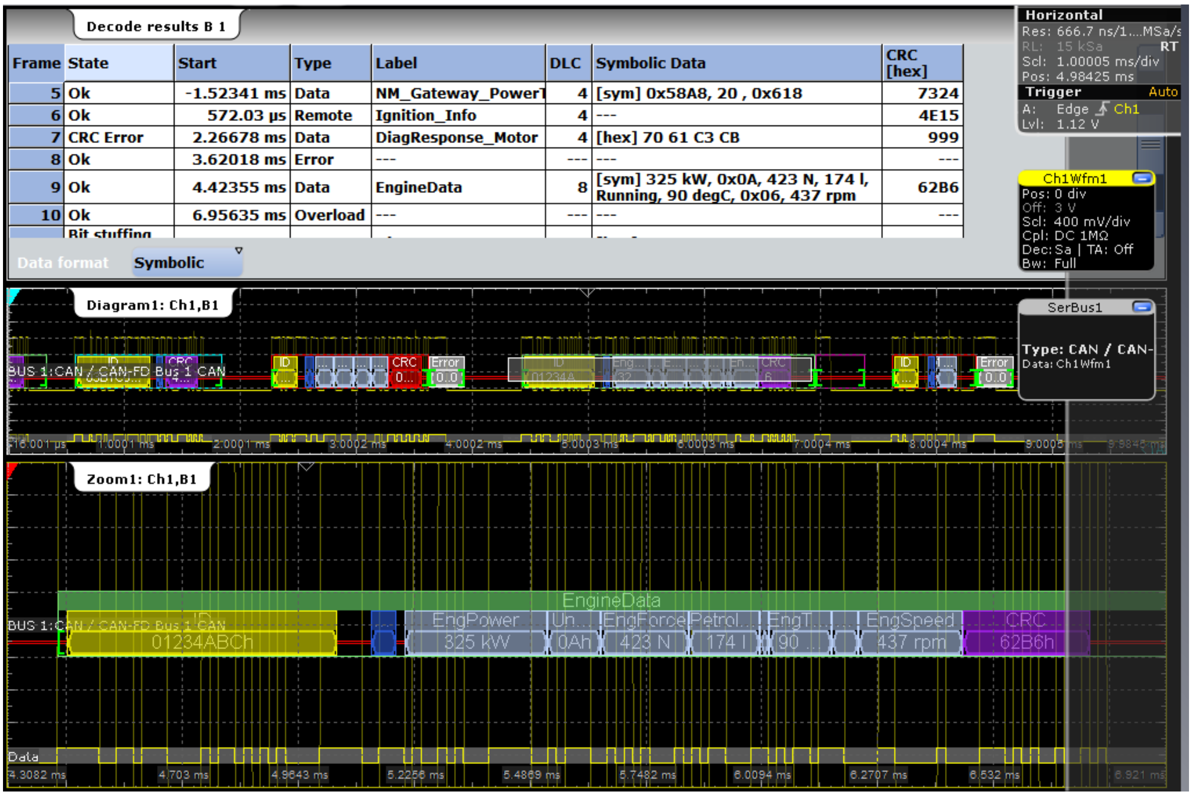


Figure 12-30: Result table and decoded CAN signal with applied DBC file and zoom on EngineData message

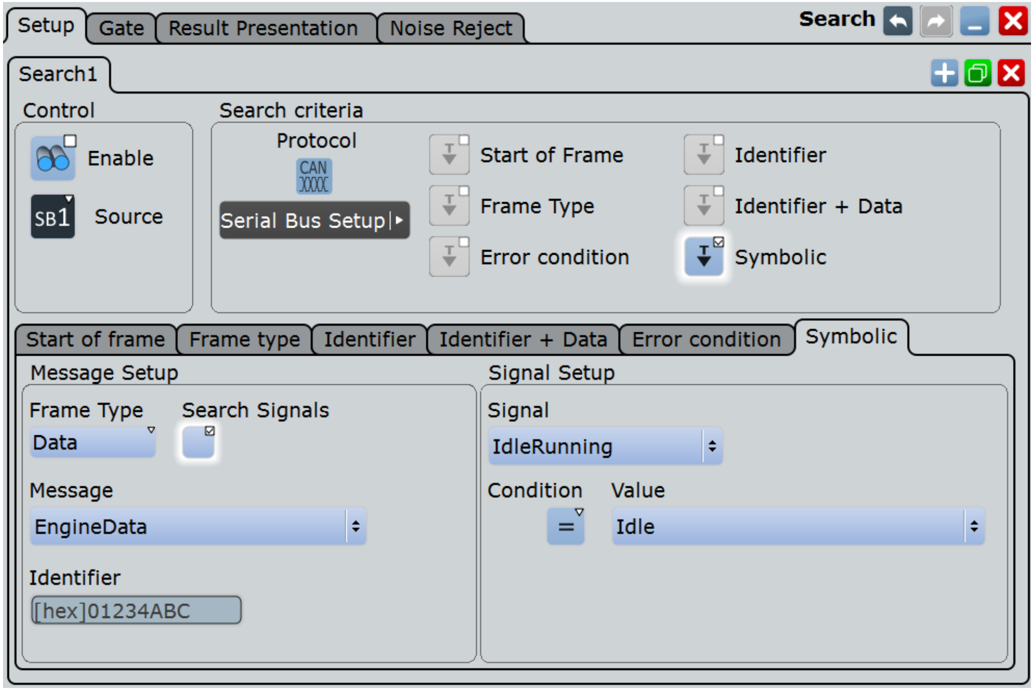
Remote command:

- `BUS<m>:CAN:FRAMe<n>:SDATa?` on page 1267

12.5.6.3 Symbolic Search

Access: SEARCH > "Setup" tab > "Symbolic" = on

If a DBC file is applied, the symbolic search for messages and signal, which are defined in the DBC file, is available. Symbolic search is an alternative to the other search criteria, you can either search for symbolic values or for an AND-combination of the other 5 criteria.



If symbolic search is active, the "Frame type" is automatically set to "Data", and the "Identifier" is shown for information.

Symbolic
Enables the symbolic search and disables all other search criteria.

Remote command:
`SEARch:TRIGger:CAN:SSYMbolic` on page 1268

Message
Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:MSGValue` on page 1268

Search signals
Enables the search for a specific signal value that is part of the selected message.

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:SSIGnals` on page 1269

Signal
Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:SIGValue` on page 1269

Condition

Sets the operator to set a specific data pattern or symbolic value ("Equal" or "Not equal") or a data range.

This condition is also used to search for data, see "Data setup: DLC, NDB, Condition, Data min, Data max" on page 512.

Remote command:
`SEARch:TRIGger:CAN:DCONdition` on page 1253

Value, Value (min)

Defines the data pattern or selects a symbolic data value.

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:DMIN` on page 1269
`SEARch:TRIGger:CAN:SYMBolic:SGEValue` on page 1270

Value (max)

The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:DMAX` on page 1270

12.5.6.4 Symbolic Search Results

If a DBC file is applied, you can search for symbolic messages and signals as described in Chapter 12.5.6.3, "Symbolic Search", on page 519. As ususal, the search results are shown in a table. You can enable the search zoom window to view the frame with the selected result in more detail.

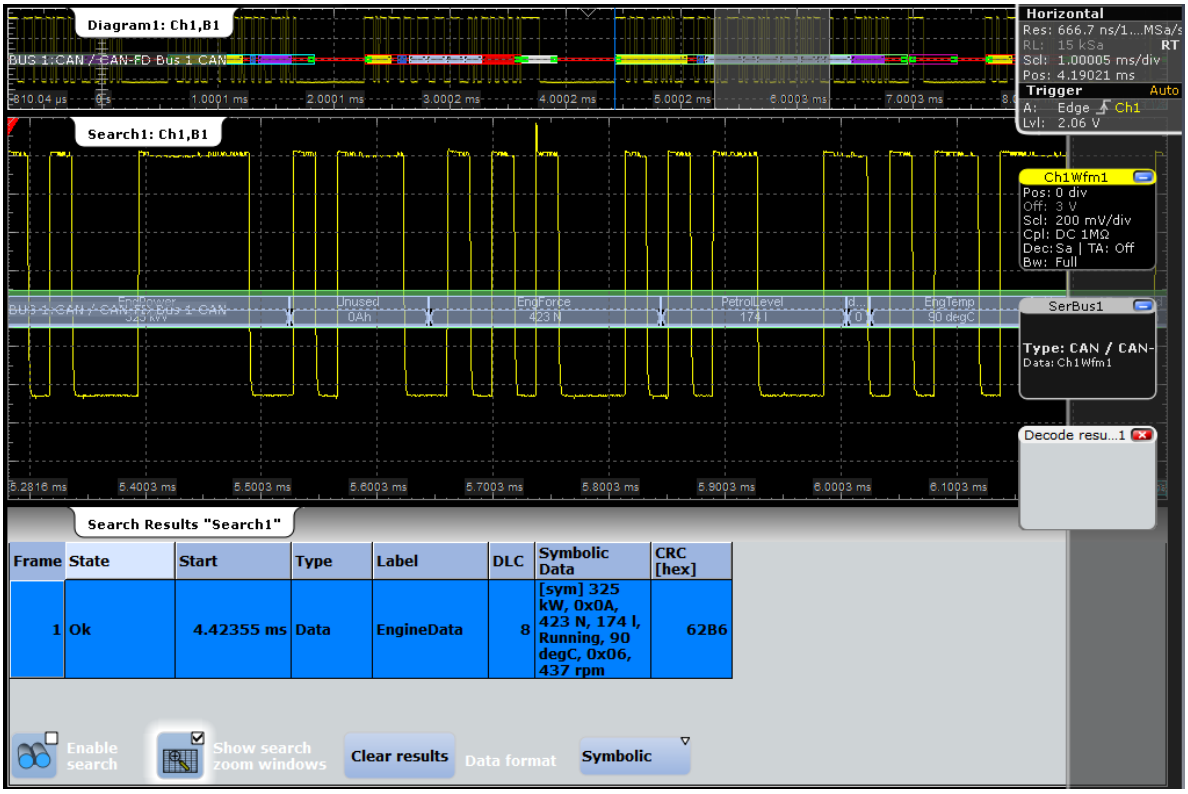


Figure 12-31: Search results table and search zoom window. Search for signal "IdleRunning" with value "Running" (bit value = 0)

The figure shows the result of a search for an "EngineData" message and the signal "IdleRunning = Running" inside the message. The result marker (blue line) ist set to the start of the frame that fulfills the search condition. The search zoom window Search1 is active. It has been moved to the right until the "IdleRunning" bit with value 0 is visible in the zoom.

Remote command:

- `SEARch:RESult:CAN:FRAMe<m>:SDATa?` on page 1268

12.6 LIN (Option R&S RTE-K3)

The Local Interconnect Network (LIN) is a simple, low-cost bus system used within automotive network architectures. LIN is usually a sub-network of a CAN bus. The primary purpose of LIN is the integration of uncritical sensors and actuators with low bandwidth requirements. Common applications in a motor vehicle are the control of doors, windows, wing mirrors, and wipers.

12.6.1 The LIN Protocol

This chapter provides an overview of protocol characteristics, frame format, identifiers and trigger possibilities. For detailed information, order the LIN specification on http://www.lin-subbus.org/ (free of charge).

LIN characteristics

Main characteristics of LIN are:

- Single-wire serial communications protocol, based on the UART byte-word interface
- Single master, multiple slaves - usually up to 12 nodes
- Master-controlled communication: master coordinates communication with the LIN schedule and sends identifier to the slaves
- Synchronization mechanism for clock recovery by slave nodes without crystal or ceramics resonator

The R&S RTE supports several versions of the LIN standard: v1.3, v2.0, v2.1 and the American SAE J2602.

Data transfer

Basic communication concept of LIN:

- Communication in an active LIN network is always initiated by the master.
- Master sends a message header including the synchronization break, the synchronization byte, and the message identifier.
- The identified node sends the message response: one to eight data bytes and one checksum byte.
- Header and response form the message frame.

The data is transmitted in bytes using the UART byte-word interface without the parity bit. Each byte consists of a start bit, 8 bits and a stop bit.

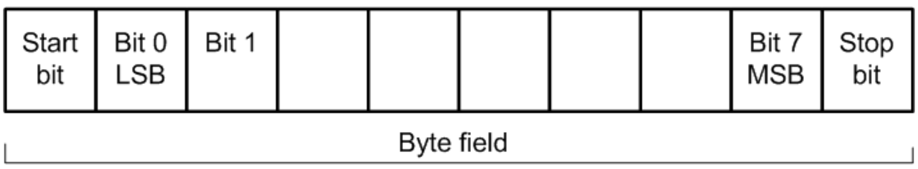


Figure 12-32: Structure of a byte field

Data bytes are transmitted LSB first.

The identifier byte consists of 6 bits for the frame identifier and two parity bits. This combination is known as protected identifier.

Trigger

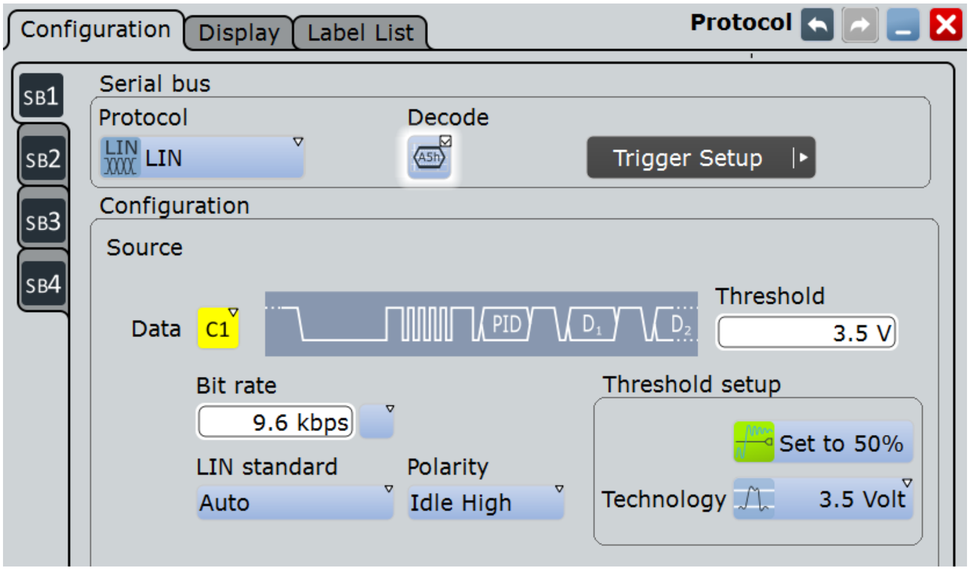
The R&S RTE can trigger on various parts of LIN frames. The data line must be connected to an input channel, triggering on math and reference waveforms is not possible.

You can trigger on:
- Frame start (synchronization field)
- Specific slave identifier or identifier range
- Data pattern in the message
- Wake up signal
- Checksum error (error in data), parity error (error in identifier)

12.6.2 LIN Configuration

Access: PROTOCOL > "Configuration" tab > "Protocol" = *LIN*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Data
Sets the source waveform of the data line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTE-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:LIN:DATA:SOURce` on page 1271

Threshold
Sets the threshold value for digitization of the signal. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold. The interpretation of HIGH and LOW is defined by the Polarity.

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:LIN:DATA:THReshold` on page 1271
`BUS<m>:LIN:TECHnology` on page 1271
`BUS<m>:SETReflevels` on page 1163

Bit rate
Sets the number of transmitted bits per second. The maximum bit rate for LIN is 20 kbit/s.

To select a bit rate from list of predefined values, tap the icon beside the "Bit rate" field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

If the "LIN standard" is "J2602", the bit rate is 10.417 kbit/s and cannot be changed.

Remote command:
`BUS<m>:LIN:BITRate` on page 1272

LIN standard
Selects the version of the LIN standard that is used in the DUT. The setting mainly defines the checksum version used during decoding.

The most common version is LIN 2.x. For mixed networks, or if the standard is unknown, set the LIN standard to "Auto".

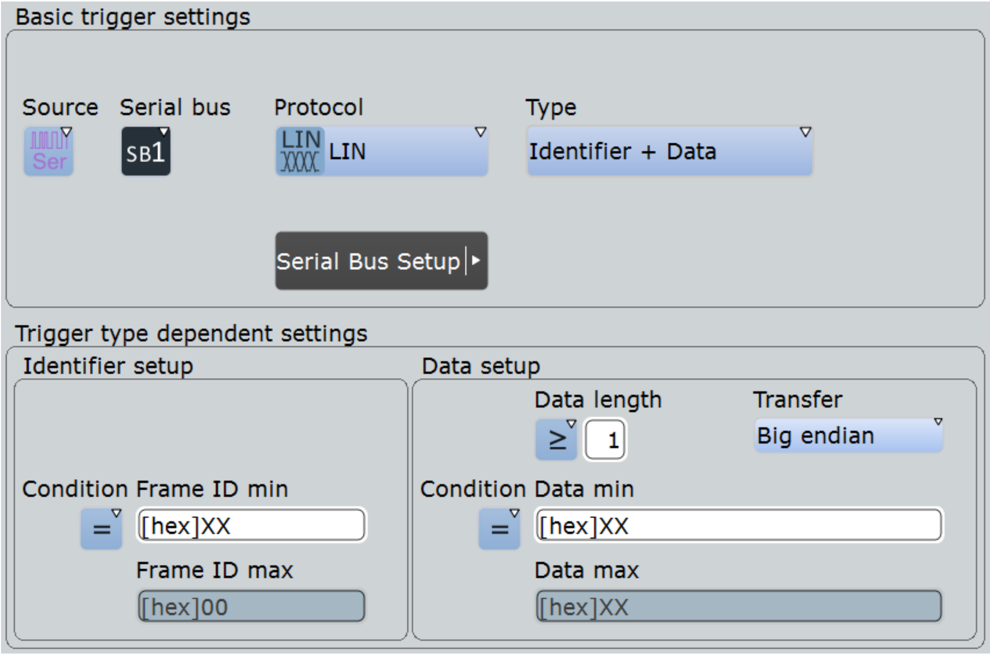
Remote command:
`BUS<m>:LIN:STANdard` on page 1272

Polarity
Defines the idle state of the bus. The idle state is the rezessive state and corresponds to a logic 1.

Remote command:
`BUS<m>:LIN:POLarity` on page 1272

12.6.3 LIN Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = LIN"



Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Trigger type

Selects the trigger type for LIN analysis.

"Start of frame (Sync)"
Triggers on the stop bit of the sync field.

"Identifier"
Sets the trigger to one specific identifier or an identifier range. Enter only the 6 bit identifier without parity bits, not the protected identifier.
Description of trigger type specific settings: "Identifier setup: Condition, Frame ID min, Frame ID max" on page 527.

"Identifier OR"
Sets the trigger to a combination of up to four identifiers.
Description of trigger type specific settings: "Identifier OR setup: Monitor, Frame ID" on page 527

"Identifier + Data": Sets the trigger to a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern.
The identifier conditions are the same as for the "Identifier" trigger type, see Identifier setup: Condition, Frame ID min, Frame ID max.
Data conditions are set with Data setup: Data length, Transfer, Condition, Data min, Data max.

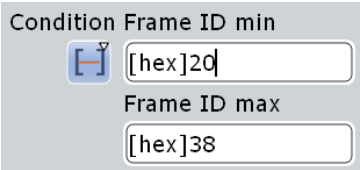
"Wakeup frame": Triggers after a wakeup frame.

"Error condition": Identifies various errors in the frame, see "Error conditions" on page 529.

Remote command:
`TRIGger<m>:LIN:TYPE` on page 1273

Identifier setup: Condition, Frame ID min, Frame ID max

The identifier setup consists of the condition and one or two identifier pattern.



"Condition": Defines the operator to set a specific identifier ("Equal" or "Not equal") or an identifier range.

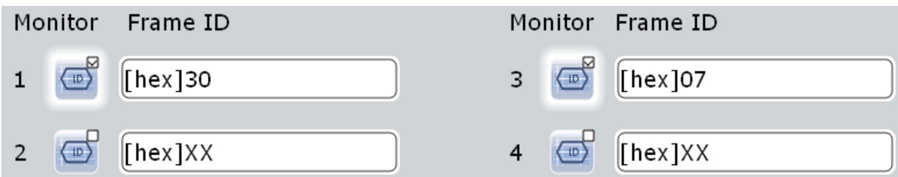
"Frame ID min / Frame ID": Defines the bit pattern of the slave identifier. Enter only the 6 bit identifier without parity bits, not the protected identifier.
In binary format, use the following characters: 1; 0; or X (don't care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"Frame ID max": The second identifier pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:LIN:ICONdition` on page 1274
`TRIGger<m>:LIN:IMIN` on page 1275
`TRIGger<m>:LIN:IMAX` on page 1275

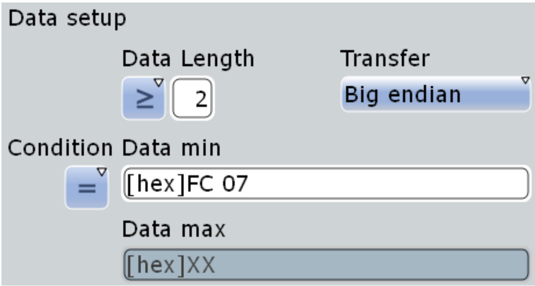
Identifier OR setup: Monitor, Frame ID

Sets the trigger to a combination of up to four identifiers. Enter the patterns in the "Frame ID" fields. In binary and hex format, characters 1, 0, and X (don't care) are allowed. For each identifier pattern to be triggered on, enable "Monitor".



Remote command:
`TRIGger<m>:LIN:IDOR<n>:ENABle` on page 1277
`TRIGger<m>:LIN:IDOR<n>[:VALue]` on page 1277

Data setup: Data length, Transfer, Condition, Data min, Data max
The data setup consists of the transfer direction, the number of bytes, the condition, and one or two data patterns.



"Transfer" Sets the byte order (endianness) of the data transfer. With "Big endian", the data is analyzed and evaluated in the order of reception. With "Little endian", the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.
According to the standard, LIN data is transmitted in little endian transfer order. The "Little endian" setting allows you to enter the required data word directly into "Data min", and the instrument triggers correctly.

"Data length" Sets the length of the bit pattern to be found, in bytes.

For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set.
Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*. With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*.

"Condition" Sets the operator to define a specific data pattern ("Equal" or "Not equal") or an data range.

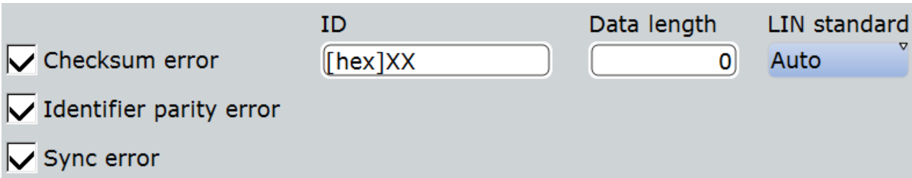
"Data min" Defines the data pattern. The pattern length is adjusted to the data length setting (and vice versa), maximum is 8 bytes.
Enter the pattern MSB first and with big endian byte order, and set the correct "Transfer" direction. The data is compared byte by byte.
In binary format, use the following characters: 1; 0; or X (don't care).
The use of X is restricted to the operators "Equal" and "Not equal".

"Data max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:LIN:BORDer on page 1276
TRIGger<m>:LIN:DLECondition on page 1276
TRIGger<m>:LIN:DLENgth on page 1276
TRIGger<m>:LIN:DCONdition on page 1275
TRIGger<m>:LIN:DMIN on page 1275
TRIGger<m>:LIN:DMAX on page 1275

Error conditions
Triggers if one or more of the following errors occur:

- Checksum error
  The checksum verifies the correct data transmission. It is the last byte of the frame response. The checksum includes not only the data but also the protected identifier (PID). To identify checksum errors caused by data, additional settings are required: Enter the bit pattern of the slave identifier ("Frame ID"), the number of data bytes ("Data length"), and select the used "LIN standard". See also: "LIN standard" on page 525.
- Identifier parity error
  Parity bits are the bits 6 and 7 of the identifier. They verify the correct transmission of the identifier.
- Sync error
  Synchronization error



Remote command:
TRIGger<m>:LIN:CHKSerror on page 1278
TRIGger<m>:LIN:ERRPattern on page 1278
TRIGger<m>:LIN:CRCDatalen on page 1279
TRIGger<m>:LIN:STANdard on page 1279
TRIGger<m>:LIN:IPERror on page 1277
TRIGger<m>:LIN:SYERror on page 1277

12.6.4 LIN Label List

Label lists are protocol-specific. A LIN label file contains two values for each identifier:

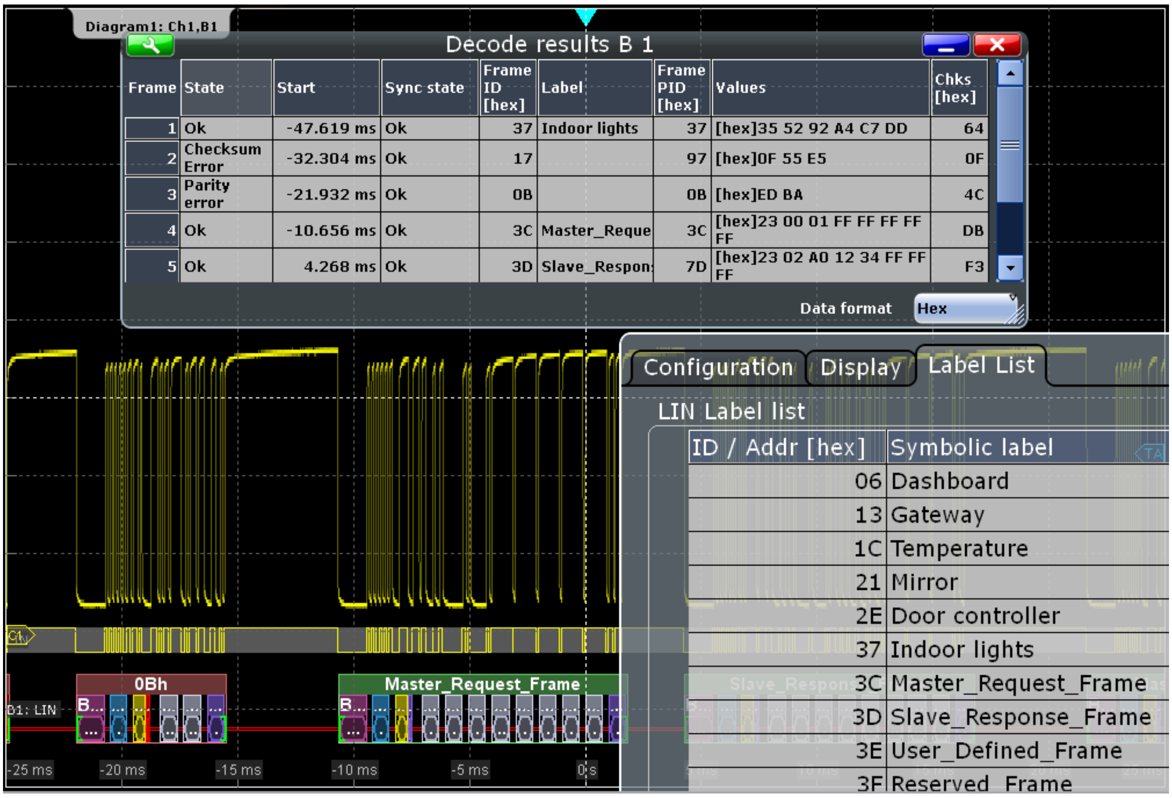
- "ID / Addr": hexadecimal identifier value
- "Symbolic label": symbolic name for the identifier

Example: LIN PTT file

```
# ----------------------------------------------------------------------------

@FILE_VERSION = 1.0
@PROTOCOL_NAME = lin
```

```
# --------------------------------------------------------------------------------
# Labels for LIN protocol
#   Column order: Identifier, Label
# --------------------------------------------------------------------------------
# Labels for standard addresses
06h,Dashboard
13h,Gateway
1Ch,Temperature
21h,Mirror
37h,Indoor lights
# Labels for reserved addresses
3Ch,Master_Request_Frame
3Dh,Slave_Response_Frame
# --------------------------------------------------------------------------------
```



For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 441.

Remote command:

- BUS<m>:LIN:FRAMe<n>:SYMBol? on page 1281

12.6.5 LIN Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The endianness setting ("Transfer") is a trigger setting and not considered for decoding. The binary results of data bytes are displayed MSB first.

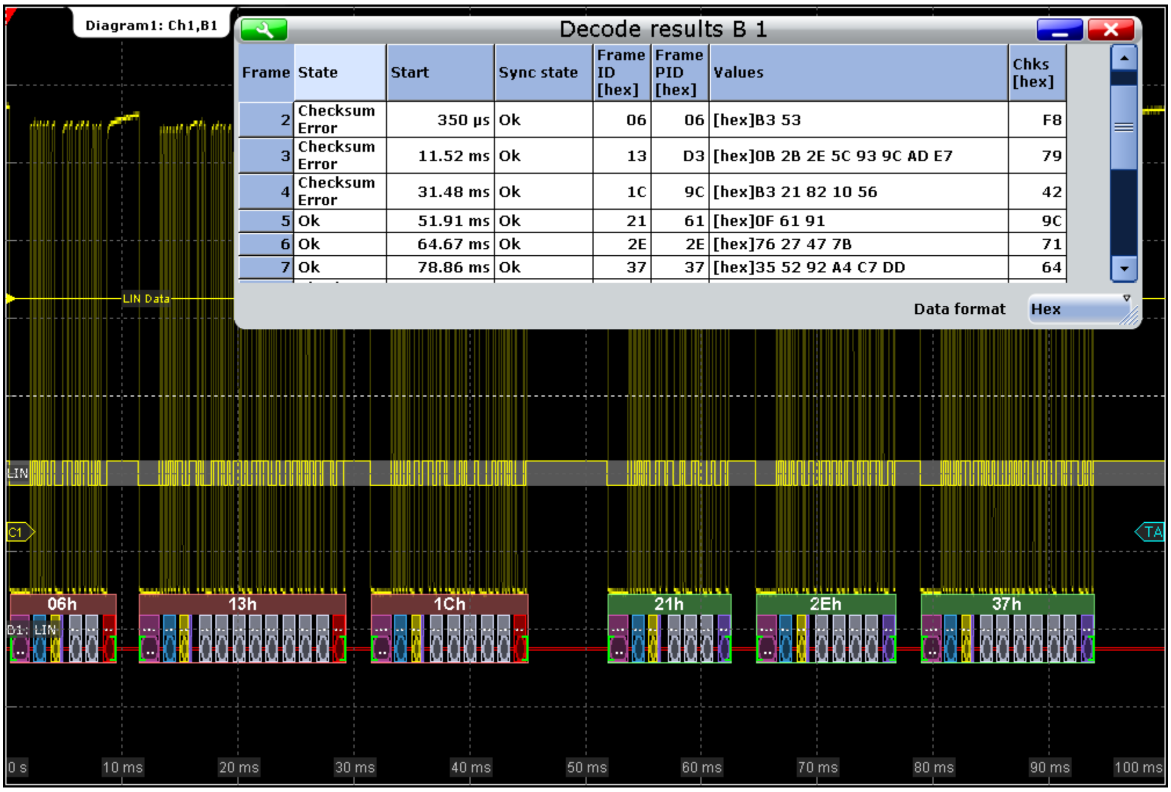


Figure 12-33: Decoded and binary LIN signal, and decode results

green brackets [...]	= start and end of frame
green frame header	= frame state is ok
red frame header	= error in frame
magenta frame header	= wakeup frame
magenta	= break
blue	= sync
yellow	= frame ID ok
grey	= data bytes
purple	= parity bit, or checksum ok
red	= error in frame ID, or checksum, or parity bit

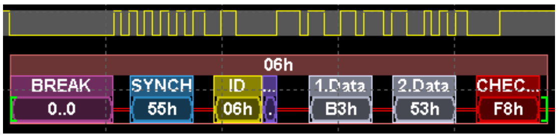


Figure 12-34: Decoded frame with checksum error (frame No 1 in figure above)

Table 12-5: Content of the "Decode results" table

Column	Description
State	Overall state of the frame.
Start	Time of frame start
Sync state	Result of synchronization
Frame ID (hex)	Identifier value
Frame PID (hex)	Protected identifier
Values	Value of the data bytes. The data format is selected below the table.
Chks (hex)	Checksum value

Remote commands:
- BUS<m>:LIN:FCOunt? on page 1279
- BUS<m>:LIN:FRAMe<n>:STATus? on page 1280
- BUS<m>:LIN:FRAMe<n>:STARt? on page 1280
- BUS<m>:LIN:FRAMe<n>:STOP? on page 1280
- BUS<m>:LIN:FRAMe<n>:VERSion? on page 1281
- BUS<m>:LIN:FRAMe<n>:SYSTate? on page 1283
- BUS<m>:LIN:FRAMe<n>:IDSTate? on page 1282
- BUS<m>:LIN:FRAMe<n>:IDValue? on page 1282
- BUS<m>:LIN:FRAMe<n>:CSSTate? on page 1284
- BUS<m>:LIN:FRAMe<n>:CSValue? on page 1284
- BUS<m>:LIN:FRAMe<n>:IDPValue? on page 1283
- BUS<m>:LIN:FRAMe<n>:DATA? on page 1281
- BUS<m>:LIN:FRAMe<n>:BYTE<o>:STATe? on page 1284
- BUS<m>:LIN:FRAMe<n>:BYTE<o>:VALue? on page 1285

12.6.6 Search on Decoded LIN Data

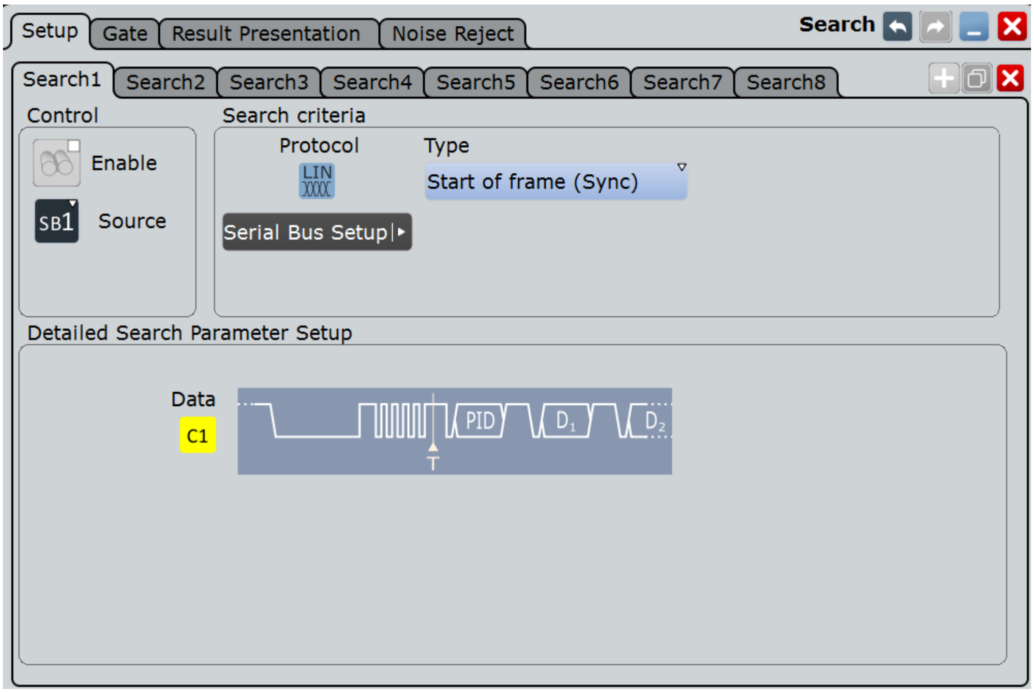
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 376.

12.6.6.1 LIN Search Setup

Access: SEARCH > "Setup" tab



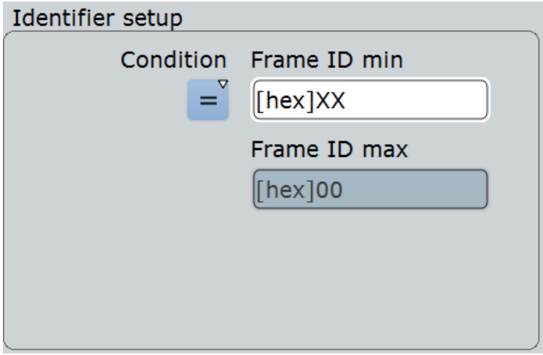
Search criteria
Sets the type to be searched for.

"Start of frame (Sync)"	Searches for the stop bit of the sync field.
"Identifier"	Searches for one specific identifier or an identifier range. See "Identifier setup: Condition, Frame ID min, Frame ID max" on page 534
"Identifier OR"	Searches for a combination of up to four identifiers. See "Identifier OR setup: Monitor, Frame ID" on page 535
"Identifier + Data"	Searches for a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern. The identifier conditions are the same as for the "Identifier" trigger type, see "Identifier setup: Condition, Frame ID min, Frame ID max" on page 527. Data conditions are set with "Data setup: Data length, Transfer, Condition, Data min, Data max" on page 528.
"Wakeup frame"	Searches for wakeup frames.
"Error condition"	Identifies various errors in the frame, see "Error conditions" on page 529.

Remote command:
`SEARch:TRIGger:LIN:SSOFrame` on page 1286
`SEARch:TRIGger:LIN:SFIDentifier` on page 1286
`SEARch:TRIGger:LIN:IDENtifieror` on page 1286
`SEARch:TRIGger:LIN:SIDData` on page 1287
`SEARch:TRIGger:LIN:WUFRame` on page 1287
`SEARch:TRIGger:LIN:SERRor` on page 1287

Identifier setup: Condition, Frame ID min, Frame ID max
The identifier setup consists of the condition and one or two frame ID patterns.

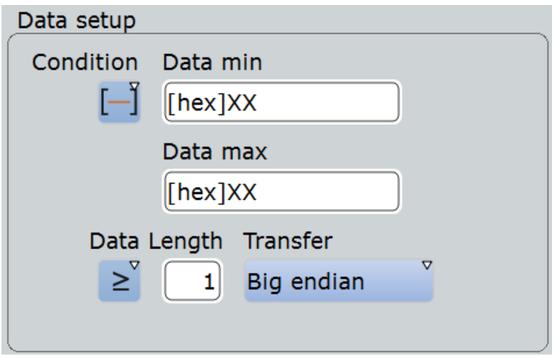
The identifier setup settings are the same as in the LIN trigger setup, see "Identifier setup: Condition, Frame ID min, Frame ID max" on page 527.



Remote command:
`SEARch:TRIGger:LIN:ICONdition` on page 1287
`SEARch:TRIGger:LIN:IMIN` on page 1288
`SEARch:TRIGger:LIN:IMAX` on page 1288

Data setup: Condition, Data min, Data max, Data length, Transfer
The data setup consists of the transfer direction, the data length, the condition, and one or two data patterns.

The data setup settings are the same as in the LIN trigger setup, see "Data setup: Data length, Transfer, Condition, Data min, Data max" on page 528.



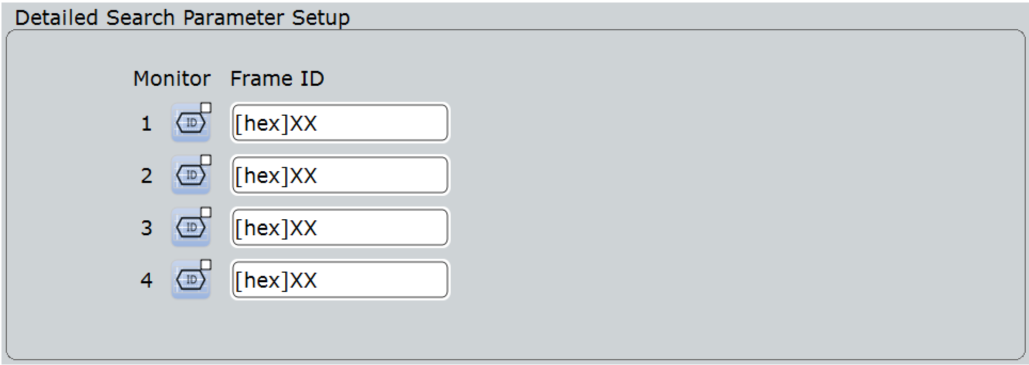
Remote command:
`SEARch:TRIGger:LIN:DCONdition` on page 1289
`SEARch:TRIGger:LIN:DMIN` on page 1289
`SEARch:TRIGger:LIN:DMAX` on page 1290

SEARch:TRIGger:LIN:DLECondition on page 1290
SEARch:TRIGger:LIN:DLENgth on page 1291
SEARch:TRIGger:LIN:BORDer on page 1290

Identifier OR setup: Monitor, Frame ID

The identifier OR setup consists of the monitor and frame ID.

The identifier OR setup settings are the same as in the LIN trigger setup, see "Identifier OR setup: Monitor, Frame ID" on page 527

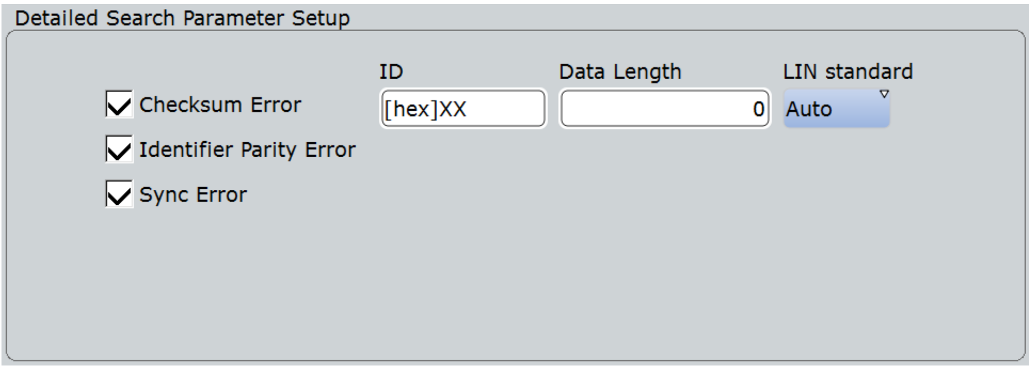


Remote command:
SEARch:TRIGger:LIN:IDOR<m>:ENABle on page 1288
SEARch:TRIGger:LIN:IDOR<m>[:VALue] on page 1289

Error Condition

Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the LIN trigger setup, see "Error conditions" on page 529.



Remote command:
SEARch:TRIGger:LIN:IPERror on page 1291
SEARch:TRIGger:LIN:SYERror on page 1291
SEARch:TRIGger:LIN:CHKSerror on page 1292
SEARch:TRIGger:LIN:ERRPattern on page 1292
SEARch:TRIGger:LIN:CRCDatalen on page 1292
SEARch:TRIGger:LIN:STANdard on page 1293

12.6.6.2 LIN Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394

The columns in the serach result table are the same as in the decoding table, see Chapter 12.6.5, "LIN Decode Results", on page 530.

Remote commands:

- `SEARch:RESult:LIN:FCOunt?` on page 1293
- `SEARch:RESult:LIN:FRAMe<m>:STATus?` on page 1294
- `SEARch:RESult:LIN:FRAMe<m>:STARt?` on page 1294
- `SEARch:RESult:LIN:FRAMe<m>:STOP?` on page 1294
- `SEARch:RESult:LIN:FRAMe<m>:DATA?` on page 1294
- `SEARch:RESult:LIN:FRAMe<m>:CSSTate?` on page 1295
- `SEARch:RESult:LIN:FRAMe<m>:CSValue?` on page 1295
- `SEARch:RESult:LIN:FRAMe<m>:IDSTate?` on page 1295
- `SEARch:RESult:LIN:FRAMe<m>:IDValue?` on page 1296
- `SEARch:RESult:LIN:FRAMe<m>:IDPValue?` on page 1296
- `SEARch:RESult:LIN:FRAMe<m>:SYMBol?` on page 1296
- `SEARch:RESult:LIN:FRAMe<m>:SYSTate?` on page 1296
- `SEARch:RESult:LIN:FRAMe<m>:VERSion?` on page 1297
- `SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:STATe?` on page 1297
- `SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:VALue?` on page 1297

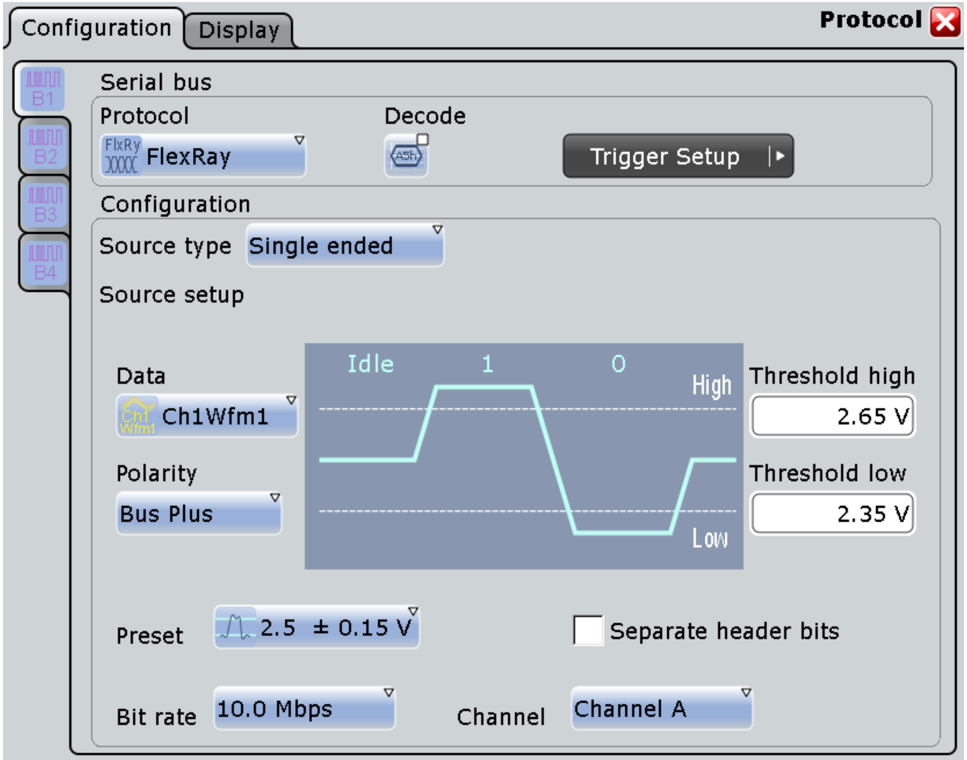
12.7 FlexRay (Option R&S RTE-K4)

FlexRay is designed for use in safety-related distributed applications in the automotive industry. It is applied in real-time applications when higher data rates and reliable communication are required. In particular, FlexRay supports x-by-wire applications, for example, steer-by-wire or brake-by-wire.

12.7.1 FlexRay Configuration

Access: PROTOCOL > "Configuration" tab > "Protocol" = *FlexRay*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Source type

Sets the type of measurement. The instrument adjusts the thresholds to the selected source type.

"Single-ended" For measurements with single-ended probes, or single-ended voltage measurements with differential probes on the FlexRay bus. Two thresholds have to be defined as absolute voltage levels.

"Differential" For differential measurements on the FlexRay bus. This is the most common measurement. Two thresholds have to be defined as differential voltages.

"Logic" For measurements of logic signals, for example, of the logic signal inside the FlexRay node, between the communication controller and the bus driver. If MSO option R&S RTE-B1 is installed, you can use digital input channels. It is possible to measure simultaneously on a data line and on the enable line. Each line requires its own threshold.

Remote command:
`BUS<m>:FLXRay:SRCType` on page 1298

Data

Sets the input channel of the bus signal, or of the data line in case of a "Logic" source type. Usually, the source is one of the analog channels. Reference and math waveforms are only available if the trigger source is one of the input channels but not the serial bus.

If the source type is "Logic", digital channels can be used (MSO option R&S RTE-B1 is required). Digital and analog channels cannot be used at the same time in a bus.

Remote command:
`BUS<m>:FLXRay:SOURce<n>` on page 1299

Enable

Sets the input channel of the enable line in case of a "Logic" source type. The enable line transfers the control signal of the bus guardian to the bus driver. None, or one of the analog channels can be used. Reference and math waveforms are only available if the trigger source is one of the input channels but not the serial bus.

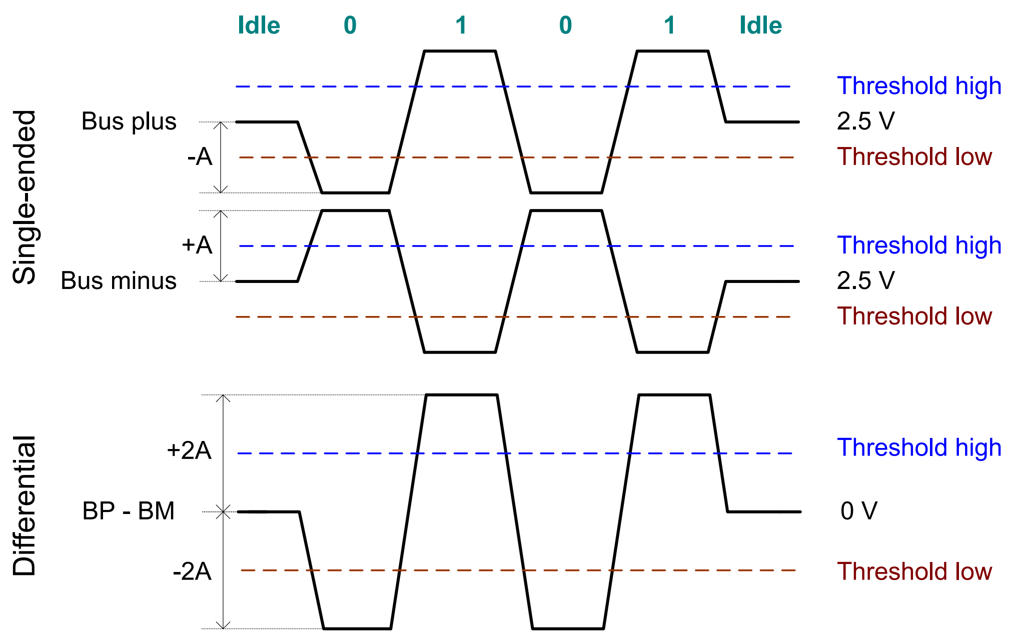
Alternatively to analog channels, digital channels can be used if MSO option R&S RTE-B1 is installed. Digital and analog channels cannot be used at the same time in a bus.

Remote command:
`BUS<m>:FLXRay:SOURce<n>` on page 1299

Thresholds

Threshold values are used for digitization of the signal.

For measurements on a FlexRay bus, two thresholds are required to distinguish the three possible states of the signal - high, low and idle. If the signal value on the line is higher than the upper threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the lower threshold. If the value is between the threshold, the signal is in idle state.



For measurements inside the FlexRay node (with "Source type" = "Logic"), each line requires its threshold level.

There are two ways to set the thresholds: selection of a predefined value, or direct entry of a value.

- "Preset"
  Selects default threshold voltages from a list. The predefined values depend on the selected source type. The value is set to "Manual" if at least one threshold was entered directly.
- "Threshold high" and "Threshold low"
  Upper and lower levels for single-ended or differential source types. You can enter the values directly in the fields.
- "Threshold data" and "Threshold enable"
  Levels for data and enable line in case of logic source type. You can enter the values directly in the fields.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:FLXRay:PRSingle` on page 1300
`BUS<m>:FLXRay:PRDiff` on page 1300
`BUS<m>:FLXRay:PRLogic` on page 1301
`BUS<m>:FLXRay:THReshold<n>` on page 1299
`BUS<m>:FLXRay:THData` on page 1300
`BUS<m>:FLXRay:THENable` on page 1299
`BUS<m>:SETReflevels` on page 1163

Polarity
Selects the wire on which the bus signal is measured in case of "Single-ended" measurement: "Bus plus" or "Bus minus". The setting affects the digitization of the signal.

Remote command:
`BUS<m>:FLXRay:POLarity` on page 1301

Bit rate
Selects the number of transmitted bits per second from a list.

Remote command:
`BUS<m>:FLXRay:BITRate` on page 1301

Channel
Selects the FlexRay channel on which the signal is measured, either cahnnel A or channel B. The setting is considered in the calculation of the frame CRC.

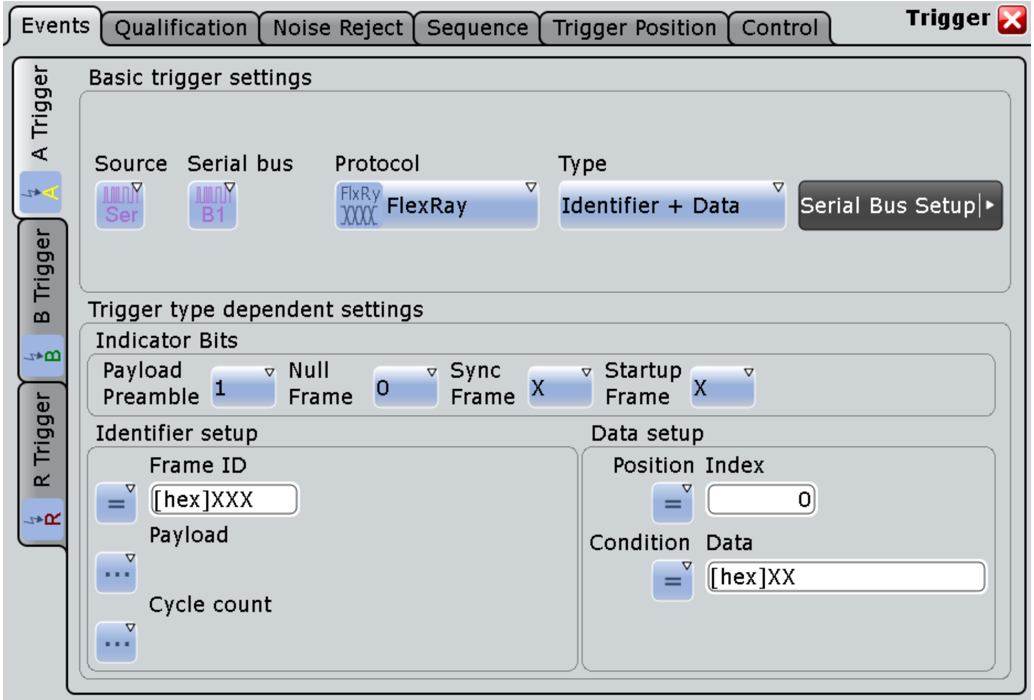
Remote command:
`BUS<m>:FLXRay:CHTYpe` on page 1302

Separate header bits
The setting affects the decoding and its display. If enabled, the leading five indicator bits of the header are decoded as five single bits. Otherwise, the indicator bits are shown as one word with word length five bits.

Remote command:
BUS<m>:FLXRay:SEHB on page 1302

12.7.2 FlexRay Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = Flex-Ray"



Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Trigger type

Selects the trigger type for FlexRay analysis.

"Start of frame" Triggers on the first rising edge after the transmission start sequence (TSS).

"Identifier +data"
Triggers on the decoded frame content, on header and payload data:
- Indicator bits, see "Indicator bits" on page 541
- Frame identifier, see "Frame ID (min/max)" on page 541
- Payload length, see "Payload length (min/max)" on page 542
- Cycle count, see "Cycle count (min, max), Step" on page 542
- Data position, see "Position, Index (min, max) - Data setup" on page 543
- Data bit pattern, see "Condition, Data (min, max) - Data setup" on page 543

"Symbol"
Triggers on a symbol or wakeup pattern, see "Symbol" on page 544.

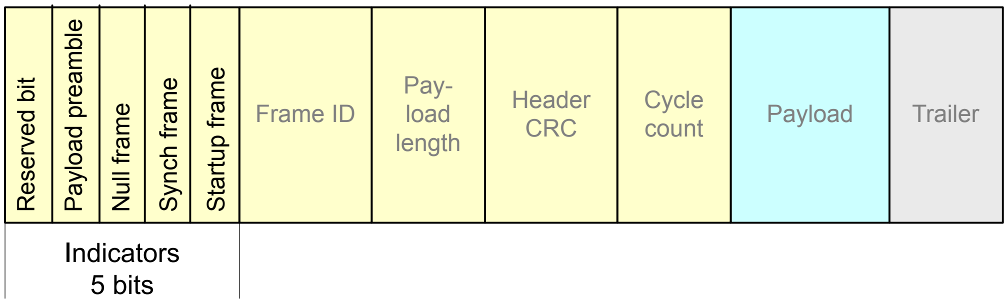
"Error condition"
Triggers on one or more errors that are detected in the decoded data, see "Error conditions" on page 544.

Remote command:
TRIGger<m>:FLXRay:TYPE on page 1303

Indicator bits

Triggers on one or more indicator bits at the beginning of the header segment. Each bit can be set to 0, 1, or X (don't care).

Trigger type: "Identifier + data"



"Payload preamble"
Indicates a Network Management Vector in the payload segment. The NMV allows the host processor to send data directly, without processing by the communication controller.

"Null frame"
Indicates a frame without usable data.

"Sync frame"
Indicates that the frame is used for synchronization of the FlexRay system. Only sync nodes can send this frame type.

"Startup frame"
Indicates a startup frame used for startup of the network. Only specific start nodes can send this frame type.

Remote command:
TRIGger<m>:FLXRay:PLPReamble on page 1304
TRIGger<m>:FLXRay:NUFRame on page 1305
TRIGger<m>:FLXRay:SYFRame on page 1305
TRIGger<m>:FLXRay:STFRame on page 1305

Frame ID (min/max)

The frame ID contains the number of the slot in which the frame is transmitted. Each frame ID occurs only once during a FlexRay cycle.

Indica-tors	Frame ID	Payload length	Header CRC	Cycle count	Payload	Trailer
5 bits	11 bits	7 bits	11 bits	6 bits		

To trigger on a frame ID, you have to define a condition and one or two identifier patterns. The second identifier pattern is required to specify a range with conditions "In range" and "Out of range". In binary format, use the following characters: 1; 0; or X (any bit). The use of X is restricted to the conditions "Equal" and "Not equal". If the identifier is not relevant for the trigger setup, set it to "Off".

The maximum length of the pattern is 11 bit. The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

Trigger type: "Identifier + data"

Remote command:
`TRIGger<m>:FLXRay:FCONdition` on page 1305
`TRIGger<m>:FLXRay:FMIN` on page 1306
`TRIGger<m>:FLXRay:FMAX` on page 1306

Payload length (min/max)
The payload length contains the number of of words transmitted in the payload segment. Information is transmitted in 2-byte words, so the number of data bytes in the payload segment is twice the payload length.

Indica-tors	Frame ID	Payload length	Header CRC	Cycle count	Payload	Trailer
5 bits	11 bits	7 bits	11 bits	6 bits		

To trigger on the payload length, you have to define a condition and one or two numbers of words. The second number is required to specify a range with conditions "In range" and "Out of range". If the payload length is not relevant for the trigger setup, set it to "Off".

Trigger type: "Identifier + data"

Remote command:
`TRIGger<m>:FLXRay:PCONdition` on page 1306
`TRIGger<m>:FLXRay:PMIN` on page 1307
`TRIGger<m>:FLXRay:PMAX` on page 1307

Cycle count (min, max), Step
The cycle count contains the number of the current FlexRay cycle.

Indica-tors	Frame ID	Payload length	Header CRC	Cycle count	Payload	Trailer
5 bits	11 bits	7 bits	11 bits	6 bits		

To trigger on the cycle count, you have to define a condition and one or two numbers. If the condition is a range ("In range" or "Out of range"), a second number "Cycle count max" is required.

Additionally, you can define a "Step" to trigger on each n-th cycle inside the given range. This allows for specific triggering if slot multiplexing is used.

If the cycle count is not relevant for the trigger setup, set it to "Off".

Trigger type: "Identifier + data"

Remote command:
`TRIGger<m>:FLXRay:CENable` on page 1307
`TRIGger<m>:FLXRay:CMIN` on page 1308
`TRIGger<m>:FLXRay:CMAX` on page 1308
`TRIGger<m>:FLXRay:CSTep` on page 1308

Position, Index (min, max) - Data setup
Sets the position of the first byte of data bit pattern within the payload segment. You can define an exact position, or a position range.

Trigger type: "Identifier + data"

"Position" Operator for the data position. Select "Off", if the position of the required pattern is not relevant for the trigger condition.

"Index" Sets the number of data bytes to be skipped after start of the payload segment if "Position" is "Equal" or "Greater or equal". The index 0 is associated with the first data byte.

"Index min, Index max"
If the "Position" operator defines a range, the indexes of the first and the last byte are defined between which the required bit pattern may start.

Remote command:
`TRIGger<m>:FLXRay:DPOPerator` on page 1309
`TRIGger<m>:FLXRay:DPOSition` on page 1309
`TRIGger<m>:FLXRay:DPTO` on page 1309

Condition, Data (min, max) - Data setup
Specifies the data bit pattern to be found in the payload segment. The starting point of the pattern is defined by "Position, Index (min, max) - Data setup" on page 543. The pattern comparision is byte-aligned, and the instrument triggers at the end of a byte.

"Condition" Sets the operator to set a specific data pattern ("Equal" or "Not equal") or a data range. Select "Off", if the data pattern is not relevant for the trigger condition.

"Data (min/max)" Enter the bytes in msb first bit order. The maximum pattern length is 8 bytes.
In binary format, you can use the following characters: 1; 0; or X (any bit). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

Remote command:
`TRIGger<m>:FLXRay:DCONdition` on page 1309
`TRIGger<m>:FLXRay:DMIN` on page 1310
`TRIGger<m>:FLXRay:DMAX` on page 1310

Symbol

Triggers on a symbol or on a wakeup pattern.

Trigger type: "Symbol"

"CAS/MTS" Collision Avoidance Symbol / Media access Test Symbol. These symbols are identical and can be sent in the optional symbol window at the end of a communication cycle. They are used to avoid collisions during the system start.

"Wakeup Pattern" The wakeup pattern is sent to activate the nodes of the system.

Remote command:
`TRIGger<m>:FLXRay:SYMBol` on page 1310

Error conditions

Triggers on one or more errors in the frame.

Trigger type: "Error conditions"

"FSS" Error in a Frame Start Sequence. FSS follows the Transmission Start Sequence TSS at the beginning of each frame.

"BSS" Error in a Byte Start Sequence. The BSS is transmitted before each byte.

"FES" Error in Frame End Sequence. FES indicates the end of each frame.

"Header CRC" Error in a cyclic redundancy check code of the header data which covers mainly frame ID and payload length.

"Payload CRC" Error in a cyclic redundancy check code of the complete frame.

Remote command:
`TRIGger<m>:FLXRay:FSSerror` on page 1311
`TRIGger<m>:FLXRay:BSSerror` on page 1311
`TRIGger<m>:FLXRay:FESerror` on page 1311
`TRIGger<m>:FLXRay:HCRCerror` on page 1311
`TRIGger<m>:FLXRay:PCRCerror` on page 1311

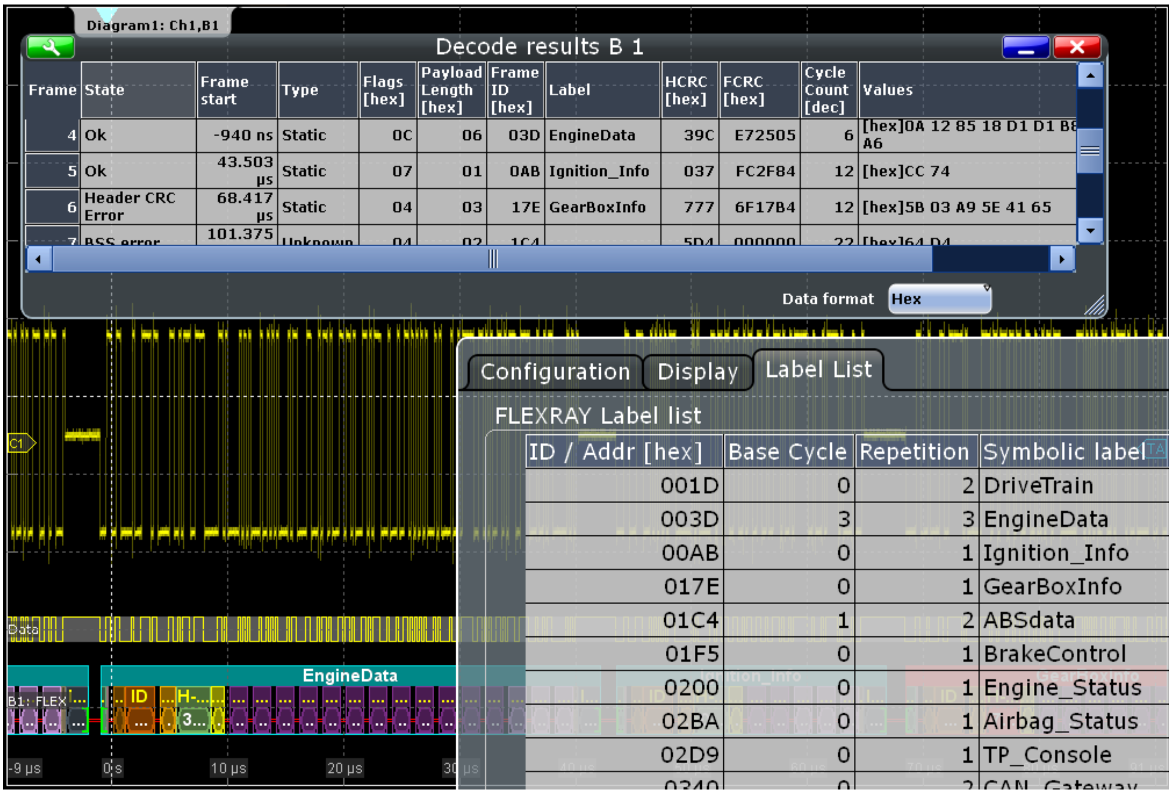
12.7.3 FlexRay Label List

Label lists are protocol-specific. A FlexRay label file contains four values for each identifier:

- "ID / Addr": number of the slot in which the frame is transmitted
- "Base cycle" and "Repetition": define the cycle indexes for which the identifier applies. Base cycle defines the first applied cycle.
  There are 64 cycles in a FlexRay communication. The same identifier can be shared by different devices, and each device uses the identifier at different cycles.
  For example:
  0x0AB,0,2,Ignition_Info: uses cycles 0,2,4,6,...,62
  0x0AB,1,2,GearBoxInfo: uses cycles 1,3,5,7,...,63
- "Symbolic label": symbolic name of the identifier, specifying the device function.

Example: FlexRay PTT file

```
# ----------------------------------------------------------------------------
@FILE_VERSION = 1.0
@PROTOCOL_NAME = flexray
# ----------------------------------------------------------------------------
# Labels for FlexRay protocol
#   Column order: Identifier, Base cycle, Cycle repetition, Label
# ----------------------------------------------------------------------------
# ----Definition----
0x01D,0,2,DriveTrain
0x03D,3,3,EngineData
0x0AB,0,2,Ignition_Info
0x0AB,1,2,GearBoxInfo
0x1C4,1,2,ABSdata
0x1F5,0,1,BrakeControl
0x200,0,1,Engine_Status
0x2BA,0,1,Airbag_Status
0x2D9,0,1,TP_Console
0x340,0,2,CAN_Gateway
0x38B,55,1,MOST_Gateway
0x3EA,0,1,PressureInfo
# ----------------------------------------------------------------------------
```



For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 441.

Remote command:
- `BUS<m>:FLXRay:FRAMe<n>:SYMBol?` on page 1313

12.7.4 FlexRay Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

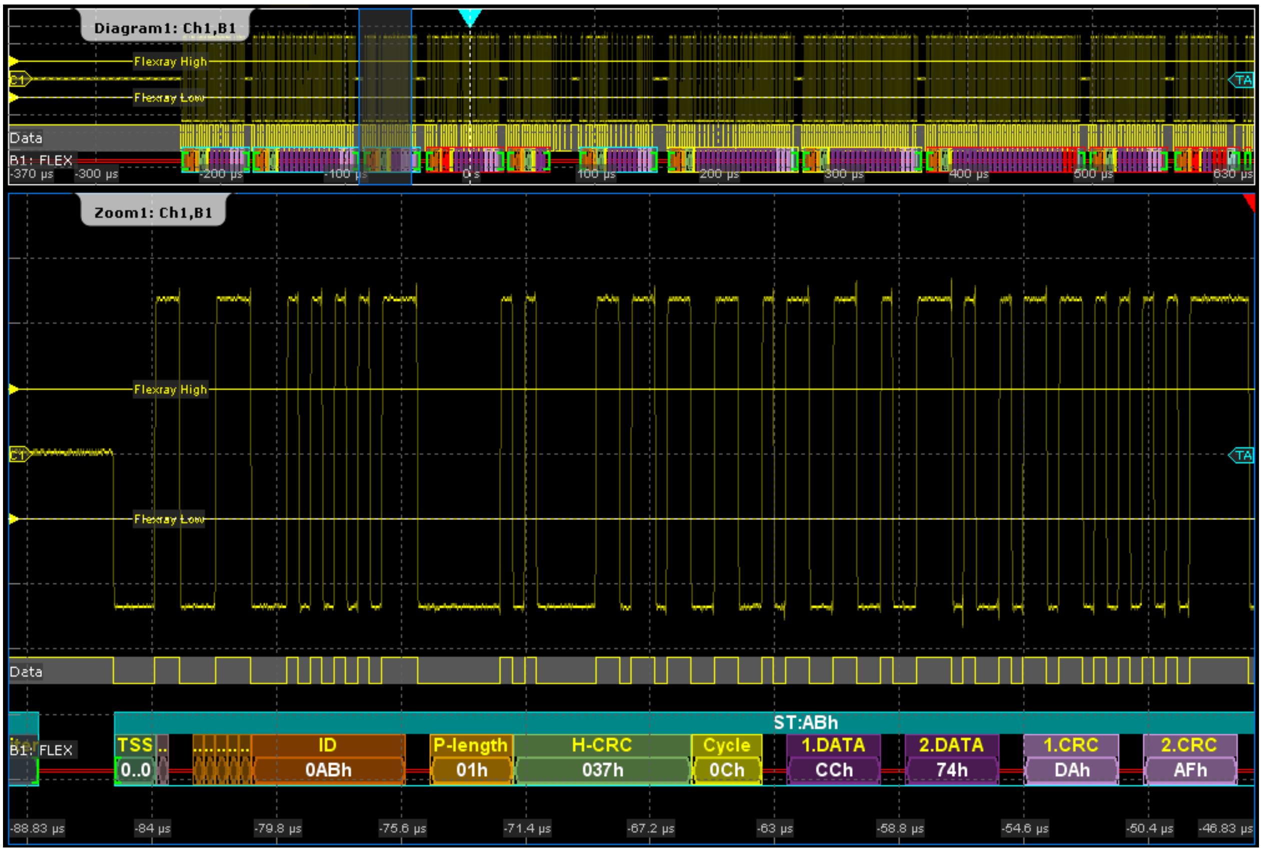


Figure 12-35: FlexRay - decoded static slot

Data is decoded and displayed in the order of its reception. The "Decode results" box shows the detailed decoded data for each frame as it is received.

Frame	State	Frame start	Type	Flags [hex]	Payload Length [hex]	Frame ID [hex]	HCRC [hex]	FCRC [hex]	Cycle Count [dec]	Values
2	Ok	-174.16 µs	Static	0C	06	03D	39C	B07EB2	6	[hex]0A 12 85 18 D1 D1 B8 A6
3	Ok	-85.27 µs	Static	07	01	0AB	037	DAAF55	12	[hex]CC 74
4	Header CRC Error	-35.44 µs	Static	04	03	17E	---	CE8D8A	12	[hex]5B 03 A9 5E 41 65
5	BSS error	30.49 µs	Unknown	04	02	1C4	5D4	000000	22	[hex]64 D4

Figure 12-36: FlexRay - decoded dynamic slot and results table

Table 12-6: Content of the "Decode results" table

Column	Description
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Frame start	Time of frame start
Type	Frame type: Frame of the static segment, frame of the dynamic segment, wakeup frame, symbol in the frame
Flags	State of indicator bits
Payload length	Number of data words in the payload segment.
Frame ID	Value of the frame ID (slot number)
HCRC	Value of the header CRC
FCRC	Value of the frame CRC
Cycle count	Number of the current FlexRay cycle
Values	Value of the data bytes. The data format is selected below the table. Wakeup and symbol frames frames do not transmit data, therefore "- - -" is displayed.

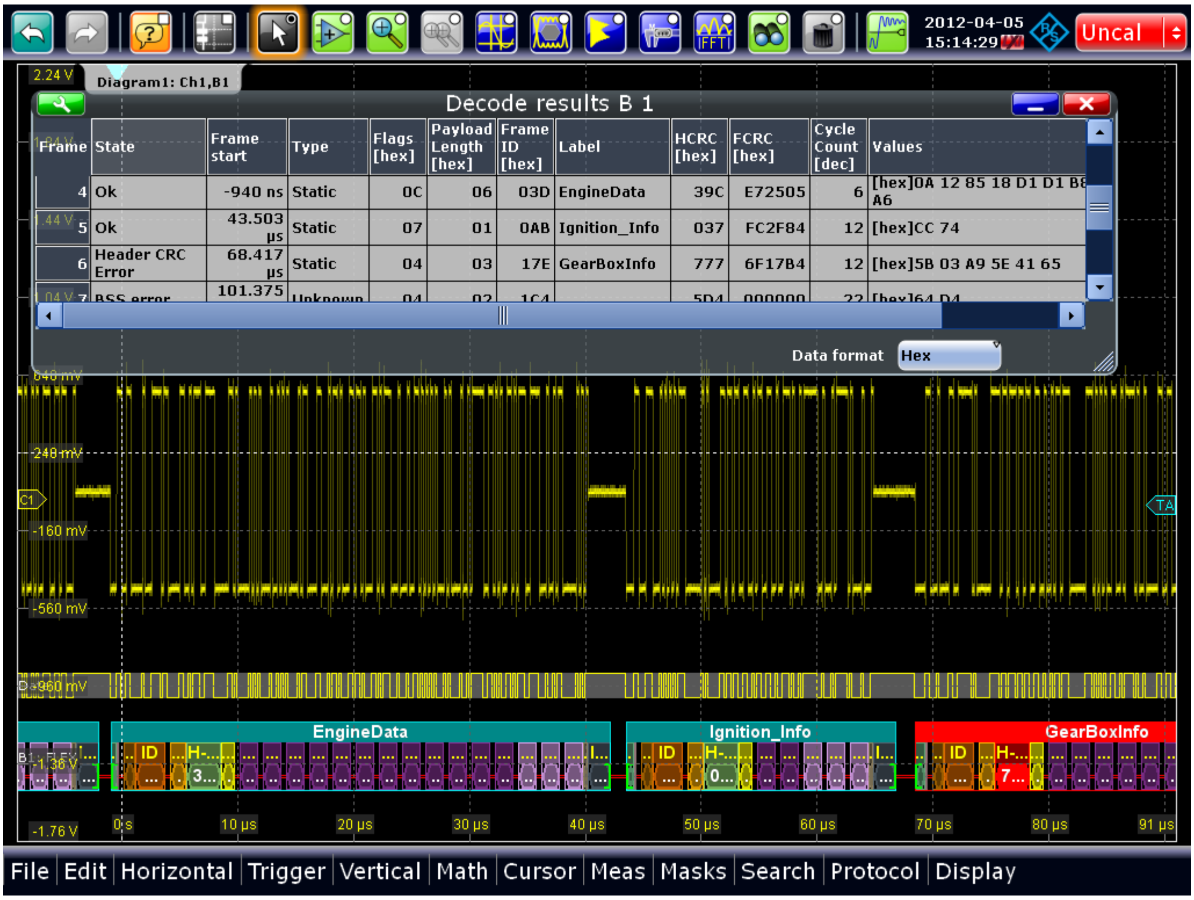


Figure 12-37: FlexRay - decode results with applied label list

Remote commands:

- BUS<m>:FLXRay:FCOunt? on page 1312
- BUS<m>:FLXRay:FRAMe<n>:DATA? on page 1314
- BUS<m>:FLXRay:FRAMe<n>:ADID? on page 1315
- BUS<m>:FLXRay:FRAMe<n>:CSSTate? on page 1316
- BUS<m>:FLXRay:FRAMe<n>:CSValue? on page 1316
- BUS<m>:FLXRay:FRAMe<n>:CYCount? on page 1316
- BUS<m>:FLXRay:FRAMe<n>:FCSTate? on page 1317
- BUS<m>:FLXRay:FRAMe<n>:FCValue? on page 1317
- BUS<m>:FLXRay:FRAMe<n>:FLAGs? on page 1314
- BUS<m>:FLXRay:FRAMe<n>:PAYLength? on page 1315
- BUS<m>:FLXRay:FRAMe<n>:STATus? on page 1312
- BUS<m>:FLXRay:FRAMe<n>:STARt? on page 1313
- BUS<m>:FLXRay:FRAMe<n>:STOP? on page 1313
- BUS<m>:FLXRay:FRAMe<n>:TYPE? on page 1314

12.7.5 Search on Decoded FlexRay Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

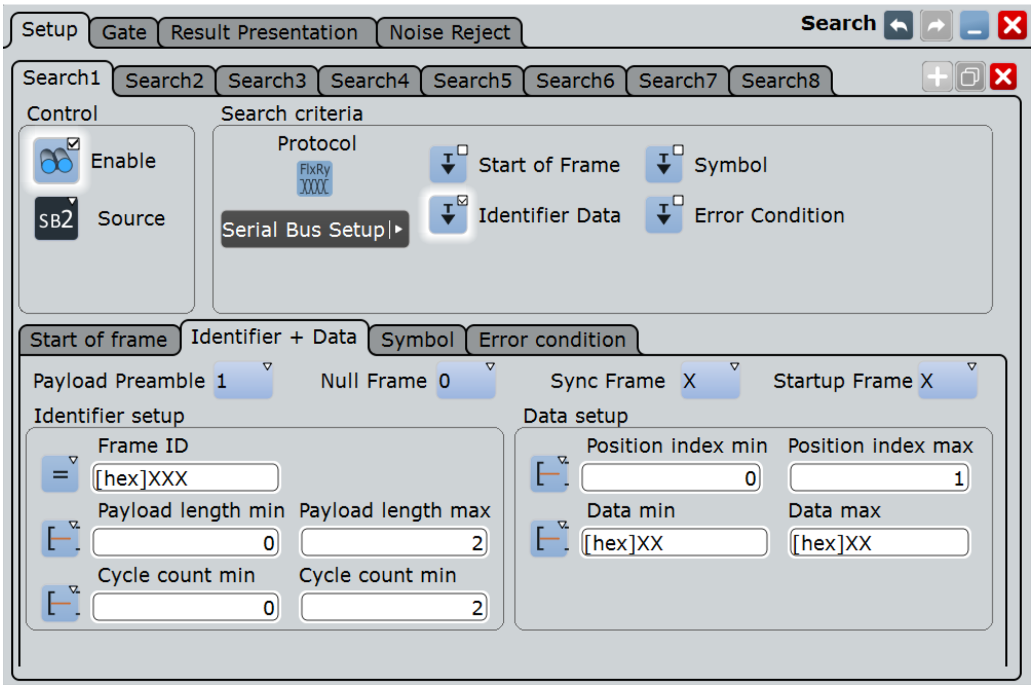
Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

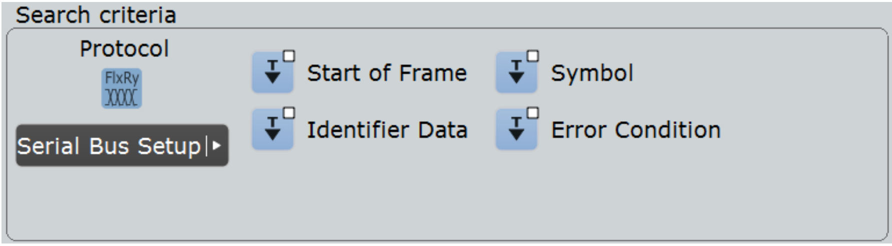
For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 376.

12.7.5.1 FlexRay Search Setup

Access: SEARCH > "Setup" tab



Search Criteria
Sets one criterion or an AND-combination of criteria to be searched for. If more than one criterion is selected, all criteria must be fulfilled by a frame for it to be shown in the search results.



"Start of frame" Searches for the first rising edge after the transmission start sequence (TSS).

"Identifier+data"
Searches for the decoded frame content, on header and payload data:
- Indicator bits, see "Indicator bits" on page 550
- Frame identifier, see "Frame ID (min/max)" on page 551
- Payload length, see "Payload length (min/max)" on page 551
- Cycle count, see "Cycle count (min, max), Step" on page 551
- Data position, see "Position, Index (min, max) - Data setup" on page 551
- Data bit pattern, see "Condition, Data (min, max) - Data setup" on page 552

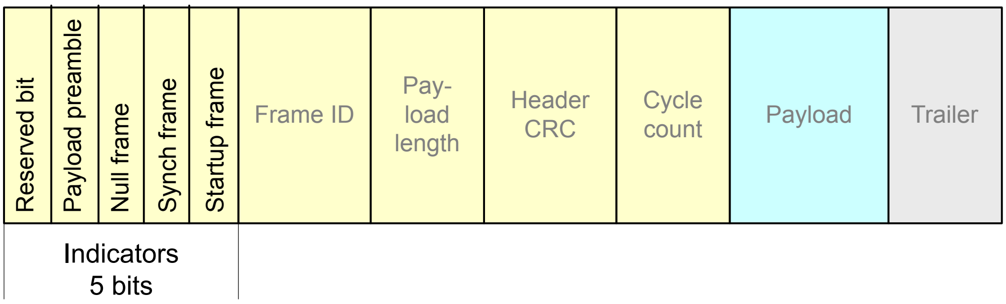
"Symbol" Searches for a symbol or wakeup pattern, see "Symbol" on page 552.

"Error condition"
Searches for one or more errors that are detected in the decoded data, see "Error Condition" on page 552.

Remote command:
`SEARch:TRIGger:FLXRay[:SSOFrame]` on page 1319
`SEARch:TRIGger:FLXRay:SSYMbol` on page 1319
`SEARch:TRIGger:FLXRay:SIDData` on page 1319
`SEARch:TRIGger:FLXRay:SERRor` on page 1319

Indicator bits

Searches for one or more indicator bits at the beginning of the header segment. Each bit can be set to 0, 1, or X (don't care).



"Payload pre-amble" Indicates a Network Management Vector in the payload segment. The NMV allows the host processor to send data directly, without processing by the communication controller.

"Null frame" Indicates a frame without usable data.

"Sync frame" Indicates that the frame is used for synchronization of the FlexRay system. Only sync nodes can send this frame type.

"Startup frame" Indicates a startup frame used for startup of the network. Only specific start nodes can send this frame type.

Remote command:
SEARch:TRIGger:FLXRay:PLPReamble on page 1324
SEARch:TRIGger:FLXRay:NUFRame on page 1324
SEARch:TRIGger:FLXRay:SYFRame on page 1326
SEARch:TRIGger:FLXRay:STFRame on page 1326

Frame ID (min/max)
The frame ID contains the number of the slot in which the frame is transmitted. Each frame ID occurs only once during a FlexRay cycle.

The setup conditions are the same as in the FlexRay trigger setup, see "Frame ID (min/max)" on page 541.

Remote command:
SEARch:TRIGger:FLXRay:FCONdition on page 1323
SEARch:TRIGger:FLXRay:FMIN on page 1324
SEARch:TRIGger:FLXRay:FMAX on page 1324

Payload length (min/max)
The payload length contains the number of of words transmitted in the payload segment. Information is transmitted in 2-byte words, so the number of data bytes in the payload segment is twice the payload length.

The setup conditions are the same as in the FlexRay trigger setup, see "Payload length (min/max)" on page 542.

Remote command:
SEARch:TRIGger:FLXRay:PCONdition on page 1325
SEARch:TRIGger:FLXRay:PMIN on page 1325
SEARch:TRIGger:FLXRay:PMAX on page 1325

Cycle count (min, max), Step
The cycle count contains the number of the current FlexRay cycle.

The setup conditions are the same as in the FlexRay trigger setup, see "Cycle count (min, max), Step" on page 542.

Remote command:
SEARch:TRIGger:FLXRay:CENable on page 1320
SEARch:TRIGger:FLXRay:CMIN on page 1320
SEARch:TRIGger:FLXRay:CMAX on page 1320
SEARch:TRIGger:FLXRay:CSTep on page 1321

Position, Index (min, max) - Data setup
Sets the position of the first byte of data bit pattern within the payload segment. You can define an exact position, or a position range.

The setup conditions are the same as in the FlexRay trigger setup, see "Position, Index (min, max) - Data setup" on page 543.

Remote command:
`SEARch:TRIGger:FLXRay:DPOPerator` on page 1322
`SEARch:TRIGger:FLXRay:DPOSition` on page 1323
`SEARch:TRIGger:FLXRay:DPTO` on page 1323

Condition, Data (min, max) - Data setup

Specifies the data bit pattern to be found in the payload segment. The starting point of the pattern is defined by "Position, Index (min, max) - Data setup" on page 551. The pattern comparision is byte-aligned, and the instrument triggers at the end of a byte.

The setup conditions are the same as in the FlexRay trigger setup, see "Condition, Data (min, max) - Data setup" on page 543.

Remote command:
`SEARch:TRIGger:FLXRay:DCONdition` on page 1321
`SEARch:TRIGger:FLXRay:DMIN` on page 1322
`SEARch:TRIGger:FLXRay:DMAX` on page 1322

Symbol

Searches for a symbol or a wakeup pattern.

"CAS/MTS" Collision Avoidance Symbol / Media access Test Symbol. These symbols are identical and can be sent in the optional symbol window at the end of a communication cycle. They are used to avoid collisions during the system start.

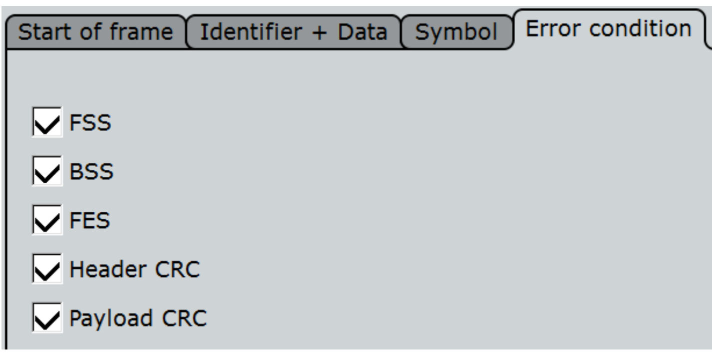
"Wakeup Pattern" The wakeup pattern is sent to activate the nodes of the system.

Remote command:
`SEARch:TRIGger:FLXRay:SYMBol` on page 1326

Error Condition

Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the FlexRay trigger setup, see "Error conditions" on page 544.



Remote command:
`SEARch:TRIGger:FLXRay:BSSerror` on page 1327
`SEARch:TRIGger:FLXRay:FESerror` on page 1327
`SEARch:TRIGger:FLXRay:FSSerror` on page 1327
`SEARch:TRIGger:FLXRay:HCRCerror` on page 1328
`SEARch:TRIGger:FLXRay:PCRCerror` on page 1328

12.7.5.2 FlexRay Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:
- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394

Remote commands:
- `SEARch:RESult:FLXRay:FCOunt?` on page 1329
- `SEARch:RESult:FLXRay:FRAMe<m>:ADID?` on page 1329
- `SEARch:RESult:FLXRay:FRAMe<m>:CSSTate?` on page 1329
- `SEARch:RESult:FLXRay:FRAMe<m>:CSValue?` on page 1329
- `SEARch:RESult:FLXRay:FRAMe<m>:CYCount?` on page 1330
- `SEARch:RESult:FLXRay:FRAMe<m>:DATA?` on page 1330
- `SEARch:RESult:FLXRay:FRAMe<m>:FCSTate?` on page 1330
- `SEARch:RESult:FLXRay:FRAMe<m>:FCValue?` on page 1330
- `SEARch:RESult:FLXRay:FRAMe<m>:FLAGs?` on page 1331
- `SEARch:RESult:FLXRay:FRAMe<m>:PAYLength?` on page 1331
- `SEARch:RESult:FLXRay:FRAMe<m>:STATus?` on page 1331
- `SEARch:RESult:FLXRay:FRAMe<m>:STARt?` on page 1332
- `SEARch:RESult:FLXRay:FRAMe<m>:STOP?` on page 1332
- `SEARch:RESult:FLXRay:FRAMe<m>:SYMBol?` on page 1333
- `SEARch:RESult:FLXRay:FRAMe<m>:TYPE?` on page 1333

12.8 Audio Signals (Option R&S RTE-K5)

The R&S RTE can analyze several standard and de-facto industry standard signals: I²S Inter-IC Sound standard audio format, left justified and right justified data formats and Time Division Multiplexed (TDM) audio format.

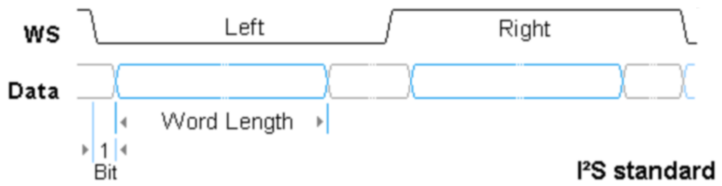
12.8.1 Audio Protocols

All audio protocols use 3 lines:

- The clock line generates the bit clock.
- The word select line (WS, also known as word clock) defines the frame start and the maximum length of the data word.
  For pulse code modulated signals (I²S standard, left and right justified data formats), the level of the WS signal assigns the data words to the left and right channels.
  TDM uses frame synchronization pulses on the WS line to identify the beginning of a frame.
- The data line transmits the audio data in time-multiplexed data channels.

12.8.1.1 I²S Standard

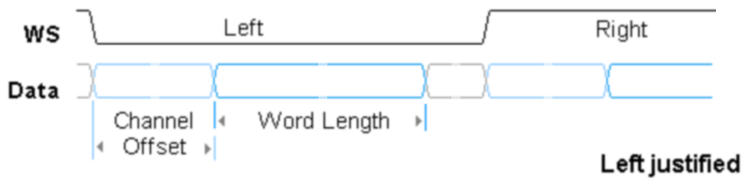
I²S standard interfaces transmit two PCM coded audio channels. The WS line selects the channel being transmitted - left or right channel. Usually, 32 bits are transmitted on each channel. The data word can be shorter than the channel length, and the receiver ignores the remaining bits. The first byte of the audio word is delayed one clock period from the leading edge of the word select pulse. The R&S RTE can decode I²S standard signals with MSBF and LSBF bit order.



12.8.1.2 Left Justified Data Format

The left justified data format is very similar to the I²S standard, but the first byte of the audio word is aligned with the leading edge of the word select pulse. Thus the audio word is left justified within the frame. The data word can be shorter than the channel length.

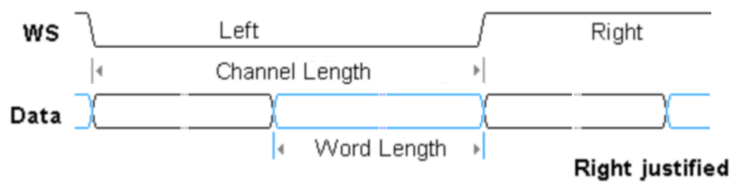
In addition to the standard configuration, the R&S RTE can analyze also left justified data formats which send the data word with offset to the WS edge. The bit order can be MSBF or LSBF.



12.8.1.3 Right Justified Data Format

The right-justified data format is similar to the left-justified, but the last byte of the word in the frame is aligned with the trailing edge of the word select pulse. Thus the audio word is right-aligned within the frame.

The R&S RTE can decode right justified signals with MSBF and LSBF bit order.



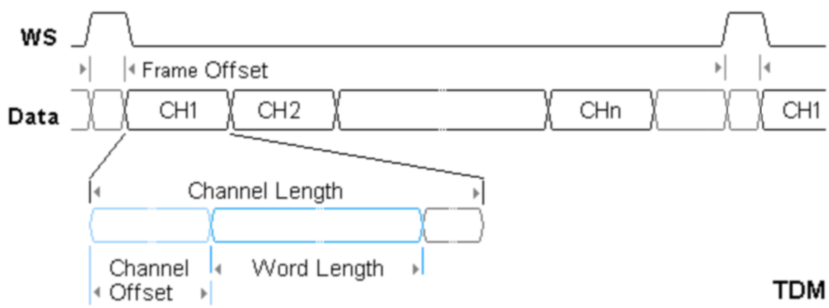
12.8.1.4 TDM

The Time Division Multiplexed (TDM) audio format is not standardized and provides high flexibility for transfer of more than two audio data channels on one line. On the word select line, it uses frame synchronization pulses to identify the beginning of a frame. On the data line, channel blocks of a defined length are transmitted. Each block contains an audio word that can be shorter than the channel length.

Each frame can start with frame offset bits, which preceed the first channel. Inside the channel, the audio word also can have an offset to the channel start.

Channel length, channel offset and word length are dependent values:

Channel length ≥ Word length + Channel offset



12.8.2 Audio Signal Configuration

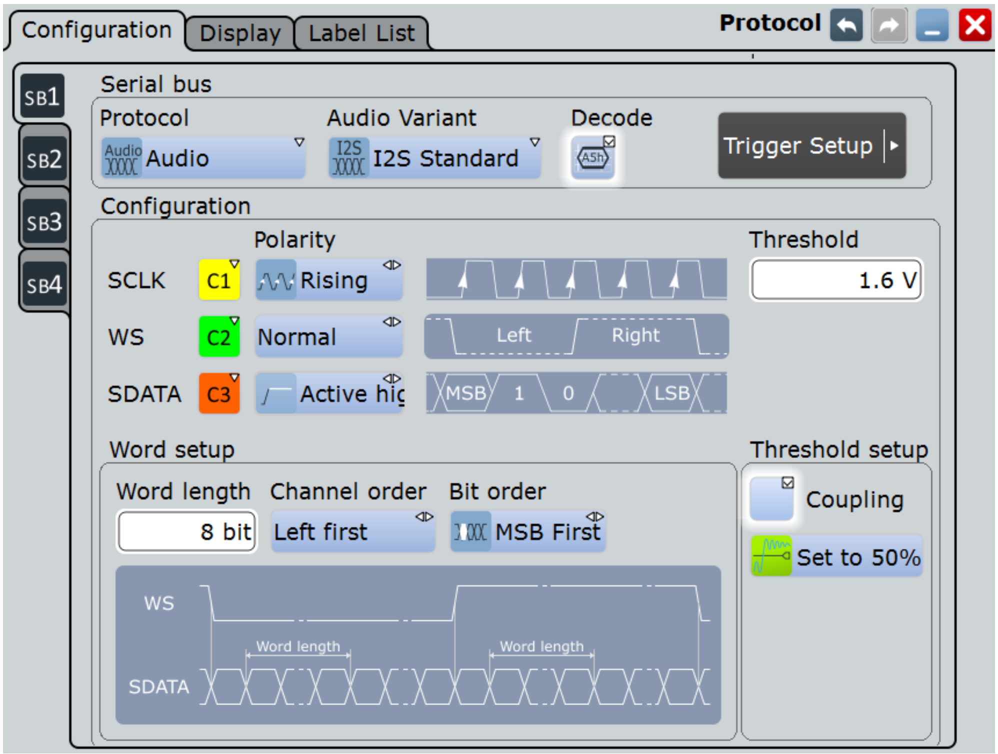
Access: PROTOCOL > "Configuration" tab > "Protocol" = *Audio*

In the "Configuration" tab you configure the audio signal. Several audio signal variants are available: the I²S standard signal, the left- and right-justified data formats, and the TDM interface.

For all audio signal variants, you define the line sources and their polarities. Additionally, if coupling is active, one threshold for all sources; if coupling is not enabled, three thresholds for each source.

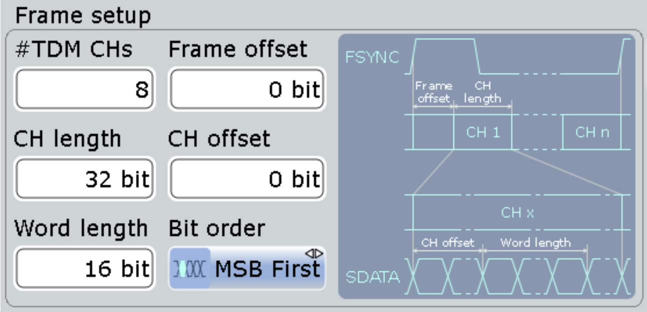
Specific settings for I²S standard signals are:

- "Channel order" on page 559
- "Word length" on page 559
- "Bit order" on page 559
- For left-justified data:
  "Channel offset" on page 559
- For right-justified data:
  "CH length" on page 560



Specific settings for TDM audio signals are:

- "Word length" on page 559
- "Bit order" on page 559
- "Channel offset" on page 559
- "#TDM CHs" on page 560
- "Frame offset" on page 560
- "CH length" on page 560



Make sure that the tab of the correct serial bus is selected on the left side.

Audio Variant

Selects the protocol variant of the audio signal. The configuration possibilities exceed the definitions of the standards.

"I2S Standard" Inter-IC Sound standard audio format.
It uses the SCLK, WS and SDATA lines. The first byte of the audio word is delayed one clock period from the leading edge of the word select pulse.

"Left justified" The left-justified data format uses the same lines as I^2S standard. The first byte of the audio word is aligned with the leading edge of the word select pulse, or left-justified within the frame. The format is word-length independent.

"Right justified" The right-justified data format is similar to the left-justified, but the last byte of the last word in the frame is aligned with the trailing edge of the word select pulse, or right-aligned within the frame. This format is not word-length independent.

"TDM" The Time Division Multiplexed audio format is not standardized and provides high flexibility for transfer of up to 8 audio data channels on one line. Instead of word select, it uses frame synchronization pulses to identify the beginning of a frame. On the data line, channel blocks of a defined length are transmitted. Each block contains an audio word followed by a number of zero bits to complete the block.

Remote command:
BUS<m>:I2S:AVARiant on page 1334

SCLK

Selects the source of the clock line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Alternatively, digital channels can be used if MSO option R&S RTE-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:I2S:CLOCk:SOURce` on page 1334

SCLK Polarity
Sets th polarity of the clock signal, that is the edge at which the instrument samples the data on the data line. Usually, the rising edge is used. The R&S RTE can also analyze the converse setup.

Remote command:
`BUS<m>:I2S:CLOCk:POLarity` on page 1334

WS / FSYNC
Selects the source of the word select line for I²S standard, left- und right-justified data formats, or the source of the frame synchronization pulse for TDM audio signals. The same waveforms as for SCLK are available, and the same restrictions are applied.

Remote command:
`BUS<m>:I2S:WSELect:SOURce` on page 1335

WS / FSYNC Polarity
For a word select line, the polarity defines the word select values assigned to the left and right channels.
- "Normal": usually, 0 indicates the left channel, and 1 indicates the right channel.
- "Inverted": 0 indicates the right channel, and 1 the left channel.

For an FSYNC line (TDM), the polarity defines the edge of the FSYNC pulse that identifies the beginning of a frame. The frame starts exactly at the next clock edge following the selected FSYNC edge.
- "Normal": usually, the frame begins with a rising edge.
- "Inverted": the frame begins with a falling edge.

Remote command:
`BUS<m>:I2S:WSELect:POLarity` on page 1335

SDATA
Selects the source of the audio data line. The same waveforms as for SCLK are available, and the same restrictions are applied.

Remote command:
`BUS<m>:I2S:DATA:SOURce` on page 1335

SDATA Polarity
Defines the interpretation of high and low signal states.
- "Active high": HIGH (signal level above the threshold level) = 1 and LOW (signal level below the threshold level) = 0
- "Active low": HIGH = 0 and LOW = 1

Remote command:
`BUS<m>:I2S:DATA:POLarity` on page 1336

Threshold setup
Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold. The interpretation of HIGH and LOW is defined by the polarity.

There are three ways to set the threshold:
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
  This option is only available for analog sources.
- "Coupling"
  Sets all thresholds to the same value. Enter the value in the "Threshold" field.
- "Threshold"
  Enter individual values for each line directly in the fields.

Remote command:
`BUS<m>:I2S:TCOupling` on page 1336
`BUS<m>:I2S:CLOCk:THReshold` on page 1336
`BUS<m>:I2S:DATA:THReshold` on page 1337
`BUS<m>:I2S:WSELect:THReshold` on page 1337
`BUS<m>:SETReflevels` on page 1163

Channel order
Defines if the left or the right channel is the first channel in the frame.

The setting is not available for TDM audio signals.

Remote command:
`BUS<m>:I2S:CHANnel:ORDer` on page 1337

Word length
Defines the number of bits in an audio data word. The minimum length is 4 bit, the maximum is 32 bit.

Remote command:
`BUS<m>:I2S:WLENgth` on page 1337

Bit order
Sets the bit order in the audio data words. Usually, the MSB is transmitted first.

Remote command:
`BUS<m>:I2S:BORDer` on page 1338

Channel offset
Sets the number of bits between the channel start and the start of the audio word. The setting is available for left-justified data format and TDM audio signals.

For TDM, possible values depend on the channel size and the word size. The maximum delay is *Channel length - Word length*.

Remote command:
`BUS<m>:I2S:CHANnel:OFFSet` on page 1338

#TDM CHs
Sets the number of channels transmitted on the TDM audio line.

Remote command:
`BUS<m>:I2S:CHANnel:TDMCount` on page 1338

Frame offset
Sets the number of bits between the frame start and the start of the first channel of a TDM audio line. The maximum offset is 256 bit. Each FSYNC edge restarts the offset count.

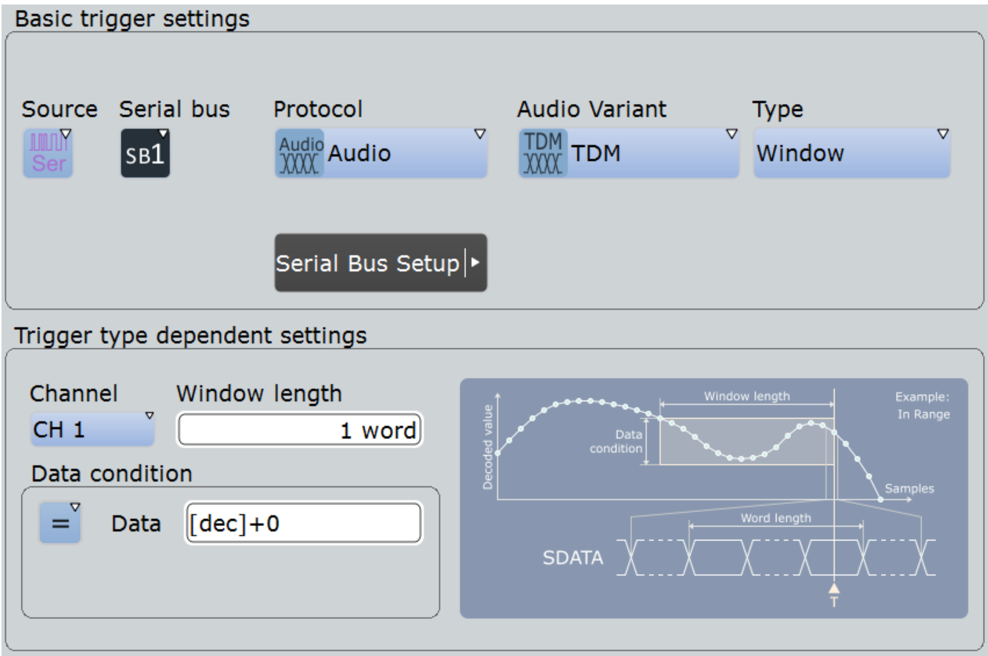
Remote command:
`BUS<m>:I2S:FOFFset` on page 1338

CH length
Sets the number of bits in a channel block for right-justified data format and TDM audio signals.

Remote command:
`BUS<m>:I2S:CHANnel:LENGth` on page 1339

12.8.3 Audio Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = Audio"



Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Type

Selects the trigger type.

"Data" Sets the trigger on a data word or a data range that occurs on a specified channel or on any channel. The instrument triggers on the last bit of the specified data pattern.

Description of specific trigger type settings:

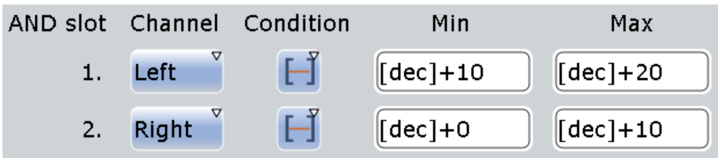
- "Channel" on page 562
- "Data condition" on page 562

"Window" This trigger checks if the decoded data values stay inside a "window" that is formed by a data range and a time specified by a number of subsequent words. It considers a selected channel or all channels. The instrument triggers at the end of the last word. Thus, for example, you can trigger on a pause.

Description of specific trigger type settings:

- "Channel" on page 562
- "Data condition" on page 562
- "Window length" on page 563

"Frame condition" Sets the trigger on an AND combination of data conditions on different channels. The instrument triggers if all conditions are met inside one frame.



Description of specific trigger type settings:

- "Channel" on page 562
- "Data condition" on page 562

Description of specific trigger type settings: "Channel" on page 562 and .

"Word select" Triggers on the selected edge of the WS line, that is, on the beginning of the left or right channel (I²S, left- and right-justified). For TDM signals, it triggers on the selected edge of the FSYNC line - on the beginning of a TDM frame.
The trigger time is the first clock edge after the selected WS/FSYNC edge.
Description of specific trigger type settings: "Word select: Slope" on page 563.

"Error condition" The oscilloscope uses the WS or FSYNC line to monitor the channel and frame length. An error is detected when two consecutive frames have different length. The instrument triggers on the first clock edge after error detection.

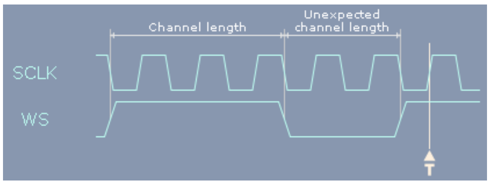


Figure 12-38: Trigger on errors in I²S standard signal with clock polarity "Rising"

Remote command:
`TRIGger<m>:I2S:TYPE` on page 1339

Channel

Selects the audio channel on which the instrument looks for the specified data condition.

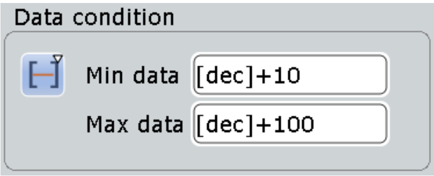
The setting is relevant for trigger types Data, Window and Frame condition.

Note: For TDM signals. the number of available channels depends on the configuration of the audio bus, see "#TDM CHs" on page 560.

Remote command:
`TRIGger<m>:I2S:TCONdition<n>:CHANnel` on page 1340

Data condition

The data condition setup consists of the operator and one or two data patterns.



The settings are relevant for trigger types Data, Window and Frame condition.

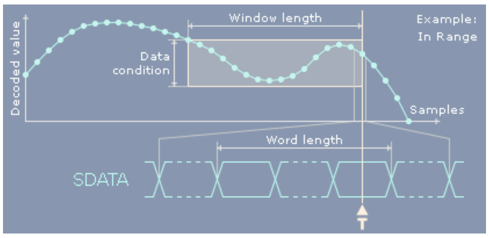
"Operator" Defines the operator to set a specific data word ("Equal" or "Not equal") or a data range.

"Min data"	Defines the data pattern. The data length is limited to the word length. Enter the pattern using the bit order defined in the signal configuration. X (don't care) is not allowed. Usually, audio words are signed numbers in 2's complement format. The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.
"Max data"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:I2S:TCONdition<n>:CONDtion` on page 1341
`TRIGger<m>:I2S:TCONdition<n>:DMIN` on page 1342
`TRIGger<m>:I2S:TCONdition<n>:DMAX` on page 1342

Window length

Sets the number of words that is used as time limit for the "Window" trigger type. The instrument triggers if the data condition is fulfilled on the same channel for the given number of subsequent frames.



Remote command:
`TRIGger<m>:I2S:SOWords` on page 1342

Word select: Slope

Sets the edge of the WS or FSYNC signal as trigger condition. The instrument triggers on the first clock edge after the specified edge.

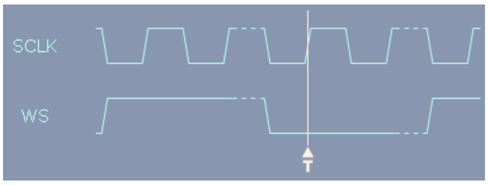


Figure 12-39: Word select trigger on I²S standard signal with clock polarity "Rising" and "Normal" WS polarity (left = 0)

The WS edge indicates the start of the left or right channel. The FSYNC edge indicates the frame start. Consider the WS / FSYNC Polarity setting in the "Protocol Configuration" dialog box.

Remote command:
`TRIGger<m>:I2S:WSSLope` on page 1343

12.8.4 Audio Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The decoding process considers the "Bit order" configuration setting of the signal and displays the the binary result MSB first. Binary values in the combs of the decoded signal also consider the "Binary bit order" setting in the "Display" tab. Thus, you can read the bits of an LSB first signal in LSB first order in the combs while the results table displays the correct values MSB first.

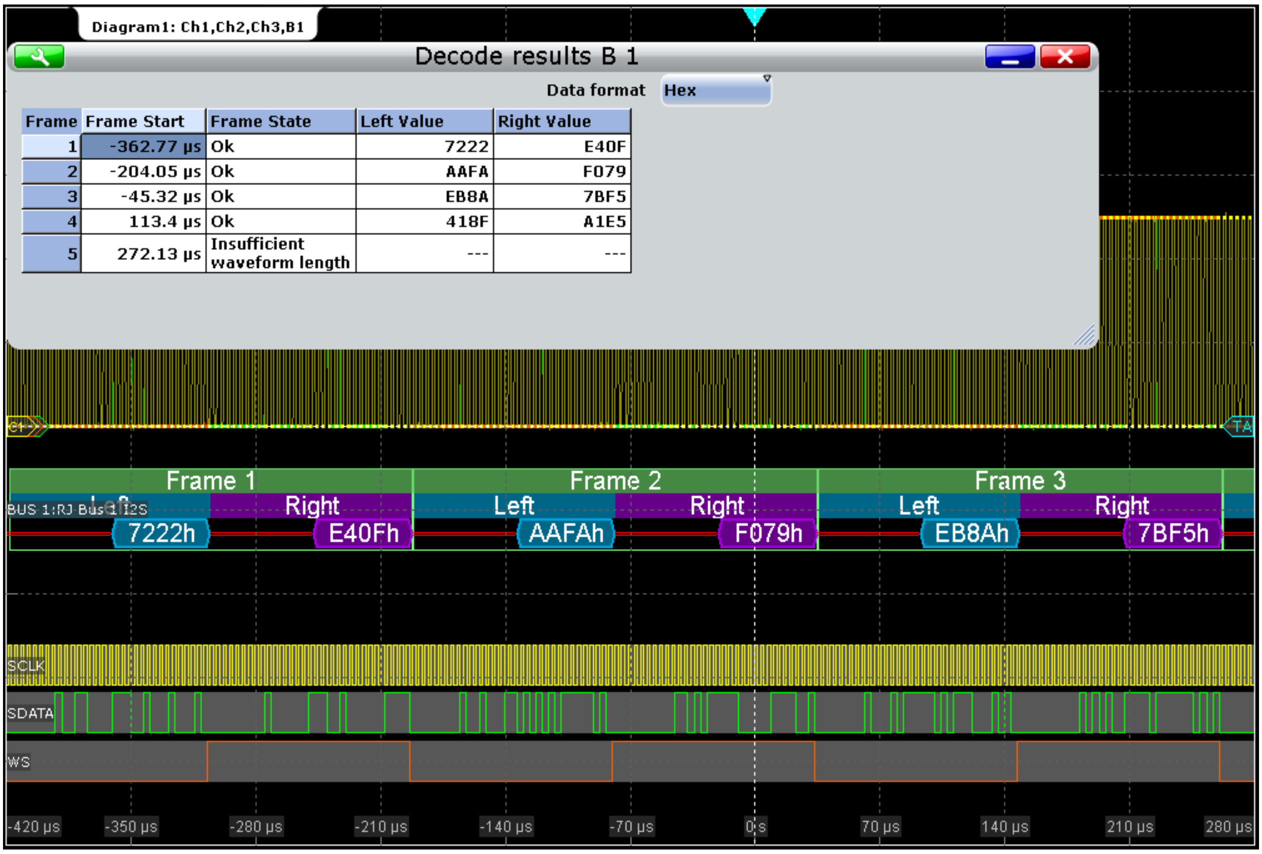


Figure 12-40: Decoded audio signal, right-justified data format

green = frame
blue = left channel
violet = right channel
orange = frame/channel is not completely contained in the acquisition
red = error

Table 12-7: Content of the "Decode results" table

Column	Description
Frame Start	Time of the frame start
Frame State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition.
Left Value	Data value of the left channel
Right Value	Data value of the right channel

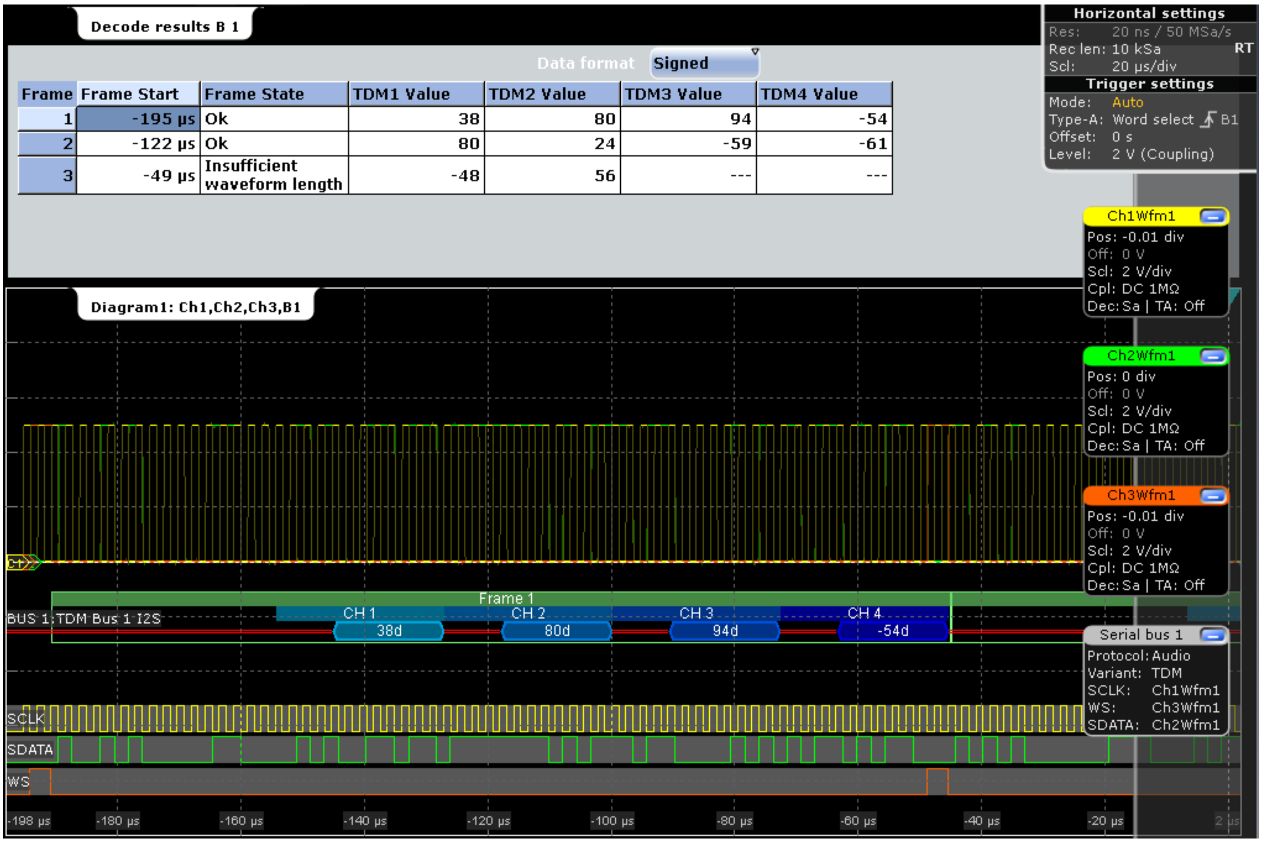


Figure 12-41: Decoded TDM signal with 4 channels, frame offset 16 bit, channel offset 4 bit, word length 8 bit and inverted FSYNC and SDATA polarity

Table 12-8: Content of the "Decode results" table

Column	Description
Frame Start	Time of the frame start
Frame State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition.
TDM<x> Value	Data value of the TDM channel

Remote commands:
- `BUS<m>:I2S:FCOunt?` on page 1343
- `BUS<m>:I2S:FRAMe<n>:STATe?` on page 1343
- `BUS<m>:I2S:FRAMe<n>:STARt?` on page 1344
- `BUS<m>:I2S:FRAMe<n>:STOP?` on page 1344
- `BUS<m>:I2S:FRAMe<n>:LEFT:VALue?` on page 1344
- `BUS<m>:I2S:FRAMe<n>:RIGHt:VALue?` on page 1344
- `BUS<m>:I2S:FRAMe<n>:LEFT:STATe?` on page 1344
- `BUS<m>:I2S:FRAMe<n>:RIGHt:STATe?` on page 1344
- `BUS<m>:I2S:FRAMe<n>:TDM<o>:STATe?` on page 1345
- `BUS<m>:I2S:FRAMe<n>:TDM<o>:VALue?` on page 1345

12.8.5 Track and Trend

12.8.5.1 Track

The track is a waveform that shows measurement values in time-correlation to the audio signal. It is the graphical interpretation of all measurement values of a single acquisition. For audio signals, the measurement values on the vertical axis are the decoded values of the audio channels, the time scale is equivalent to the scale of the source waveforms.

You can display the values of several channels in one track, or create one track for each channel and display them in parallel.

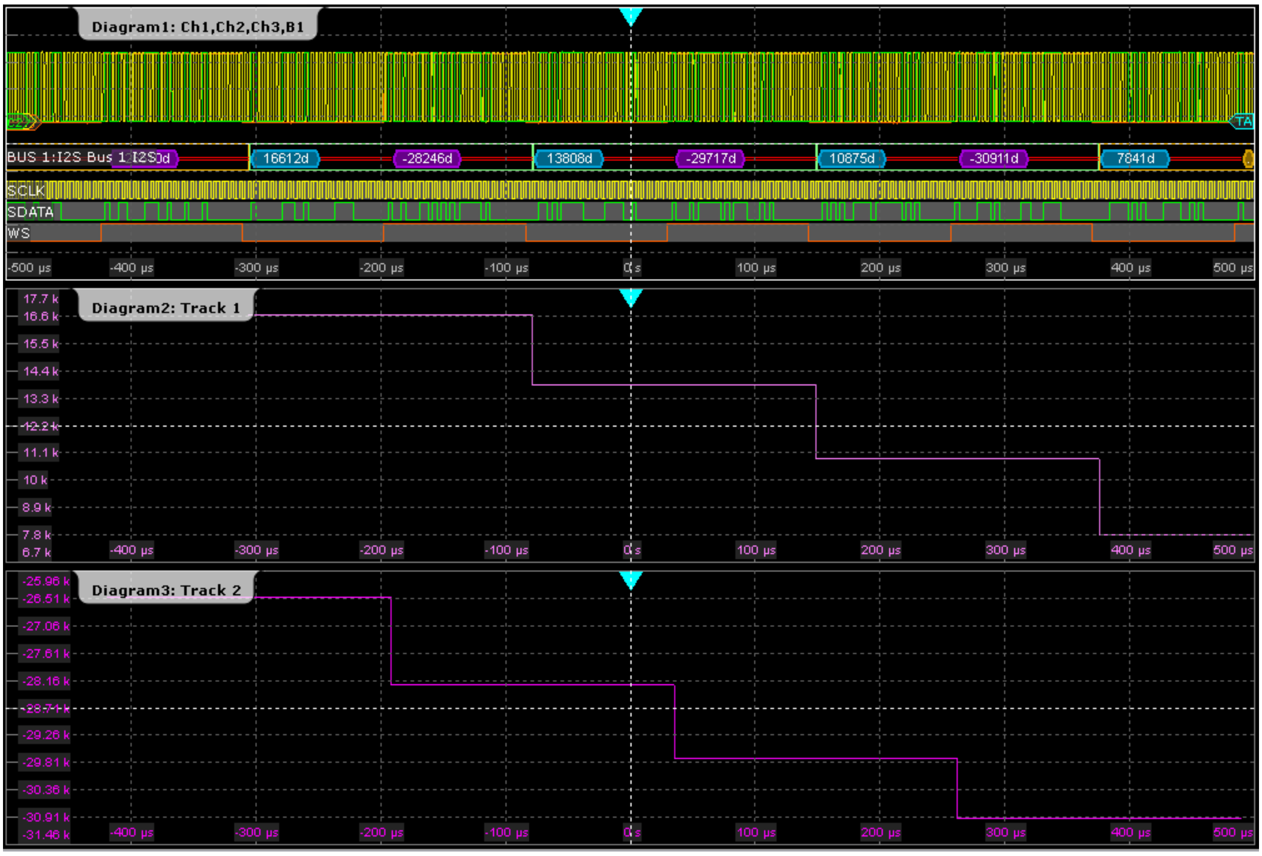


Figure 12-42: Tracks of left and right channel of I²S standard signal

The track is a special measurement waveform, so it can be used for further analysis like cursor measurements and zoom.

The instrument uses the bus data format to interpret audio data ("Display" tab > "Data format"). If the "Signed" data format ist set, decoded data is displayed as signed integers in the comb display and in the result table. For all other data formats, unsigned integers are used.

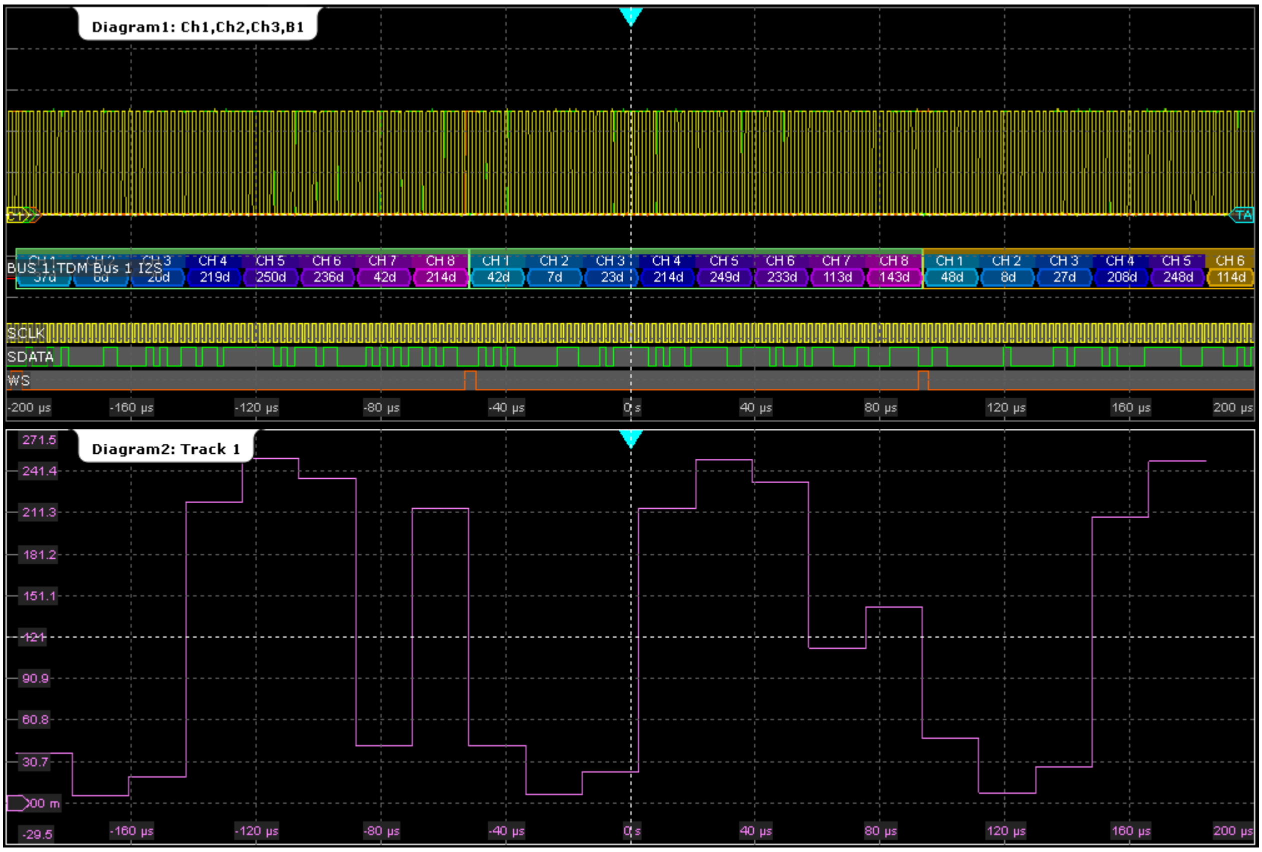


Figure 12-43: Track of all 8 channels of a TDM signal

Displaying and Configuring a Track

To get a first impression of the track, you can display it quickly. For further analysis, some configuration settings are available.

1. Press the PROTOCOL key.
2. Select the "Display" tab.
3. Tap the "Show Track Waveform(s)" button.
4. Select the "Audio channel" to be tracked.

   The track waveform with default settings is enabled and displayed.

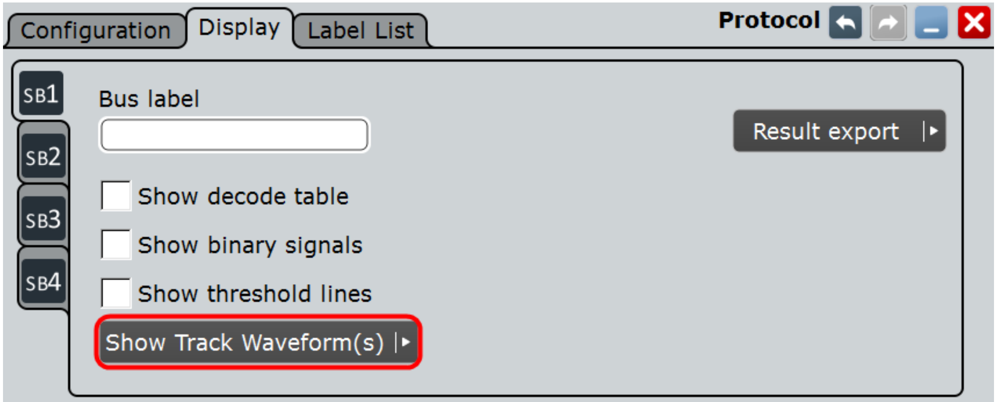
   Tip: Alternatively, you can enable the track in the "Measurements" dialog box, on the "LongTerm/Track" tab if the audio serial bus is selected as source of the measurement on the "Setup" tab.
5. If you want to change the track settings, tap "Track Setup".
6. By default, the track is displayed using "Continuous auto scale". If you want to change the scaling, proceed as follows:
   a) Select the "LongTerm/Track" tab.
   b) Disable "Continuous auto scale".

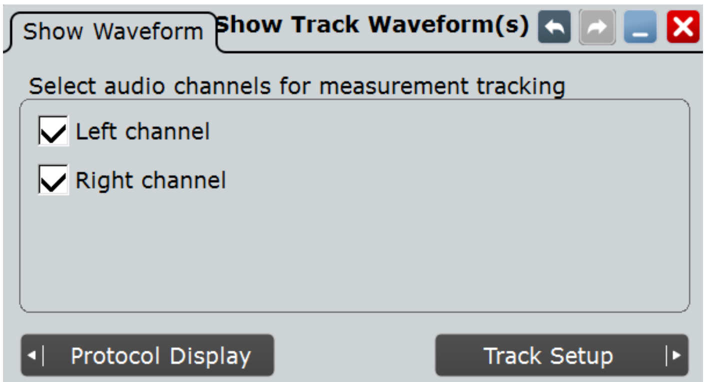
c) Adjust "Vertical scale" and "Vertical offset".

Track Settings in Protocol Setup

You can enable the track waveforms in the protocol display settings. As the track is based on measurement, you can use the "Measurement" dialog box alternatively, see "Track Enabling in Measurement Setup" on page 570.

Access: PROTOCOL > "Display tab"





To set the vertical scale of the track waveform, use the measurement scale settings on the "Measurements - Long Term/Track" tab, see "Meas scaling" on page 321.

Show Track Waveform(s)
Enables and displays the track(s) for the seleceted channels of the decoded bus for the current acquisition using unsigned data format and continuous auto scale.

See also: Chapter 12.8.5.1, "Track", on page 566.

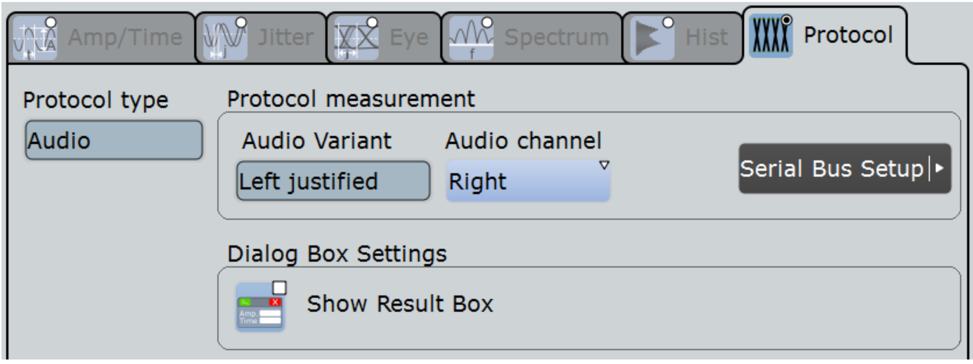
Remote command:
`BUS<m>:I2S:TRACk:LEFT` on page 1346
`BUS<m>:I2S:TRACk:RIGHt` on page 1346
`BUS<m>:I2S:TRACk:TD1Ch` on page 1346
`BUS<m>:I2S:TRACk:TD2Ch` on page 1346
`BUS<m>:I2S:TRACk:TD3Ch` on page 1346
`BUS<m>:I2S:TRACk:TD4Ch` on page 1346
`BUS<m>:I2S:TRACk:TD5Ch` on page 1346

BUS<m>:I2S:TRACk:TD6Ch on page 1346
BUS<m>:I2S:TRACk:TD7Ch on page 1346
BUS<m>:I2S:TRACk:TD8Ch on page 1346

Track and Trend Settings in Measurement Setup

As track and trend are based on measurements, the main settings are available in the "Measurement" dialog box.

Access: "Meas" menu > "Setup" > "Protocol" subtab



Protocol type, Audio variant
Show the current protocol settings for information

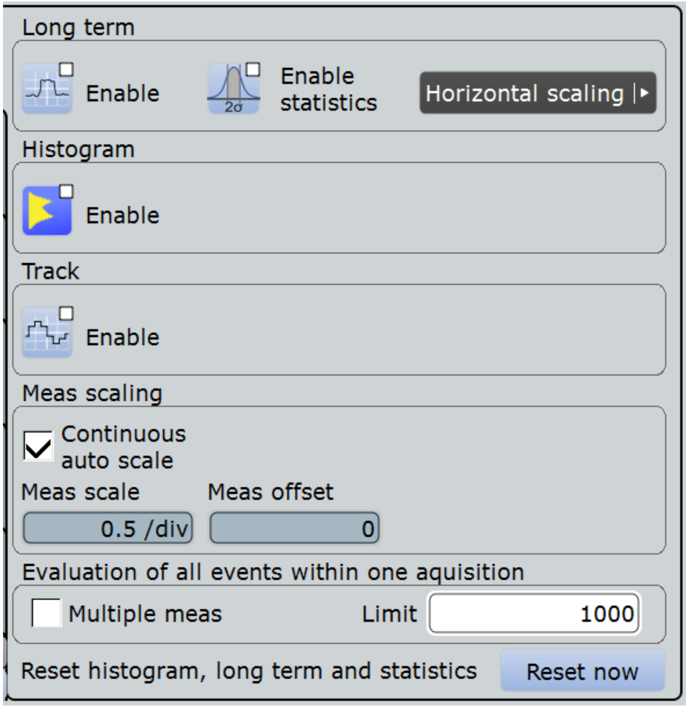
Audio channel
Selects the channel that is shown in the track and trend waveforms.

Show Result Box
Hides or shows the measurement result box. For track and trend, no numerical results are available in the result box, so you can hide it.

Track Enabling in Measurement Setup

As the track is based on measurement, it can be set up in the "Long Term/Track" tab of the "Measurement" dialog box. Alternatively, you can enable the track in the protocol display settings, see "Track Settings in Protocol Setup" on page 569.

Access: "Meas" menu > "LongTerm/Track"



To set the vertical scale of the track waveform, use the measurement scale settings on "LongTerm/Track" tab, see "Meas scaling" on page 321.

Enable (Track)

Enables the track measurement and displays the track of the selected waveform.

The track functionality requires at least one option:

- Option R&S RTE-K31 Power Analysis
  Enables the track for amplitude and time measurements.
- Option R&S RTE-K5 I²S Audio Signals
  Enables the track for protocol measurements on decoded audio buses, see Chapter 12.8.5.1, "Track", on page 566.

Remote command:
`MEASurement<m>:TRACk[:STATe]` on page 1055

12.8.5.2 Trend

The trend is a special long term measurement that shows the evolution of measurement values in a running continuous acquisitions. For audio signals, each decoded channel value is a measurement result that creates a point on the trend curve. You can configure the number of points that builds the complete trend curve.

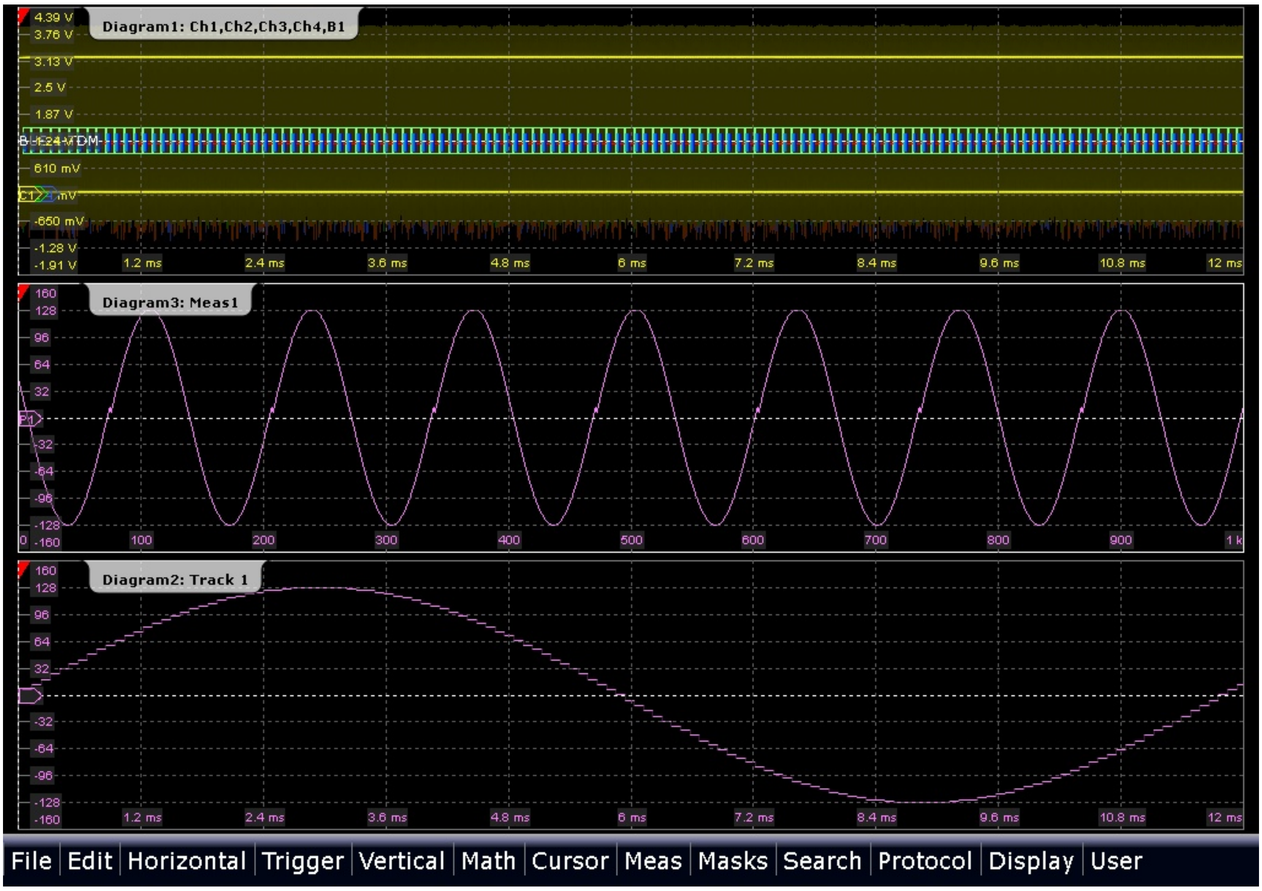
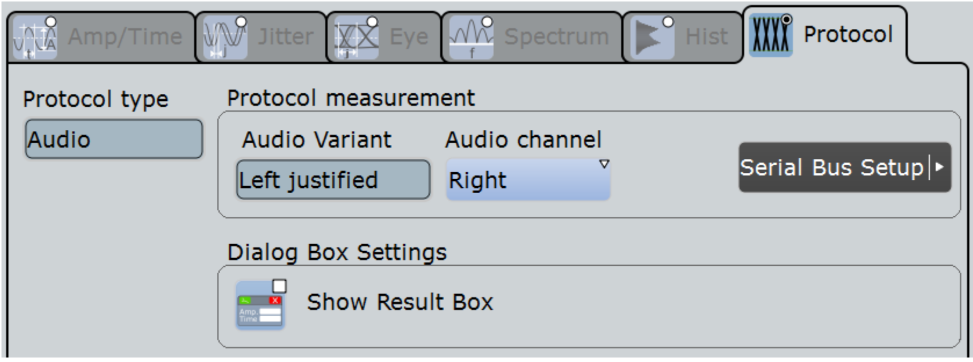


Figure 12-44: Trend (Diagram3) and track of an audio signal

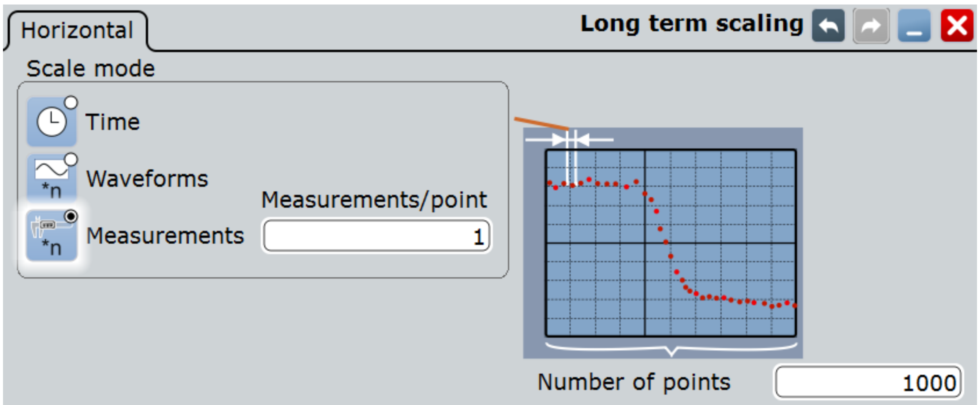
Displaying and Configuring the Trend

If an audio bus is configured, the MEAS key and the "Measurement" icon can identify the bus and preconfigure the measurement. The following procedure describes the complete trend setup using the "Meas" menu.

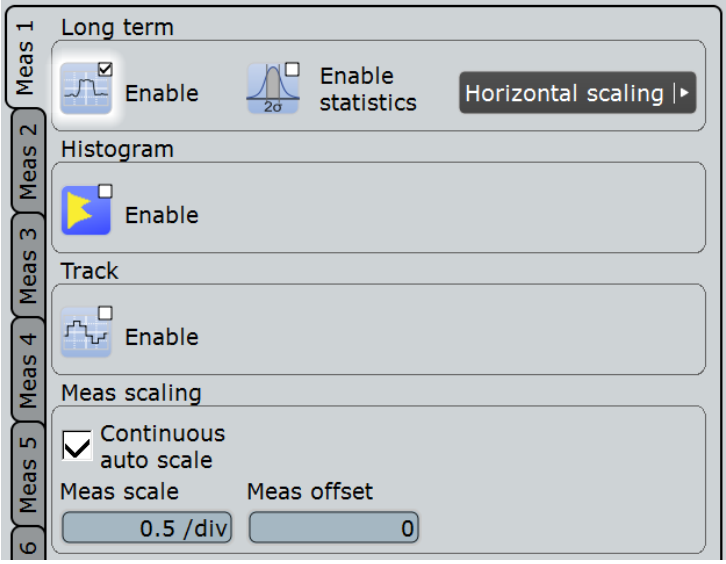
1. On the "Meas" menu, select "Setup".
2. Select the "Source" of the measurement: "Serial bus".
3. Select the "Audio channel" for which you want to analyze the trend.
4. Enable "State".



5. Select the "Long term/Track" tab.
6. Tap "Horizontal scaling".
7. Set the scale mode to "Measurements" and the number of "Measurements/point" to *1*.



8. Tap "Long term/Track".
9. Set the "Vertical scaling" to "Continuous auto scale".
10. Under "Long term", select "Enable".



An empty trend diagram is displayed.

11. Start continuous acquisition.

    The trend fills up with measurement points from left to right.

12. If you want to change the vertical scaling of the trend curve, disable "Continuous auto scale" and adjust "Vertical scale" and "Vertical offset".

12.9 MIL-1553 (Option R&S RTE-K6)

12.9.1 The MIL-STD-1553

The MIL-STD-1553 specification defines the characteristics of a serial data bus originally designed for use in the military avionics. Nowadays it is also used in spacecraft on-board data handling.

The bus is a 2-wire bus that uses differential signals.

A MIL-STD-1553 system consists of the following components:

- Bus Controller (BC): initiates and coordinates the data flow in the system.
- Remote Terminal (RT): interfaces various subsystems with the data bus. A system can consists of up to 31 RTs and each RT can have 31 subaddresses.
  The subaddresses 0 and 31 refer to a mode code command.
- Bus Monitor (BM) (optional): listens to all messages and can record selected data for real-time or off-line analysis.

The information is transmitted over the bus in defined series of words using Manchester code, where each bit is transmitted as high-low for a logical 1 or a low-high for a logical 0. There are three types of words: command, data and status.

Command Word

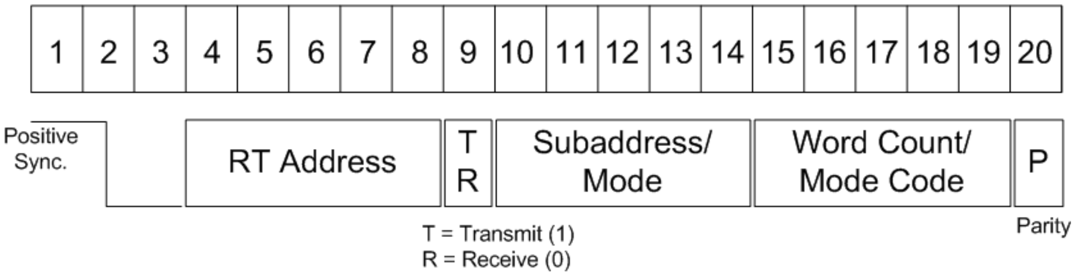


Figure 12-45: Structure of a command word

The format of a command word consists of the following parts (see Figure 12-45):

- Sync: an invalid Manchester waveform.
- Remote Terminal (RT) Address: the unique address of the corresponding RT.
- Transmit/Receive (T/R): indicates the action required from the RT.
- Subaddress/Mode Code: indicates the RT subaddress. The subaddresses 0 and 31 signalize the transmission of a mode code.
- Data Word Count /Mode Code: indicates the number of words that are sent/ received by the RT. A maximum of 32 words is allowed. This field may be used for the transmission of the mode code value.
- Parity: checks if there are bit errors during the transmission. The total number of logic 1 bits for the word (sync bits not included) shall be odd.

Data Word

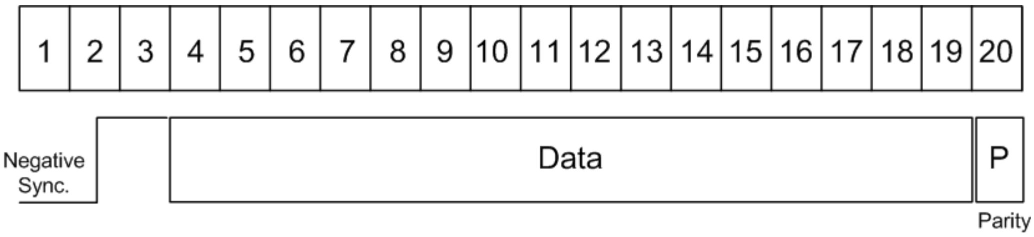


Figure 12-46: Structure of a data word

The format of a data word consists of the following parts (see Figure 12-46):

- Sync: an invalid Manchester waveform.
- Data: the transferred information (16 bit).
- Parity: checks if there are bit errors during the transmission. The total number of logic 1 bits for the word (sync bits not included) shall be odd.

Status Word

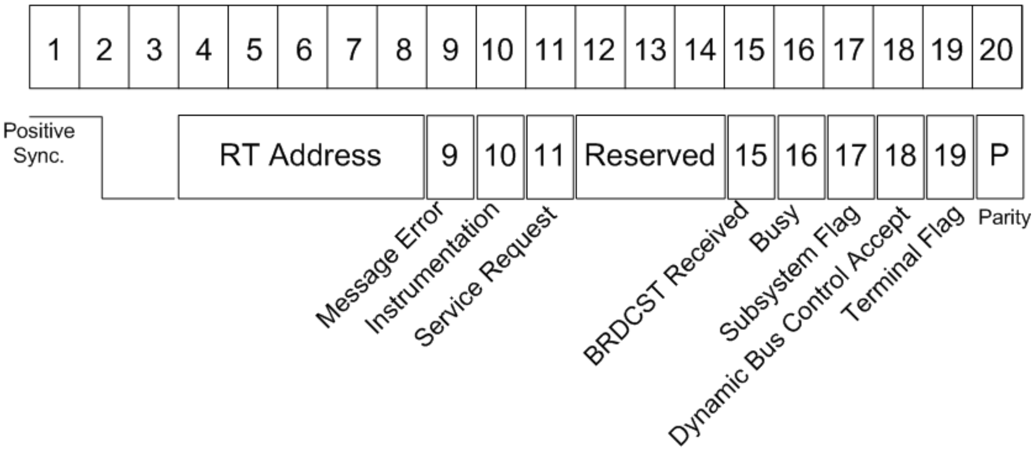


Figure 12-47: Structure of a status word

The format of a status word consists of the following parts (see Figure 12-47):

- Sync: an invalid Manchester waveform.
- Remote Terminal (RT) Address: the unique address of the corresponding RT.
- Message error: indicates an error in the command/data word transmission from the BC. A logic 1 indicates presence of a message error and a logic 0 indicates its absence.
- Instrumentation: helps to distinguish between a status word and a command word. The logic state of this bit shall be 0.
- Service Request: indicates that the RT requires service. A logic 1 indicates a presence of a service request and logic 0 indicates its absence.
- Reserved: bits reserved for future uses.
- Broadcast Command: a logic 1 indicates that the preceding valid command word was a broadcast command and a logic 0 that it wasn't.
- Busy: a busy state indicates that the RT or the subsystem is not able to transfer data. A logic 1 indicates a presence of a busy condition and logic 0 indicates its absence.
- Subsystem Flag: flags a subsystem fault. A logic 1 indicates a presence of a flag and logic 0 indicates its absence.
- Dynamic Bus Control Acceptance: a logic 1 indicates acceptance of a dynamic bus control and a logic 0 a rejection.
- Terminal Flag: flags an RT fault condition. A logic 1 indicates a presence of a flag and logic 0 indicates its absence.
- Parity: checks if there are bit errors during the transmission. The total number of logic 1 bits for the word (sync bits not included) shall be odd.

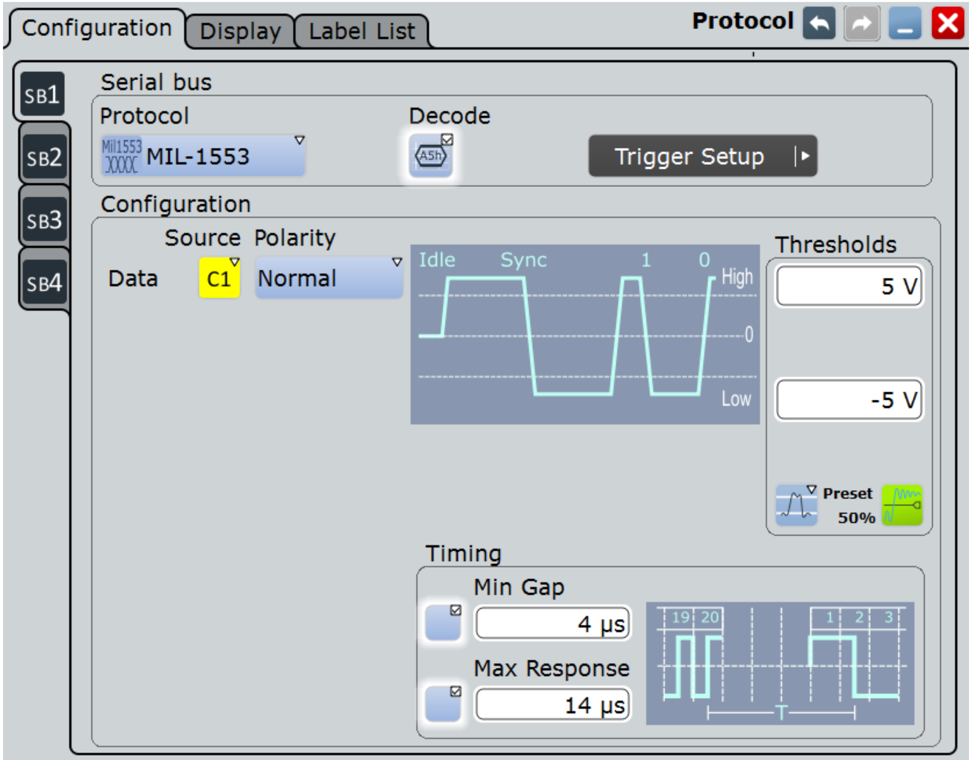
For comfortable analysis, you can load an editable label list, to interpret transferred numeric values as meaningful text labels.

12.9.2 MIL-STD-1553 Configuration

12.9.2.1 MIL-STD-1553 Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *MIL-STD-1553*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Data

Sets the source of the selected data line. Analog channels, math waveforms, and reference waveforms can be used.

For triggering on a serial bus, a channel signal is required.

Remote command:

`BUS<m>:MILStd:SOURce` on page 1348

Polarity

Selects the wire on which the bus signal is measured : "Normal" or "Inverted". The setting affects the digitization of the signal.

Remote command:

`BUS<m>:MILStd:POLarity` on page 1350

Thresholds
Threshold values are used for digitization of the signal.

Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high (1 or true for the boolean logic). Otherwise, the signal state is considered low (0 or false) if the signal value is below the threshold.

There are three ways to set the thresholds:
- "High" and "Low"
  Upper and lower threshold levels. You can enter the values directly in the fields.
- "Preset"
  Selects the default threshold voltage from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Remote command:
`BUS<m>:MILStd:THReshold:HIGH` on page 1350
`BUS<m>:MILStd:THReshold:LOW` on page 1350
`BUS<m>:MILStd:PRESet` on page 1350

Min Gap
Selects and sets a value for the intermessage gap beween the last bit of a message and the following command word sync. The time is measured between the mid bit zero crossings. According to the standard, the minimum idle time is 4 µs.

The minimum gap time is relevant for protocol configuration and error trigger.

If "Min Gap" is enabled, the instrument detects the specified gap during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the gap is shrter than specified.

Remote command:
`BUS<m>:MILStd:MINGap:BITS` on page 1349
`BUS<m>:MILStd:MINGap:SELect` on page 1349
`TRIGger<m>:MILStd:MINGap:BITS` on page 1359
`TRIGger<m>:MILStd:MINGap:SELect` on page 1359

Max Response
Selects and sets a value for the maximum response time between the last bit of a word and the following status word sync. The time is measured between the mid bit zero crossings. According to the standard, the RT shall respond to a valid command word within the time period of 4 to 12 µs.

The max response time is relevant for protocol configuration and error trigger.

If "Max response" is enabled, the instrument detects the specified gap during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the response time is longer than specified.

Remote command:
`BUS<m>:MILStd:MAXResponse:BITS` on page 1348
`BUS<m>:MILStd:MAXResponse:SELect` on page 1349

`TRIGger<m>:MILStd:MAXResponse:BITS` on page 1359
`TRIGger<m>:MILStd:MAXResponse:SELect` on page 1359

12.9.2.2 Configuring MIL-STD-1553

For configuration assign the line to the input channel, set the threshold and the timing conditions.

For details on configuration settings, see Chapter 12.9.2.1, "MIL-STD-1553 Configuration Settings", on page 577.

To display the decoded signal, option R&S RTO-K6 is required.

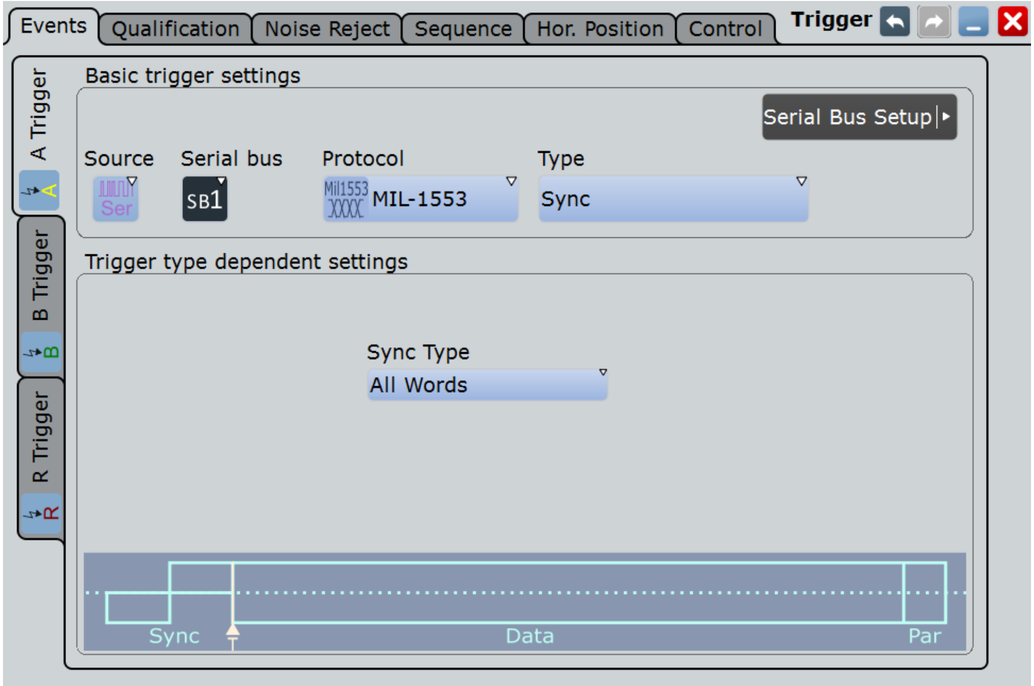
1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "MIL-STD-1553".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "Polarity" button, and select the waveform of the data line.
7. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fields.
8. If required tap the "Min Gap" button to select it and set the minimum gap time.
9. If required tap the "Max Response" button to select it and set the maximum response time.

12.9.3 MIL-STD-1553 Trigger

12.9.3.1 Trigger Settings MIL-STD-1553

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = MIL-1553 "

Make sure that:
- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.



Trigger Type
Selects the trigger type for MIL-STD-1553 analysis.

"Sync" Triggers on a sync impulse.

"Word" Triggers on the selected word type.

"Data Word" Triggers on a specified data word or data word range.

"Command/ Status Word"
Triggers on a specified command word or on a status word.

"Command Word"
Triggers on a specified command word.

"Status Word" Triggers on a specified status word.

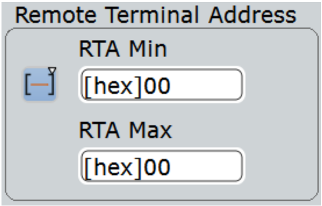
"Error Condition" Triggers on any combination of protocol errors.

Remote command:
`TRIGger<m>:MILStd:TYPE` on page 1352

Sync Type / Word Type
Triggers on a sync impulse or word type. You can select to trigger on "Command/ Status", on "All" or on "Data" sync pulses / word types.

Remote command:
`TRIGger<m>:MILStd:TPSPecifier` on page 1361

Remote Terminal Address
The RTA setup consists of the condition and one or two RTA patterns.



"Condition"
Defines the operator to set a specific RTA ("Equal" or "Not equal") or an RTA range.

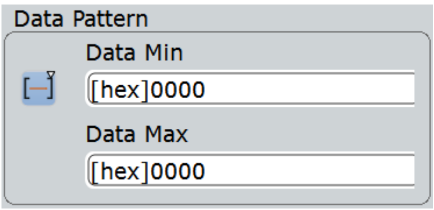
"RTA Min/ RTA"
Defines the bit pattern of the RTA.
In binary format, use the following characters: 1; 0; or X (don't care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"RTA Max"
The second RTA pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:MILStd:CDST:RCONdition on page 1352
TRIGger<m>:MILStd:CDST:RMAX on page 1353
TRIGger<m>:MILStd:CDST:RMIN on page 1353
TRIGger<m>:MILStd:CMD:RCONdition on page 1352
TRIGger<m>:MILStd:CMD:RMAX on page 1353
TRIGger<m>:MILStd:CMD:RMIN on page 1353
TRIGger<m>:MILStd:DATA:RCONdition on page 1352
TRIGger<m>:MILStd:DATA:RMAX on page 1353
TRIGger<m>:MILStd:DATA:RMIN on page 1353

Data Pattern

The data pattern setup consists of the condition and one or two data patterns.



"Condition"
Defines the operator to set a specific data pattern ("Equal" or "Not equal") or a data patter range.

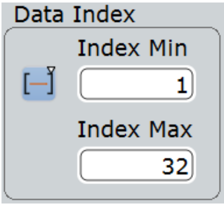
"Data Min/ Data"
Defines the bit pattern of the data pattern.
In binary format, use the following characters: 1; 0; or X (don't care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"Data Max"
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:MILStd:DATA:DCONdition on page 1356
TRIGger<m>:MILStd:DATA:DMAX on page 1357
TRIGger<m>:MILStd:DATA:DMIN on page 1357

Data Index

The MIL-MIL-STD-1553 standard defines the length of a message to a series of up to 32 words. Data index sets the range within this series of the data words that is considered for the analysis. The data index setup consists of the condition and one or two data index values.



"Condition" Defines the operator to set a specific data ("Equal") or a data range.

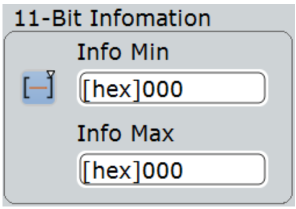
"Index Min/Index"
Defines the minimum index.

"Index Max" The second data pattern is required to specify a range with conditions "In range".

Remote command:
TRIGger<m>:MILStd:DATA:ICONdition on page 1357
TRIGger<m>:MILStd:DATA:IMAX on page 1358
TRIGger<m>:MILStd:DATA:IMIN on page 1358

11-Bit Information

The 11-Bit information sets bits 9 to 19 in case of a command or status word. The 11-Bit information consists of the condition and one or two 11-Bit information patterns.



"Condition" Defines the operator to set a specific info ("Equal" or "Not equal") or an info range.

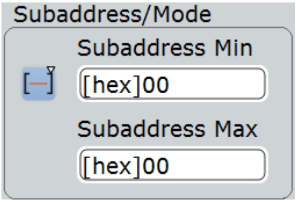
"Info Min/Info" Defines the bit pattern of the 11-Bit information.
In binary format, use the following characters: 1; 0; or X (don't care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"Info Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:MILStd:CDST:ICONdition on page 1356
TRIGger<m>:MILStd:CDST:IMAX on page 1356
TRIGger<m>:MILStd:CDST:IMIN on page 1356

Subaddress/ Mode

The subaddress/mode setup consists of the condition and one or two subaddress/ mode patterns.



"Condition"
Defines the operator to set a specific subaddress/mode ("Equal" or "Not equal") or a subaddress range.

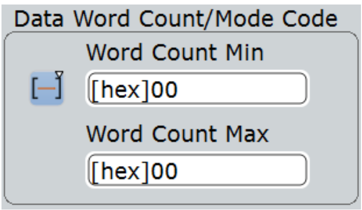
"Subaddress Min / Subaddress/Mode"
Defines the bit pattern of the subaddress/mode.
In binary format, use the following characters: 1; 0; or X (don't care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"Subaddress Max"
The second subaddress/mode pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:MILStd:CMD:SCONdition on page 1354
TRIGger<m>:MILStd:CMD:SMAX on page 1355
TRIGger<m>:MILStd:CMD:SMIN on page 1355

Data Word Count/Mode Code

The data word count/ mode code setup consists of the condition and one or two patterns.



"Condition"
Defines the operator to set a specific data word count/ mode code ("Equal" or "Not equal") or a range.

"Word Count Min/ Count Code"
Defines the bit pattern of the data.
In binary format, use the following characters: 1; 0; or X (don't care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"Word Count Max"
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

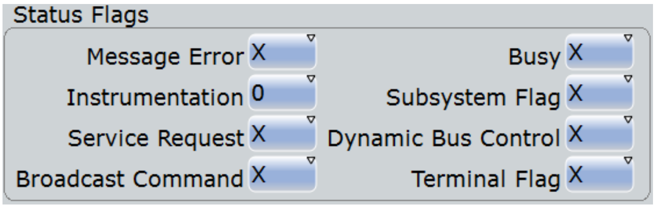
Remote command:
TRIGger<m>:MILStd:CMD:CCONdition on page 1353
TRIGger<m>:MILStd:CMD:CMAX on page 1354
TRIGger<m>:MILStd:CMD:CMIN on page 1354

T/R (Transmit/receive)
Toggles the data direction of the selected command: 1 (transmit), 0 (receive), or X (either).

Remote command:
TRIGger<m>:MILStd:CMD:TR on page 1355

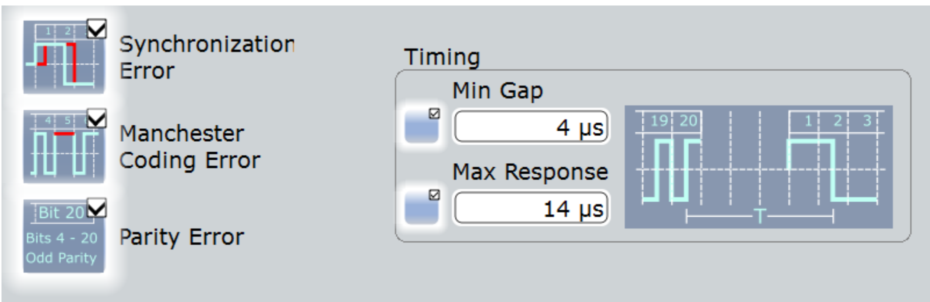
Status Flags
Specifies the values of the status flags. You can use the following characters: 1; 0; or X (don't care).

For details, see "Status Word" on page 576.



Remote command:
TRIGger<m>:MILStd:STATus:BCReceived on page 1360
TRIGger<m>:MILStd:STATus:BUSY on page 1360
TRIGger<m>:MILStd:STATus:DBCaccept on page 1360
TRIGger<m>:MILStd:STATus:INSTrument on page 1360
TRIGger<m>:MILStd:STATus:MERRor on page 1360
TRIGger<m>:MILStd:STATus:SREQuest on page 1361
TRIGger<m>:MILStd:STATus:SUBSystem on page 1361
TRIGger<m>:MILStd:STATus:TERMinal on page 1361

Error Condition
Specify the error conditions to be triggered on.



Synchronization Error ← Error Condition
Triggers if a sync impulse doesn't fulfill the technical requirements or when the transmission is not valid.

Remote command:
TRIGger<m>:MILStd:ERRor:SYNC on page 1359

Manchester Coding Error ← Error Condition
Triggers if there is an error in the Manchester coding of the signal.

Remote command:
TRIGger<m>:MILStd:ERRor:MANChester on page 1358

Parity Error ← Error Condition
Checks the parity of every word and triggers if the parity is even.

Remote command:
TRIGger<m>:MILStd:ERRor:PARity on page 1358

Min Gap ← Error Condition
Selects and sets a value for the intermessage gap beween the last bit of a message and the following command word sync. The time is measured between the mid bit zero crossings. According to the standard, the minimum idle time is 4 µs.

The minimum gap time is relevant for protocol configuration and error trigger.

If "Min Gap" is enabled, the instrument detects the specified gap during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the gap is shrter than specified.

Remote command:
BUS<m>:MILStd:MINGap:BITS on page 1349
BUS<m>:MILStd:MINGap:SELect on page 1349
TRIGger<m>:MILStd:MINGap:BITS on page 1359
TRIGger<m>:MILStd:MINGap:SELect on page 1359

Max Response ← Error Condition
Selects and sets a value for the maximum response time between the last bit of a word and the following status word sync. The time is measured between the mid bit zero crossings. According to the standard, the RT shall respond to a valid command word within the time period of 4 to 12 µs.

The max response time is relevant for protocol configuration and error trigger.

If "Max response" is enabled, the instrument detects the specified gap during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the response time is longer than specified.

Remote command:
BUS<m>:MILStd:MAXResponse:BITS on page 1348
BUS<m>:MILStd:MAXResponse:SELect on page 1349
TRIGger<m>:MILStd:MAXResponse:BITS on page 1359
TRIGger<m>:MILStd:MAXResponse:SELect on page 1359

12.9.3.2 Triggering on MIL-STD-1553

Prerequisites: A bus is configured for the MIL-STD-1553 signal to be analyzed.

1. Press the TRIGGER key.
2. Tap the "Source" button and select the "Serial" trigger source.
3. Select the serial bus that is set to MIL-STD-1553.
4. Select the "Trigger type".
5. For more complex trigger types, enter the data pattern conditions.
   For details, see Chapter 12.9.3.1, "Trigger Settings MIL-STD-1553", on page 579.

12.9.4 MIL-STD-1553 Label List

Label lists are protocol-specific. A MIL-STD-1553 label file contains four values for each identifier:

- "RTA": hexadecimal remote terminal address value
- "Sub Addr": hexadecimal sub address value
- "Sub Address Label Name": the label name corresponding to the value of the sub-address.
- "Symbolic label": symbolic name of addressed device, specifying the device function, and the label of the sub address.

Example: MIL PTT file

```
# -----------------------------------------------------------
# Labels for MIL.1553 protocol
# Column order: RT address, RT label, Subaddress, Subaddress Label
# -----------------------------------------------------------------
@PROTOCOL_NAME = mil1553
0Ah,Engine,01x,Thrust
03h,Main panel,07x,Altimeter
03h,Main panel,01x,Speed
0Eh,Only RTA
```

MIL-1553 Label List

RTA	Sub Addr	Sub address Label Name	Symbolic Label
[hex] 03	*		Main panel
[hex] 03	1	Speed	Main panel - Speed
[hex] 03	7	Altimeter	Main panel - Altimeter
[hex] 0A	1	Thrust	Engine - Thrust
[hex] 0E	*		Only RTA

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 441.

Remote command:

- `BUS<m>:MILStd:WORD<n>:SYMBol?` on page 1364

12.9.5 MIL-STD-1553 Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

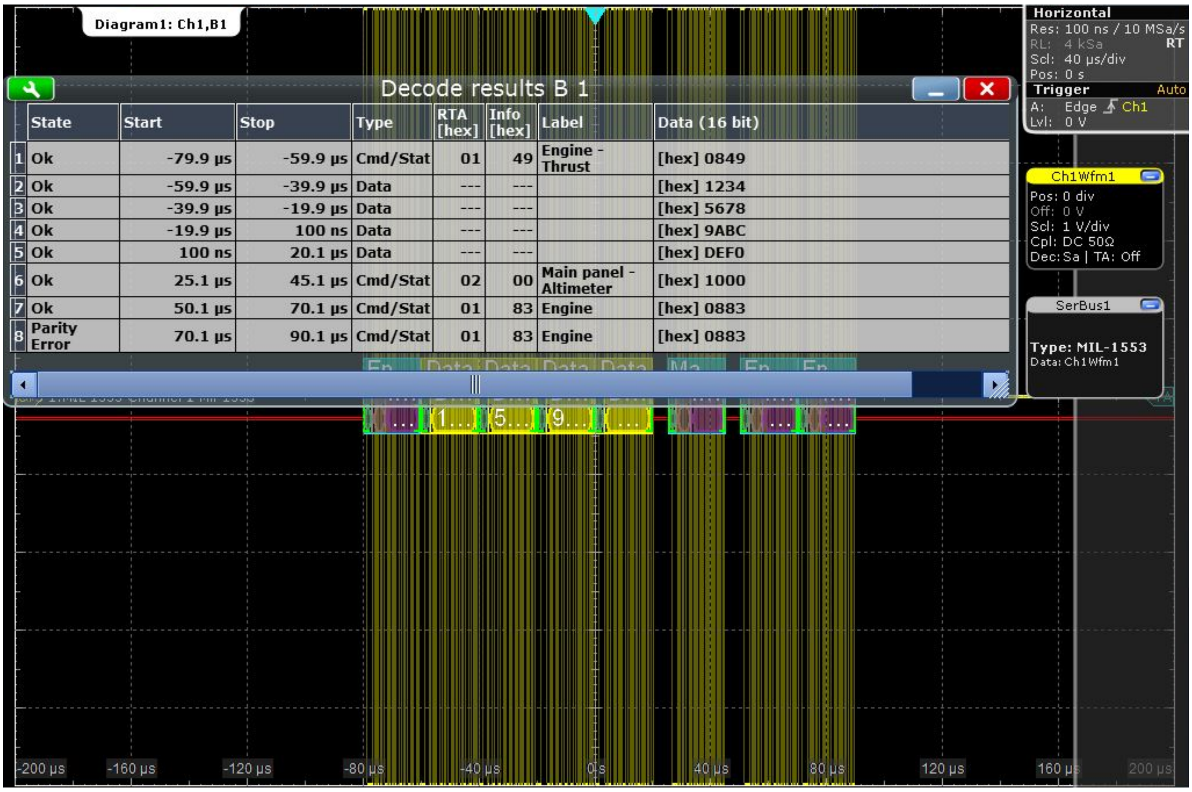


Figure 12-48: Decoded MIL-1553 signal with applied lebel list and results table. The last frame contains an error.

Table 12-9: Content of the decode result table

Column	Description
State	Overall state of the word
Start	Time of word start in relation to the trigger point
Stop	Time of word stop in relation to the trigger point
Type	Word type
RTA	Remote terminal address

Column	Description
Info	The hexadecimal value of the 9th to 1th bit of a command/status word
Label	The label name defined in the label list
Data	The values of the data bytes

Remote commands:
- BUS<m>:MILStd:WCOunt? on page 1362
- BUS<m>:MILStd:WORD<n>:DATA? on page 1362
- BUS<m>:MILStd:WORD<n>:INFO? on page 1362
- BUS<m>:MILStd:WORD<n>:RTADdress? on page 1363
- BUS<m>:MILStd:WORD<n>:STARt? on page 1363
- BUS<m>:MILStd:WORD<n>:STATus? on page 1363
- BUS<m>:MILStd:WORD<n>:STOP? on page 1364
- BUS<m>:MILStd:WORD<n>:TYPE? on page 1364

12.9.6 Search on Decoded MIL Data

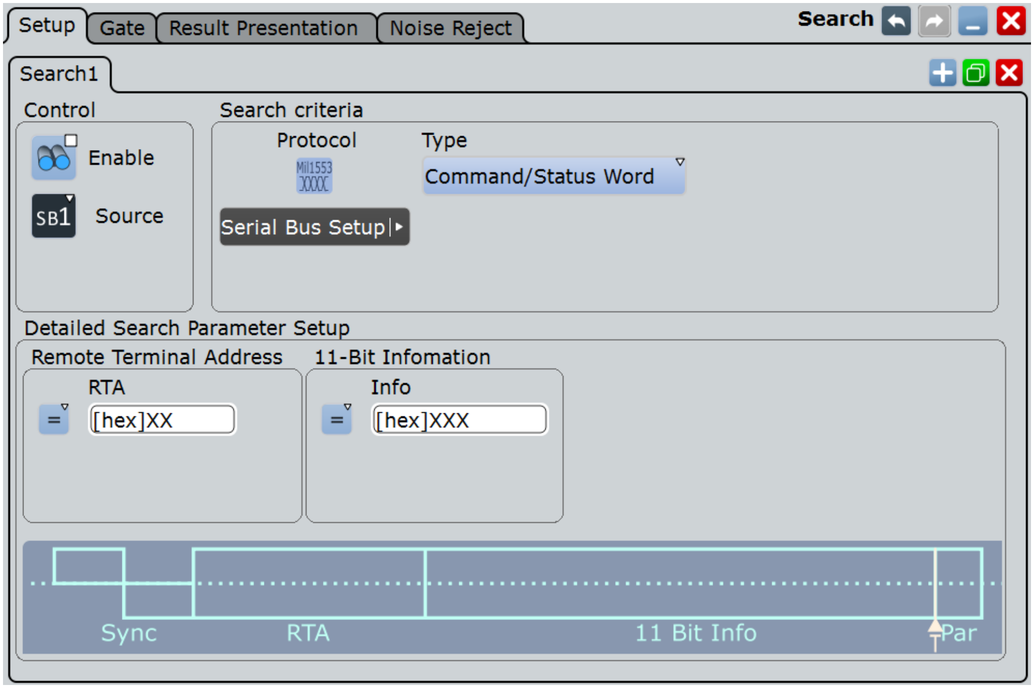
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 376.

12.9.6.1 MIL Search Setup

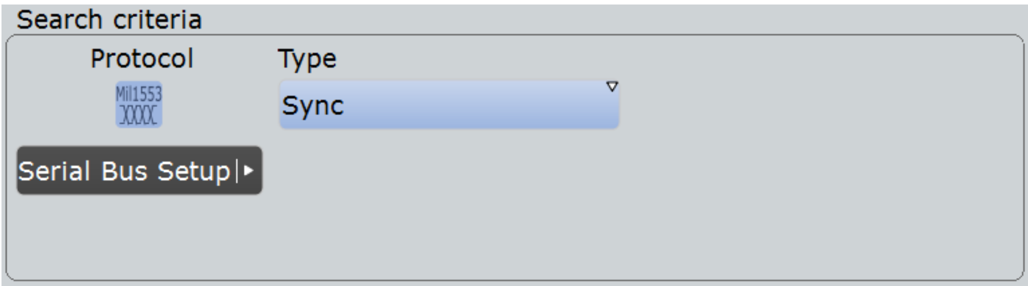
Access: SEARCH > "Setup" tab



Type

The search criterion is defined by "Type". All trigger types are also available for search.

Additional search parameters are provided under "Detailed Search Parameter Setup".



"Sync" Searches for a sync impulse.

"Word" Searches for the selected word type.

"Data Word" Searches for the specified data word. Additonal search parameters: remote terminal address, data pattern and data index.

"Command / Status Word" Searches for command or status words.Additonal search parameters: remote terminal address, and 11-bit information.

"Command Word" Searches for a command word. Additonal search parameters: remote terminal address, subaddress / mode, and data word count / mode code.

"Status Word" Searches for a status word.Additonal search parameters: remote terminal address, and status flags.

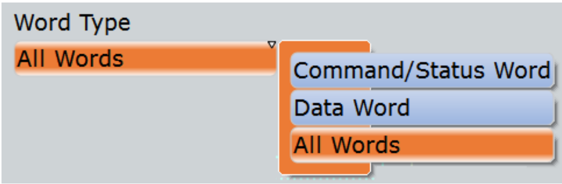
"Error condition"

Identifies various errors in the frame, see "Error Condition" on page 584.

Remote command:
SEARch:TRIGger:MILStd:TYPE on page 1366

Sync Type / Word Type

Searches for a sync impulse/ word type. You can search for "Command/Status", "All" or "Data" sync pulses/ word types.

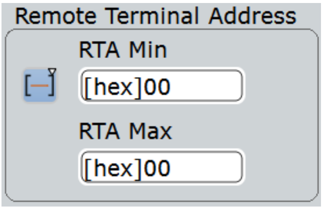


Remote command:
SEARch:TRIGger:MILStd:TPSPecifier on page 1371

Remote terminal address setup: Condition, RTA

The remote terminal address setup consists of the condition and one or two RTA patterns.

The RTA setup settings are the same as in the MIL trigger setup, see "Remote Terminal Address" on page 580.

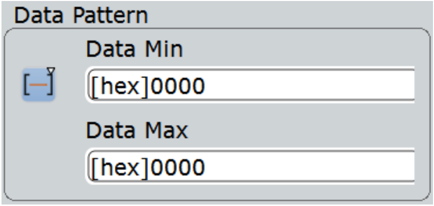


Remote command:
SEARch:TRIGger:MILStd:CDST:RCONdition on page 1366
SEARch:TRIGger:MILStd:CMD:RCONdition on page 1366
SEARch:TRIGger:MILStd:DATA:RCONdition on page 1366
SEARch:TRIGger:MILStd:CDST:RMIN on page 1367
SEARch:TRIGger:MILStd:CMD:RMIN on page 1367
SEARch:TRIGger:MILStd:DATA:RMIN on page 1367
SEARch:TRIGger:MILStd:CDST:RMAX on page 1367
SEARch:TRIGger:MILStd:CMD:RMAX on page 1367
SEARch:TRIGger:MILStd:DATA:RMAX on page 1367

Data pattern setup: Condition, Data min, Data max

The data pattern setup consists of the condition and one or two data patterns.

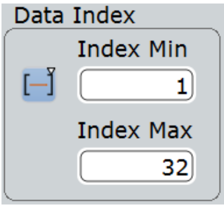
The data pattern setup settings are the same as in the MIL trigger setup, see "Data Pattern" on page 581.



Remote command:
`SEARch:TRIGger:MILStd:DATA:DCONdition` on page 1368
`SEARch:TRIGger:MILStd:DATA:DMIN` on page 1368
`SEARch:TRIGger:MILStd:DATA:DMAX` on page 1369

Data index setup: Condition, Index min, Index max
The data index setup consists of the condition and one or two index patterns.

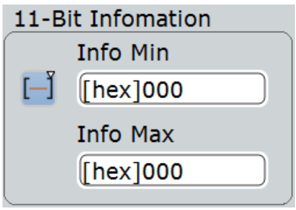
The data index setup settings are the same as in the MIL trigger setup, see "Data Index" on page 582.



Remote command:
`SEARch:TRIGger:MILStd:DATA:ICONdition` on page 1369
`SEARch:TRIGger:MILStd:DATA:IMIN` on page 1369
`SEARch:TRIGger:MILStd:DATA:IMAX` on page 1369

11-Bit information setup: Condition, Info min, Info max
The 11-bit information setup consists of the condition and one or two 11-bit information patterns.

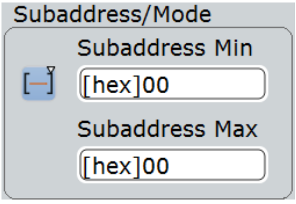
The 11-bit information setup settings are the same as in the MIL trigger setup, see "11-Bit Information" on page 582.



Remote command:
`SEARch:TRIGger:MILStd:CDST:ICONdition` on page 1368
`SEARch:TRIGger:MILStd:CDST:IMIN` on page 1368
`SEARch:TRIGger:MILStd:CDST:IMAX` on page 1368

Subaddress / Mode setup: Condition, Subaddress min, Subaddress max
The subaddress/mode setup consists of the condition and one or two subaddress/mode patterns.

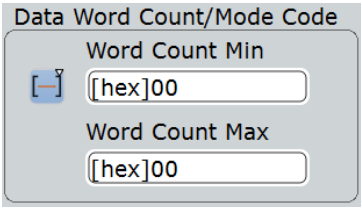
The subaddress/mode setup settings are the same as in the MIL trigger setup, see "Subaddress/ Mode" on page 583.



Remote command:
`SEARch:TRIGger:MILStd:CMD:SCONdition` on page 1368
`SEARch:TRIGger:MILStd:CMD:SMIN` on page 1368
`SEARch:TRIGger:MILStd:CMD:SMAX` on page 1369

Data word count / Mode code setup: Condition, Word count min, Word count max
The data word count/mode code setup consists of the condition and one or two patterns.

The subaddress/mode setup settings are the same as in the MIL trigger setup, see "Data Word Count/Mode Code" on page 583.



Remote command:
`SEARch:TRIGger:MILStd:CMD:CCONdition` on page 1368
`SEARch:TRIGger:MILStd:CMD:CMIN` on page 1368
`SEARch:TRIGger:MILStd:CMD:CMAX` on page 1368

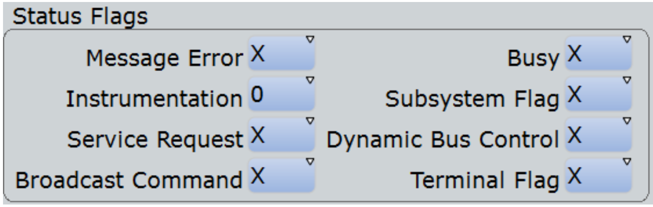
T/R (Transmit/receive)
Specifies the data direction of the selected command.

For details, see "T/R (Transmit/receive)" on page 584.

Remote command:
`SEARch:TRIGger:MILStd:CMD:TR` on page 1370

Status flags setup
Specifies the values (X, 0, 1) of the status flags.

The status flags setup settings are the same as in the MIL trigger setup, see "Status Flags" on page 584.

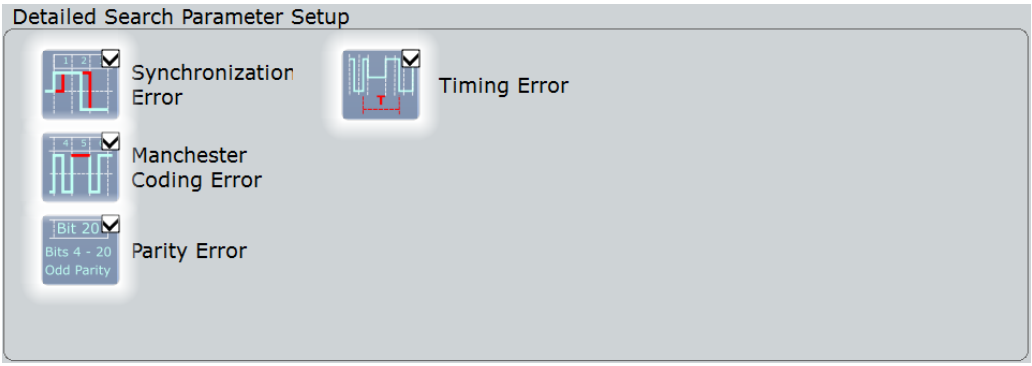


Remote command:
`SEARch:TRIGger:MILStd:STATus:BCReceived` on page 1370
`SEARch:TRIGger:MILStd:STATus:BUSY` on page 1370
`SEARch:TRIGger:MILStd:STATus:DBCaccept` on page 1371
`SEARch:TRIGger:MILStd:STATus:INSTrument` on page 1371
`SEARch:TRIGger:MILStd:STATus:MERRor` on page 1371
`SEARch:TRIGger:MILStd:STATus:SREQuest` on page 1371
`SEARch:TRIGger:MILStd:STATus:SUBSystem` on page 1371
`SEARch:TRIGger:MILStd:STATus:TERMinal` on page 1371

Error Condition

Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the MIL trigger setup, see "Error Condition" on page 584



Remote command:
`SEARch:TRIGger:MILStd:ERRor:MANChester` on page 1370
`SEARch:TRIGger:MILStd:ERRor:PARity` on page 1370
`SEARch:TRIGger:MILStd:ERRor:SYNC` on page 1370
`SEARch:TRIGger:MILStd:ERRor:TIMing` on page 1370

12.9.6.2 MIL Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394

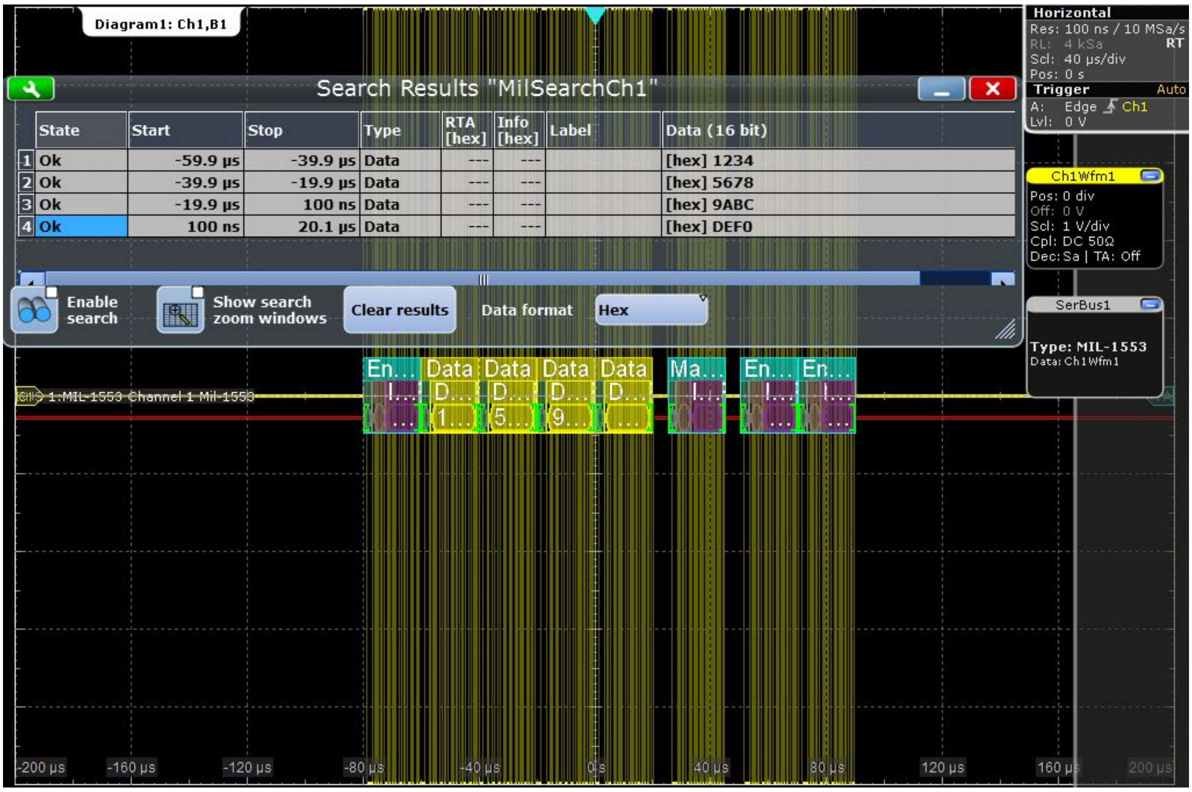


Figure 12-49: Results of a search for all data words (any RTA and any data pattern)

Remote commands:

- SEARch:RESult:MILStd:WCOunt on page 1372
- SEARch:RESult:MILStd:WORD<m>:INFO? on page 1374
- SEARch:RESult:MILStd:WORD<m>:RTADdress? on page 1373
- SEARch:RESult:MILStd:WORD<m>:STARt? on page 1372
- SEARch:RESult:MILStd:WORD<m>:STATus? on page 1372
- SEARch:RESult:MILStd:WORD<m>:STOP? on page 1373
- SEARch:RESult:MILStd:WORD<m>:SYMBol? on page 1373
- SEARch:RESult:MILStd:WORD<m>:TYPE? on page 1372

12.10 ARINC 429 (Option R&S RTE-K7)

12.10.1 ARINC 429 Basics

The ARINC 429 is a specification that defines the characteristics of an avionic data bus used on commercial and transport aircraft.

In an ARINC 429 system, a single transmitter/source is connected to 1-20 receivers/ sinks on one twisted wire pair. The bus uses differential signals. The ARINC 429 standard uses a simplex communication - data may be transmitted in only one direction. The information is transmitted over the bus in defined series of words.

Word Format

MSB LSB

32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
P	SSM		Data																			SDI		Label							

Figure 12-50: Structure of an ARINC 429 word

An ARINC 429 word is 32-bits and consists of the following parts (see Figure 12-50):

- Parity: the most significant bit (MSB). Checks if there are bit errors during the transmission. The total number of logic 1 bits for the word shall be odd.
- Sign/Status Matrix (SSM): the value of these bits depend on the data type. It may be used to report the status of hardware equipment.
- Data:
  – Binary (BNR): stores the data as a binary number.
  – Binary Coded Decimal (BCD): uses 4 data field bits to represent a decimal digit.
  – Discrete data: a combination of BNR and/ or BCD or individual bits that express specific equipment conditions.
  – Maintenance data and acknowledgment
  – Williamsburg / Buckhorn protocol: a bit-oriented protocol that is used for file transfer.
- Source/Destination Identifier (SDI): indicates the intended receiver or the transmitting subsystem.
- Label: gives information about the word's data type.

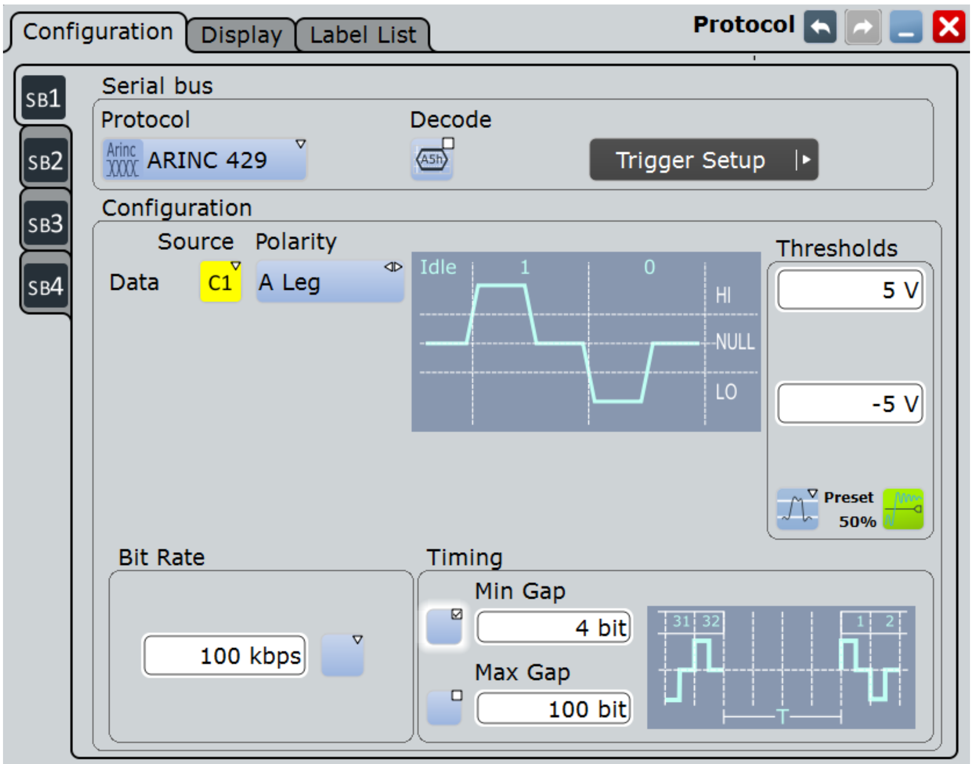
For comfortable analysis, you can load an editable label list, to interpret transferred numeric values as meaningful text labels.

12.10.2 ARINC 429 Configuration

12.10.2.1 ARINC 429 Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *ARINC 429*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Data

Sets the source of the selected data line. Usually, the source is one of the analog channels. Reference and math waveforms are only available if the trigger source is one of the input channels but not the serial bus.

For triggering on a serial bus, a channel signal is required.

Remote command:
`BUS<m>:ARINc:SOURce` on page 1375

Polarity

Selects the wire on which the bus signal is measured : "A Leg" or "B Leg". The setting affects the digitization of the signal.

Remote command:
`BUS<m>:ARINc:POLarity` on page 1376

Thresholds

Sets the threshold value for digitization of the data signal. If the signal value on the line is higher than the threshold, the signal state is high (1 or true for the boolean logic). Otherwise, the signal state is considered low (0 or false) if the signal value is below the threshold.

There are three ways to set the thresholds:
- "High" and "Low"
  Upper and lower threshold levels. You can enter the values directly in the fields.
- "Preset"
  Selects the default threshold voltage from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.
- "Set to 50%"
  Sets the thresholds to the middle reference level of the measured amplitudes.

Remote command:
`BUS<m>:ARINc:THReshold:HIGH` on page 1377
`BUS<m>:ARINc:THReshold:LOW` on page 1377
`BUS<m>:ARINc:PRESet` on page 1377

Bit Rate

Selects the number of transmitted bits per second. The value can be set to high speed (100 kbps) or low speed (12.0- 14.5 kbps).

Remote command:
`BUS<m>:ARINc:BRValue` on page 1375
`BUS<m>:ARINc:BRMode` on page 1375

Timing: Min gap, Max gap

Defines the idle time between two words, which is needed for word synchronization. The beginning of the first bit after the gap marks the start of a new word.

You can define a minimum idle time "Min gap", and/or a maximum time "Max gap". The standard defines a minimum of 4 bit times to separate two subsequent words.

Timing settings are relevant for protocol configuration and error trigger.

If "Min gap" and/or "Max gap" are enabled, the instrument detects the specified gaps during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the gap is shorter or longer than the specified gaps, respectively.

Remote command:
`BUS<m>:ARINc:MAXGap:BITS` on page 1376
`BUS<m>:ARINc:MAXGap:SELect` on page 1375
`BUS<m>:ARINc:MINGap:BITS` on page 1376
`BUS<m>:ARINc:MINGap:SELect` on page 1376
`TRIGger<m>:ARINc:MINGap:BITS` on page 1380
`TRIGger<m>:ARINc:MINGap:SELect` on page 1380
`TRIGger<m>:ARINc:MAXGap:BITS` on page 1380
`TRIGger<m>:ARINc:MAXGap:SELect` on page 1380

12.10.2.2 Configuring ARINC 429 Signals

For configuration assign the line to the input channel, set the threshold and the timing conditions.

For details on configuration settings, see Chapter 12.10.2.1, "ARINC 429 Configuration Settings", on page 596.

To display the decoded signal, option R&S RTO-K7 is required.

1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "ARINC 429".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "Polarity" button, and select the waveform of the data line.
7. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fields.
8. Tap the "Bit Rate" button and set it for high or low speed.
9. If required tap the "Min Gap" button to select it and set the minimum gap time.
10. If required tap the "Max Response" button to select it and set the maximum response time.

12.10.3 ARINC 429 Trigger

12.10.3.1 Triggering on ARINC 429

Prerequisites: A bus is configured for the ARINC 429 signal to be analyzed.

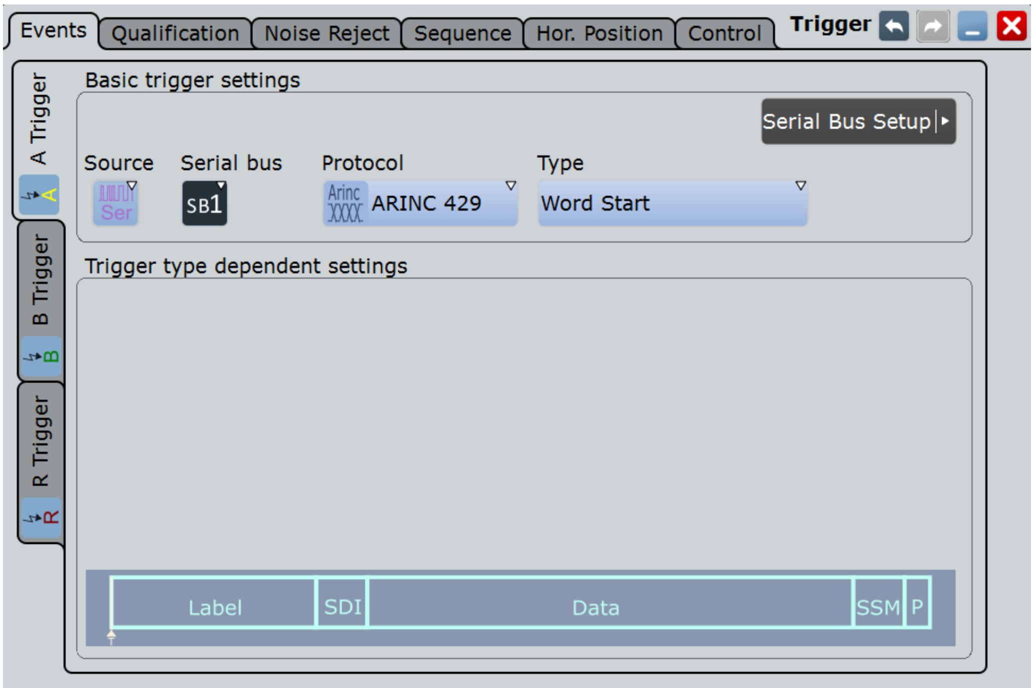
1. Press the TRIGGER key.
2. Tap the "Source" button and select the "Serial" trigger source.
3. Select the serial bus that is set to ARINC 429.
4. Select the "Trigger type".
5. For more complex trigger types, enter the data pattern conditions.
   For details, see Chapter 12.10.3.2, "ARINC 429 Trigger Settings", on page 599.

12.10.3.2 ARINC 429 Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = ARINC 429"

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.



Trigger Type

Selects the trigger type for ARINC 429 analysis.

"Word Start" Sets the trigger to the start of the word.

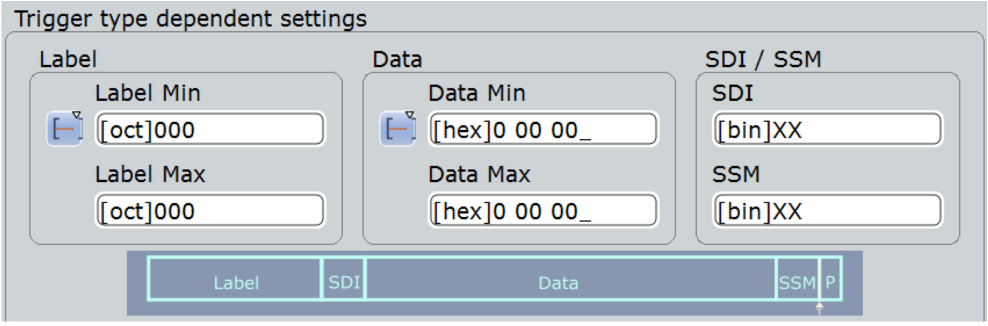
"Word Stop" Sets the trigger to the stop of the word.

"Label + Data" Sets the trigger on a defined word format. You can define the label, the data and the SDI / SSM bits separately, see "Label + Data" on page 600.

"Error Condition" Identifies various errors in the word, see "Error Conditions" on page 601.

Remote command:
`TRIGger<m>:ARINc:TYPE` on page 1378

Label + Data



Label setup: Condition, Label Min, Label Max ← Label + Data
The label setup consists of the condition and one or two label patterns.

"Condition" Defines the operator to set a specific label ("Equal" or "Not equal") or a label range.

"Label Min" Defines the bit pattern of the label.
In binary format, use the following characters: 1; 0; or X (don't care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"Label Max" The second label pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:ARINc:LABel:CONDition` on page 1379
`TRIGger<m>:ARINc:LABel:MIN` on page 1379
`TRIGger<m>:ARINc:LABel:MAX` on page 1380

Data setup: Condition, Data Min, Data Max ← Label + Data
The data setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific data ("Equal" or "Not equal") or a data range.

"Data Min" Defines the bit pattern of the data.
In binary format, use the following characters: 1; 0; or X (don't care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

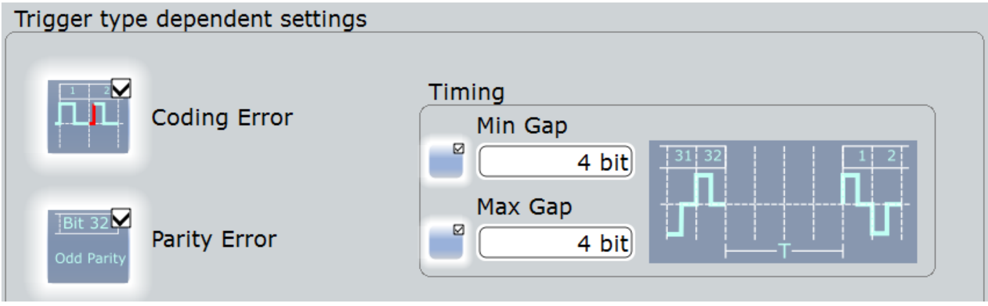
"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:ARINc:DATA:CONDition` on page 1378
`TRIGger<m>:ARINc:DATA:MIN` on page 1378
`TRIGger<m>:ARINc:DATA:MAX` on page 1379

SDI / SSM ← Label + Data
Sets the values for the source/destination identifier (SDI) and the sign/status matrix (SSM) bits.

Remote command:
TRIGger<m>:ARINc:SDI on page 1381
TRIGger<m>:ARINc:SSM on page 1381

Error Conditions
Specifies the error conditions to be triggered on.



Coding error ← Error Conditions
Triggers on a coding error.

Remote command:
TRIGger<m>:ARINc:ERRor:CODing on page 1379

Parity Error ← Error Conditions
Checks the parity and triggers if the parity is even.

Remote command:
TRIGger<m>:ARINc:ERRor:PARity on page 1379

Timing: Min gap, Max gap ← Error Conditions
Defines the idle time between two words, which is needed for word synchronization. The beginning of the first bit after the gap marks the start of a new word.

You can define a minimum idle time "Min gap", and/or a maximum time "Max gap". The standard defines a minimum of 4 bit times to separate two subsequent words.

Timing settings are relevant for protocol configuration and error trigger.

If "Min gap" and/or "Max gap" are enabled, the instrument detects the specified gaps during decoding. If the trigger type "Error condition" is selected in addition, the instrument triggers when the gap is shorter or longer than the specified gaps, respectively.

Remote command:
BUS<m>:ARINc:MAXGap:BITS on page 1376
BUS<m>:ARINc:MAXGap:SELect on page 1375
BUS<m>:ARINc:MINGap:BITS on page 1376
BUS<m>:ARINc:MINGap:SELect on page 1376
TRIGger<m>:ARINc:MINGap:BITS on page 1380
TRIGger<m>:ARINc:MINGap:SELect on page 1380
TRIGger<m>:ARINc:MAXGap:BITS on page 1380
TRIGger<m>:ARINc:MAXGap:SELect on page 1380

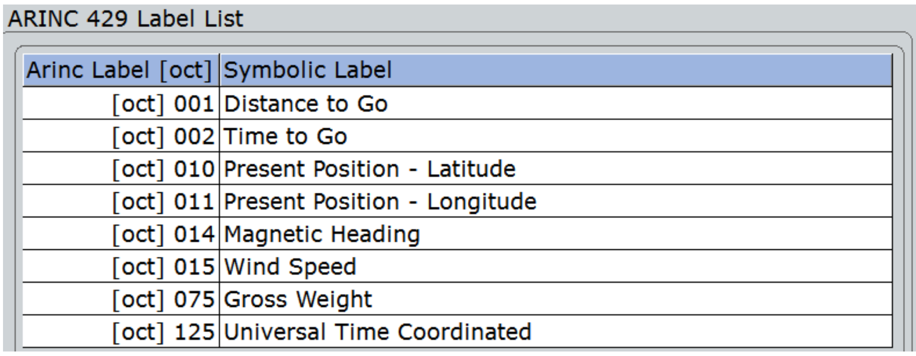
12.10.4 ARINC 429 Label List

Label lists are protocol-specific. An ARINC 429 label file contains four values for each identifier:

- "Arinc Label": the Arinc 429 label value, that identifies the data type and the parameters associated with it. The usual data format is octal.
- "Symbolic label": symbolic name of the label, specifying the device function.

Example: ARINC 429 PTT file

```
# ----------------------------------------------------------------------------
@FILE_VERSION = 1.0
@PROTOCOL_NAME = arinc429
# ----------------------------------------------------------------------------
# Labels for ARINC 429 protocol
#   Column order: Arinc Label, Symbolic Label
# ----------------------------------------------------------------------------
# ----Definition----
001o, Distance to Go
002o, Time to Go
010o, Present Position - Latitude
011o, Present Position - Longitude
014o, Magnetic Heading
015o, Wind Speed
075o, Gross Weight
125o, Universal Time Coordinated
# ----------------------------------------------------------------------------
```


ARINC 429 Label List

Arinc Label [oct]	Symbolic Label
[oct] 001	Distance to Go
[oct] 002	Time to Go
[oct] 010	Present Position - Latitude
[oct] 011	Present Position - Longitude
[oct] 014	Magnetic Heading
[oct] 015	Wind Speed
[oct] 075	Gross Weight
[oct] 125	Universal Time Coordinated

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 441.

Remote command:

- `BUS<m>:ARINc:WORD<n>:SYMBol?` on page 1384

12.10.5 ARINC 429 Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

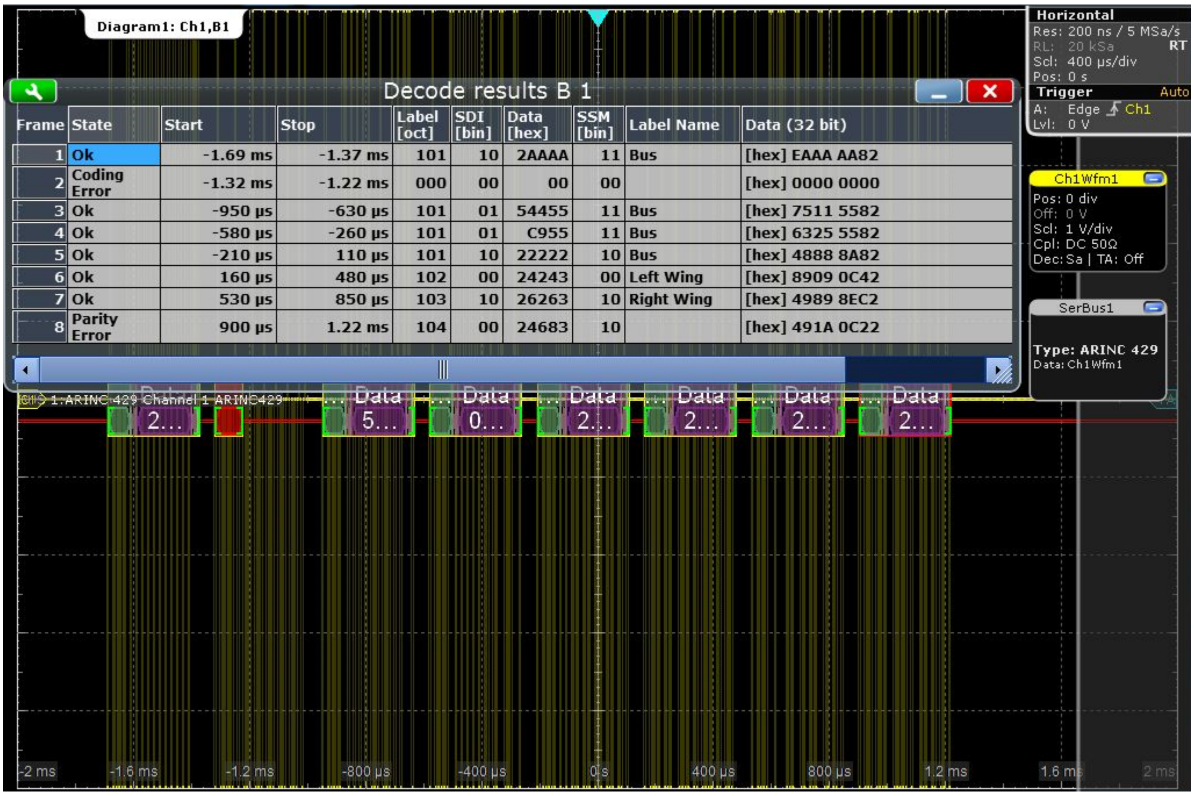


Figure 12-51: Decoded ARINC 429 signal with applied lebel list and results table. The second and eight frame contain errors.

Table 12-10: Content of the "Decode results" table

Column	Description
State	Overall state of the frame.
Start	Time of word start in relation to the trigger point
Stop	Time of word stop in relation to the trigger point
Label	The value of the label bytes
SDI	The state of the SDI bits
DATA	All 32 bits of the word.
SSM	The state of the SSM bits

Column	Description
Label Name	The label name
Data	The value of the data bytes

Remote commands:
- `BUS<m>:ARINc:WCOunt?` on page 1381
- `BUS<m>:ARINc:WORD<n>:DATA?` on page 1381
- `BUS<m>:ARINc:WORD<n>:LABel?` on page 1382
- `BUS<m>:ARINc:WORD<n>:PATTern?` on page 1382
- `BUS<m>:ARINc:WORD<n>:SDI?` on page 1382
- `BUS<m>:ARINc:WORD<n>:SSM?` on page 1383
- `BUS<m>:ARINc:WORD<n>:STARt?` on page 1383
- `BUS<m>:ARINc:WORD<n>:STATe?` on page 1383
- `BUS<m>:ARINc:WORD<n>:STOP?` on page 1384

12.10.6 Search on Decoded ARINC 429 Data

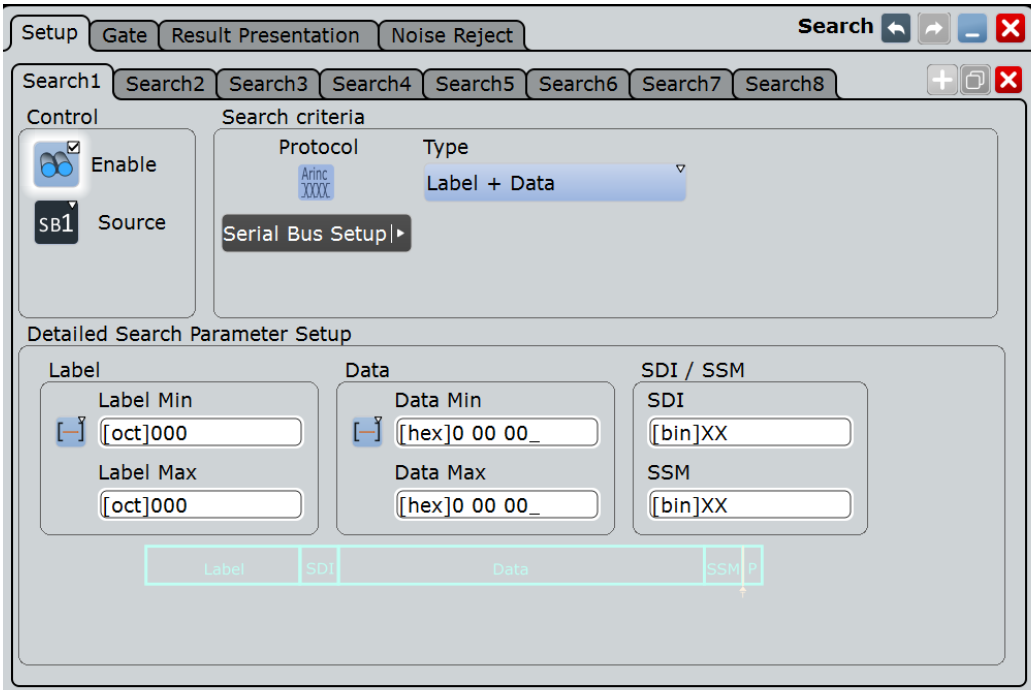
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 376.

12.10.6.1 ARINC 429 Search Setup

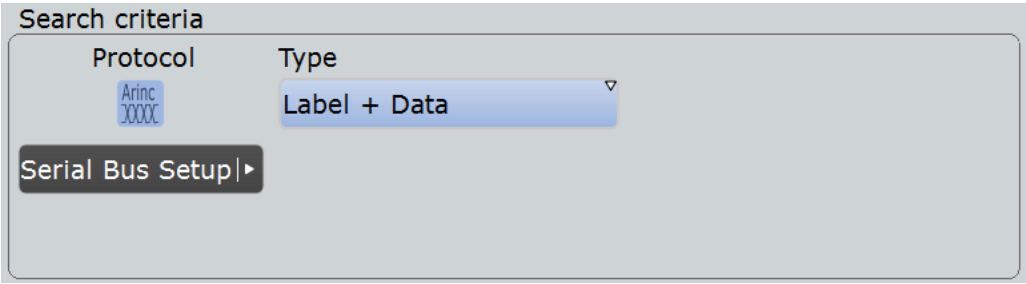
Access: SEARCH > "Setup" tab



Type

The search criterion is defined by "Type". All trigger types are also available for search.

Additional search parameters are provided under "Detailed Search Parameter Setup".



"Word Start" Searches for the start word.

"Word Stop" Searches for the stop word.

"Label + Data" Searches for a defined word format. You can search for the label, the data, the SDI, and SSM bits separately.
For details, see "Label + Data" on page 600.

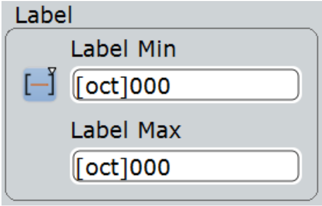
"Error condition"
Identifies various errors in the frame, see "Error Conditions" on page 601.

Remote command:
`SEARch:TRIGger:ARINc:TYPE` on page 1385

Label setup: Condition, Label min, Label max

The label setup consists of the condition and one or two label patterns.

The label setup settings are the same as in the ARINC trigger setup, see "Label setup: Condition, Label Min, Label Max" on page 600.

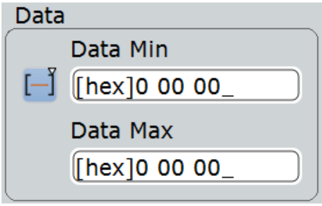


Remote command:
`SEARch:TRIGger:ARINc:LABel:CONDition` on page 1385
`SEARch:TRIGger:ARINc:LABel:MIN` on page 1385
`SEARch:TRIGger:ARINc:LABel:MAX` on page 1386

Data setup: Condition, Data min, Data max

The data setup consists of the condition and one or two data patterns.

The data setup settings are the same as in the ARINC trigger setup, see "Data setup: Condition, Data Min, Data Max " on page 600.

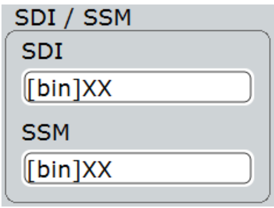


Remote command:
`SEARch:TRIGger:ARINc:DATA:CONDition` on page 1385
`SEARch:TRIGger:ARINc:DATA:MIN` on page 1385
`SEARch:TRIGger:ARINc:DATA:MAX` on page 1386

SDI / SSM setup: SDI, SSM

The SDI / SSM setup consists of the SDI and SSM.

The SDI / SSM setup settings are the same as in the ARINC trigger setup, see "SDI / SSM" on page 601.

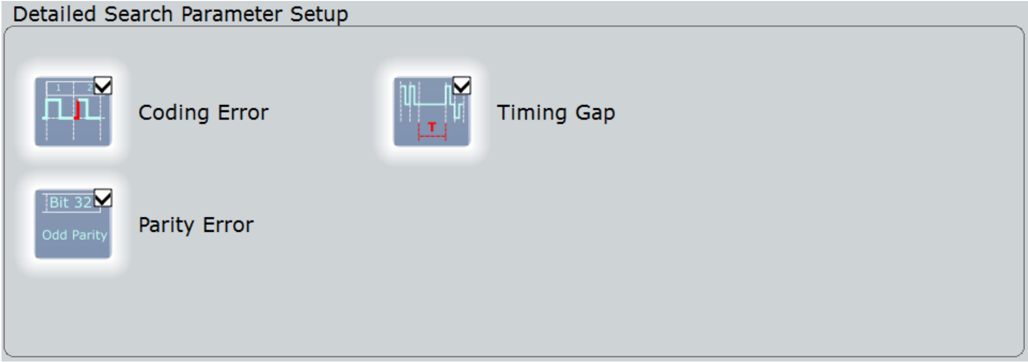


Remote command:
`SEARch:TRIGger:ARINc:SDI` on page 1386
`SEARch:TRIGger:ARINc:SSM` on page 1386

Error Condition

Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the ARINC trigger setup, see "Error Conditions" on page 601



Remote command:
`SEARch:TRIGger:ARINc:ERRor:CODing` on page 1386
`SEARch:TRIGger:ARINc:ERRor:PARity` on page 1387
`SEARch:TRIGger:ARINc:ERRor:TIMing` on page 1387

12.10.6.2 ARINC Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394

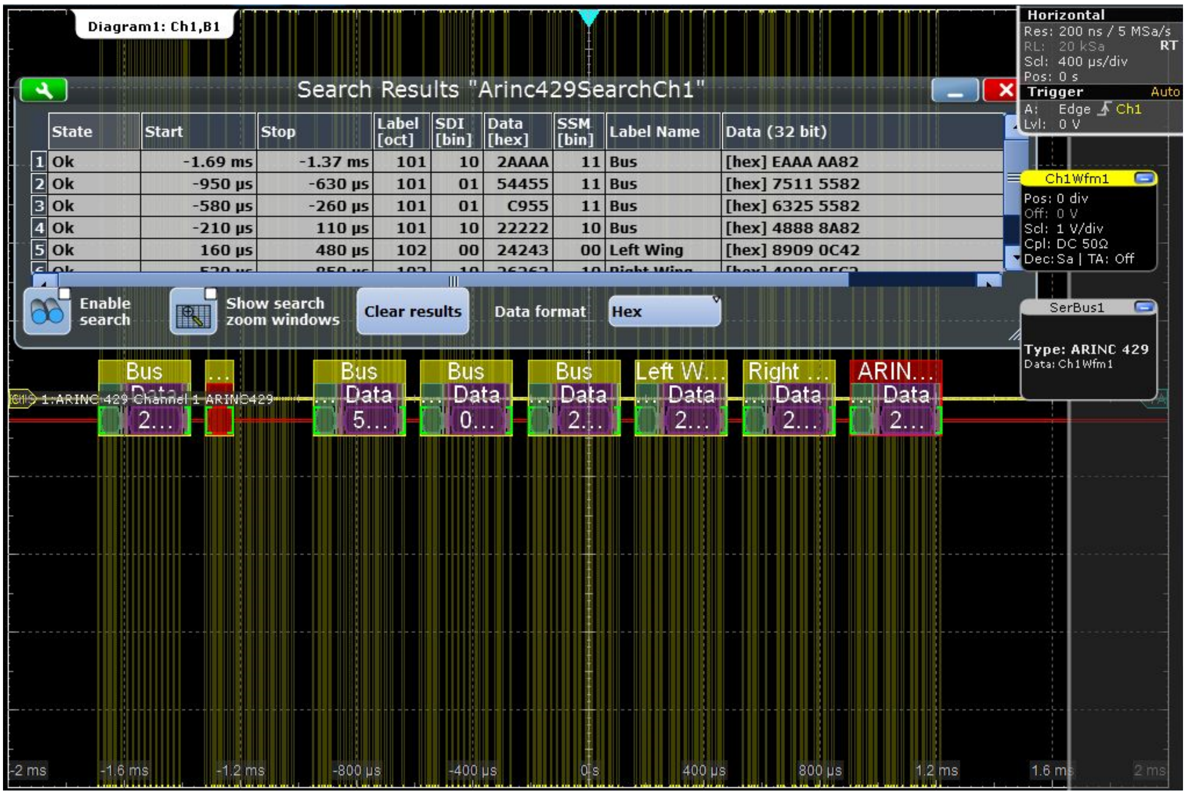


Figure 12-52: Results of a general "Label +data" search with applied label list. All frames are found that contain any label, any data, and any SDI/SSM bits.

Remote commands:

- `SEARch:RESult:ARINc:WCOunt` on page 1389
- `SEARch:RESult:ARINc:WORD<m>:DATA?` on page 1388
- `SEARch:RESult:ARINc:WORD<m>:LABel?` on page 1388
- `SEARch:RESult:ARINc:WORD<m>:PATTern?` on page 1388
- `SEARch:RESult:ARINc:WORD<m>:SDI?` on page 1389
- `SEARch:RESult:ARINc:WORD<m>:SSM?` on page 1388
- `SEARch:RESult:ARINc:WORD<m>:STARt?` on page 1390
- `SEARch:RESult:ARINc:WORD<m>:STATe?` on page 1390
- `SEARch:RESult:ARINc:WORD<m>:STOP?` on page 1389
- `SEARch:RESult:ARINc:WORD<m>:SYMBol?` on page 1389

12.11 Ethernet (Option R&S RTE-K8)

Twisted-pair Ethernet technologies are based on the family of standards IEEE 802.3, issued by the Institute of Electrical and Electronics Engineers (IEEE).

R&S RTE-K8 is a firmware option that enables the R&S RTE to analyze Ethernet protocol variants 10BASE-T and 100BASE-TX, by decoding the signal and searching within the decoded events. To trigger the signal, use the edge trigger on the source channel. The option is compatible with the standards IEEE 802.3i of 1990 (10BASE-T) and IEEE 802.3u of 1995 (100BASE-TX). R&S RTE-K8 supports bit rates up to 10 Mbit/s for 10BASE-T and up to 100 Mbit/s for 100BASE-TX.

12.11.1 The Ethernet Protocol

The two Ethernet protocol variants that R&S RTE-K8 can process have the following features:

- 10BASE-T uses Manchester coding (or phase encoding, PE). In terms of a logical Boolean operation, the Manchester value of each bit is the exclusive disjunction (XOR) of the original data value and the clock value. A "0" is expressed by a high-to-low transition, a "1" by a low-to-high transition. These transitions, which occur at the middle of each bit period, make the signal self-clocked.
- 100BASE-TX uses a 4B5B Multi-Level Transmit (MLT-3) encoding. This protocol sequentially cycles through a sequence of the voltage levels -1 V, 0 V, +1 V, and 0 V. To transmit a "1" bit, MLT-3 moves to the next state; to transmit a "0" bit, it stays in the same state. 4B5B block coding is used to map groups of four bits onto groups of five bits. Additionally, the signal is scrambled.

All Ethernet-over-twisted-pair technologies use wires with four twisted pairs of cables (and 8P8C connectors), but 10BASE-T and 100BASE-TX only require two pairs of wires.

12.11.2 Ethernet Configuration

If you need information on how to get started with configuring the Ethernet setup, see Chapter 12.11.2.3, "Configuring Ethernet Signals", on page 613. Otherwise proceed with the configuration settings.

12.11.2.1 Ethernet Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *Ethernet*

Make sure that the tab of the correct serial bus is selected on the left side.

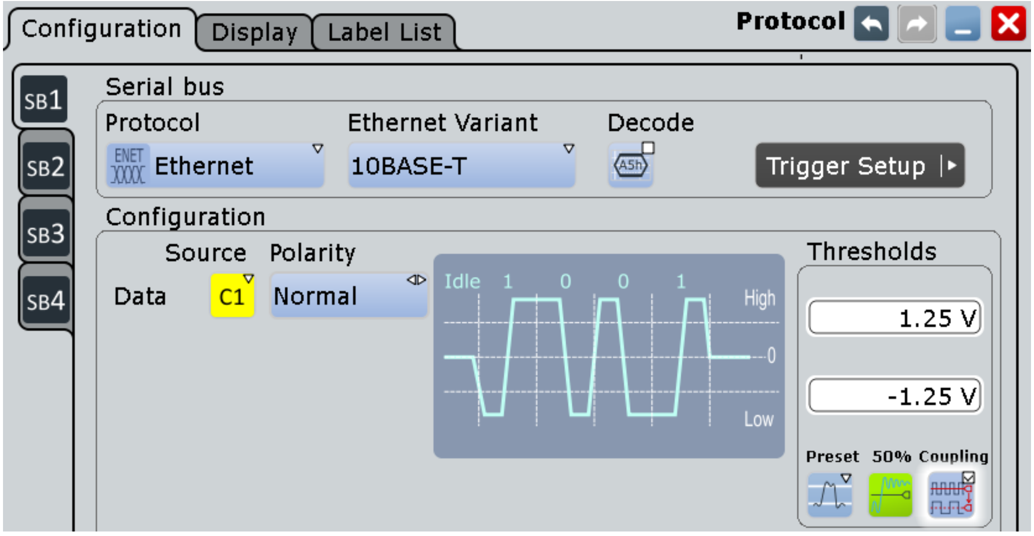


Figure 12-53: Serial bus protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Ethernet Variant

Defines the Ethernet protocol variant and transmission speed.

Note: Note that no triggering on the serial bus is available.
To trigger the signal, use the edge trigger on the source channel.

"10BASE-T"

Selects the Ethernet protocol variant 10BASE-T (standard data rate 10 Mbit/s).

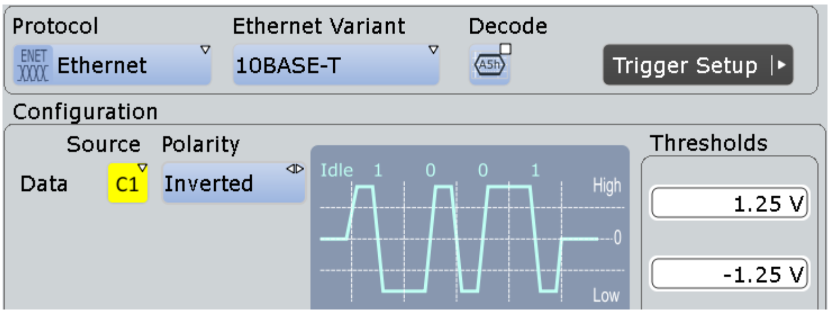


Figure 12-54: Ethernet 10BASE-T protocol configuration (here with inverted polarity)

"100BASE-TX"

Selects the Ethernet protocol variant 100BASE-TX, which provides 100 Mbit/s use data rate. Due to 4b/5b encoding, the raw data rate on the line is 125 Mbit/s. This value is used by R&S RTE-K8 as the bit rate default for 100BASE-TX.

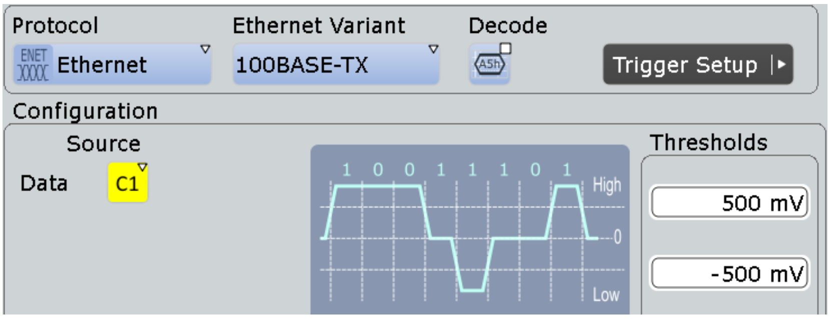


Figure 12-55: Ethernet 100BASE-TX protocol configuration

Remote command:
BUS<m>:ETHernet:VARiant on page 1391

Source

Defines the source settings for the data signal.

Permitted source selections are the analog, mathematical, and reference channels.

Remote command:
BUS<m>:ETHernet:SOURce on page 1391

Polarity

Defines the polarity ("Normal" or "Inverted") of the data signal. This setting is only available in 10BASE-T.

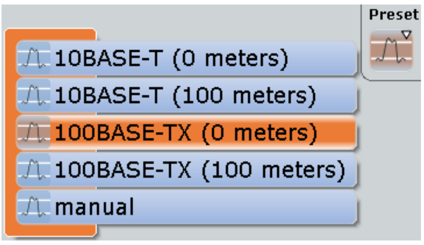
Remote command:
BUS<m>:ETHernet:POLarity on page 1391

Thresholds

Sets the threshold value for the digitization of each signal line. If the signal value on the line is higher than the upper threshold, the signal state is high. Otherwise, if the signal value is below the lower threshold, the signal state is considered low.

There are four ways to set the threshold:

- "Thresholds"
  Enter the values directly: upper threshold in the upper field, lower threshold in the lower field.
- "Preset"
  Either allows to set individual voltages by selecting "manual",
  or sets the voltages to one out of four pre-defined levels:
  – 10BASE-T (0 meters): *±1.25 V*
  – 10BASE-T (100 meters): *±750 mV*
  – 100BASE-TX (0 meters): *±500 mV*
  – 100BASE-TX (100 meters): *±350 mV*



The "Preset" levels depend on:

– the Ethernet variant
– the distance from the transmitter. "0 meters" represents "voltage at transmitter" and "100 meters" represents "voltage at the maximum cable length", according to the standard.

As soon as any non-predefined threshold is set, the "Preset" value automatically changes to manual (without affecting anything else).

- "50%"
  Executes a measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Coupling"
  Couples threshold settings between upper and lower threshold.

Remote command:
`BUS<m>:ETHernet:THReshold:HIGH` on page 1392
`BUS<m>:ETHernet:THReshold:LOW` on page 1392
`BUS<m>:ETHernet:PRESet` on page 1392

Bit rate
Defines the transmission speed setting for the data signal:

- 10BASE-T: default bit rate 10 Mbps
- 100BASE-TX: default bit rate 125 Mbps

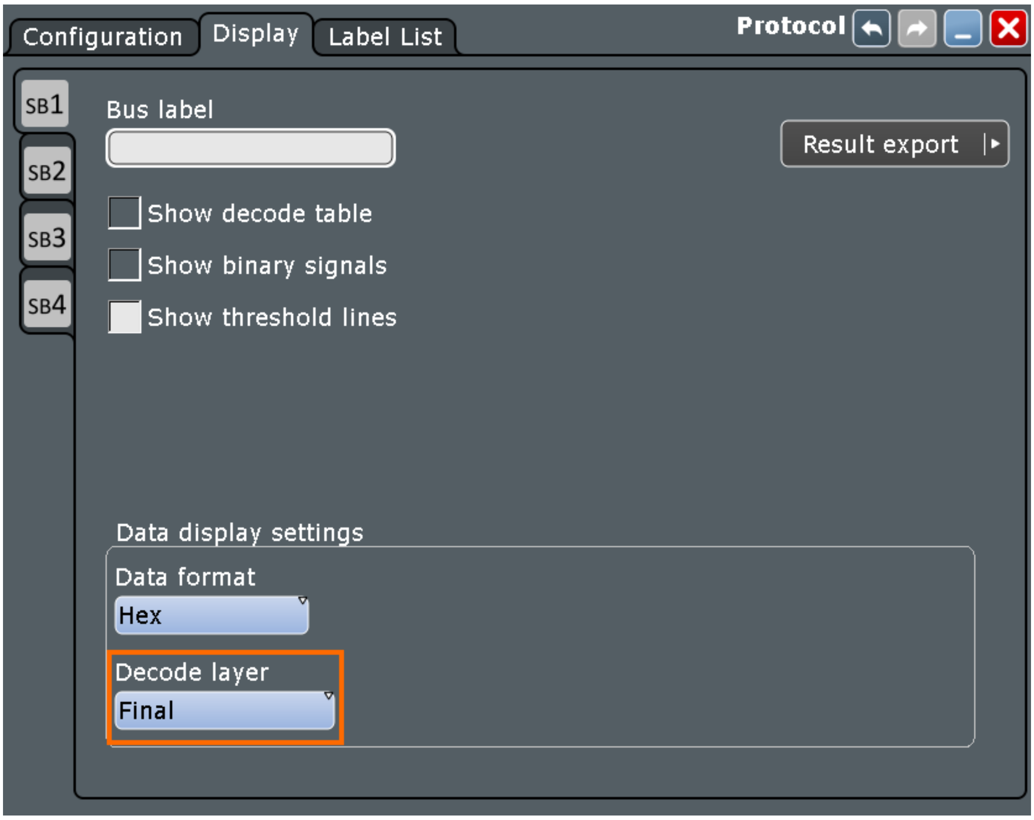
In both variants, the permitted bit rates range from 10 kbps to 150 Mbps. Switching the variant adjusts the bit rate, independent of the previous setting.

Remote command:
`BUS<m>:ETHernet:BITRate` on page 1393

12.11.2.2 Ethernet Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = Ethernet" > "Display" tab

To enhance the decode possibilities of the Ethernet protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 440.

Decode layer

Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final"	...
"Edges"	...
"Binary"	...
"Descramble"	...
"4b/5b Decode"	...

12.11.2.3 Configuring Ethernet Signals

For configuration, assign the lines to the input channels and define the active states and the logical thresholds.

Serial Bus Setup

1. Press the PROTOCOL key on the front panel.

2. At the left hand-side, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Select the "Configuration" tab.
4. Tap "Protocol" and select the protocol: "Ethernet".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Tap "Ethernet Variant" and select the variant ("10BASE-T" or "100BASE-TX") you want to set up.

   Note: Note that no triggering on the serial bus is available.
   To trigger the signal, use the edge trigger on the source channel.
7. In case of the variant "10BASE-T", select the polarity ("Normal" or "Inverted") of the data signal.
8. Set the logical thresholds, see "Thresholds" on page 611.
9. In the protocol "Configuration" tab, select "Decode" to activate the decode functionality.

For details on configuration settings, see Chapter 12.11.2.1, "Ethernet Configuration Settings", on page 609.

12.11.3 Ethernet Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Examples

The example in Figure 12-56 shows decoded and binary signals in Ethernet 10BASE-T.

Note that activating "Show details" in the decode table provides a more detailed analysis for decode results of one selected frame. All data bytes are displayed (in hexadecimal format).

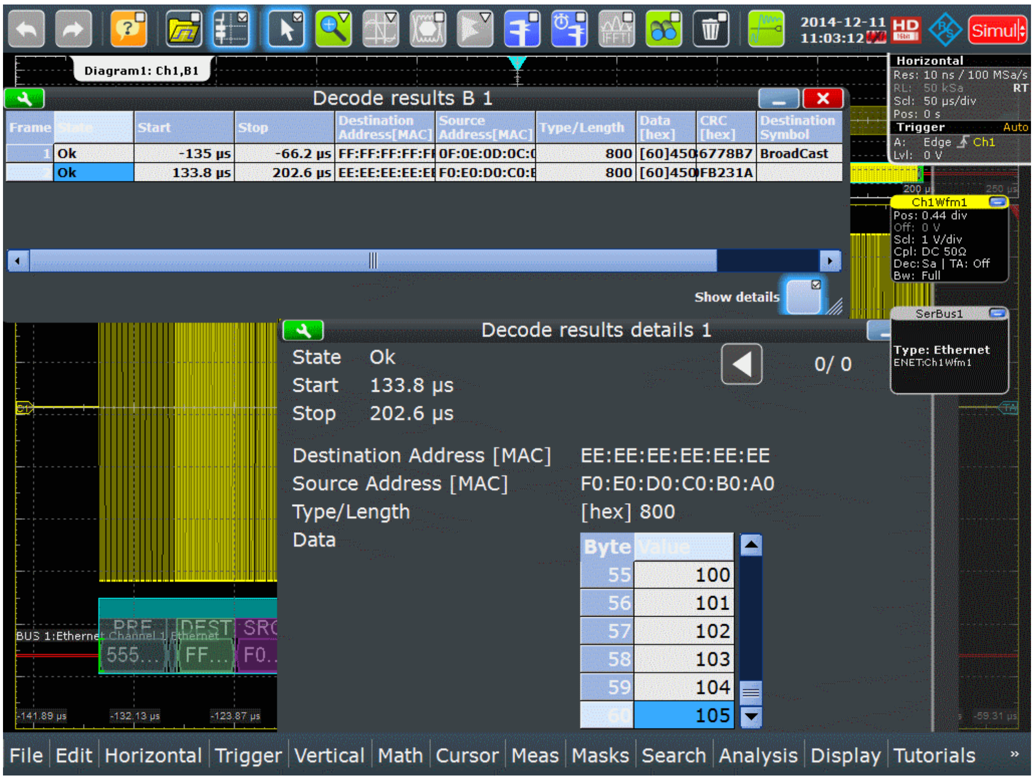


Figure 12-56: Ethernet 10BASE-T: decoded and binary signal, with decode results table and details

green brackets [...]	= start / end of frame
blue frame	= frame ok
red frame	= error frame
grey	= preamble / SFD / FrameCheck
green	= destination address
purple	= source address
brown	= address
yellow	= data

The screenshot in Figure 12-57 is a view of Figure 12-56 without the decode results table and details.

The screenshot in Figure 12-58 is a zoomed view of Figure 12-57.

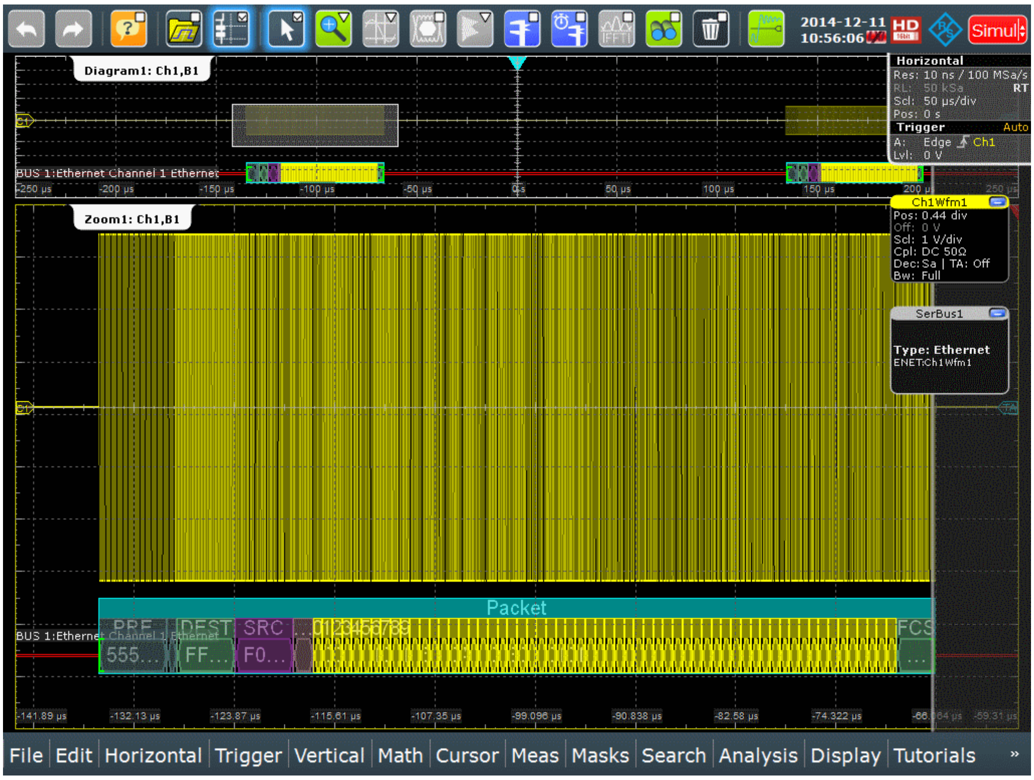


Figure 12-57: Ethernet 10BASE-T: decoded and binary signal

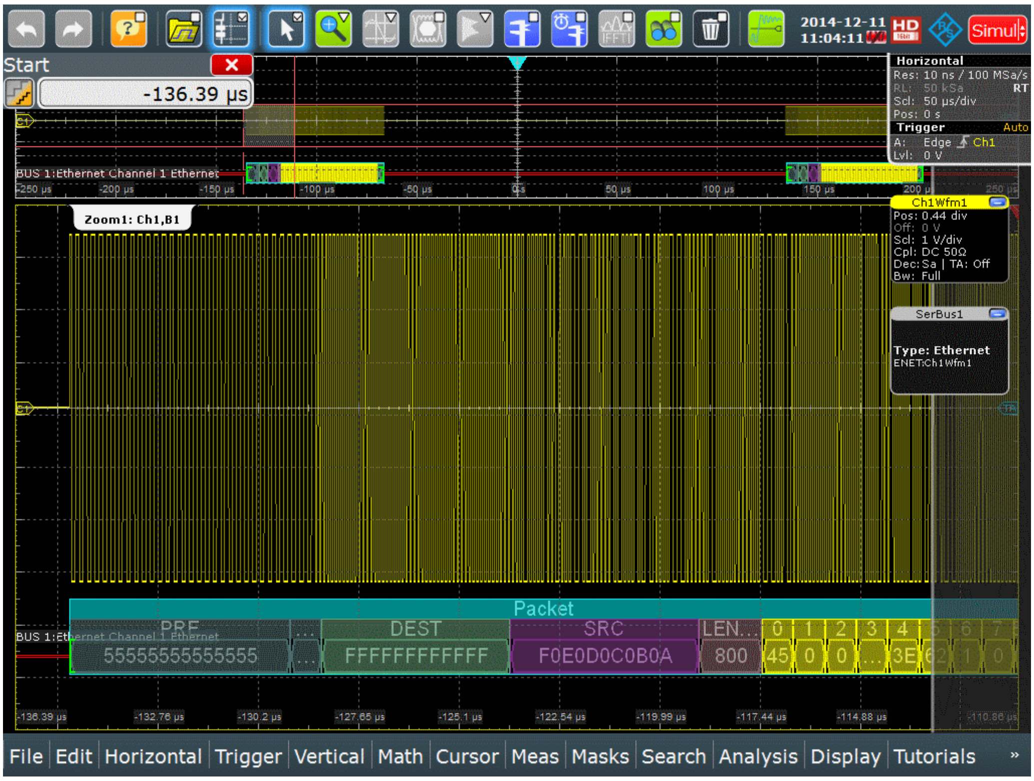


Figure 12-58: Ethernet 10BASE-T: decoded and binary signal (zoomed view)

The example in Figure 12-59 shows a zoomed view of binary signals and decode results in Ethernet 100BASE-TX.

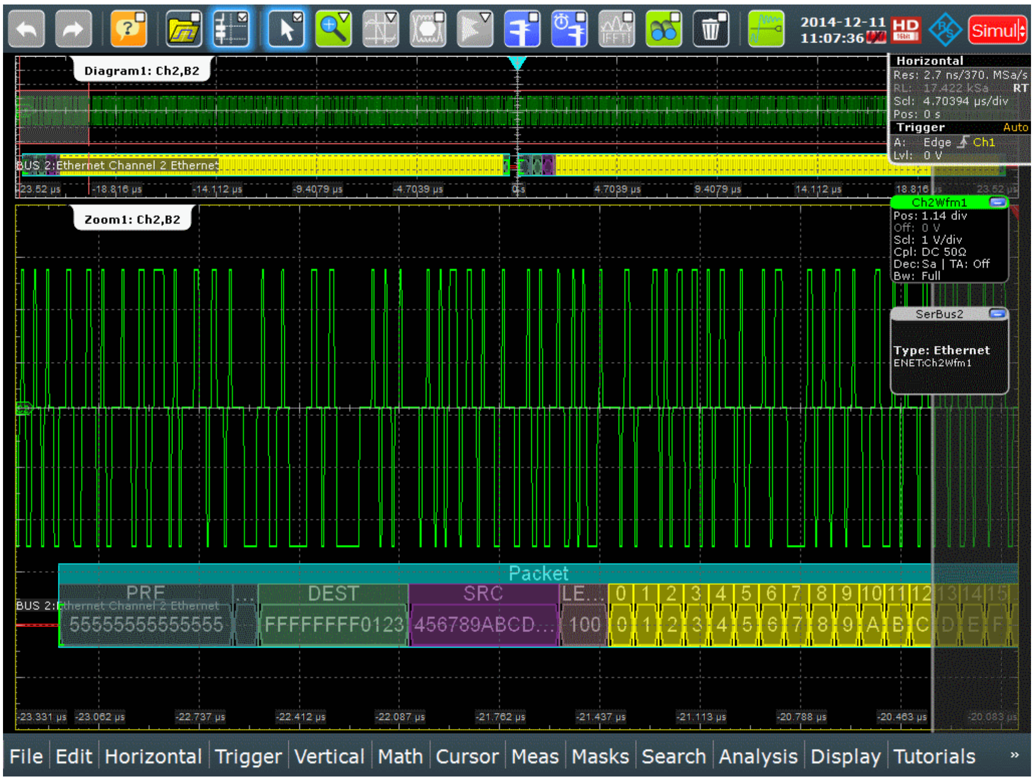


Figure 12-59: Ethernet 100BASE-TX: decoded and binary signal (zoomed view)

green brackets [...]	= start / end of frame
blue frame	= frame ok
red frame	= error frame
grey	= preamble / SFD / FrameCheck
green	= destination address
purple	= source address
brown	= address
yellow	= data

The content of the "Decode results" table in Figure 12-56 is described in Table 12-11:

Table 12-11: Content of the "Decode results" table

Column	Description
State	Overall state of the frame: either OK or the relevant error condition (preamble, length)
Start	Start time of the frame
Stop	Stop time of the frame
Destination Address	Destination address of the frame
Source Address	Source address of the frame
Type/Length	The sub-protocol (e.g. HTML, video, etc.) determines what meaning this field has. Since the content of this data area is not decoded, the interpretation of this field is ambivalent. It could either be the word type (specific for the sub-protocol) or the word length.

Column	Description
Data	Values of the data bytes in a frame. The table shows a truncated version; to see all the bytes in a separate data table, activate "Show details". The data format is always hexadecimal.
CRC	FrameCheck (Cyclic Redundancy Code, CRC)
Destination Symbol	Translation (or symbolic label) of the destination address, if the label list is enabled.
Source Symbol	Translation (or symbolic label) of the source address, if the label list is enabled.

The following commands are used to retrieve decode results in remote control. For an example on how to query the status of a frame, see Chapter 16.17.12.2, "Decode Results", on page 1393.

Remote commands:

- `BUS<m>:ETHernet:WCOunt?` on page 1394
- `BUS<m>:ETHernet:WORD<n>:STATe?` on page 1394
- `BUS<m>:ETHernet:WORD<n>:STARt?` on page 1395
- `BUS<m>:ETHernet:WORD<n>:STOP?` on page 1395
- `BUS<m>:ETHernet:WORD<n>:DESTaddress?` on page 1395
- `BUS<m>:ETHernet:WORD<n>:SRCaddress?` on page 1396
- `BUS<m>:ETHernet:WORD<n>:TYPE?` on page 1396
- `BUS<m>:ETHernet:WORD<n>:DATA?` on page 1396
- `BUS<m>:ETHernet:WORD<n>:CRC?` on page 1397
- `BUS<m>:ETHernet:WORD<n>:DSYMbol?` on page 1397
- `BUS<m>:ETHernet:WORD<n>:SSYMbol?` on page 1397
- `BUS<m>:ETHernet:WORD<n>:BYTE<o>:VALue?` on page 1397

12.11.4 Search on Decoded Ethernet Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

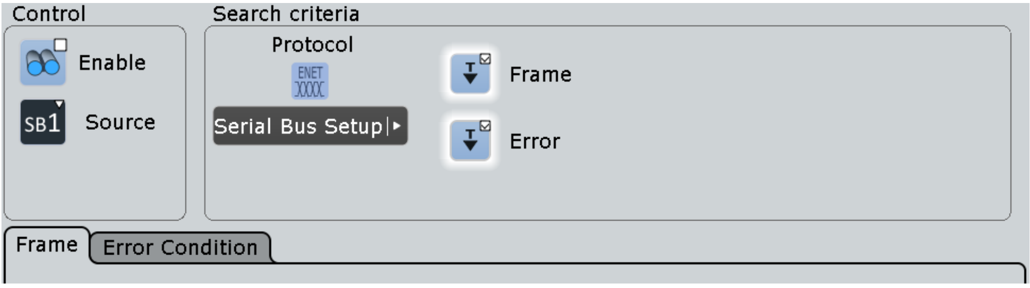
For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 376.

If you need information on how to get started with searching Ethernet data, see Chapter 12.11.4.3, "Searching Ethernet Data", on page 621. Otherwise proceed with the Ethernet search setup.

12.11.4.1 Ethernet Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for Ethernet

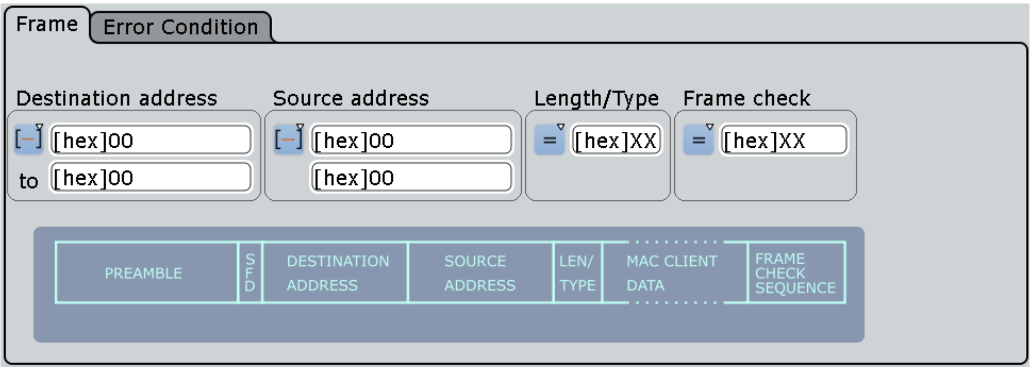
Search criteria
Use the "Search criteria" dialog to define the event types to be searched. Available event types are "Frame" and "Error".



Individual search parameters, which do not depend on the Ethernet protocol variant, can be specified in the tabs below the "Search criteria" dialog.

Remote command:
SEARch:TRIGger:ETHernet:FRAMe:SELect on page 1398
SEARch:TRIGger:ETHernet:ERRor:SELect on page 1402

Frame
Searches for four different frame conditions: "Destination address", "Source address", "Length/Type", or "Frame check".



Remote command:
SEARch:TRIGger:ETHernet:FRAMe:SELect on page 1398

Destination address ← Frame
To search for a destination address, an address pattern or optionally an address range have to be specified.

Remote command:
SEARch:TRIGger:ETHernet:FRAMe:DCONdition on page 1398
SEARch:TRIGger:ETHernet:FRAMe:DMIN on page 1399
SEARch:TRIGger:ETHernet:FRAMe:DMAX on page 1399

Source address ← Frame
To search for a source address, an address pattern or optionally an address range have to be specified.

Remote command:
SEARch:TRIGger:ETHernet:FRAMe:SCONdition on page 1399
SEARch:TRIGger:ETHernet:FRAMe:SMIN on page 1400
SEARch:TRIGger:ETHernet:FRAMe:SMAX on page 1400

Length/Type ← Frame
To search for a frame length or frame type, a type/length pattern or optionally a range of type/length patterns have to be specified.

Remote command:
SEARch:TRIGger:ETHernet:FRAMe:TCONdition on page 1400
SEARch:TRIGger:ETHernet:FRAMe:TMIN on page 1401
SEARch:TRIGger:ETHernet:FRAMe:TMAX on page 1401

Frame check ← Frame
To search for a specific pattern, this pattern or optionally a range of patterns have to be specified.

Remote command:
SEARch:TRIGger:ETHernet:FRAMe:CCONdition on page 1401
SEARch:TRIGger:ETHernet:FRAMe:CMIN on page 1402
SEARch:TRIGger:ETHernet:FRAMe:CMAX on page 1402

Error Condition
Searches for two error conditions: "Preamble Error" or "Length Error".

Preamble Error ← Error Condition
Searches for any preamble errors.

Remote command:
SEARch:TRIGger:ETHernet:ERRor:PREamble on page 1403

Length Error ← Error Condition
Searches for any preamble errors.

Remote command:
SEARch:TRIGger:ETHernet:ERRor:LENGth on page 1403

12.11.4.2 Ethernet Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394

Remote commands:

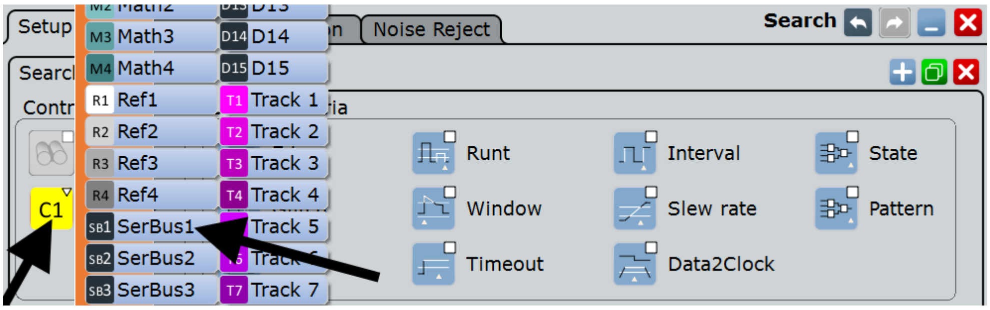
- SEARch:RESult:ETHernet:WCOunt on page 1404
- SEARch:RESult:ETHernet:WORD<m>:TYPE? on page 1405
- SEARch:RESult:ETHernet:WORD<m>:STATe? on page 1404
- SEARch:RESult:ETHernet:WORD<m>:STARt? on page 1404
- SEARch:RESult:ETHernet:WORD<m>:STOP? on page 1404
- SEARch:RESult:ETHernet:WORD<m>:DESTaddress? on page 1405
- SEARch:RESult:ETHernet:WORD<m>:SRCaddress? on page 1405
- SEARch:RESult:ETHernet:WORD<m>:DATA? on page 1406
- SEARch:RESult:ETHernet:WORD<m>:CRC? on page 1406
- SEARch:RESult:ETHernet:WORD<m>:DSYMbol? on page 1406
- SEARch:RESult:ETHernet:WORD<m>:SSYMbol? on page 1407
- SEARch:RESult:ETHernet:WORD<m>:BYTE<n>:VALue? on page 1407

12.11.4.3 Searching Ethernet Data

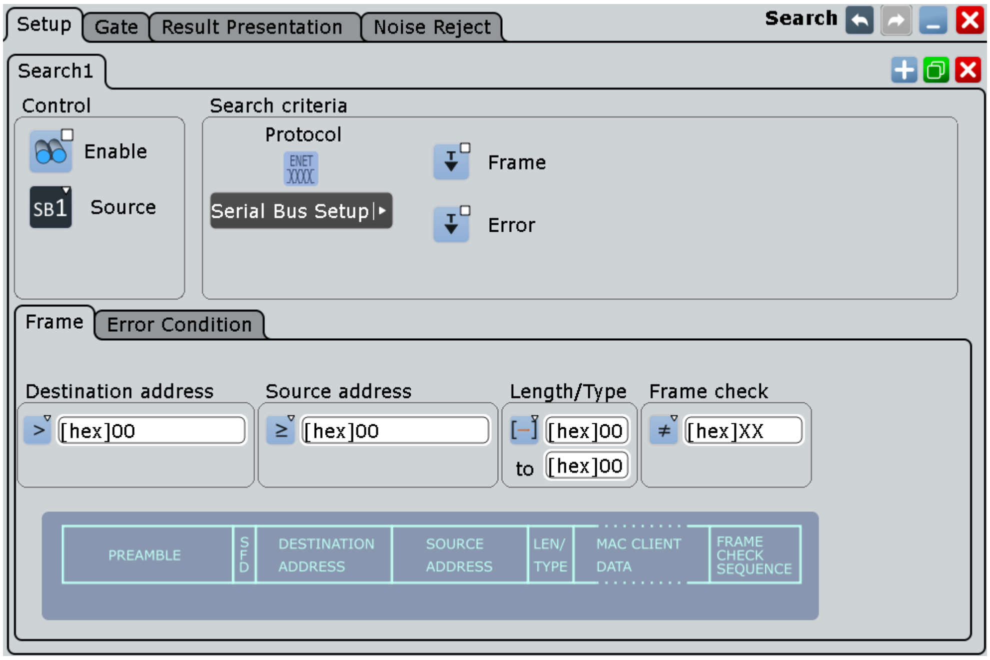
Prerequisite: A serial bus is configured for the Ethernet signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 391.
3. Tap "Source" and select the serial bus that is set to Ethernet (e.g. "SerBus1", unless already selected).

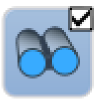


The search dialog for Ethernet protocol analysis is opened.



4. Specify search criteria according to Chapter 12.11.4.1, "Ethernet Search Setup", on page 619.
5. To acquire a waveform, press RUN N× SINGLE.

   The R&S RTE performs an Ethernet decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTE displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 397 and "Navigating search results" on page 378.

12.12 SENT (Option R&S RTE-K10)

Single Ended Nibble Transmission (SENT) is a serial transmission interface protocol originally specified for the communication of sensors and control units in automotive electronics.

SENT is a protocol standard governed by Society of Automotive Engineers (SAE J2716). For detailed information, refer to the SENT standard specification on http://www.sae.org.

The SENT protocol is used exclusively in automotive applications, as for example electrical power steering, advanced driver assistance like parking assist or sensing of pressure, throttle position, pedal position, airflow mass, liquid level, etc.

The R&S RTE option R&S RTE-K10 provides serial triggering, decoding and a highly customizable search on decoded SENT signals.

12.12.1 The SENT Protocol

This chapter provides an overview of the protocol characteristics, encoding scheme, identifiers and trigger possibilities.

The SENT protocol transmits signal values point-to-point from a sensor to a controller (ECU Electronic Control Unit), unidirectional. In contrast to conventional measurements, you can receive multiple data parameters via the SENT interface in a single transmission. Nevertheless, SENT is characterized by its simplicity and yet very high customizability to meet the individual requirements of the applications.

SENT operates via a three wire connection, a signal line, a supply voltage line for the sensor and a ground line. It transmits data digitally in variable timing units and evaluates the time between two falling edges (single edges). The signal is amplitude modulated with a constant amplitude voltage. Thus influences of interfering signals are not critical.

SENT key features

Main characteristics of SENT are:

- serial communication protocol
- 3 wires: SENT (signal line), 5V (voltage line), GND (ground line)
- output only, from sensor to receiver
- point-to-point transmission, no bus
- digital transmission
- high baud rate
- data transmission in variable timing units of 4 bits (1 nibble) between two falling edges
- transmitter specific clock period (tick)
- time measured between single falling edges

12.12.1.1 SENT Transmission Concept

A sensor converts the analog measured data to a digital signal, and thus transmits a series of pulses to the receiver. The receiver, e.g. an ECU processes the received signal also digitally.

The format of a SENT message frame has a fixed pulse order and a transmitter specific clock period. The total transmission time varies depending on the clock variation of the transmitter and the transmitted data values. The data pulses embedded in the transmission sequence represent one or multiple data parameters to be communicated. The last pulses in a message frame are the CRC check pulse, allowing the receiver to perform a number of diagnostic tests, and an optional pause pulse.

A SENT transmission starts without a request from the receiver. Consecutive sequences are transmitted continuously after the falling edge of the last pulse.

The SENT protocol distinguishes between two channel types:

- **Fast channel:** transmits primary data, i.e. sensor readings like temperature, pressure, mass air flow, throttle position, etc.
- **Slow channel:** transmits secondary data consisting of transfer characteristics, sensor ID, type, manufacturer diagnostic, etc.
  The slow channel transmission provides two serial message formats *Short* and *Enhanced* for customizing the secondary data.

The data of both, the fast and the slow channel are transmitted simultaneously, by including two bits of a slow channel message in the message frame of the fast channel. Even though it requires many fast channel messages to complete a slow channel message, you can use this function to transmit several slow channel messages with minimal impact on the primary sensor data and the data rate.

12.12.1.2 SENT Message Definitions

SENT terms

See the specific terms and definition used in SENT protocol:

- **Tick (clock tick):** basic unit of time
  - transmitter specific nominal clock period
  - 3 µs < clock tick <90 µs, with max. 20 % clock variation
- **Nibble:** minimum unit of data
  - used to transmit data
  - variable timing units between two falling edges

SENT Fast Channel

The SENT protocol enables you to transmit measurements of multiple sensors in one transmission sequence with data signals of varying length. The diagram in Figure 12-60 shows for example the enchoding scheme for two 12 bit data signals.

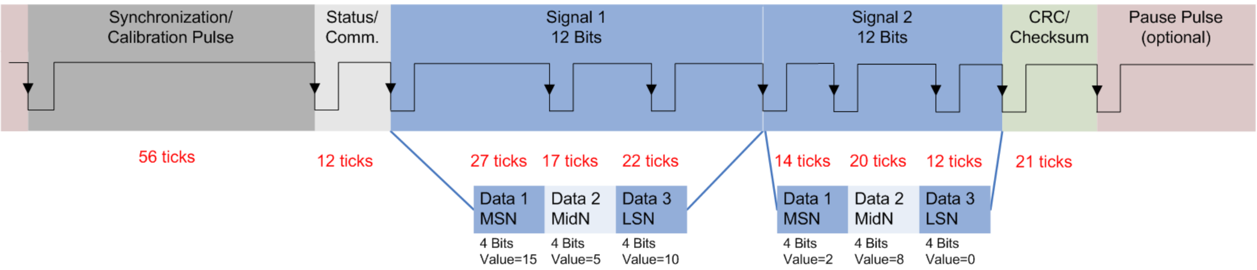


Figure 12-60: Example of a SENT transmission sequence

The format of a SENT transmission sequence consists of the following pulses:

- **Synchronization/Calibration Pulse:**
  – initial sequence of the receiver
  – the start condition is the falling edge of the last pulse (CRC or Pause)
  – nominal pulse period is 56 clock ticks
  – measures the actual clock variation of the transmitter and calculates the tick timing
- **Status/Communication Pulse (Nibble)**
  – one 4 bit pulse
  – communicates status and enables the sensor to include slow channel message bits
    0: (LSB) specific application
    1: specific application
    2: Serial Data message
    3: (MSB) 1= message start; 0=Serial Data message
  – 12 to 27 clock ticks
  – not included in CRC frame calculation
- **Data Pulses (Nibbles)**
  – one up to six 4 bit data nibbles
  – 12 to 27 clock ticks pulse period
  – initial logic 0 time with ≥5 ticks, subsequent logical 1 with variable duration
- **CRC/Checksum**
  – one 4 bit pulse
  – used for error checking of data nibbles (status nibble not included)
  – detects single bit, odd number of nonconsecutive and single burst errors
- **Pause Pulse**
  – one optional pulse
  – variable pulse length: 12 to 768 clock ticks
  – can be used to create a transmission with constant number of clock ticks

SENT Slow Channel

Short Serial Messages

For transmission of a slow channel message, 2 bits are included in a fast channel message, see the status nibble (Bit 2,3) in Figure 12-61.

A short serial message needs 16 fast channel messages until it is completely transmitted. Prerequisite for the complete transmission of the slow channel message are 16 consecutive error-free fast channel transmissions.

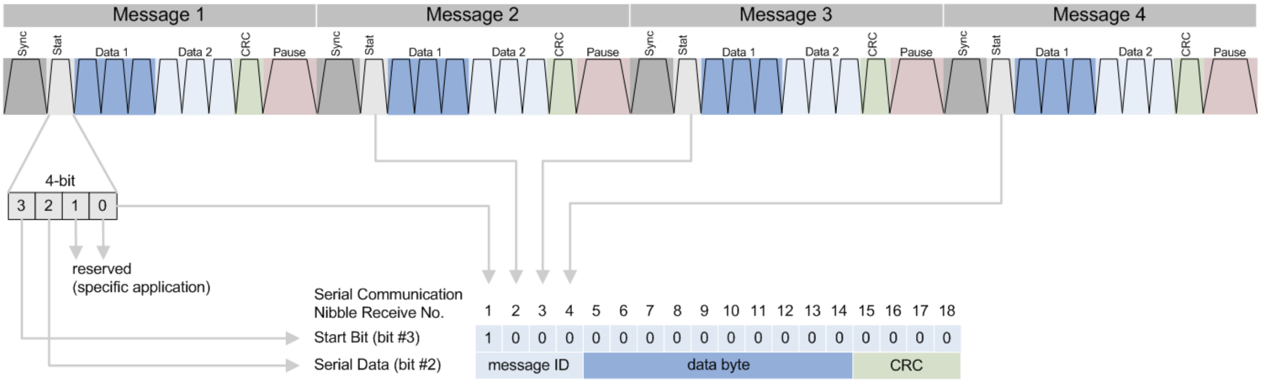


Figure 12-61: One serial message, composed of 16 SENT consecutive fast channel transmissions

Enhanced Serial Messages

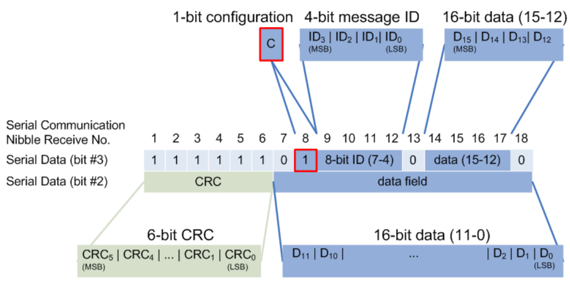
The transmission of an enhanced serial message format requires 18 fast channel transmissions. Each slow channel message is assigned a message ID, which is transmitted with the data.

The enhanced serial message format provides two alternatives for configuring the message:

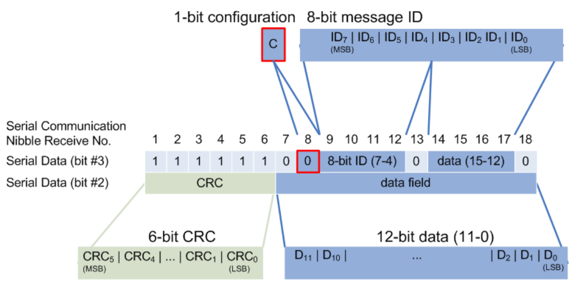
- 4 bit ID and 16 bit data
- 8 bit ID and 12 bit data

The graphs below illustrate the variants.

Table 12-12: Enhanced serial message formats



16 bit data and 4 bit message ID



12 bit data and 8 bit message ID

Trigger

The R&S RTE can trigger on various parts of SENT pulses. The data line must be connected to an input channel, triggering on math and reference waveforms is not possible.

SENT enables you to trigger on:

- Calibration/synchronization pulse
- Transmission sequence
- Serial messages
- Error Conditions

12.12.2 SENT Configuration

Access: PROTOCOL > "Configuration" tab > "Protocol" = *SENT*

Make sure that the tab of the correct serial bus is selected on the left side.

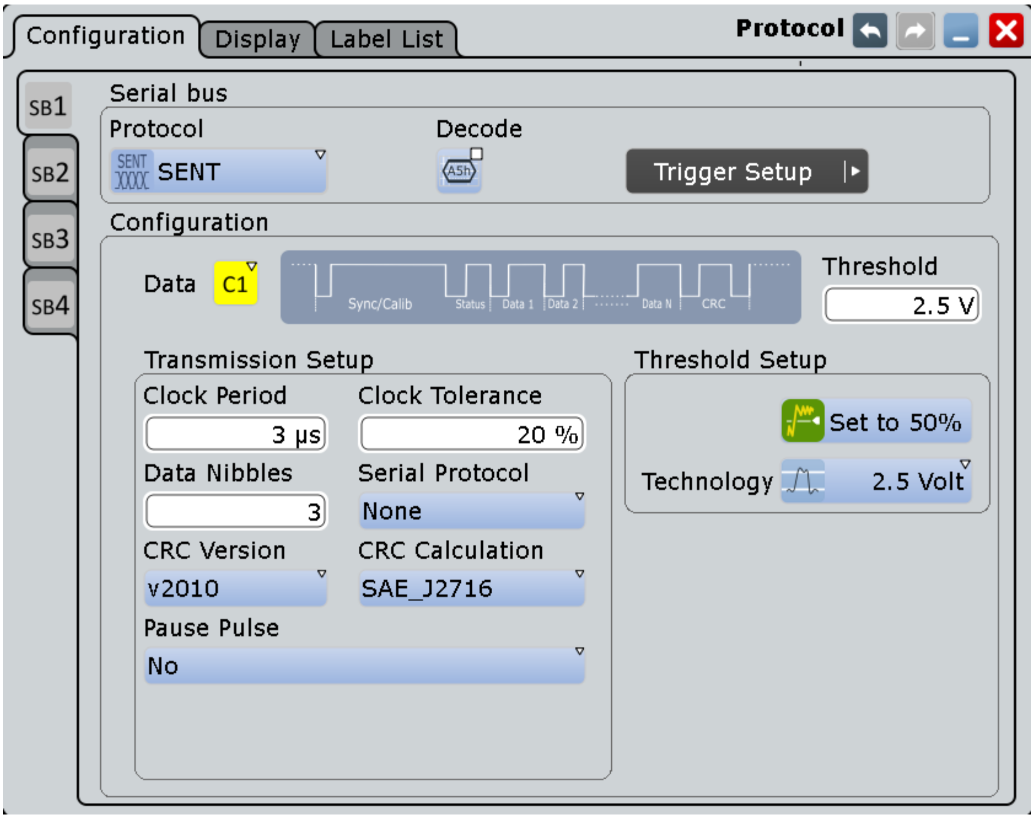


Figure 12-62: SENT protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Data
Sets the source of the data line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Remote command:
`BUS<m>:SENT:DATA:SOURce` on page 1408

Threshold
Sets the threshold value for digitization of the signal. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold.

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Remote command:
`BUS<m>:SENT:DATA:THReshold` on page 1408
`BUS<m>:SENT:TECHnology` on page 1408
`BUS<m>:SETReflevels` on page 1163

Clock Period
Sets the transmitter specific nominal clock period (clock tick).

The clock period and signal length determine the speed of transmission.

Remote command:
`BUS<m>:SENT:CLKPeriod` on page 1409

Clock Tolerance
Specifies a tolerated deviation of the clock.

Remote command:
`BUS<m>:SENT:CLKTolerance` on page 1409

Data Nibbles
Sets the number of data units in a single transmission sequence.

The maximum number of data nibbles is 6.

Remote command:
`BUS<m>:SENT:DNIBbles` on page 1409

Serial Protocol
Selects the protocol format in the transmitted signal.

"Short" Short serial messages.

"Enhanced" Enhanced serial messages.

"None" No serial messages. Transmission sequences only.

Remote command:
BUS<m>:SENT:SFORmat on page 1410

CRC Version

Selects the version the CRC check is based on.

"Legacy" Based on the crc calculation version used earlier than 2010.

"v2010" Based on the recent crc calculation version updated in 2010.

Remote command:
BUS<m>:SENT:CRCVersion on page 1410

CRC Calculation

Selects the method for CRC calculation.

SENT CRC calculates the checksum over all nibbles except the communication and status nibble.

"SAE_J2716" Calculates the CRC according to the SAE standard.

"TLE_4998X" Calculates the CRC according to the standard computing method for Infineon TLE_4998X sensors.

Remote command:
BUS<m>:SENT:CRCMethod on page 1410

Pause Pulse

Determines whether a pause pulse is transmitted after the checksum nibble.

You can use this pulse to create a transmission with a constant number of clock ticks. The pause pulse length can be between a minimum of 12 clock ticks up to 768 (3*256) ticks at a maximum.

"No"
No pause pulse between the transmission sequences.

"Yes" Pause pulse with fixed length at the end of each transmission sequence.
The R&S RTE computes the length of the pause pulse automatically.

"For constant frame length"
Pause pulse with dynamic length to maintain a fixed transmission sequence length.
To define the constant frame length, set the number of clock ticks under Frame Length in clock ticks.

Remote command:
BUS<m>:SENT:PPULse on page 1410

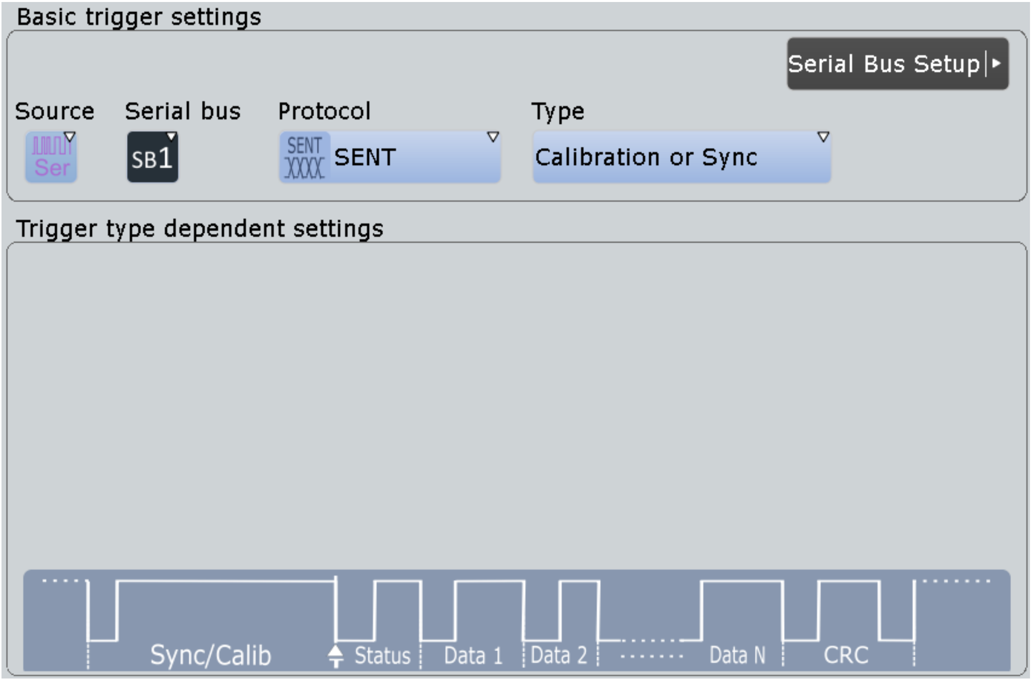
Frame Length in clock ticks

Determines the frame length in terms of ticks. The dialog displays this settings parameter, if the signal has a constant frame length.

Remote command:
`BUS<m>:SENT:PPFLength` on page 1411

12.12.3 SENT Trigger

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = SENT"



Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Type
Selects the event of the SENT transmission sequence or message to be triggered on.

The RTE triggers always on the falling edge of a pulse, i.e. at the end of the selected type nibble in a transmission sequence.

"Calibration or Sync"
Triggers at the end of the "Synchronization/Calibration" pulse.

This setting does not require any input parameters.

"Transmission Sequence"

Triggering depends on the additionally selectable "Sequence" parameter:

- "Sequence > Status": triggers at the end of the "Status" nibble.

- "Sequence > Status+Data": triggers at the end of the last data nibble.

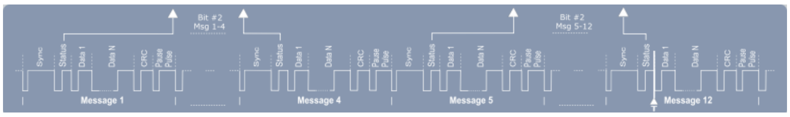
Description of trigger type specific settings: "Transmission Sequence setup" on page 632

"Serial Message"

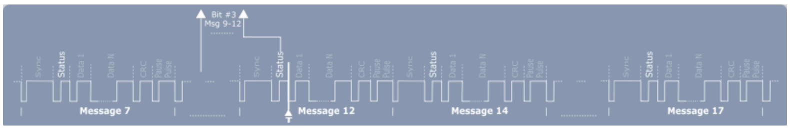
Triggering on a serial message depends on the serial protocol selected with Serial Protocol > Short | Enhanced and the associated setting parameters:

- "Short" serial message
  – "Sequence > Identifier": triggers at the end of the "ID".

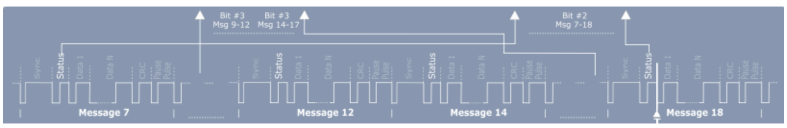
  – "Sequence > ID+Data": triggers at the end of the "ID and Data".



  Description of trigger type specific settings: "Serial Message setup" on page 633
- "Enhanced" serial message
  – "Sequence > Identifier": triggers at the end of the "ID".



  – "Sequence > ID+Data": triggers at the end of the "ID and Data".



  Description of trigger type specific settings: "Serial Message setup" on page 633

"Error condition"

Triggers if certain errors occur.

You can select the following error events for triggering:
- "Form Error"
- "Calibration Pulse Error"
- "Pulse Period Error"
- "CRC Error"
- "Irregular Frame Length Error"

Description of error specific trigger conditions, see "Error conditions setup" on page 635.

Remote command:
`TRIGger<m>:SENT:TYPE` on page 1412

Transmission Sequence setup

Configures the trigger conditions for trigger type transmission sequence.

Note: The displayed parameters depend on the selected "Sequence". The instrument displays the data setting parameters when you select "Status+Data", see "Type" on page 630.

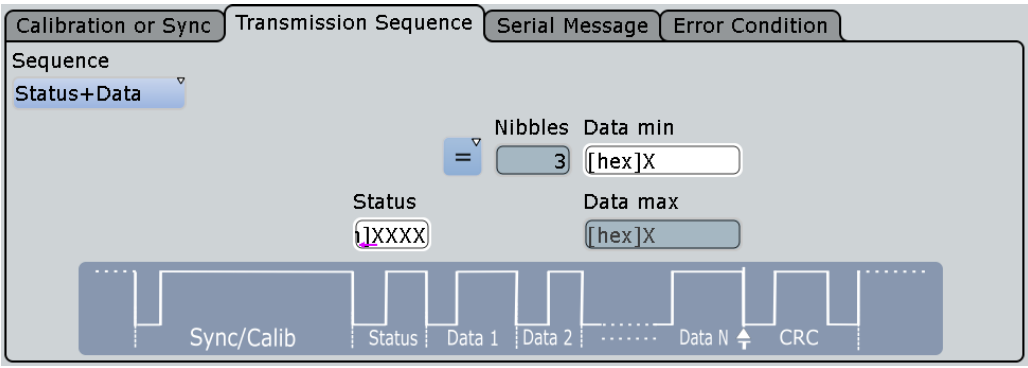


Figure 12-63: Trigger setting parameters of a transmission sequence

Sequence ← Transmission Sequence setup

Selects the condition for triggering in a single transmission sequence.

You can trigger on the end of the status nibble or the combination of the status and data nibble(s).

Remote command:
`TRIGger<m>:SENT:TTYPe` on page 1412

Status ← Transmission Sequence setup

Defines the data bits for the status nibble.

Remote command:
`TRIGger<m>:SENT:STATus` on page 1413

Condition ← Transmission Sequence setup

Selects the operator to define a specific data pattern or a data range.

The available operators:
- Equal, Not equal
- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:
TRIGger<m>:SENT:TDCN on page 1413

Nibbles ← Transmission Sequence setup
Displays the number of data nibbles of the transmission sequence.

Remote command:
BUS<m>:SENT:DNIBbles on page 1409

Data min ← Transmission Sequence setup
Sets the data pattern. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Remote command:
TRIGger<m>:SENT:TDMN on page 1413

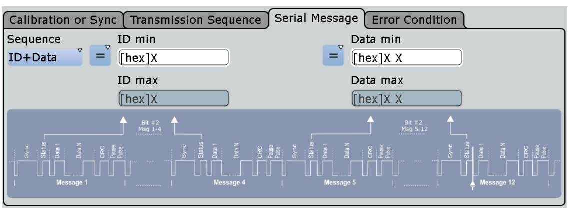
Data max ← Transmission Sequence setup
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:SENT:TDMX on page 1414

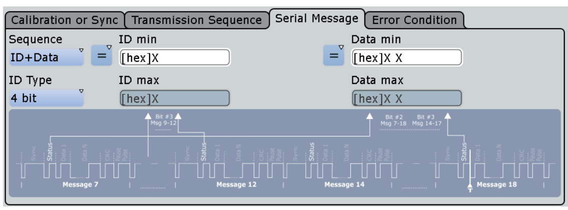
Serial Message setup
Configures the trigger conditions for a serial message.

Note: The displayed parameters depend on the selected "Sequence". The instrument indicates the data setting parameters when you select "ID+Data", see "Type" on page 630.

Trigger setting parameters of the serial message types



Short Serial Message



Enhanced Serial Message

Sequence ← Serial Message setup
Selects the condition for triggering in a serial message.

You can trigger on the end of an identifier nibble or the combination of the identifier and data nibble(s).

Remote command:
TRIGger<m>:SENT:STYPe on page 1414

ID Type ← Serial Message setup
Selects the message ID format for the enhanced serial message type.

You can select either 4 bit or 8 bit message ID.

Remote command:
`TRIGger<m>:SENT:SIDType` on page 1414

Identifier Condition ← Serial Message setup
The available operators:
- Equal, Not equal
- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:
`TRIGger<m>:SENT:SICN` on page 1414

Identifier min ← Serial Message setup
Defines the bit pattern of the message identifier. In binary format, use the following characters: 1; 0; or X (any bit).

The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

Remote command:
`TRIGger<m>:SENT:SIMN` on page 1415

Identifier max ← Serial Message setup
The second identifier pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:SENT:SIMX` on page 1415

Data Condition ← Serial Message setup
Selects the operator to set a specific data pattern or a data range.

The available operators:
- Equal, Not equal
- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:
`TRIGger<m>:SENT:SCONdition` on page 1415

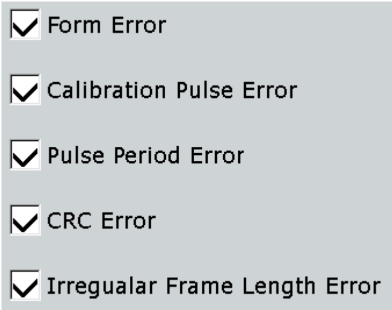
Data min ← Serial Message setup
Sets the data pattern. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Remote command:
`TRIGger<m>:SENT:SDMN` on page 1416

Data max ← Serial Message setup
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:SENT:SDMX on page 1416

Error conditions setup



Executes a trigger event if one or more of the following errors occur:

- "Form Error"
  Detects a form error in serial messages (short and enhanced).
  An error occurs when at least one of the transmission sequences that form a serial message has an error.
- "Calibration Pulse Error"
  Detects a calibration pulse error in transmission sequences.
  An error occurs when
  – the duration of the "Calibration/Sync" pulse (in ticks) is less than 56*(1-clock tolerance) or more than 56*(1+clock tolerance)
  – the "Calibration/Sync" pulse duration of frame (–1) varies by more than 1.5625% from the "Calibration/Sync" pulse duration of frame (n)
- "Pulse Period Error"
  Detects an error in the "Calibration/Sync" pulse in transmission sequences.
  An error occurs when a nibble has any of the following:
  – number of ticks at low is less than 4 ticks.
  – nibble value < 0 (less than 12 ticks) or > 15 (more than 27 ticks).
- "CRC Error"
  Detects a checksum error in both, the transmission sequences and serial messages.
  The CRC length is 4 bits for transmission sequences and short serial messages, and 6 bit of enhanced serial messages.
- "Irregular Frame Length Error"
  Detects frame length errors in transmission sequences when pause pulse mode constant frame length is set, see "Pause Pulse" on page 629.
  A frame length error occurs, when the total length of the transmission sequence (including pause pulse) does not match the frame length setting, see "Frame Length in clock ticks" on page 629.

Remote command:
TRIGger<m>:SENT:FORMerror on page 1416
TRIGger<m>:SENT:PULSeerror on page 1416
TRIGger<m>:SENT:PPERioderror on page 1417

`TRIGger<m>:SENT:CRCerror` on page 1417
`TRIGger<m>:SENT:IRFLength` on page 1417

12.12.4 SENT Label List

SENT label lists provide a very useful way of translating the decoded data into user format. The label lists are highly customizable. The format of supplying the label list description is through a `.xml` file and is explained with an example, see "Label List Structure for SENT Protocol" on page 636.

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 441.

Label List Structure for SENT Protocol

```
# ---------------------------------------------------------------------------
# Label list explained
# ---------------------------------------------------------------------------

<sb:FRAME NAME="Diagnostic Error Codes" STATE="ON">
  <!-- Start of a Frame Definition -->
  <!-- This block defines the information of a Transmission Sequence
   or Serial Message:
   NAME => Symbolic Label of the Frame
   STATE [ON/OFF] => When ON, this frame Translation is taken into consideration.
                     When OFF, this frame Translation is skipped.-->
<sb:DESCRIPTION> used to diagnose the current SENT System</sb:DESCRIPTION>
  <!-- Doesn't affect the Translation -->
<sb:ID-VALUE>01</sb:ID-VALUE>
  <!-- ID Value of the Serial Message (in decimal) -->
  <!-- Absence of the ID-VALUE field implies that the current Frame Translation
   is to be used for Transmission Sequences and not for a Serial Message -->
<sb:ID-LENGTH>8</sb:ID-LENGTH>
  <!-- ID Length of the Serial Message (in bits) -->
<sb:DATA-SIZE>12</sb:DATA-SIZE>
  <!-- Data Length of the Serial Message (in bits) -->
<sb:SIGNALS>
  <!-- This block defines the information of the Signals embedded
   in the Data Field of the Frame (Transmission Sequence or Serial Message) -->
<sb:SIGNAL ID="Diagnostic">
  <!-- Unique ID of the Signal (no effect on Translation) -->
<sb:SHORT-NAME>Diagnostic Code</sb:SHORT-NAME>
  <!-- Name of the Signal -->
<sb:DESCRIPTION></sb:DESCRIPTION>
  <!-- Info Field (no effect on Translation) -->
<sb:BIT-POSITION>11</sb:BIT-POSITION>
  <!-- Starting Bit position of the Signal
   (The whole Data Field is represented as MSB -> LSB Sequence) -->
<sb:BIT-LENGTH>12</sb:BIT-LENGTH>
  <!-- Number of Bits representing the Signal Value -->
```

```
<sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
  <!-- Byte Order of the Signal Value [MSB or LSB], Default: MSB -->
<sb:VALUE-TYPE>ENUM</sb:VALUE-TYPE>
  <!-- Representation of the Bits [ENUM, UNSIGNED_INT, INT, FLOAT, DOUBLE],
   Default: UNSIGNED_INT
   The Signal Value is calculated according to the following:
   Translated_Value = Encoded_Value * FACTOR + OFFSET -->
<sb:FACTOR>1.0</sb:FACTOR>
  <!-- Signal Factor (decimal value)-->
<sb:OFFSET>0.0</sb:OFFSET>
  <!-- Signal Offset (decimal value)-->
<sb:MIN>0</sb:MIN>
  <!-- Minimum Signal Value (decimal value) -->
<sb:MAX>4096</sb:MAX>
  <!-- Maximum Signal Value (decimal value) -->
<sb:ENUM-VALUES>
  <!-- This block is only valid (and taken into consideration)
   when the VALUE-TYPE is ENUM
   It defines the Enumeration List Translation of the Signal -->
<sb:ENUM INDEX="0" LABEL="No Error"/>
   <!-- INDEX is the Enum Value (corresponds to the Signal Value in decimal),
    LABEL is the matching Translated Signal Value -->
<sb:ENUM INDEX="1" LABEL="Channel 1 out of range high"/>
</sb:ENUM-VALUES>
  <!-- End of Signal Enumeration List Definition -->
</sb:SIGNAL>
  <!-- End of a Signal Definition -->
  <!-- More Signals can be defined here! -->
</sb:SIGNALS>
  <!-- End of list of Signals Definition -->
</sb:FRAME>
  <!-- End of Frame Definition -->
```

For an example to label list translation, see Chapter 12.12.4.1, "SENT Label List Translation Example", on page 639.

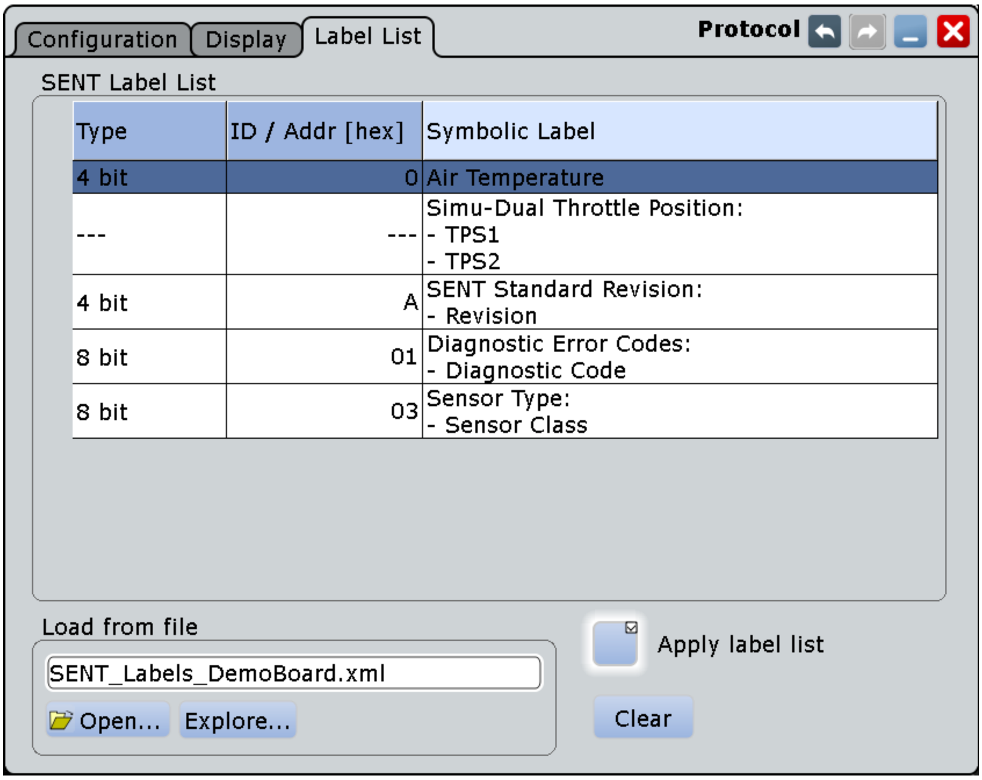


Figure 12-64: SENT label list

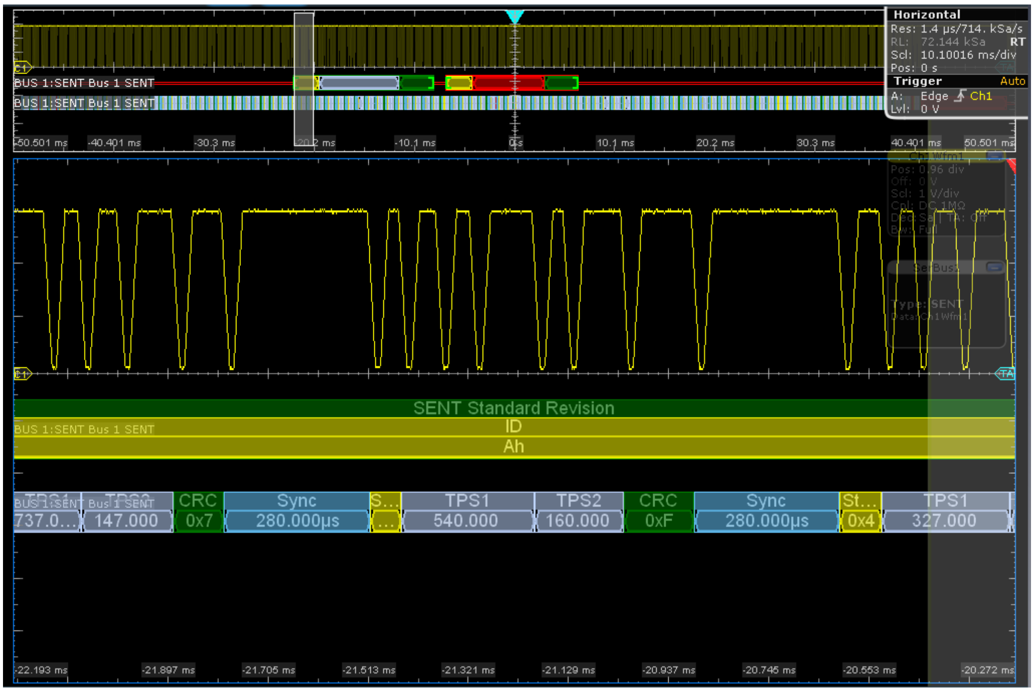


Figure 12-65: SENT decode results with label list translation

Remote command:

BUS<m>:SENT:FRAMe<n>:SYMBol? on page 1423

12.12.4.1 SENT Label List Translation Example

The example shows the `xml` sequence for a label list translation in the SENT protocol:

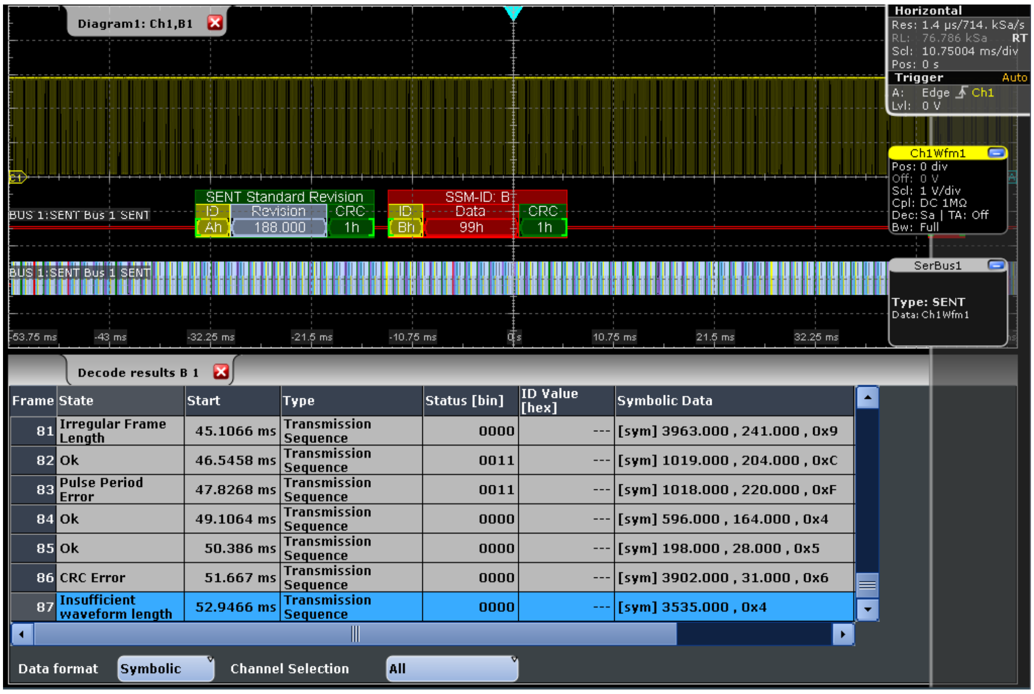


Figure 12-66: SENT label list translation

```
# ---------------------------------------------------------------------------
# Labels for SENT protocol
# Column order: Type, Identifier/Address, Symbolic Label
# ---------------------------------------------------------------------------

<?xml version="1.0" encoding="UTF-8"?>
<sb:LABEL-LIST-FILE>
 <sb:PROJECT ID="SENT-TRANSLATION SYSTEM">
  <sb:SHORT-NAME>SENT</sb:SHORT-NAME>
  <sb:LONG-NAME>SENT-Translation System Demo</sb:LONG-NAME>
  <sb:DESCRIPTION>This is the database for Translation demo for SENT.</sb:DESCRIPTION>
 </sb:PROJECT>
 <sb:FRAMES>
  <sb:FRAME NAME="Air Temperature" STATE="ON">
   <sb:DESCRIPTION></sb:DESCRIPTION>
   <sb:ID-VALUE>0</sb:ID-VALUE>
   <sb:ID-LENGTH>4</sb:ID-LENGTH>
   <sb:DATA-SIZE>16</sb:DATA-SIZE>
  </sb:FRAME>
  <sb:FRAME NAME="Humidity" STATE="OFF">
   <sb:DESCRIPTION></sb:DESCRIPTION>
```

```
 <sb:ID-VALUE>2</sb:ID-VALUE>
 <sb:ID-LENGTH>4</sb:ID-LENGTH>
 <sb:DATA-SIZE>16</sb:DATA-SIZE>
</sb:FRAME>
<sb:FRAME NAME="Barometric Pressure" STATE="OFF">
 <sb:DESCRIPTION></sb:DESCRIPTION>
 <sb:ID-VALUE>4</sb:ID-VALUE>
 <sb:ID-LENGTH>4</sb:ID-LENGTH>
 <sb:DATA-SIZE>16</sb:DATA-SIZE>
</sb:FRAME>
<sb:FRAME NAME="Configuration Code" STATE="OFF">
 <sb:DESCRIPTION></sb:DESCRIPTION>
 <sb:ID-VALUE>04</sb:ID-VALUE>
 <sb:ID-LENGTH>8</sb:ID-LENGTH>
 <sb:DATA-SIZE>12</sb:DATA-SIZE>
</sb:FRAME>
<sb:FRAME NAME="Manufacturer Code" STATE="OFF">
 <sb:DESCRIPTION></sb:DESCRIPTION>
 <sb:ID-VALUE>05</sb:ID-VALUE>
 <sb:ID-LENGTH>8</sb:ID-LENGTH>
 <sb:DATA-SIZE>12</sb:DATA-SIZE>
</sb:FRAME>
<sb:FRAME NAME="Sensor Type" STATE="ON">
 <sb:DESCRIPTION>specifies the SENT Sensor Type</sb:DESCRIPTION>
 <sb:ID-VALUE>03</sb:ID-VALUE>
 <sb:ID-LENGTH>8</sb:ID-LENGTH>
 <sb:DATA-SIZE>12</sb:DATA-SIZE>
 <sb:SIGNALS>
  <sb:SIGNAL ID="Sensor Class">
   <sb:SHORT-NAME>Sensor Class</sb:SHORT-NAME>
   <sb:BIT-POSITION>11</sb:BIT-POSITION>
   <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
   <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
   <sb:VALUE-TYPE>ENUM</sb:VALUE-TYPE>
   <sb:FACTOR>1.0</sb:FACTOR>
   <sb:OFFSET>0.0</sb:OFFSET>
   <sb:MIN>0</sb:MIN>
   <sb:MAX>32.0</sb:MAX>
   <sb:ENUM-VALUES>
    <sb:ENUM INDEX="0" LABEL="Not Specified"/>
    <sb:ENUM INDEX="1" LABEL="P"/>
    <sb:ENUM INDEX="2" LABEL="P/-"/>
    <sb:ENUM INDEX="3" LABEL="P/S"/>
    <sb:ENUM INDEX="4" LABEL="P/S/Default T"/>
    <sb:ENUM INDEX="5" LABEL="P/S/Sensor-Specific T"/>
    <sb:ENUM INDEX="6" LABEL="P1/P2"/>
    <sb:ENUM INDEX="7" LABEL="P/Default T"/>
    <sb:ENUM INDEX="8" LABEL="P/Sensor-Specific T"/>
    <sb:ENUM INDEX="9" LABEL="P1/P2/Default T"/>
    <sb:ENUM INDEX="10" LABEL="P1/P2/Sensor-Specific T"/>
```

```
      <sb:ENUM INDEX="16" LABEL="Not Defined"/>
      <sb:ENUM INDEX="17" LABEL="MAF (hi-res,lin)"/>
      <sb:ENUM INDEX="18" LABEL="MAF (hi-res,non-lin)"/>
      <sb:ENUM INDEX="19" LABEL="MAF (hi-res,lin) / Pressure"/>
      <sb:ENUM INDEX="20" LABEL="MAF (hi-res,non-lin) / Pressure"/>
      <sb:ENUM INDEX="21" LABEL="MAF (lin) / Pressure (hi-res)"/>
      <sb:ENUM INDEX="22" LABEL="MAF (non-lin) / Pressure (hi-res)"/>
     </sb:ENUM-VALUES>
    </sb:SIGNAL>
   </sb:SIGNALS>
  </sb:FRAME>
  <sb:FRAME NAME="SENT Standard Revision" STATE="ON">
   <sb:SHORT-NAME>SENT Standard</sb:SHORT-NAME>
   <sb:DESCRIPTION>specifies the SENT Standard Revision Number</sb:DESCRIPTION>
   <sb:ID-VALUE>10</sb:ID-VALUE>
   <sb:ID-LENGTH>4</sb:ID-LENGTH>
   <sb:DATA-SIZE>8</sb:DATA-SIZE>
   <sb:SIGNALS>
    <sb:SIGNAL ID="Revision">
     <sb:SHORT-NAME>Revision</sb:SHORT-NAME>
     <sb:DESCRIPTION>SENT-Standard Revision Number</sb:DESCRIPTION>
     <sb:BIT-POSITION>7</sb:BIT-POSITION>
     <sb:BIT-LENGTH>8</sb:BIT-LENGTH>
     <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
     <sb:VALUE-TYPE>ENUM</sb:VALUE-TYPE>
     <sb:FACTOR>1.0</sb:FACTOR>
     <sb:OFFSET>0.0</sb:OFFSET>
     <sb:MIN>0</sb:MIN>
     <sb:MAX>4.0</sb:MAX>
     <sb:ENUM-VALUES>
      <sb:ENUM INDEX="0" LABEL="Not defined"/>
      <sb:ENUM INDEX="1" LABEL="J2716 Rev 1"/>
      <sb:ENUM INDEX="2" LABEL="J2716 Rev 2"/>
      <sb:ENUM INDEX="3" LABEL="J2716 Rev 3"/>
     </sb:ENUM-VALUES>
    </sb:SIGNAL>
   </sb:SIGNALS>
  </sb:FRAME>
  <sb:FRAME NAME="Diagnostic Error Codes" STATE="ON">
   <sb:DESCRIPTION>used to diagnose the current SENT System</sb:DESCRIPTION>
   <sb:ID-VALUE>01</sb:ID-VALUE>
   <sb:ID-LENGTH>8</sb:ID-LENGTH>
   <sb:DATA-SIZE>12</sb:DATA-SIZE>
   <sb:SIGNALS>
    <sb:SIGNAL ID="Diagnostic">
     <sb:SHORT-NAME>Diagnostic Code</sb:SHORT-NAME>
     <sb:DESCRIPTION></sb:DESCRIPTION>
     <sb:BIT-POSITION>11</sb:BIT-POSITION>
     <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
     <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
```

```
      <sb:VALUE-TYPE>ENUM</sb:VALUE-TYPE>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>4096</sb:MAX>
      <sb:ENUM-VALUES>
       <sb:ENUM INDEX="0" LABEL="No Error"/>
       <sb:ENUM INDEX="1" LABEL="Channel 1 out of range high"/>
       <sb:ENUM INDEX="2" LABEL="Channel 1 out of range low"/>
       <sb:ENUM INDEX="3" LABEL="Initialization Error (Channel 1)"/>
       <sb:ENUM INDEX="4" LABEL="Channel 2 out of range high"/>
       <sb:ENUM INDEX="5" LABEL="Channel 2 out of range low"/>
       <sb:ENUM INDEX="6" LABEL="Initialization Error (Channel 2)"/>
       <sb:ENUM INDEX="7" LABEL="Channel 1 and 2 Rationality Error"/>
       <sb:ENUM INDEX="1025" LABEL="Slow Channel Temperature out of range high"/>
       <sb:ENUM INDEX="1026" LABEL="Slow Channel Temperature out of range low"/>
       <sb:ENUM INDEX="1027" LABEL="Slow Channel Temperature initialization error"/>
       <sb:ENUM INDEX="1028" LABEL="Slow Channel Humidity out of range high"/>
       <sb:ENUM INDEX="1029" LABEL="Slow Channel Humidity out of range low"/>
       <sb:ENUM INDEX="1030" LABEL="Slow Channel Humidity initialization error"/>
       <sb:ENUM INDEX="1031" LABEL="Slow Channel Barometric Pressure out of range high"/>
       <sb:ENUM INDEX="1032" LABEL="Slow Channel Barometric Pressure out of range low"/>
       <sb:ENUM INDEX="1033" LABEL="Slow Channel Barometric Pressure initialization error"/>
      </sb:ENUM-VALUES>
     </sb:SIGNAL>
    </sb:SIGNALS>
   </sb:FRAME>
   <sb:FRAME NAME="Simu-Dual Throttle Position" STATE="ON">
    <sb:SHORT-NAME>DTP</sb:SHORT-NAME>
    <sb:DATA-SIZE>20</sb:DATA-SIZE>
    <sb:SIGNALS>
     <sb:SIGNAL ID="Channel_1">
      <sb:SHORT-NAME>TPS1</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>19</sb:BIT-POSITION>
      <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
      <sb:VALUE-TYPE>UNSIGNED_INT</sb:VALUE-TYPE>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
     </sb:SIGNAL>
     <sb:SIGNAL ID="Channel_2">
      <sb:SHORT-NAME>TPS2</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>7</sb:BIT-POSITION>
      <sb:BIT-LENGTH>8</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
```

```
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
    </sb:SIGNAL>
  </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Dual Throttle Position" STATE="OFF">
  <sb:SHORT-NAME>DTP</sb:SHORT-NAME>
  <sb:DATA-SIZE>24</sb:DATA-SIZE>
  <sb:SIGNALS>
    <sb:SIGNAL ID="Channel_1">
      <sb:SHORT-NAME>TPS1</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>23</sb:BIT-POSITION>
      <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
      <sb:VALUE-TYPE>UNSIGNED_INT</sb:VALUE-TYPE>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
    </sb:SIGNAL>
    <sb:SIGNAL ID="Channel_2">
      <sb:SHORT-NAME>TPS2</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>11</sb:BIT-POSITION>
      <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
    </sb:SIGNAL>
  </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Mass Air Flow (16)" STATE="OFF">
  <sb:SHORT-NAME>MAF/P</sb:SHORT-NAME>
  <sb:DATA-SIZE>24</sb:DATA-SIZE>
  <sb:SIGNALS>
    <sb:SIGNAL ID="Channel_1">
      <sb:SHORT-NAME>MAF</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>23</sb:BIT-POSITION>
      <sb:BIT-LENGTH>16</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
```

```
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
    </sb:SIGNAL>
  </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Mass Air Flow (16/8)" STATE="OFF">
  <sb:SHORT-NAME>MAF/P</sb:SHORT-NAME>
  <sb:DATA-SIZE>24</sb:DATA-SIZE>
  <sb:SIGNALS>
    <sb:SIGNAL ID="Channel_1">
      <sb:SHORT-NAME>MAF</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>23</sb:BIT-POSITION>
      <sb:BIT-LENGTH>16</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
    </sb:SIGNAL>
    <sb:SIGNAL ID="Channel_2">
      <sb:SHORT-NAME>Pressure</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>7</sb:BIT-POSITION>
      <sb:BIT-LENGTH>8</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
    </sb:SIGNAL>
  </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Mass Air Flow (14/10)" STATE="OFF">
  <sb:SHORT-NAME>MAF/P</sb:SHORT-NAME>
  <sb:DATA-SIZE>24</sb:DATA-SIZE>
  <sb:SIGNALS>
    <sb:SIGNAL ID="Channel_1">
      <sb:SHORT-NAME>MAF</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>23</sb:BIT-POSITION>
      <sb:BIT-LENGTH>14</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
```

```
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
    </sb:SIGNAL>
    <sb:SIGNAL ID="Channel_2">
      <sb:SHORT-NAME>Pressure</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>9</sb:BIT-POSITION>
      <sb:BIT-LENGTH>10</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
    </sb:SIGNAL>
  </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Single Secure Sensor" STATE="OFF">
  <sb:SHORT-NAME>SSS</sb:SHORT-NAME>
  <sb:DATA-SIZE>24</sb:DATA-SIZE>
  <sb:SIGNALS>
    <sb:SIGNAL ID="Channel_1">
      <sb:SHORT-NAME>Ch1</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>23</sb:BIT-POSITION>
      <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
    </sb:SIGNAL>
    <sb:SIGNAL ID="Channel_2">
      <sb:SHORT-NAME>Counter</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>11</sb:BIT-POSITION>
      <sb:BIT-LENGTH>8</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>256.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
    </sb:SIGNAL>
  </sb:SIGNALS>
</sb:FRAME>
<sb:FRAME NAME="Pressure Sensor" STATE="OFF">
  <sb:SHORT-NAME>P</sb:SHORT-NAME>
  <sb:DATA-SIZE>24</sb:DATA-SIZE>
```

```
  <sb:SIGNALS>
   <sb:SIGNAL ID="Channel_1">
    <sb:SHORT-NAME>Pressure1</sb:SHORT-NAME>
    <sb:DESCRIPTION>""</sb:DESCRIPTION>
    <sb:BIT-POSITION>23</sb:BIT-POSITION>
    <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
    <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
    <sb:FACTOR>1.0</sb:FACTOR>
    <sb:OFFSET>0.0</sb:OFFSET>
    <sb:MIN>0</sb:MIN>
    <sb:MAX>10000.0</sb:MAX>
    <sb:UNIT></sb:UNIT>
   </sb:SIGNAL>
   <sb:SIGNAL ID="Channel_2">
    <sb:SHORT-NAME>Pressure2</sb:SHORT-NAME>
    <sb:DESCRIPTION>""</sb:DESCRIPTION>
    <sb:BIT-POSITION>11</sb:BIT-POSITION>
    <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
    <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
    <sb:FACTOR>1.0</sb:FACTOR>
    <sb:OFFSET>0.0</sb:OFFSET>
    <sb:MIN>0</sb:MIN>
    <sb:MAX>10000.0</sb:MAX>
    <sb:UNIT></sb:UNIT>
   </sb:SIGNAL>
  </sb:SIGNALS>
 </sb:FRAME>
 <sb:FRAME NAME="Pressure and Temperature Sensor" STATE="OFF">
  <sb:SHORT-NAME>P/T</sb:SHORT-NAME>
  <sb:DATA-SIZE>24</sb:DATA-SIZE>
  <sb:SIGNALS>
   <sb:SIGNAL ID="Channel_1">
    <sb:SHORT-NAME>Pressure</sb:SHORT-NAME>
    <sb:DESCRIPTION>""</sb:DESCRIPTION>
    <sb:BIT-POSITION>23</sb:BIT-POSITION>
    <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
    <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
    <sb:FACTOR>1.0</sb:FACTOR>
    <sb:OFFSET>0.0</sb:OFFSET>
    <sb:MIN>0</sb:MIN>
    <sb:MAX>10000.0</sb:MAX>
    <sb:UNIT></sb:UNIT>
   </sb:SIGNAL>
   <sb:SIGNAL ID="Channel_2">
    <sb:SHORT-NAME>Temperature</sb:SHORT-NAME>
    <sb:DESCRIPTION>""</sb:DESCRIPTION>
    <sb:BIT-POSITION>11</sb:BIT-POSITION>
    <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
    <sb:BYTE-ORDER>LSB</sb:BYTE-ORDER>
    <sb:FACTOR>1.0</sb:FACTOR>
```

```
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
     </sb:SIGNAL>
    </sb:SIGNALS>
   </sb:FRAME>
   <sb:FRAME NAME="Pressure and Secure Sensor" STATE="OFF">
    <sb:SHORT-NAME>P/S</sb:SHORT-NAME>
    <sb:DATA-SIZE>24</sb:DATA-SIZE>
    <sb:SIGNALS>
     <sb:SIGNAL ID="Channel_1">
      <sb:SHORT-NAME>Pressure</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>23</sb:BIT-POSITION>
      <sb:BIT-LENGTH>12</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
     </sb:SIGNAL>
     <sb:SIGNAL ID="Channel_2">
      <sb:SHORT-NAME>Counter</sb:SHORT-NAME>
      <sb:DESCRIPTION>""</sb:DESCRIPTION>
      <sb:BIT-POSITION>11</sb:BIT-POSITION>
      <sb:BIT-LENGTH>8</sb:BIT-LENGTH>
      <sb:BYTE-ORDER>MSB</sb:BYTE-ORDER>
      <sb:FACTOR>1.0</sb:FACTOR>
      <sb:OFFSET>0.0</sb:OFFSET>
      <sb:MIN>0</sb:MIN>
      <sb:MAX>10000.0</sb:MAX>
      <sb:UNIT></sb:UNIT>
     </sb:SIGNAL>
    </sb:SIGNALS>
   </sb:FRAME>
  </sb:FRAMES>
</sb:LABEL-LIST-FILE>
```


12.12.5 SENT Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Data is decoded and displayed in the order of its reception. The "Decode results" box shows the detailed decoded data for each frame as it is received.

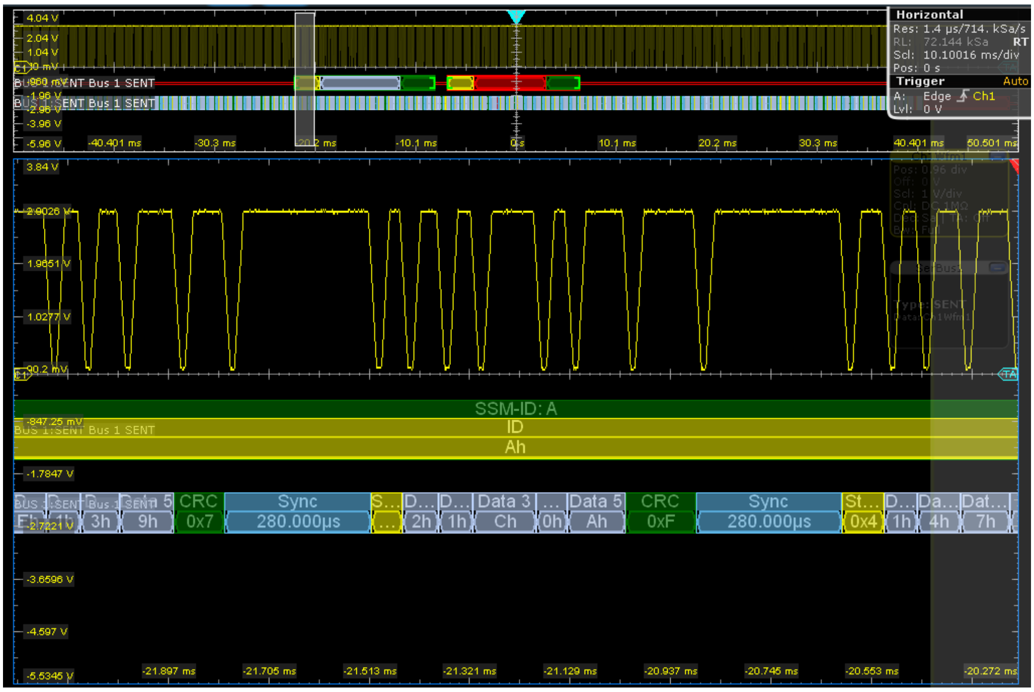


Figure 12-67: SENT decode results display

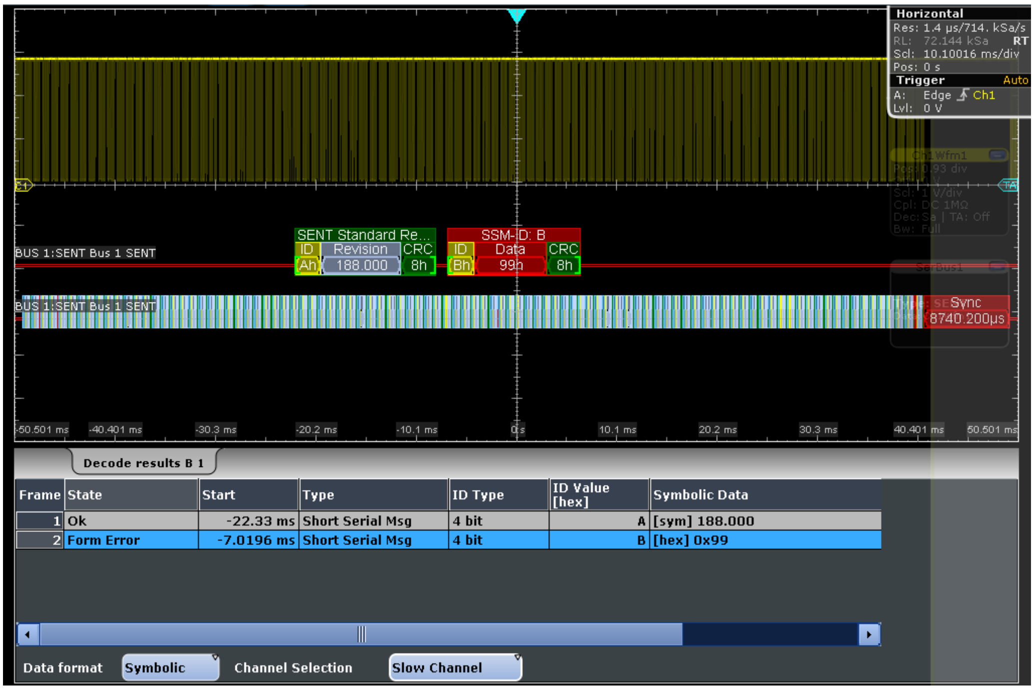


Figure 12-68: SENT decode results of a short serial message

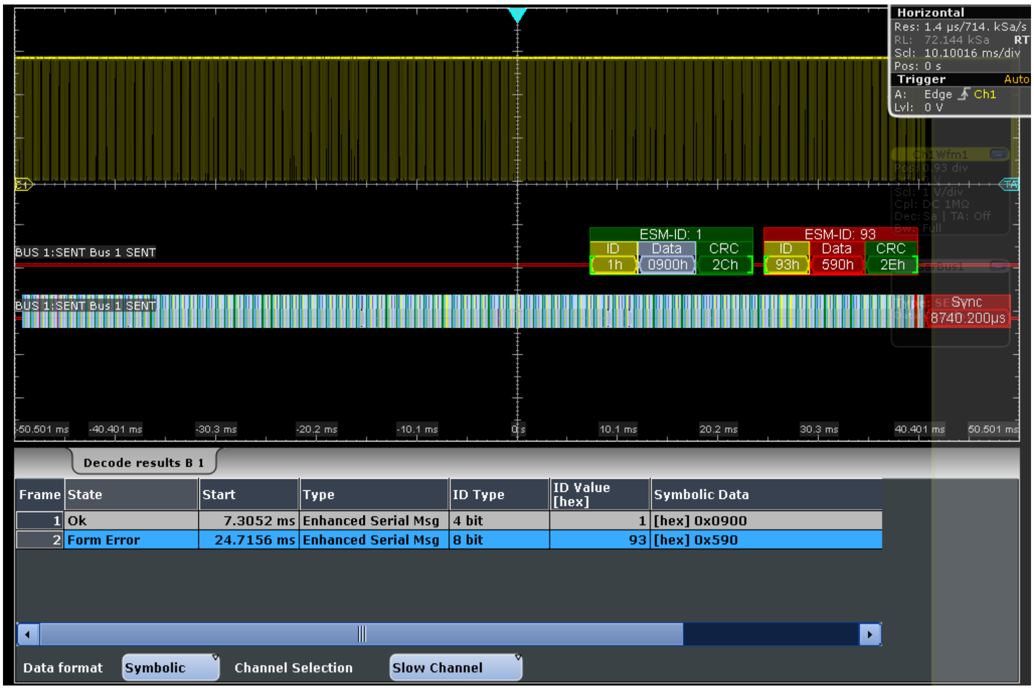


Figure 12-69: SENT decode results of an enhanced serial message

Remote commands:

- `BUS<m>:SENT:FCOunt?` on page 1418
- `BUS<m>:SENT:FRAMe<n>:STATus?` on page 1418
- `BUS<m>:SENT:FRAMe<n>:STARt?` on page 1419

- BUS<m>:SENT:FRAMe<n>:STOP? on page 1419
- BUS<m>:SENT:FRAMe<n>:CSValue? on page 1419
- BUS<m>:SENT:FRAMe<n>:DATA? on page 1420
- BUS<m>:SENT:FRAMe<n>:IDTYpe? on page 1420
- BUS<m>:SENT:FRAMe<n>:IDValue? on page 1420
- BUS<m>:SENT:FRAMe<n>:NIBBle<o>:STATe? on page 1421
- BUS<m>:SENT:FRAMe<n>:NIBBle<o>:VALue? on page 1421
- BUS<m>:SENT:FRAMe<n>:PAPTicks? on page 1422
- BUS<m>:SENT:FRAMe<n>:SCOM? on page 1422
- BUS<m>:SENT:FRAMe<n>:SDATa? on page 1422
- BUS<m>:SENT:FRAMe<n>:SYMBol? on page 1423
- BUS<m>:SENT:FRAMe<n>:SYNCduration? on page 1423
- BUS<m>:SENT:FRAMe<n>:TYPE? on page 1423
- BUS<m>:SENT:RDSL on page 1424

12.12.6 Search on Decoded SENT Data

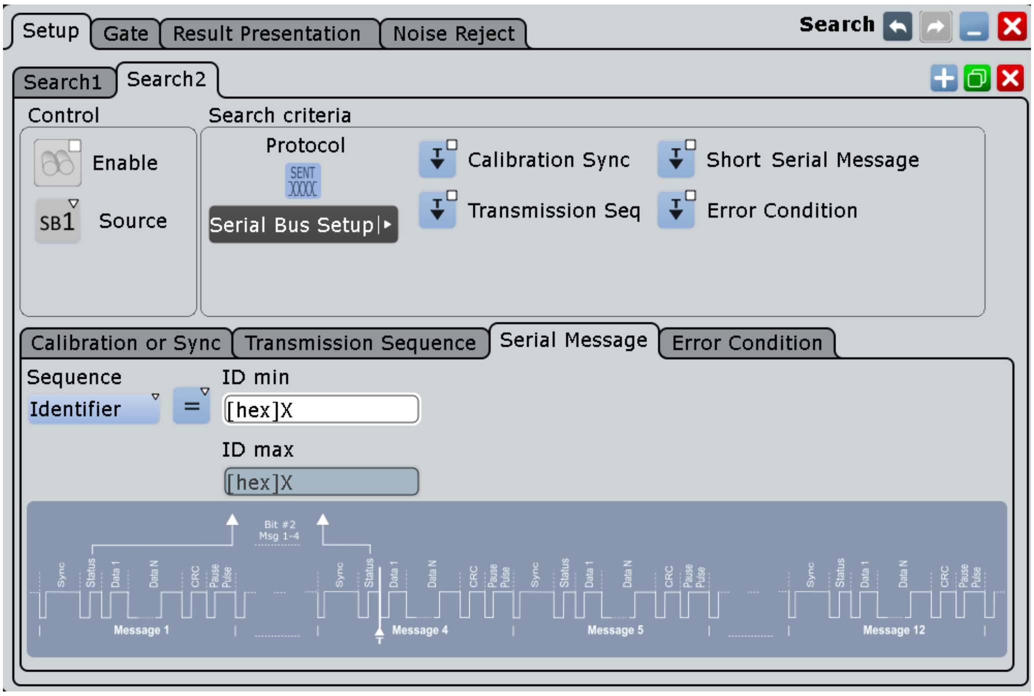
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 376.

12.12.6.1 SENT Search Setup

Access: SEARCH > "Setup" tab



Search criteria

Enable the events to be searched for.

Unlike triggering, where you can trigger only on one defined event, you can search for various different events in one search.

"Calibration Sync"
: Searches for the end of the "Calibration/Synchronization" sequence, i.e. the falling edge.
This setting does not require any input parameters.

"Transmission Seq"
: Searches for the end of the status nibble in a single transmission sequence, or the end of the combination of the status and data nibble(s).
Description of the specific settings: "Transmission Sequence setup" on page 652

"Serial Message"
: Searching on a serial message depends on the serial protocol selected with Serial Protocol > Short | Enhanced and the associated setting parameters:
- "Sequence > Identifier": searches for the end of the identifier nibble.
- "Sequence > ID+Data": searches for the end of the "ID and Data" nibble.

Description of the serial messages specific settings: "Serial Message setup" on page 653

"Error Condition"
Searches for the end of certain error events.
Description of trigger type specific settings: "Error conditions setup" on page 655

Remote command:
`SEARch:TRIGger:SENT:TYPE` on page 1425
`SEARch:TRIGger:SENT:CALibration` on page 1425
`SEARch:TRIGger:SENT:TRANsmission` on page 1426
`SEARch:TRIGger:SENT:SMSG` on page 1426
`SEARch:TRIGger:SENT:ERRor` on page 1426

Transmission Sequence setup
Configures the search conditions for the transmission sequence.

Note: The displayed parameters depend on the selected "Sequence". The instrument displays the data setting parameters when you select "Status+Data", see "Sequence" on page 652.
The search type specific conditions are the same as for the trigger type, see "Transmission Sequence setup" on page 632.

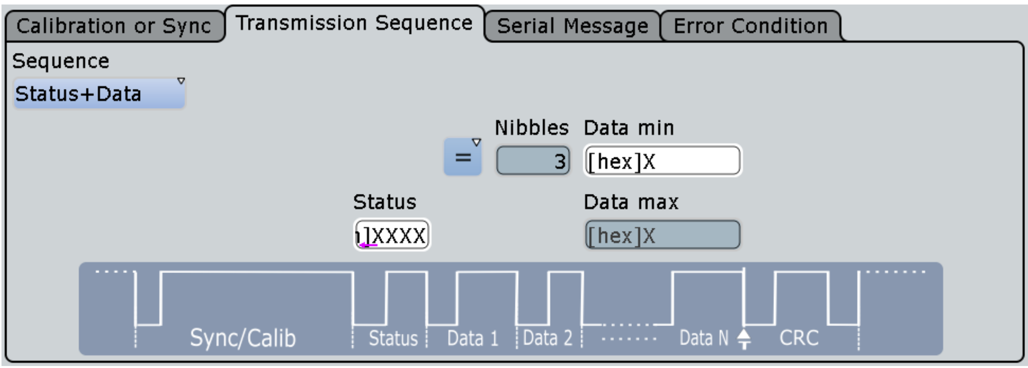


Figure 12-70: Search setting parameters of a transmission sequence

Sequence ← Transmission Sequence setup
Selects the condition for searching in a single transmission sequence.

You can search for the end of the status nibble or the combination of the status and data nibble(s).

Remote command:
`SEARch:TRIGger:SENT:TTYPe` on page 1426

Status ← Transmission Sequence setup
Defines the data bits for the status nibble.

Remote command:
`SEARch:TRIGger:SENT:STATus` on page 1427

Condition ← Transmission Sequence setup
Selects the operator to define a specific data pattern or a data range.

The available operators:
- Equal, Not equal

- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:
`SEARch:TRIGger:SENT:TDCN` on page 1427

Data Nibbles ← Transmission Sequence setup
Sets the number of data units in a single transmission sequence.

The maximum number of data nibbles is 6.

Remote command:
`BUS<m>:SENT:DNIBbles` on page 1409

Data min ← Transmission Sequence setup
Sets the data pattern. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Remote command:
`SEARch:TRIGger:SENT:TDMN` on page 1428

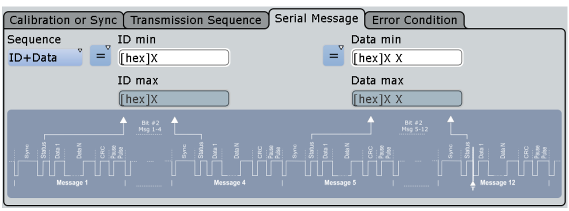
Data max ← Transmission Sequence setup
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:SENT:TDMX` on page 1428

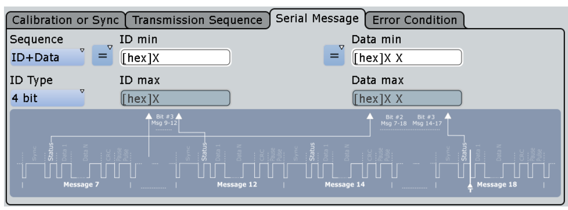
Serial Message setup
Configures the search conditions for a serial message.

Note: The displayed parameters depend on the selected "Sequence". The instrument indicates the data setting parameters when you select "ID+Data", see "Sequence" on page 653.
The description of the search type specific settings are the same as for the trigger type, see "Serial Message setup" on page 633.

Search setting parameters of the serial message types



Short Serial Message



Enhanced Serial Message

Sequence ← Serial Message setup
Selects the condition for searching in a serial message.

You can search for the end of an identifier nibble or the combination of the identifier and data nibble(s).

Remote command:
SEARch:TRIGger:SENT:STYPe on page 1428

ID Type ← Serial Message setup
Selects the message ID format for the enhanced serial message type.

You can select either 4 bit or 8 bit message ID.

Remote command:
SEARch:TRIGger:SENT:SIDType on page 1429

Identifier Condition ← Serial Message setup
Selects the operator to set a specific identifier or an identifier range.

The available operators:
- Equal, Not equal
- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:
SEARch:TRIGger:SENT:SICN on page 1429

Identifier min ← Serial Message setup
Defines the bit pattern of the message identifier. In binary format, use the following characters: 1; 0; or X (any bit).

The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

Remote command:
SEARch:TRIGger:SENT:SIMN on page 1429

Identifier max ← Serial Message setup
The second identifier pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
SEARch:TRIGger:SENT:SIMX on page 1430

SSM Data Condition ← Serial Message setup
Selects the operator to set a specific data pattern or a data range.

The available operators:
- Equal, Not equal
- Less than, Greater than
- Less or equal, Greater or equal
- In range, Out of range

Remote command:
SEARch:TRIGger:SENT:SDCN on page 1430

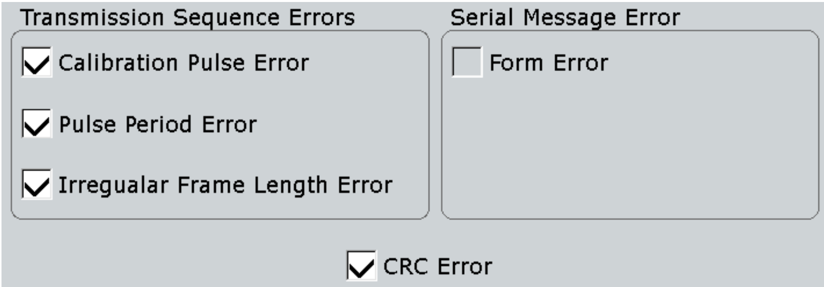
Data min ← Serial Message setup
Sets the data pattern. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Remote command:
`SEARch:TRIGger:SENT:SDMN` on page 1430

Data max ← Serial Message setup
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:SENT:SDMX` on page 1431

Error conditions setup



Performs the search on one or more of the following error events:
- "Transmission sequence errors"
  - "Calibration Pulse Error"
    Searches for calibration pulse errors.
  - "Pulse Period Error"
    Searches for pulse period errors in a transmission sequence.
  - "Irregular Frame Length Error"
    Searches for irregular frame length errors in a transmission sequence.
- Serial message error
  - "Form Error"
    Searches for format errors in serial messages.
- "CRC Error"
  Searches for errors in the complete data transmission.

Remote command:
`SEARch:TRIGger:SENT:PULSeerror` on page 1431
`SEARch:TRIGger:SENT:PPERioderror` on page 1431
`SEARch:TRIGger:SENT:FORMerror` on page 1432
`SEARch:TRIGger:SENT:CRCerror` on page 1432
`SEARch:TRIGger:SENT:IRFLength` on page 1431

12.12.6.2 SENT Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394

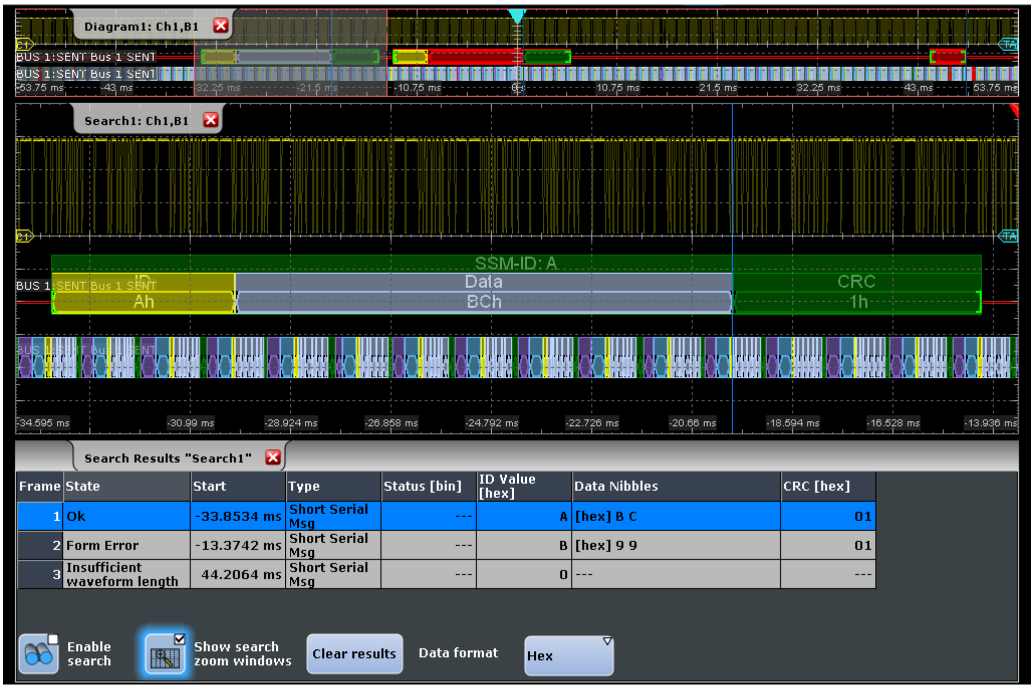


Figure 12-71: Search on the Status nibble in a SENT transmission signal

The columns in the search result table are the same as in the decoding table, see Chapter 12.12.5, "SENT Decode Results", on page 647.

Remote commands:

- `SEARch:RESult:SENT:FCOunt?` on page 1433
- `SEARch:RESult:SENT:FRAMe<m>:STATus?` on page 1436
- `SEARch:RESult:SENT:FRAMe<m>:STARt?` on page 1436
- `SEARch:RESult:SENT:FRAMe<m>:STOP?` on page 1436
- `SEARch:RESult:SENT:FRAMe<m>:DATA?` on page 1433
- `SEARch:RESult:SENT:FRAMe<m>:CSValue?` on page 1433
- `SEARch:RESult:SENT:FRAMe<m>:IDTYpe?` on page 1433
- `SEARch:RESult:SENT:FRAMe<m>:IDValue?` on page 1434
- `SEARch:RESult:SENT:FRAMe<m>:NIBBle<n>:STATe?` on page 1434
- `SEARch:RESult:SENT:FRAMe<m>:NIBBle<n>:VALue?` on page 1434
- `SEARch:RESult:SENT:FRAMe<m>:PAPTicks?` on page 1435
- `SEARch:RESult:SENT:FRAMe<m>:SCOM?` on page 1435
- `SEARch:RESult:SENT:FRAMe<m>:SDATa?` on page 1435
- `SEARch:RESult:SENT:FRAMe<m>:SYMBol?` on page 1436
- `SEARch:RESult:SENT:FRAMe<m>:SYNCduration?` on page 1437

- SEARch:RESult:SENT:FRAMe<m>:TYPE? on page 1437

12.13 Custom: Manchester / NRZ (Option R&S RTE-K50)

R&S RTE-K50 is a firmware option that enables the R&S RTE to analyze customizable serial bus signals encoded by the following coding standards:

- Manchester
- Manchester II
- NRZ Clocked
- NRZ Unclocked

For analysis, signals encoded in any of these protocols can be triggered and decoded.

Due to the free format description, no search within the decoded events is available.

This chapter describes:

12.13.1 Custom: Manchester / NRZ Protocols

"Manchester" coding is a self-clocked coding scheme also known as phase-shift keying (or phase encoding, PE). It is used in protocols such as ProfiBus (IEC 61158), DALI (Digital Addressable Lighting Interface, IEC 60929 and IEC 62386), MVB (Multifunction Vehicle Bus, part of IEC 61375 for Train Communication Networks, TCN), and Ethernet 10BASE-T (10 Mbit/s, IEEE 802.3i). In terms of a logical Boolean operation, the Manchester value of each bit (as per G. E. Thomas) is the exclusive disjunction (XOR) of the original data value and the clock value. A "0" is expressed by a high-to-low transition, a "1" by a low-to-high transition. These transitions, which occur at the middle of each bit period, make the signal self-clocked.

"Manchester II" coding (as per IEEE 802.3) is represented by inverted Manchester values: a "0" is expressed by a low-to-high transition, a "1" by a high-to-low transition.

NRZ stands for "non-return-to-zero" coding: Typically a "1" is represented by a positive voltage and a "0" is represented by a negative voltage, with no "zero" voltage state. NRZ code requires only half the bandwidth of Manchester code, and it can either be clocked or unclocked. NRZ unclocked signals require a user-defined bit rate and gap time setting for triggering and decoding.

12.13.1.1 Special Features of Manchester Coding

In practical protocols, Manchester coding appears in many variations, often employing deliberate coding violations to encode special waveform features, such as unambiguous synchronization and termination patterns. To adapt to these specific Manchester implementations and handle ambiguous signals, the option R&S RTE-K50 for Custom Serial Bus uses a combination of automatic algorithms and user configurable parameters.

Quaternary Symbols

The software supports not just traditional binary symbols "0" and "1", but also arbitrary violation waveforms that use two additional symbols, yielding a total of four valid "quaternary bit" values. The two additional violation symbols are "H" (high) and "L" (low). Values of "H" correspond to a waveform lacking a transition in the center of the bit, with a physical high voltage state. Similarly, "L" violations also lack a center transition, but have a physical low voltage state. Most Manchester synchronization and termination conventions, even those containing violations, may be expressed as sequences of these four symbols. R&S RTE-K50 uses the quaternary notation to support Manchester patterns in the honeycomb display and to describe synchronization and termination patterns in the frame description table.

Idle Conditions

The state of the signal line in between messages is the idle condition. Manchester appears in practical standards with varying idle conditions: it can idle at the high, low, or middle voltage state. High and low idle states correspond to "biphase" Manchester, while the middle voltage (often ground) adds a third state to become "ternary" Manchester. Using ternary Manchester, option R&S RTE-K50 can usually establish the gaps between messages automatically. Using binary Manchester, the software has no way to automatically discriminate an idling bus from monotonic sequences of "H" or "L" violations. For these biphase situations, R&S RTE-K50 offers a "Gap Time" detection feature, which allows to distinguish long intervals of non-transitions between bus idling and sequences of violations. Other differences between biphase and ternary Manchester are managed automatically by the software, with no user input required.

Edge Conventions

Most Manchester encodings establish the beginning of the first bit by a first transition, hence an "overhead" edge. The center of the bit is then marked by a second transition, which is a "sampling" edge. Some Manchester implementations, however, sample the first bit on the first edge. The option R&S RTE-K50 attempts to automatically detect this situation. Unfortunately, it is possible to trick the algorithm with waveforms that contain many (legitimate) violations. In these situations, the user can force a "First Edge" or "Second Edge" convention for handling edges. Edge sampling according to the "First Edge" convention is more likely to appear in biphase Manchester, but the software also supports this setting for ternary Manchester situations.

Bit Rate

Typically, a single bit rate is clearly specified in Manchester protocols; however, some implementations use a variable bit rate. By default, R&S RTE-K50 automatically determines the bit rate with no user input required. However, there are fundamental ambiguities possible in Manchester, if the bitrate is unknown. In particular, sequences like "0000", "1111", "0101", "1010", and many situations involving "H" and "L" violations, cannot be decoded without a known bit rate. The situation becomes even less defined with eventual Manchester coding violations. In these situations, a fixed "Bit Rate" setting has to be provided by the user to bypass the software's estimation algorithm.

12.13.2 Custom: Manchester / NRZ Configuration

If you need information on how to get started with configuring the custom serial bus setup, see Chapter 12.13.2.5, "Configuring Custom Manchester / NRZ Signals", on page 678. Otherwise proceed with the configuration settings.

12.13.2.1 Custom: Manchester / NRZ Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *Custom*

Make sure that the tab of the correct serial bus is selected on the left side.

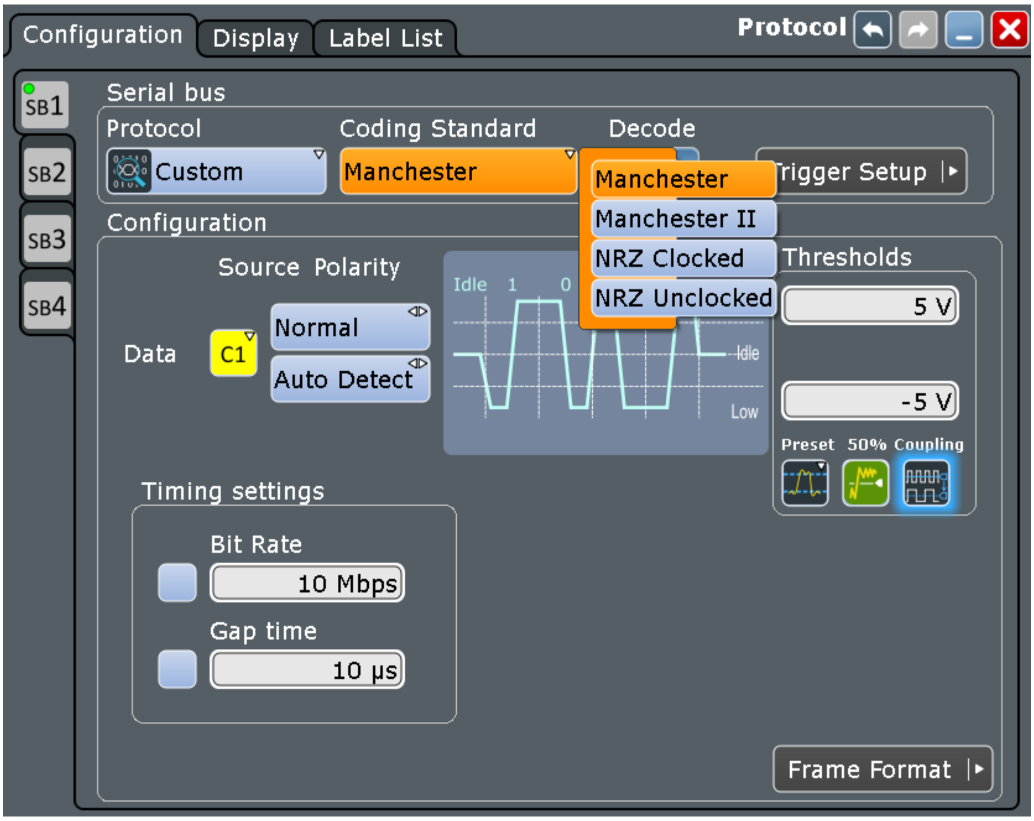


Figure 12-72: Coding standard selection in the serial bus protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Coding Standard

To define the coding of the custom serial bus to be analyzed, select one of the following standards:

"Manchester" Selects the coding standard Manchester.
Optional "Timing settings" are "Bit Rate" (default: disabled, 10 Mbit/s) and "Gap time" (default: disabled, 10 μs), as shown in Figure 12-72.

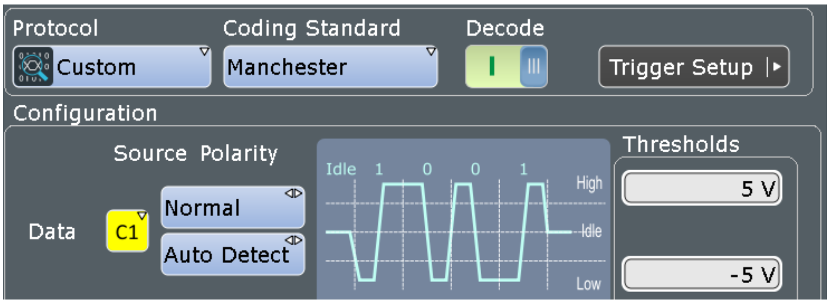


Figure 12-73: Custom serial bus coding configuration Manchester

"Manchester II" Selects the coding standard Manchester II, which is the inverted signal of the coding standard Manchester.
Optional "Timing settings" are "Bit Rate" (default: disabled, 10 Mbit/s) and "Gap time" (default: disabled, 10 μs), as shown in Figure 12-72.

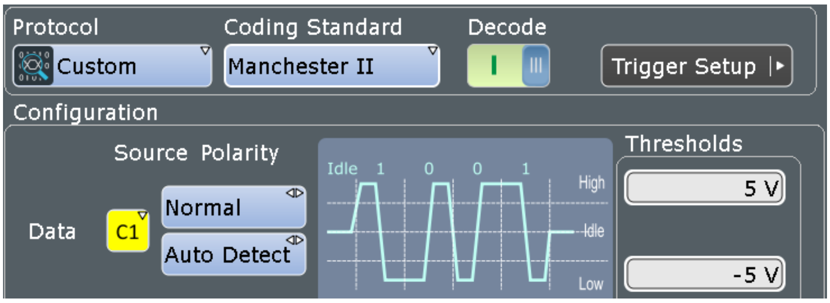


Figure 12-74: Custom serial bus coding configuration Manchester II

"NRZ Clocked" Selects the coding standard NRZ Clocked.
Optional "Timing settings" is "Gap time" (default: disabled, 10 μs), as shown in Figure 12-75.

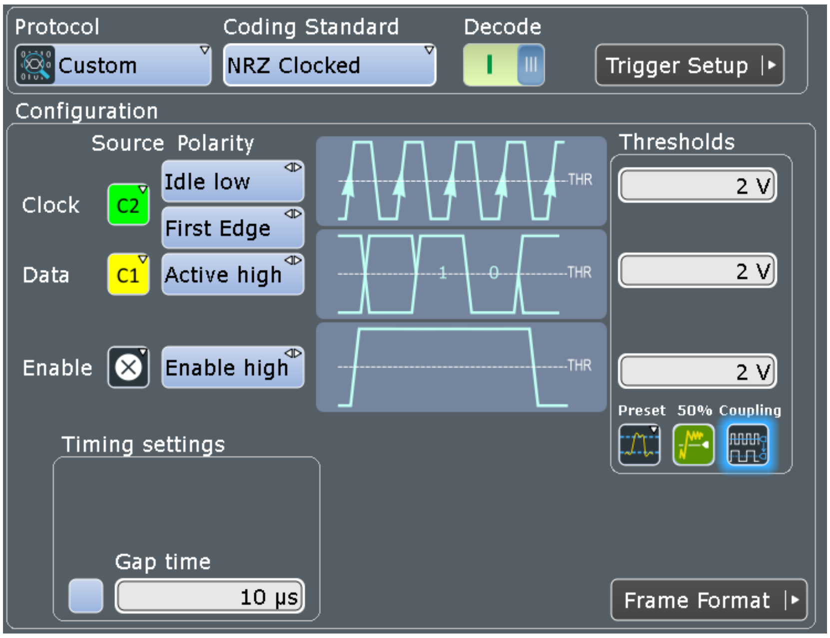


Figure 12-75: Custom serial bus coding configuration NRZ Clocked

"NRZ Unclocked" Selects the coding standard NRZ Unclocked.
Obligatory "Timing settings" are "Bit Rate" (default 10 Mbit/s) and "Gap time" (default 10 μs), as shown in Figure 12-76.

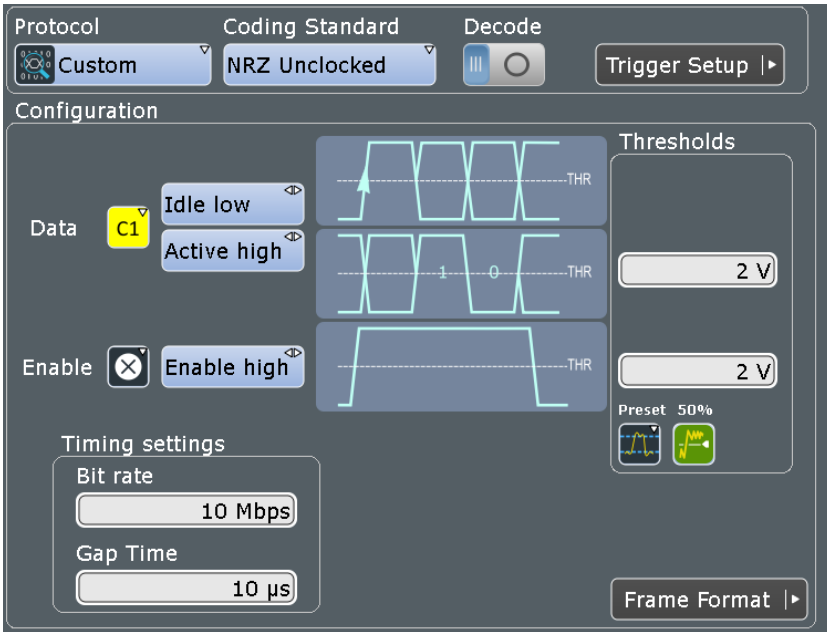


Figure 12-76: Custom serial bus coding configuration NRZ Unclocked

Remote command:
`BUS<m>:CMSB:CODing` on page 1438

Data Source
Defines the input source for the custom serial bus data signal.

The data source for Manchester and NRZ coding standards are selected separately, independent of each other. The data source is set to default upon switching the coding standard.

Permitted source selections are:
- For "Manchester"/ "Manchester II":
  – Deocding: the analog, mathematical, and reference channels
  – Triggering: the analog channels
- For "NRZ Clocked":
  – Deocding: the analog, mathematical, reference and digital channels
    Digital channels can be only used if MSO option R&S RTE-B1 is installed. Digital and analog channels cannot be used at the same time.
  – Triggering: the analog and digital channels
- For "NRZ Unclocked":
  – Deocding: the analog, mathematical, reference and digital channels
    Digital channels can be only used if MSO option R&S RTE-B1 is installed. Digital and analog channels cannot be used at the same time.
  – Triggering: the analog channels

Remote command:
`BUS<m>:CMSB:MANChester:DATA` on page 1439
`BUS<m>:CMSB:NRZ:DATA` on page 1442

Clock Source
Defines the source for the custom serial bus clock signal (only available for the coding standard "NRZ Clocked").

Permitted source selections are the analog, mathematical, reference and digital channels.

Digital channels can be only used if MSO option R&S RTE-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on the serial bus when the NRZ clocked coding standard is selected, analog or digital channel sources are required.

Remote command:
`BUS<m>:CMSB:NRZ:CLCK` on page 1441

Data Polarity (Manchester)
Defines the polarity of the custom serial bus data signal in Manchester coding standards. The available settings are "Normal" or "Inverted".

Remote command:
`BUS<m>:CMSB:MANChester:POLarity` on page 1439

Data Polarity (NRZ)
Defines the polarity of the custom serial bus data signal in NRZ coding standards. The available settings are:

"Active high" The value "1" is represented by a voltage above the threshold.

"Active low" The value "1" is represented by a voltage below the threshold.

Remote command:
BUS<m>:CMSB:NRZ:POLarity on page 1444

Data Idle Polarity (NRZ Unclocked)
Defines the idle polarity of the custom serial bus data signal (only available for the coding standard "NRZ Unclocked"). The available settings are:

"Idle low" The base value of the clock is "0"; after an idle period, the data signal starts with a low-to-high transition.

"Idle high" The base value of the clock is "1"; after an idle period, the data signal starts with a high-to-low transition.

Remote command:
BUS<m>:CMSB:NRZ:IDLPolarity on page 1442

Clock Polarity (NRZ Clocked)
Defines the polarity of the custom serial bus clock signal (only available for the coding standard "NRZ Clocked"). The available settings are:

"Idle low" The base value of the clock is "0".

"Idle high" The base value of the clock is "1".

Remote command:
BUS<m>:CMSB:NRZ:CPOLarity on page 1443

Clock Phase (Manchester)
Defines the phase of the custom serial bus clock signal for the Manchester coding standards. The available settings are:

"Auto Detect" Lets the decoder automatically select the method ("First Edge" or "Second Edge") for detecting the clock phase.

"First Edge"
- At "Idle" = "low": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge.
- At "Idle" = "high": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge.

"Second Edge"
- At "Idle" = "low": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge.
- At "Idle" = "high": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge.

Note: The requirement to specify "First Edge" or "Second Edge" (or let the decoder decide) has the following background: In Manchester coding, an edge is always a transition from high to low (0) or from low to high (1). However, if the signal comes from the idle state, this implies that right before the first valid edge, there is always an overhead transition from idle to high or from idle to low. Some standards may regard this as a valid transition. To avoid a potentially ambiguous situation, a decision has to be made if the first edge is indeed only some overhead transition - or a transition that needs to be sampled.

For more details on edge conditions, see Chapter 12.13.1.1, "Special Features of Manchester Coding", on page 657.

Remote command:
`BUS<m>:CMSB:MANChester:CPHase` on page 1441

Clock Phase (NRZ Clocked)

Defines the phase of the custom serial bus clock signal for the coding standard "NRZ Clocked", depending on "Clock Polarity". The available settings are:

"First Edge"
- At "Idle" = "low": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge
- At "Idle" = "high": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge

"Second Edge"
- At "Idle" = "low": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge
- At "Idle" = "high": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge

Remote command:
`BUS<m>:CMSB:NRZ:CPHase` on page 1443

Enable Source (NRZ)

Defines the input source for the custom serial bus enable signal.

If an input is chosen, signals are only decoded when this channel is in the enabled state. This allows you to mark a time when the signal on the selected source is active and when not.

Permitted source selections are the analog, mathematical, and reference channels.

As soon as the serial bus trigger has been selected, the only permitted source selections are the analog channels "C1" – "C4", which are required for triggering.

Math and Ref channels can only be selected, if no serial bus trigger is selected.

Remote command:
`BUS<m>:CMSB:NRZ:ENBLe` on page 1443

Enable Polarity (NRZ)
Selects whether the transmitted enable signal is active when the voltage is below the Thresholds ("Enable low") or higher than it ("Enable high").

Remote command:
`BUS<m>:CMSB:NRZ:ENAPolarity` on page 1444

Thresholds
Sets the threshold value for the digitization of each signal line. If the signal voltage on the line is higher than the upper threshold, the signal state is high. Otherwise, if the signal voltage is below the lower threshold, the signal state is considered low.

- Manchester coding standards use 3-state signals with an upper and a lower voltage threshold in the range of -25 V to +25 V. A low-to-high transition requires the signal to exceed the upper threshold; a high-to-low transition requires the signal to fall below the lower threshold.
- NRZ coding standards use a single voltage threshold for the data line. The value in the range of -25 V to +25 V is entered into the middle of three available threshold input fields, or into the upper available threshold input field in case of NRZ Unclocked.
- In the NRZ Clocked coding standard, there is an additional clock voltage threshold available. This value in the range of -25 V to +25 V is entered into the upper threshold input field.

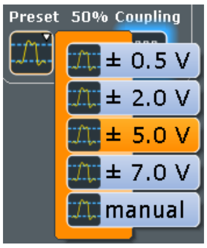
There are four ways to set the threshold:

"Threshold" Directly sets the threshold values.

- For Manchester: upper threshold in the upper field, lower threshold in the lower field.
- For NRZ Clocked: clock threshold in the upper field, data threshold in the middle field and enable threshold in the lower field.
- For NRZ Unclocked: data threshold in the upper field and enable threshold in the lower field.

Remote command:
`BUS<m>:CMSB:MANChester:THReshold:HIGH` on page 1440
`BUS<m>:CMSB:MANChester:THReshold:LOW` on page 1440
`BUS<m>:CMSB:NRZ:THReshold:CLCK` on page 1445
`BUS<m>:CMSB:NRZ:THReshold:DATA` on page 1445
`BUS<m>:CMSB:NRZ:THReshold:ENBLe` on page 1445

"Preset"
- Either sets individual voltages by selecting "manual",
- or sets the voltages to one out of various pre-defined levels.



As soon as any non-predefined threshold is set, the "Preset" status automatically changes to "manual" (without affecting anything else).

Remote command:
BUS<m>:CMSB:MANChester:THReshold:PRESet on page 1440
BUS<m>:CMSB:NRZ:THReshold:PRESet on page 1446

"50%" Executes a measurement of reference levels and sets the thresholds to the middle reference voltage level of the measured amplitude.

Remote command:
BUS<m>:SETReflevels on page 1163

"Coupling"
- In case of Manchester and Manchester II coding, the upper and lower threshold are coupled to voltage values with the same magnitude but opposite sign (positive for the upper threshold and negative for the lower threshold). However, if the upper threshold is set to a negative voltage or the lower threshold is set to a positive voltage, coupling is disabled, and the other voltage (the one that was not actively set) is automatically adjusted, to avoid an upper threshold below the lower one, or a lower threshold above the upper one.
- In case of NRZ Clocked coding, the clock and data threshold values are coupled to the same voltage.

Remote command:
BUS<m>:CMSB:MANChester:THReshold:COUPling on page 1441
BUS<m>:CMSB:NRZ:THReshold:COUPling on page 1446

Enable Bit Rate
Enables the bit rate settings for the coding standards "Manchester" and "Manchester II" (not available for "NRZ Clocked", but always enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard).

Remote command:
BUS<m>:CMSB:BITRate:ENABle on page 1446

Bit Rate
Defines the transmission speed setting for the data signal. A bit rate definition is optional for the coding standards "Manchester" and "Manchester II", not available for "NRZ Clocked", but obligatory for "NRZ Unclocked" (and also for triggering on signals in any coding standard). Default bit rate is 10 Mbps, permitted bit rates range from 300 bps to 50 Mbps.

For more details on the bit rate, see Chapter 12.13.1.1, "Special Features of Manchester Coding", on page 657.

Remote command:
`BUS<m>:CMSB:BITRate:VALue` on page 1447

Enable Gap Time
Enables the gap time settings (always enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard).

Remote command:
`BUS<m>:CMSB:GAPTime:ENABle` on page 1447

Gap time
Specifies a minimum gap time (idle time or timeout) between two frames. A gap time definition is optional for the coding standards "Manchester", "Manchester II" and "NRZ Clocked", but obligatory for "NRZ Unclocked" (and also for triggering on signals in any coding standard). Default gap time is 10 µs, permitted gap times range from 1 ns to 1 s.

For more details on gap time and idle conditions, see Chapter 12.13.1.1, "Special Features of Manchester Coding", on page 657.

Remote command:
`BUS<m>:CMSB:GAPTime:VALue` on page 1447

Trigger Setup
The navigation button "Trigger Setup" in the upper right corner of the protocol configuration menu (Figure 12-72) opens the trigger setup dialog, which is described in Chapter 12.13.3, "Custom: Manchester / NRZ Trigger", on page 679.

Frame Format
The navigation button "Frame Format" in the lower right corner of the protocol configuration menu (Figure 12-72) opens the frame format dialog, which is described in Chapter 12.13.2.2, "Frame Format Configuration", on page 667.

12.13.2.2 Frame Format Configuration

This dialog enables the user to describe the generic format and logical structure of typical protocols by creating customized frame descriptions of various structure and length.

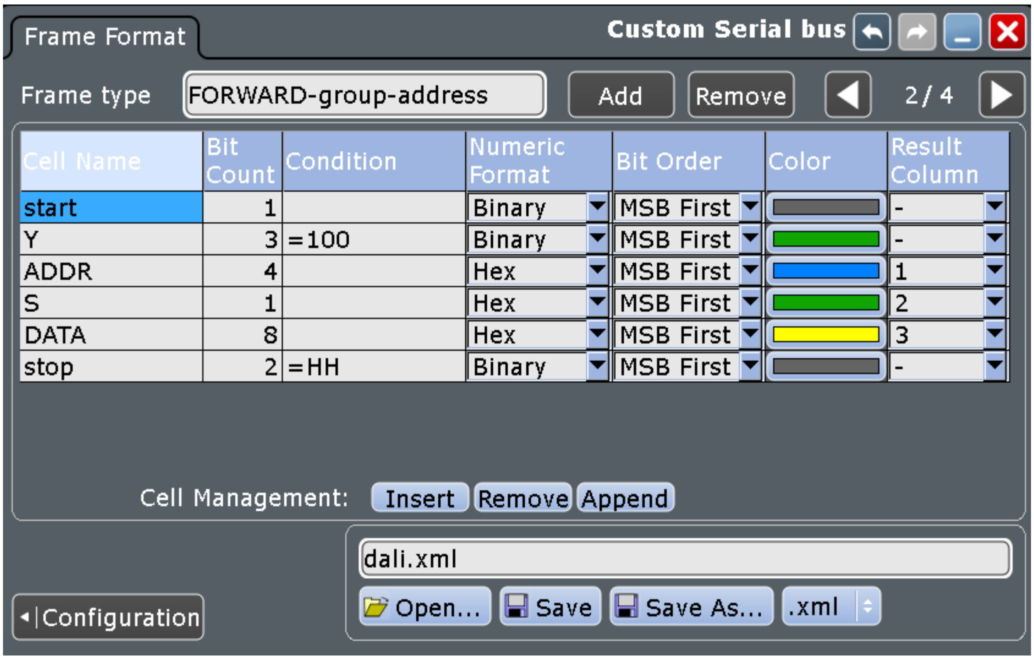


Figure 12-77: Example of a custom "DALI" frame format description (frame 2 of 4)

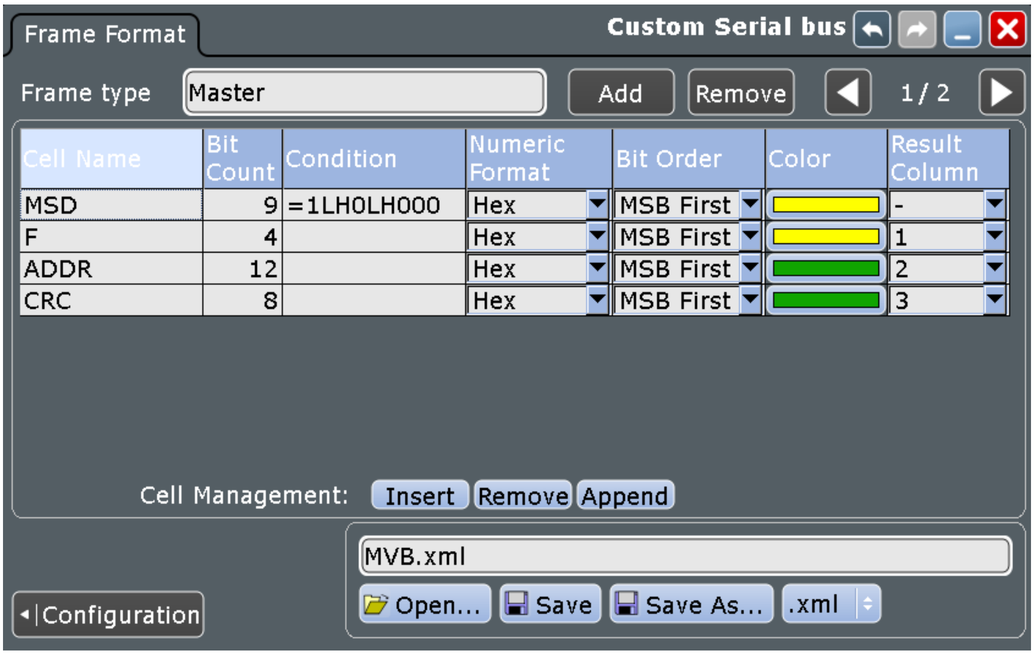


Figure 12-78: Example of a custom "MVB" frame format description (frame 1 of 2)

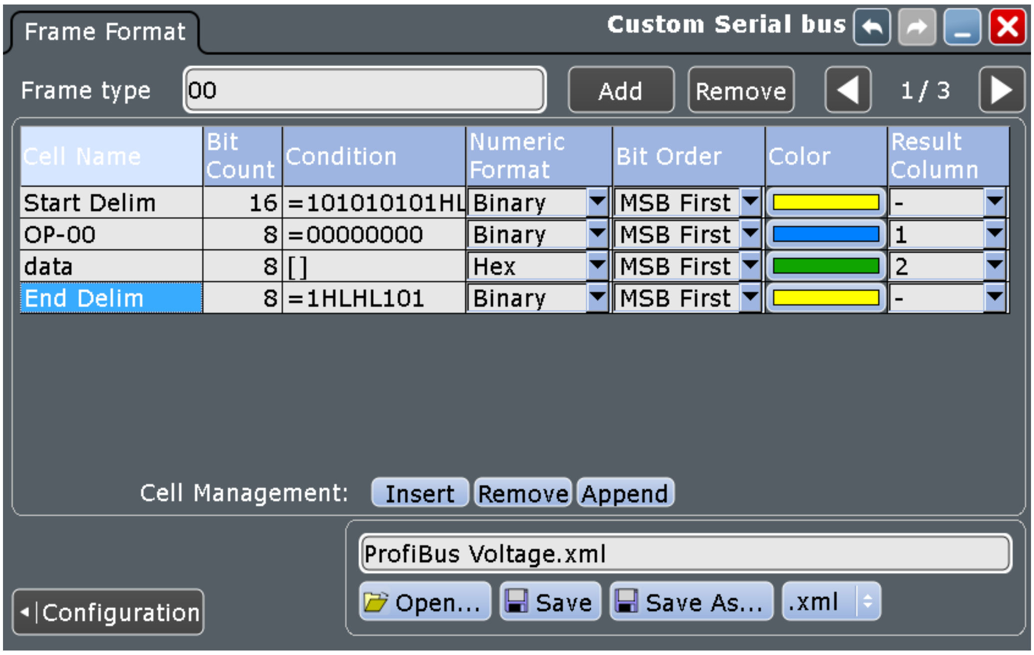


Figure 12-79: Example of a custom "ProfiBus Voltage" frame format description (frame 1 of 3)

Frames

A frame format description (or *frame description*, for short) is represented by one "page" in this dialog. It can be created by clicking on "Add". If one or several frame descriptions already exist, the new frame description is then created at the end of the frame format description list (or *frame list*, for short). Describing a frame format requires assigning it a name as well as creating Cells and specifying cell descriptions. The number of frame descriptions is limited to 50. The frame description that is currently on display can be deleted from the frame list by clicking on "Remove".

The "Frame type" string is intended for the user to label the frame description (typically according to the specifications of the applicable protocol standard). For example, MDIO (Management Data Input/Output) specifies the frames "READ", "WRITE", "ADDRESS", etc. The example for the DALI protocol in Figure 12-77 has been created with the frame type "*FORWARD-group-address*".

The frame format dialog also provides the features "Open", "Save", "Save As...", and "Explore...", to store created sets of frame descriptions into files (in ".xml" format), or load existing files of this kind.

The frame identification is executed top down, in the order in which the frame formats are described in the frame list. This provides a hierarchy of criteria for identifying frames.

In case it is required to change the order of previously created frame descriptions, it is recommended to save the set of frame descriptions, and then edit the XML file with any suitable editor. (This also allows - with due care - additional editing features, if required.)

If no user-defined frame description should be suitable to identify an incoming frame, per default such a "missed" frame is reproduced as "Undescribed Bits" in the honeycomb display, as in the example in Figure 12-86. These bits are not shown in the results table.

Note: There may be frame descriptions that will positively identify each kind of frame, e.g. if no **equal** operator (see Condition) is defined for any of the cells. This will "catch" every single frame, even if there are other frame descriptions to follow in the frame list. Therefore, if a "catch all" frame description is used, it should be placed at the end of the frame list, or it will overwrite any subsequent frame description. However, instead of using a "catch all" frame description, the built-in "undescribed bits" display as mentioned above may be the better approach to create frame descriptions.

It is in the responsibility of the user to define unambiguous settings for each frame type. For a description of these conditions in `XML` file format and the required `XML` grammar and syntax, see Chapter 12.13.2.3, "XML Syntax", on page 676.

Remote command:
`BUS<m>:CMSB:FRAMe<n>:TYPE` on page 1448
`BUS<m>:CMSB:ADDFrame` on page 1448
`BUS<m>:CMSB:CLR` on page 1448
`BUS<m>:CMSB:FCOunt?` on page 1448

Cells

A cell description (which is represented by one row in one frame description) can be created at any position of a frame description (see Frames) by clicking on "Insert". This brings up a new cell description in the active frame description, on top of the selected position. The "Append" button adds a cell description at the end of a frame description, below the lowest existing cell description. The number of cell descriptions is not limited. The "Remove" button deletes a selected cell description from the active frame description.

The cell result can be selected to be displayed in a specified result column of the decode table (see "Result Column" on page 675).

Note: The cell descriptions must be sequential and complete. No gaps are allowed, since the Bit Count is used to calculate the start position of the next cell.

A frame type is identified as soon as all user-defined cell conditions are met, which can be regarded as related by the Boolean AND operator.

This can also locate a synchronization pattern, specified by the equal operator in the Condition cell. For example, if the user defines a "Preamble" cell with the condition *=FFFFFFFF*, the decoder will scan the data for this pattern, and then synchronize to it.

The cells in a frame are described by:

- Cell Name
- Bit Count
- Condition
- Numeric Format
- Bit Order
- Color
- Result Column

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CCOunt?` on page 1449
`BUS<m>:CMSB:FRAMe<n>:APPend` on page 1448

Cell Name

The strings in the column title describe cell names. They do not have to be unique; cell names are just for user support.

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:NAME` on page 1449

Bit Count

This crucial information defines the length of the cell and - based upon the previous cells - also the cell end position and the next cell start position within a frame.

If, for a given bit count, the Condition value is longer, it will be truncated. If the condition value is shorter, it will be padded with 0. Both truncation and padding occur at the left side of the condition value.

Examples:
- if "Condition" is "=111000" and the Bit Order is "MSB", then
  - if "Bit Count" is 4, the truncated condition is "=1000"
  - if "Bit Count" is 8, the padded condition is "=00111000"
- if "Condition" is "=111000" and the bit order is "LSB" (accordingly, the condition in "MSB" format would be "=000111"), then
  - if "Bit Count" is 4, the truncated condition is "=1000" for LSB and "=0001" for MSB
  - if "Bit Count" is 8, the padded condition is "=00111000" for LSB and "=00011100" for MSB

These examples are true for the Numeric Format specified as "binary".

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITCount` on page 1449

Condition

This text field is used to apply various conditions and functionalities for a cell. Among others, it can be used to identify mandatory values (such as CRC checksum or ID) that help to identify a frame. The numeric format and bit order of the condition value has to match up with what is defined in the fields Numeric Format and Bit Order.

The following conditions are implemented:

"= (equal)"

The **equal** operator (represented by the "=" sign) defines a pattern for the cell to match. Valid condition entries are characters that match the cell's defined Numeric Format, Bit Order, and Bit Count. In binary format, for example, valid characters are "1", "0", "H" (high), and "L" (low).

Three cases have to be distinguished (cases A, B1, and B2), depending on the presence of a Variable Length Array: [] in the same frame description:

- **Case A**: If there is **no** "Variable Length Array" cell, then each cell marked with the equal operator acts as a key to identify a frame type. Only if all these cells match up with the expected value, the frame type will be identified.
- **Cases B1 and B2**: If there **is** a "Variable Length Array" cell, then the equal operator has two different functionalities, depending on the position of the equal-operator cell within the frame description:
  – **B1**: If the cell is located *anywhere before* the "Variable Length Array" cell, the condition acts as a key to identify a frame type (as in case A).
  – **B2**: If the cell is located *immediately after* the "Variable Length Array" cell, the condition acts as an array delimiter. (Note: If the cell, which is marked with the equal operator, is located after the "Variable Length Array" cell, but *not* immediately after it, the decode result is unpredictable.)

Typically, Manchester protocols use code violations for synchronization. The states "H" and "L", supported by the equal operator in binary Numeric Format, mark that a transition is expected at this bit, but only a high or low signal is found.
Examples for the MVB protocol:
Master - Delimiter: "*=1LH0LH000*" (also shown in Figure 12-78)
Slave - Delimiter: "*=0000LH0LH*"
For more details on the violation symbols "H" and "L", see Chapter 12.13.1.1, "Special Features of Manchester Coding", on page 657.
Also, the length of the pattern must correspond to the bit field length (or the results are unpredictable).

"[ ] (array)"

The **array** operator (represented by the "[" and "]" bracket signs) defines the number of permissible repetitions of the cell.

Example: Fixed Length Array: [n]

The length parameter "n" is a decimal number > 0, which determines that the cell will be repeated n times within the frame. If, for example, the Bit Count is 8, then the array operator will identify n cells of 8 bit length, and present them in the results table and honeycomb display with the specified name and color.

A fixed length array is treated the same as other cells, except the real length of such an array is n · bit count.

Example: Variable Length Array: []

This array operator with empty "[" and "]" bracket signs does not determine a fixed size array. The cell could be repeated any number of times, including 0 times. As a result, the cell and the frame are of unspecified length (a situation that covers typical use cases). For an example, see Figure 12-79.

The length of the frame is then determined by the end of frame condition, which can be an operator or a gap.

For processing reasons, only one (1) variable length array is supported in a frame, and a delimiter must follow immediately in the next cell after it. This is required to enable the software to correctly terminate the array. Otherwise the bits could not be assigned correctly, and it would not be possible to determine where a repletion starts and where it ends. With an end of frame condition, the software can calculate the length of one single array within a frame. But if there were more arrays, it would be impossible to know which array was how long.

The variable length array can also be the last cell of a frame. In this case, no delimiter is required. If decoded successfully, the detailed view in the results table shows the elements of the array. If the cell name of the array is "Data", then the detail view of result table displays the elements with an array index as "Data: 1", "Data: 2" ... etc.

If the variable length array cell is selected in the Result Column, it is shown as array [n], where n is the actual size detected in the waveform.

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:CONDition` on page 1449

Numeric Format
Selects from the following numeric data formats for the Condition value:
- Decimal
- Hexadecimal
- Octal
- Binary

The following rules apply:

- If the condition value contains at least one "H", "h", "L", "l", "X", "x", and the remaining characters only contain "1" and/or "0", the numeric format is automatically interpreted as binary, regardless of its definition.
- The wild-card characters "x" and "X" are only supported in binary format.
  Examples: if the numeric format is set to be "HEX", then
  – "=1HL111000" is valid (read as binary)
  – "=0x10101" is valid (read as binary, the "x" is interpreted here as a wild card)
  – "=1010" is valid (read as HEX, with a total of 16 bits)
  – "=0x5A" is valid (read as HEX "5A", since "0x" is a valid HEX prefix; nevertheless, it is recommended to enter "5A" instead)
  – "=5X12" is invalid
  – "=1H33" is invalid

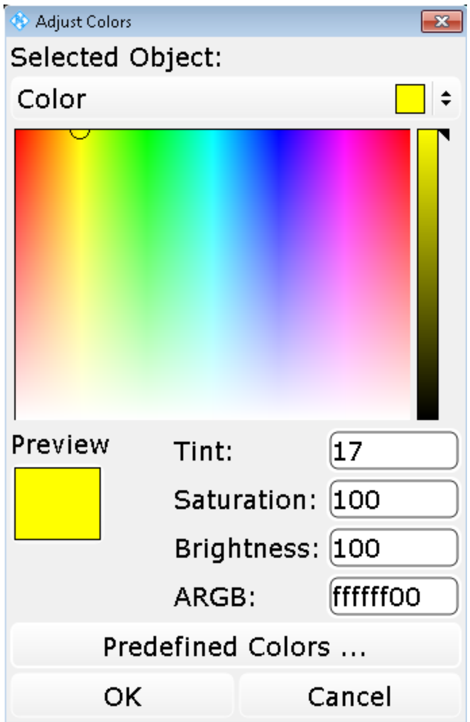
Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:FORMat` on page 1450

Bit Order
This defines, in which order the bits of a cell's Condition value are evaluated: either the most significant bit (MSB) or the least significant bit (LSB) first. Since the bit order is taken into consideration for the interpretation of the condition, the user should specify MSB or LSB correctly.

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITorder` on page 1450

Color
Opens a dialog to select the color representation of different cells in the honeycomb display. Assigning user-selected colors helps to interpret the decode results more easily.

In the "Adjust Colors" dialog, you can either select one of the predifined colors or define a new one.



Remote command:
BUS<m>:CMSB:FRAMe<n>:CELL<o>:CRGB on page 1451

Result Column

This determines which cells shall be displayed in which result columns of the decode table. No index means that the result is not displayed. The decode table supports three result columns, which have to be unique for each frame type. For different frame types, though, the user can define different result columns, to display unrelated information.

Note: To see more than the three selected results, bring up a full list of the states and values of all cells by activating "Show details" in the decode table dialog. For an example, see Figure 12-85.

Remote command:
BUS<m>:CMSB:FRAMe<n>:CELL<o>:CLMN on page 1451

Open or Save XML File

For efficient working and for convenient exchange of frame descriptions, they can both be loaded ("Open") or saved ("Save" / "Save As...") in XML file format. "Explore..." opens the SaveXML folder, which is the "Default Path" for saving frame descriptions.

Remote command:
BUS<m>:CMSB:LOAD on page 1452
BUS<m>:CMSB:SAVE on page 1452

12.13.2.3 XML Syntax

This chapter explains the required grammar and syntax of `XML` files, which contain frame descriptions and can be loaded or saved. Below is a typical example of such an `XML` file:

```xml
<?xml version="1.0" encoding="utf-8"?>
<FrameDescription xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" Version="1" xsi:noNamespaceSchemaLocation=".\Schema\FrameDescription.xsd">
  <Frame Type="00">
    <Format Name="Start Delim" BitCount="16" Condition="=101010101HL" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
    <Format Name="OP-00" BitCount="8" Condition="=00000000" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="0080ff" Column="1"/>
    <Format Name="data" BitCount="8" Condition="[]" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="10a500" Column="2"/>
    <Format Name="End Delim" BitCount="8" Condition="=1HLHL101" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
  </Frame>
  <Frame Type="01">
    <Format Name="Start Delim" BitCount="16" Condition="=101010101HL" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
    <Format Name="OP-01" BitCount="8" Condition="=00000001" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="0080ff" Column="1"/>
    <Format Name="data" BitCount="8" Condition="[]" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="10a500" Column="2"/>
    <Format Name="CRC" BitCount="16" Condition="" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="ff808080" Column="2"/>
    <Format Name="End Delim" BitCount="8" Condition="=1HLHL101" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00"" Column="-"/>
  </Frame>    <Frame Type="ff">
    <Format Name="Start Delim" BitCount="16" Condition="=101010101HL" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
    <Format Name="OP-ff" BitCount="8" Condition="=11111111" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="0080ff" Column="1"/>
    <Format Name="data" BitCount="8" Condition="[]" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="ffb233af" Column="2"/>
    <Format Name="CRC" BitCount="16" Condition="" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="ff808080" Column="2"/>
    <Format Name="End Delim" BitCount="8" Condition="=1HLHL101" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
  </Frame>
</FrameDescription>
```

Figure 12-80: Example of XML file syntax with three custom frame format descriptions

The first out of three `XML` frames in Figure 12-80 is interpreted by the software in the following way:

Cell Name	Bit Count	Condition	Numeric Format	Bit Order	Color	Result Column
Start Delim	16	=101010101HL	Binary	MSB First		-
OP-00	8	=00000000	Binary	MSB First		1
data	8	[]	Hex	MSB First		2
End Delim	8	=1HLHL101	Binary	MSB First		-

Figure 12-81: Example of one custom frame format description for the MVB protocol

For the context of this figure, see Chapter 12.13.2.2, "Frame Format Configuration", on page 667.

A suitable `XML` file as shown in Figure 12-80 is composed as follows:

Header:

```xml
<?xml version="1.0" encoding="utf-8"?>
```

Root Element:

```xml
<FrameDescription xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 Version="1" xsi:noNamespaceSchemaLocation=".\Schema\FrameDescription.xsd">
```

The root element contains the "Frame Description" attributes, including a link for the file`FrameDescription.xsd`. This schema file, which is installed in the system, enables the software to validate an `XML` file before opening it.

Frame:

A frame description must include between *0* and *n* tags of the following kind:

```
<Frame> </Frame>
```

Frame Type:

Each "<Frame>" tag requires a "Type" attribute in string format:

```
<Frame Type = "string">
```

This tells the software the name of each frame, as described in section Frame Type.

Format:

Each frame must include between *1* and *n* tags of the following kind:

```
<Format> </Format>
```

Together with the attributes, this is written in short form, as in Figure 12-80:

```
<Format attribute... attribute... attribute... />
```

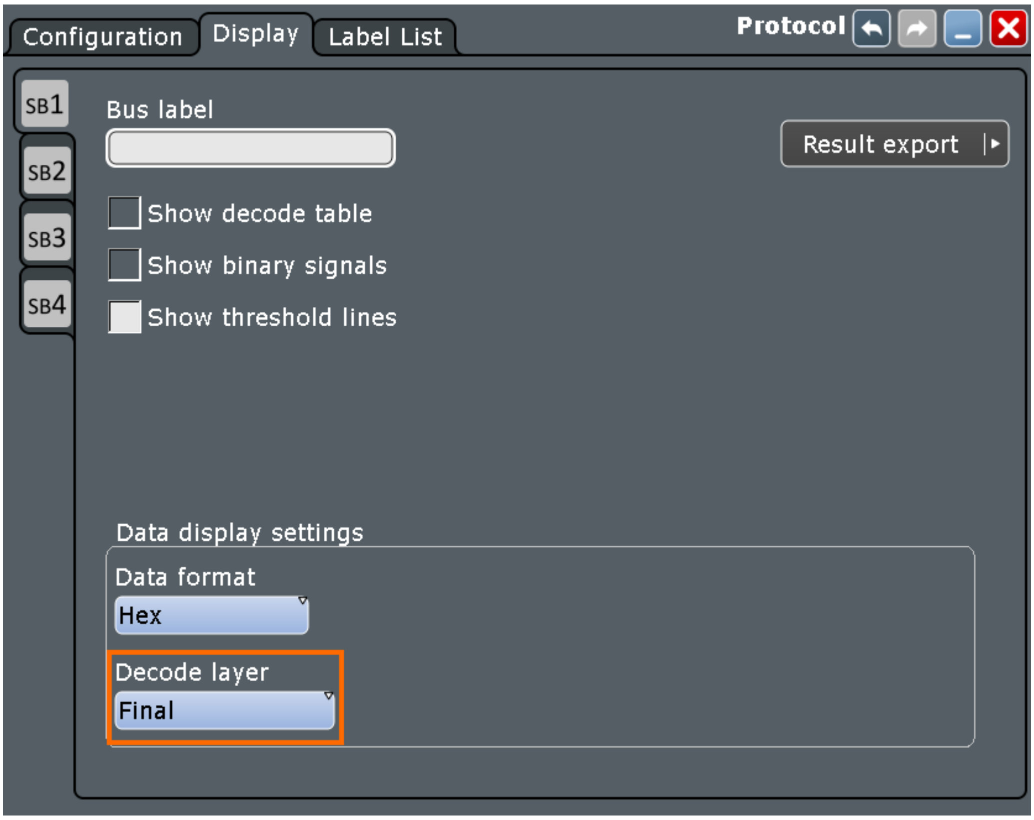
The format describes the fields (or Cells) in each frame. It can have the following attributes:

- Name (optional) is the "Cell Name", in string format.
- BitCount specifies the length of bits, in numerical format.
- Condition (optional) identifies the bit pattern to match, in string format.
- NumericFormat allows the following choices:
  - "Decimal"
  - "Hex"
  - "Octal"
  - "Binary"
- BitOrder allows two alternatives:
  - "MSB First" (most significant bit first)
  - "LSB First" (least significant bit first)
- Color allows to set a user defined ARGB hexadecimal color value.
- Column is the "Result Column" with four options:
  - "-" (none, which is the default
  - "1"
  - "2"
  - "3"

12.13.2.4 Custom: Manchester / NRZ Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = Custom" > "Display" tab

To enhance the decode possibilities of the custom serial protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 440.

Decode layer

Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final"	...
"Edges"	...
"Binary"	...
"Synchronization"	...

12.13.2.5 Configuring Custom Manchester / NRZ Signals

For configuration, assign the lines to the input channels, define the active states and the logical thresholds, and specify frame format descriptions.

Serial Bus Setup

1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the serial bus (SB1–SB4) you want to set up.

3. Select the "Configuration" tab.
4. Tap "Protocol" and select the protocol: "Custom".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Switch to the "Trigger Setup" dialog, tap "Source" and select "Serial bus".

   This prevents using digital waveforms (Math and Ref) as channel signals.

   Note: For triggering on a custom serial bus, analog input channels are required.
7. Switch back to the "Serial Bus Setup" dialog.
8. Tap "Coding Standard" and select the coding ("Manchester", "Manchester II", "NRZ Clocked", or "NRZ Unclocked") you want to set up.
9. Select the polarity and phase of the data signal (and potentially of the clock signal).
10. Set the logical thresholds, see "Thresholds" on page 665.
11. Still in the protocol "Configuration" tab, select "Decode" to activate the decode functionality.
12. Switch to the "Frame Format" dialog and open or create frame format descriptions.

For details on configuration settings, see Chapter 12.13.2.1, "Custom: Manchester / NRZ Configuration Settings", on page 659.

12.13.3 Custom: Manchester / NRZ Trigger

If you need information on how to get started with triggering on Custom serial bus signals, see Chapter 12.13.3.2, "Triggering on Custom Manchester / NRZ Serial Bus", on page 682. Otherwise proceed with the Custom serial bus trigger settings.

12.13.3.1 Custom: Manchester / NRZ Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = Custom"

In this section, all trigger settings are described. Their availability on the instrument depends on the selected coding standard and trigger type. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to the data sheet.

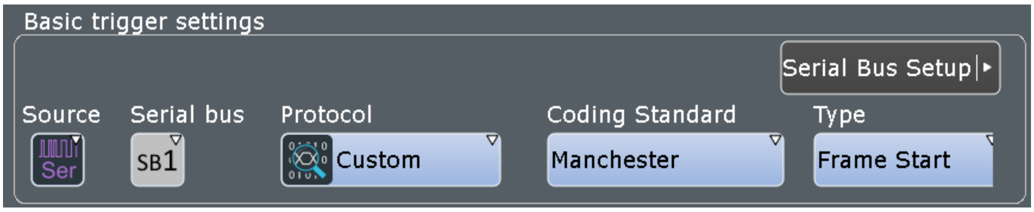


Figure 12-82: Custom serial bus trigger event settings dialog (here with "Manchester" and "Frame Start" selected)

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configu-ration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

Type
Defines the trigger type for custom serial bus analysis. The available trigger types are "Frame Start" and "Pattern".

Remote command:
`TRIGger<m>:CMSB:TYPE` on page 1453

Frame Start ← Type
For Manchester and NRZ Clocked coding standards, the frame start trigger is set to the end of the gap time. The start of frame (SOF) condition is the first bit after the gap (timeout).

For the NRZ Unclocked coding standard, the trigger requires that the signal contains a start bit. The frame start trigger follows the gap time and is set to the end of the start bit.

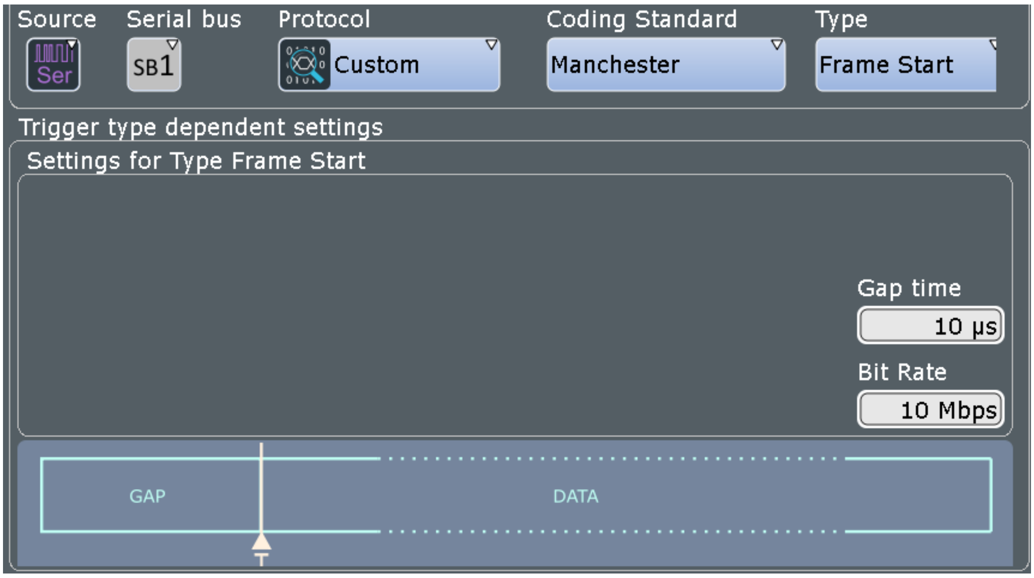


Figure 12-83: Custom serial bus dialog for setting the frame start trigger

Pattern ← Type

Specifies the pattern match conditions for a payload data check. The trigger is set to the first occurrence of a matching data bit pattern (which can be freely specified), starting after the minimum gap time, and after the detected start of the data frame. The trigger instant is after the last bit of the specified data pattern.

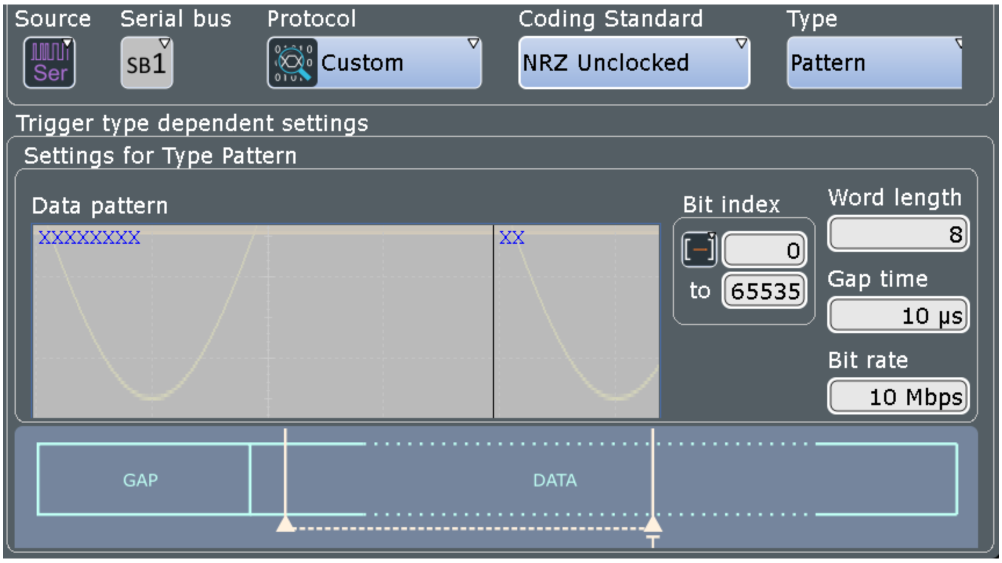


Figure 12-84: Custom serial bus pattern trigger settings dialog (here for coding standard "NRZ Unclocked")

"Data Pattern"	Specifies the data pattern that is to be found and triggered. The pattern can be entered in binary or hexadecimal format, maximum pattern length is 256 binary characters or 64 hexadecimal characters.
"Bit index operator"	Sets the operator ("Equal", "Greater or equal", or "In range") to set a specific bit index (data position).

"Bit index" Sets the bit index (data position), or the start value of a bit index range. Default bit index value is 0, permitted values range from 0 to 65535.

"Bit index to" Sets the end value of a bit index range (data position range). Available only, if the "Bit index operator" is set to "In range". Default bit index end value is 65535, permitted values range from 0 to 65535.

"Word Length" Sets the number of bits in an NRZ Unclocked word (hence, the size of the data frame). Default word length is 8 bits, permitted lengths range from 0 to 31 bits.

Note: The NRZ Unclocked coding standard requires a signal that contains both a start bit and a stop bit:
- The start bit should be opposite in polarity to the idle state of the signal, and it is the first transition detected following the gap time.
- The stop bit should be the same polarity of the idle state, and it is the last bit in a data frame.

The end of the stop bit and the detection of the next frame's start bit constitutes the maximum gap time.

In order for the trigger to operate correctly, the **user has to specify** the correct word length in the trigger menu. The trigger then counts the number of bits it decodes, and when the count matches the word length, the next bit is treated as the stop bit.

"Gap Time" Sets the minimum gap time for synchronization. The trigger is set to a position after the gap time, as soon as the other trigger conditions are met. Default gap time is 10 µs, permitted gap times range from 1 ns to 1 s.

"Bit Rate" Sets the transmission speed for the data signal. Default bit rate is 10 Mbps, permitted bit rates range from 300 bps to 50 Mbps.

Remote command:
`TRIGger<m>:CMSB:PATTern` on page 1453
`TRIGger<m>:CMSB:ICONdition` on page 1453
`TRIGger<m>:CMSB:IMIN` on page 1454
`TRIGger<m>:CMSB:IMAX` on page 1454
`BUS<m>:CMSB:GAPTime:VALue` on page 1447
`TRIGger<m>:CMSB:NRZ:WRDLength` on page 1454

12.13.3.2 Triggering on Custom Manchester / NRZ Serial Bus

Prerequisite: A bus is configured for the custom serial bus signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.13.2.1, "Custom: Manchester / NRZ Configuration Settings", on page 659), tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to Custom serial bus, e.g.:

   The "Protocol" selection is then automatically set to "Custom".

4. Tap "Type" and select the trigger type to be used for custom serial bus protocol analysis.
   Available trigger types are "Frame Start" and "Pattern".

5. Depending on the selected custom serial bus coding standard, more setup conditions have to be specified.

For information on how to proceed with the configuration settings, see Chapter 12.13.3.1, "Custom: Manchester / NRZ Trigger Settings", on page 679.

12.13.4 Custom: Manchester / NRZ Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" (and optionally "Show threshold lines"). For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the Frame Format Configuration settings.

The color-coding of the various Cells simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The Frame Format Configuration defines the cells and their Color scheme. The honeycomb display applies these settings according to the following rules:

- Each frame is displayed as a honeycomb frame with the frame type being displayed (in the 1st line of the honeycomb).
- Each cell (row) is displayed as a honeycomb cell with the name in the header line (2nd line in the honeycomb) and the formatted content in the value line (3rd line in the honeycomb).

Since the frame description is customizable, the result table has to be mostly generic. Due to the limited width of the result table, the user has to select a limited amount of results (i.e., the three results defined in the Result Column) to be displayed by specifying this in the frame description. This leads to a detailed view that shows all information on a per-frame base.

Examples

The example in Figure 12-85 shows decoded and binary signals of a custom serial bus. The format information of DALI is being used to display as a result.

Note that activating "Show details" in the decode table provides a more detailed analysis of decode results for one selected frame. This brings up a list of the states and values of all cells of the selected frame (in binary format). With this details dialog open, the user can still click on the basic decode table, to change the selection of the frame to be displayed in detail.

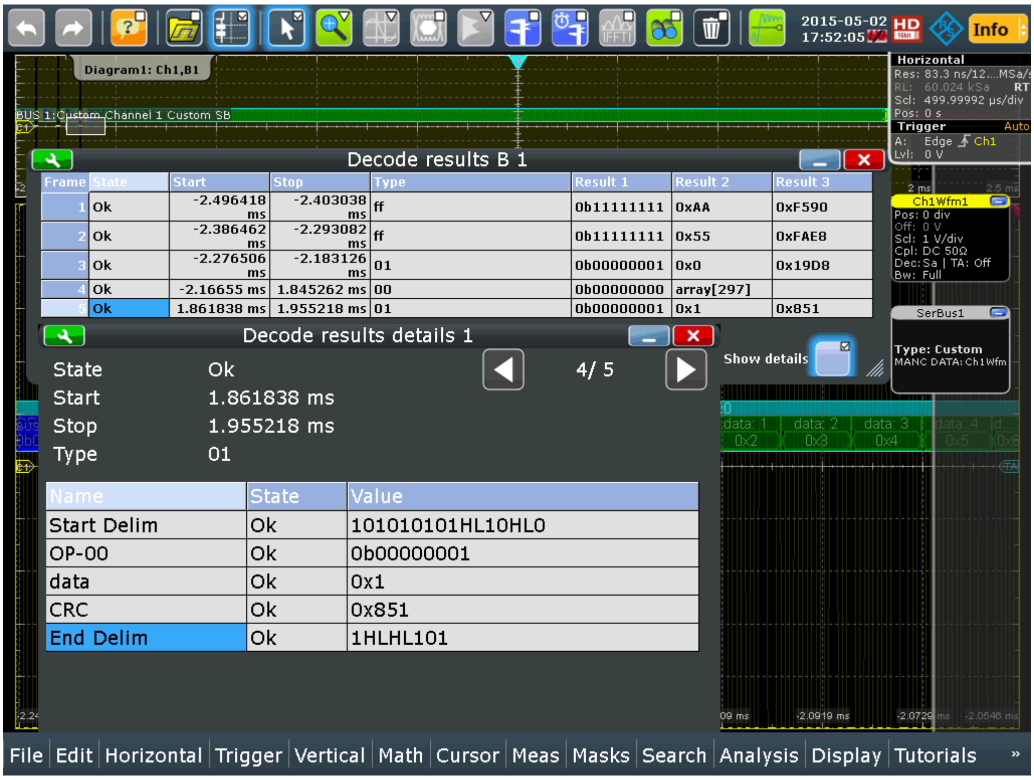


Figure 12-85: Decode results table and details of a "ProfiBus Voltage" protocol sample waveform

In the honeycomb display, Cells are shown in the Color that have been set by the user in the Frame Format Configuration.

For example, the result "array[297]" in "Frame 4", "Result 2" of the decoding table in Figure 12-85, is the short name for an array field display, and the number in the brackets indicates the length of the array, as described in Variable Length Array: [].

The tables "Decode results" and "Decode results details" in Figure 12-85 are described in Table 12-13 and Table 12-14:

Table 12-13: Content of the "Decode results" table

Column	Description
State	Overall state of the frame: either OK or the relevant error condition (e.g. preamble, length)
Start	Start time of the frame

Column	Description
Stop	Stop time of the frame
Type	Frame type as specified in the "Frame type" field of the "Frame Format" description dialog (see "Frames" on page 669)
Result 1	1st cell content as specified in the Result Column of the "Frame Format" description dialog (see "Frames" on page 669)
Result 2	2nd cell content (as above)
Result 3	3rd cell content (as above)

Table 12-14: Content of the "Decode results details" table

Column	Description
Name	Name of the cell (e.g. Start, Data) as specified in the Cell Name column of the "Frame Format" description dialog (see "Frames" on page 669)
State	Overall state of the cell: either OK or the relevant error condition (e.g. length error)
Value	Data content of the cell (e.g. 0x1, 1000LL00L)

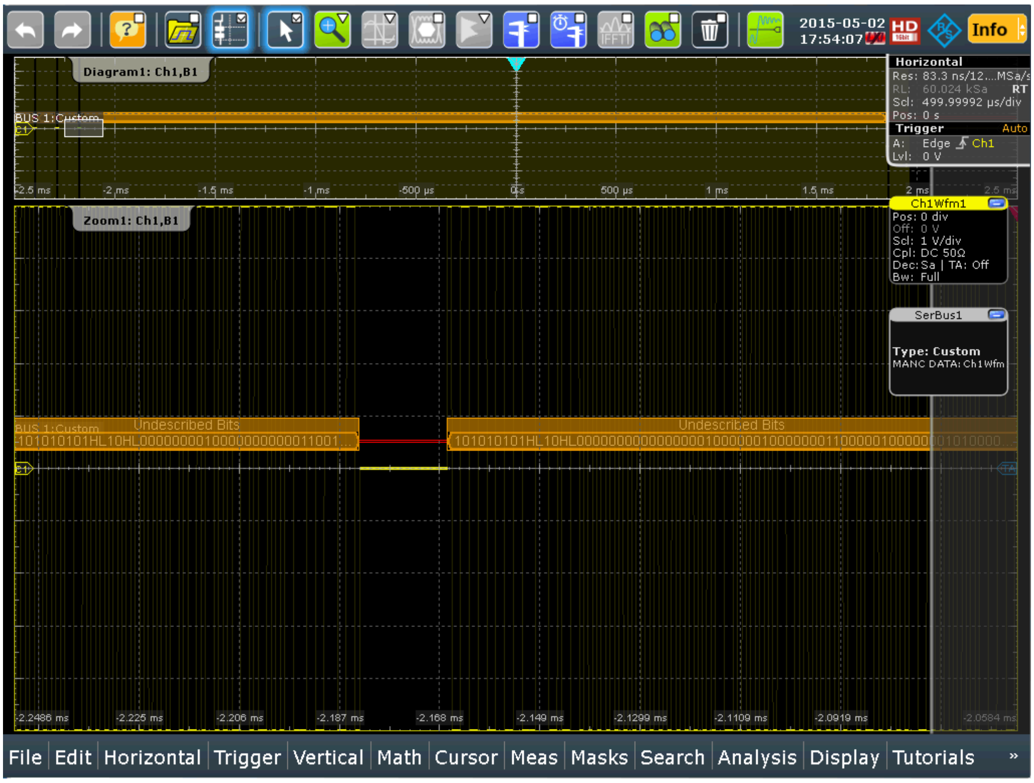


Figure 12-86: The function "Undescribed Bits" catches frames missed by the frame format descriptions

In the result presentation, frames labeled "Undescribed Bits" (as in Figure 12-86) show the bit patterns that are not matched by any user defined frame format description. Showing these raw bits is a functionality to help the user develop suitable frame format descriptions.

The following commands are used to retrieve decode results in remote control. For an example on how to query the status of a frame, see Chapter 16.17.14.3, "Decode Results", on page 1454.

Remote commands:

- `BUS<m>:CMSB:RCOunt?` on page 1455
- `BUS<m>:CMSB:RESult<n>:STATe?` on page 1456
- `BUS<m>:CMSB:RESult<n>:STARt?` on page 1456
- `BUS<m>:CMSB:RESult<n>:STOP?` on page 1457
- `BUS<m>:CMSB:RESult<n>:TYPE?` on page 1457
- `BUS<m>:CMSB:RESult<n>:CONE?` on page 1457
- `BUS<m>:CMSB:RESult<n>:CTWO?` on page 1457
- `BUS<m>:CMSB:RESult<n>:CTHRee?` on page 1458
- `BUS<m>:CMSB:RESult<n>:CCOunt?` on page 1458
- `BUS<m>:CMSB:RESult<n>:CELL<o>:NAME?` on page 1458
- `BUS<m>:CMSB:RESult<n>:CELL<o>:STATe?` on page 1459
- `BUS<m>:CMSB:RESult<n>:CELL<o>:VALue?` on page 1459

12.14 MDIO (Option R&S RTE-K55)

The R&S RTE-K55 option enables the R&S RTE to analyse Management Data Input/ Output (MDIO) protocols. The option is compatible with the Ethernet standard IEEE 802.3 (http://standards.ieee.org/findstds/standard/802.3-2012.html) and supports simplified triggering and decoding for both variants of MDIO: Clause 22 with basic addressing, and Clause 45 with advanced addressing that meets the requirements of 10 Gigabit Ethernet devices.

12.14.1 The MDIO Protocol

MDIO is used for bidirectional transfer of control and status information between the physical layer entity (PHY) and the station management entities (STA).

A major application of MDIO is fault detection by interrogating registers of physical devices. Hence, MDIO serial bus visualization helps debugging new products by giving developers a quick insight into the native data on the bus without using a special decoder.

On physical level, MDIO is a clocked non-return-to-zero (NRZ) code similar to SPI. According to the Ethernet standard, the protocol defines two threshold levels, 2 V and 0.8 V, which establish a hysteresis.

On logical level, MDIO is a fairly simple protocol with a fixed word length of 64 bits. The structure of MDIO frames is shown in the following tables:

Table 12-15: MDIO frame structure according to Clause 22

	Management Frame Fields							
Frame	PRE	ST	OP	PHYAD	REGAD	TA	DATA	IDLE
WRITE	1...1	01	01	AAAAA	RRRRR	10	DDDDDDDDDDDDDDDD	Z
READ	1...1	01	10	AAAAA	RRRRR	Z0	DDDDDDDDDDDDDDDD	Z

Table 12-16: MDIO frame structure according to Clause 45

	Management Frame Fields							
Frame	PRE	ST	OP	PRTAD	DEVAD	TA	ADDRESS / DATA	IDLE
ADDRESS	1...1	00	00	PPPPP	EEEEE	10	AAAAAAAAAAAAAAAA	Z
WRITE	1...1	00	01	PPPPP	EEEEE	10	DDDDDDDDDDDDDDDD	Z
READ	1...1	00	11	PPPPP	EEEEE	Z0	DDDDDDDDDDDDDDDD	Z
POST-READ increment address	1...1	00	10	PPPPP	EEEEE	Z0	DDDDDDDDDDDDDDDD	Z

PRE = preamble, consisting of 32 logic "one" bits ("1...1")

ST = start of frame code (2 bits), "01" for Clause 22, "00" for Clause 45, "0X" for any, no other options permitted

OP = operation code or "OpCode" (2 bits). This is a frame type code specifying the type of transaction. For more details on the OpCode, see "OP" in Table 12-17, or `TRIGger<m>:MDIO:FRAMetype`.

PHYAD = address of a physical layer entity (in Clause 22)

PRTAD = address of a port (in Clause 45)

REGAD = register address within a PHY (in Clause 22)

DEVAD = device address within a port (in Clause 45)

TA = turnaround time, a 2-bit time spacing between REGAD/DEVAD and DATA. The turnaround provides the slave some time to answer upon a read command. TA is hard-wired even in write commands, although it is not required there.

ADDRESS / DATA = address or payload data, 16 bits

IDLE = A single value (high-impedance state) indicating to the Physical Medium Attachment (PMA) that there is no data to convey

Instead of a specific hardware trigger, the option R&S RTE-K55 uses a predefined generic serial bus pattern trigger. It simply triggers on a bit pattern in the data stream. This is very fast, but limited in the complexity of the conditions.

The MDIO trigger settings allow the user to define the MDIO fields individually. The firmware concatenates the settings to a single search pattern that is then used by the serial bus pattern.

While this design is simple, it doesn't allow triggering on a data range or even inequality. This explains the much simpler structure compared to other protocols.

12.14.2 MDIO Configuration

If you need information on how to get started with configuring the MDIO setup, see Chapter 12.14.2.3, "Configuring MDIO Signals", on page 690. Otherwise proceed with the configuration settings.

12.14.2.1 MDIO Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *MDIO*

Make sure that the tab of the correct serial bus is selected on the left side.

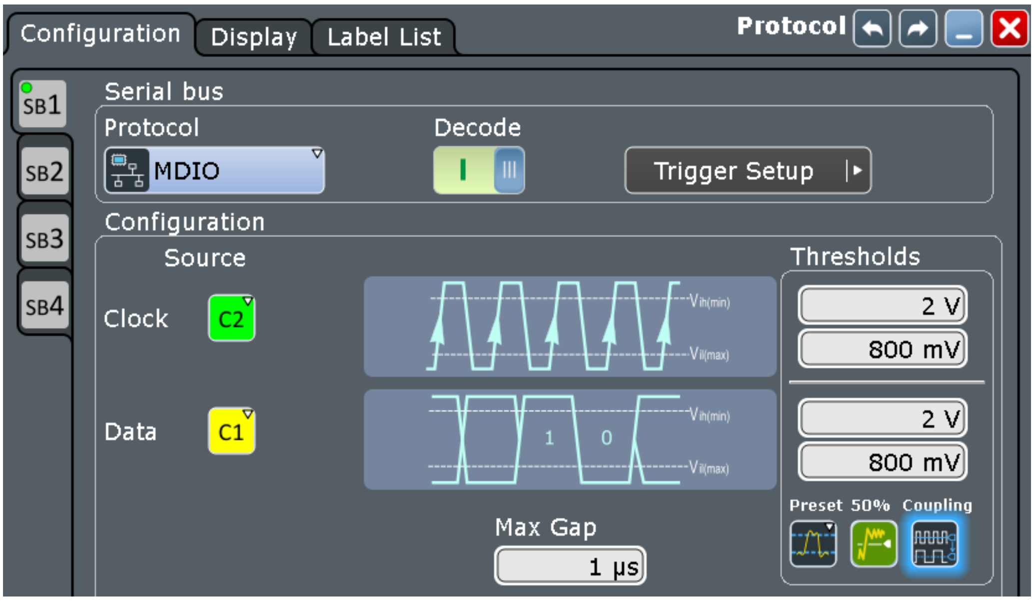


Figure 12-87: Serial bus MDIO protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Source

MDIO requires two source channels, one for clock and one for data.

"Clock" Defines the source settings for the clock line (management data clock, MDC). Typically, select any of the the analog channels "C1" – "C4" or digital channels "D0" – "D15", depending on the test application. "Math" or "Ref" waveforms are also permitted.

"Data" Defines the source settings for the data signal. Typically, select any of the the analog channels "C1" – "C4" or digital channels "D0" – "D15", depending on your application, but not the same as for "Clock". "Math" or "Ref" waveforms are also permitted.

Remote command:
`BUS<m>:MDIO:CLOCk:SOURce` on page 1460
`BUS<m>:MDIO:DATA:SOURce` on page 1460

Max Gap
Sets the maximum idle time between two frames.

Remote command:
`BUS<m>:MDIO:MAXGap` on page 1461

Thresholds
MDIO defines two thresholds for each source line:
- Vih(min) is being used for the rising edge evaluation. This "h" (high) threshold is the minimum value for the signal to be identified as "1". If the signal value comes from a low state (hence, rising edge), the state remains to be considered as low ("0"), until it has risen above Vih(min).
- Vil(max) is being used for the falling edge evaluation. This "l" (low) threshold is the maximum level for the signal to be identified as "0". If the signal value comes from a high state (hence, falling edge), the state remains to be considered as high ("1"), until it has fallen below Vil(max).

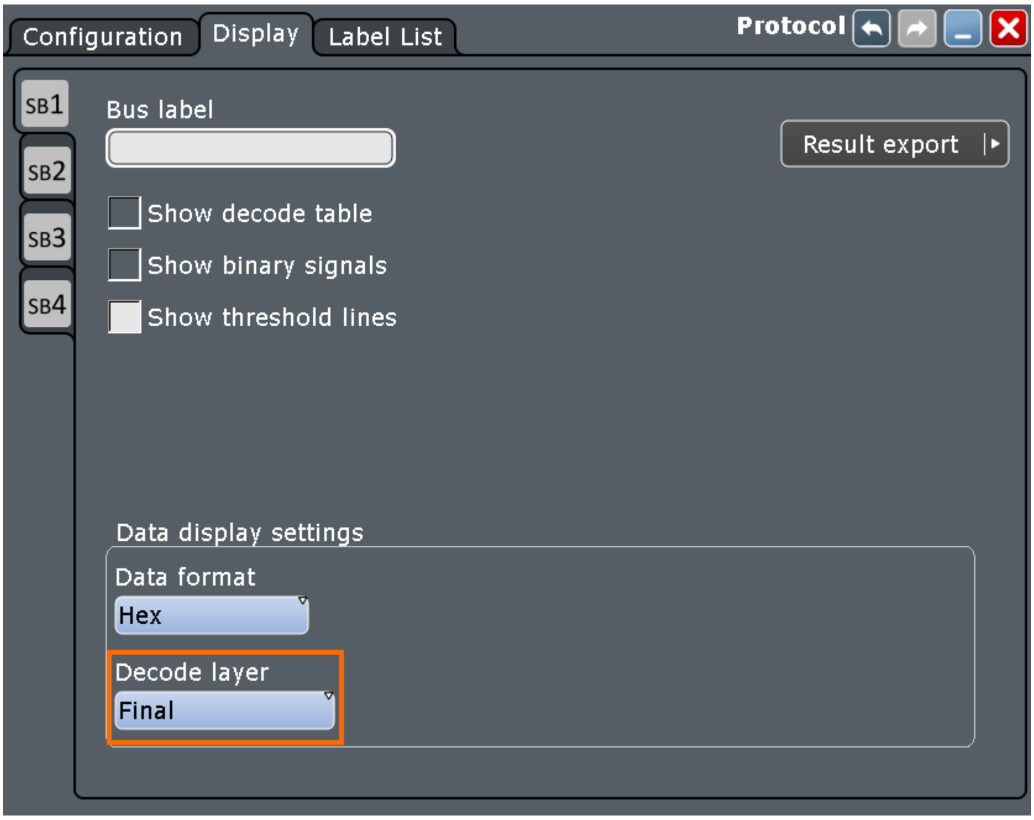
There are four ways to set the thresholds for the digitization of the signal lines:
- "Threshold"
  Enter the values directly in the fields.
- "Preset"
  Allows to select the default threshold settings according to the Ethernet standard: 2.0 V and 0.8 V.
- "50%"
  Executes a measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Coupling"
  Overwrites the data thresholds with the clock thresholds.

Remote command:
`BUS<m>:MDIO:CLOCk:THReshold:HIGH` on page 1461
`BUS<m>:MDIO:CLOCk:THReshold:LOW` on page 1461
`BUS<m>:MDIO:DATA:THReshold:HIGH` on page 1461
`BUS<m>:MDIO:DATA:THReshold:LOW` on page 1462
`BUS<m>:MDIO:PRESet` on page 1462
`BUS<m>:SETReflevels` on page 1163
`BUS<m>:MDIO:COUPling` on page 1462

12.14.2.2 MDIO Display Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = MDIO" > "Display" tab

To enhance the decode possibilities of the MDIO protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 440.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final" ...

"Edges" ...

"Binary" ...

12.14.2.3 Configuring MDIO Signals

For configuration, assign the lines to the input channels and define the active states and the logical thresholds.

Serial Bus Setup

1. Press the PROTOCOL key on the front panel.
2. At the left hand-side of the "Configuration" tab, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Tap "Protocol" and select the protocol: "MDIO".
4. Optionally, you can enter a "Bus label" in the "Display" tab.
5. Switch to the "Trigger Setup" dialog, tap "Source" and select "Serial bus".
   Note: For triggering on a serial bus, analog or digital input channels are required!
6. Switch back to the "Serial Bus Setup" dialog.
7. Select the waveform for the "Clock" and "Data" lines.
8. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels by setting it to "50%", or enter a user-defined value directly in the "Threshold" fields. Optionally, use "Coupling" to couple the data thresholds to the clock thresholds.
9. In the protocol "Configuration" tab, select "Decode" to activate the decode functionality.

For details on configuration settings, see Chapter 12.14.2.1, "MDIO Configuration Settings", on page 688.

12.14.3 MDIO Trigger

If you need information on how to get started with triggering on MDIO signals, see Chapter 12.14.3.2, "Triggering on MDIO", on page 694. Otherwise proceed with the MDIO trigger settings.

12.14.3.1 MDIO Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = MDIO"

In this section, all trigger settings are described. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to the data sheet.

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

MDIO Trigger Type

Selects the trigger type for MDIO analysis.

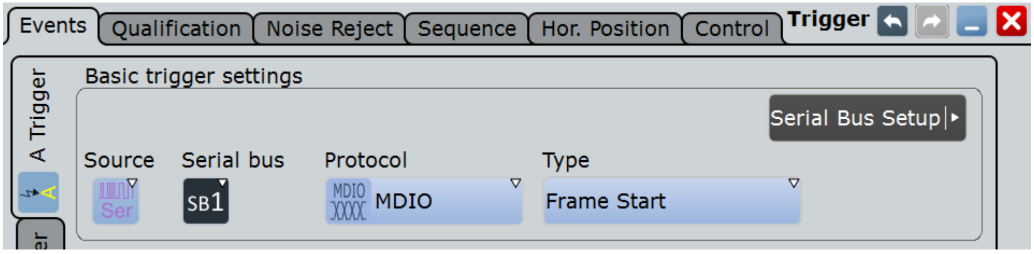
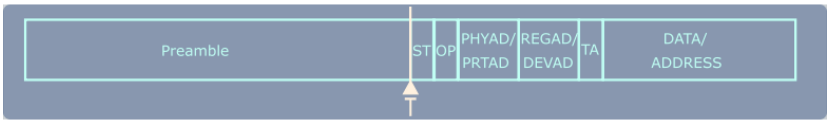


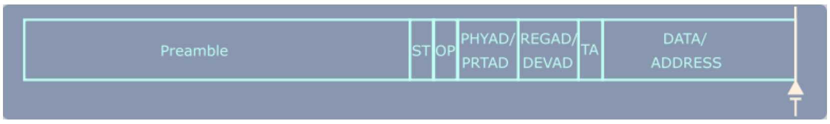
Figure 12-88: MDIO trigger event settings dialog

"Frame Start" Sets the trigger to the start of frame (SOF) field. The start of frame condition and the trigger instant is the end of the preamble.
Trigger pattern: preamble (32 bits "1")



There are no additional parameters to be specified.

"Frame Stop" Sets the trigger to the end of frame (EOF) field. The trigger instant is after the last data bit.
Trigger pattern: preamble (32 bits "1") + 32 bits "X"

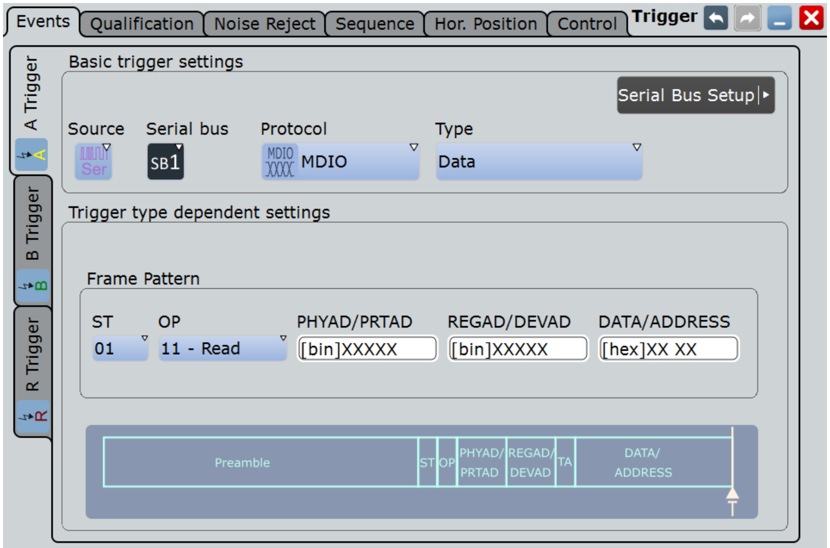


There are no additional parameters to be specified.

"Data"
Sets the trigger to the data field. For more information on the data condition, see MDIO in the Ethernet standard. The trigger instant is at the end of the frame after the last data bit, as indicated in the GUI.

Note: All data triggers are always at the end of the frame, even if the specified pattern to trigger for is at a different position within the data word.

Trigger pattern: preamble (32 bits "1") + "ST" (2 bits, Start of Frame Code) + "OP" (2 bits, operation code or frame type code) + "PHYAD/PRTAD" (5 bits, Physical Layer Entity Address / Port Address) + "REGAD/DEVAD" (5 bits, Register Address / Device Address) + "TA" (2 "X" bits, turnaround time) + "DATA/ADDRESS" (16 bits)
For the parameters to be specified, see "ST" on page 693, "OP" on page 693, "PHYAD/PRTAD" on page 694, "REGAD/DEVAD" on page 694, and "DATA/ADDRESS" on page 694.



Remote command:
`TRIGger<m>:MDIO:TYPE` on page 1463

ST ← MDIO Trigger Type
Selects the start of frame code of the frame pattern; available only in trigger type "Data". Permissible frame patterns are: Clause 22, Clause 45, or Any

Remote command:
`TRIGger<m>:MDIO:ST` on page 1463

OP ← MDIO Trigger Type
Selects the type of frame code (or OP code, OpCode, operation code); available only in trigger type "Data". Available frame types are: Address, Write, Read, Post Read, or Any

Remote command:
`TRIGger<m>:MDIO:FRAMetype` on page 1464

PHYAD/PRTAD ← MDIO Trigger Type
Sets the physical address or port address (5 bits) of the frame pattern; available only in trigger type "Data".

Remote command:
`TRIGger<m>:MDIO:PHYS` on page 1464

REGAD/DEVAD ← MDIO Trigger Type
Sets the register address or device address (5 bits) of the frame pattern; available only in trigger type "Data".

Remote command:
`TRIGger<m>:MDIO:REGI` on page 1464

DATA/ADDRESS ← MDIO Trigger Type
Defines the payload data pattern or address pattern (16 bits); available only in trigger type "Data".

Remote command:
`TRIGger<m>:MDIO:DATA` on page 1464

12.14.3.2 Triggering on MDIO

Prerequisite: A serial bus is configured for the MDIO signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.14.2, "MDIO Configuration", on page 688), tap "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to MDIO, e.g.:

   The "Protocol" selection is then automatically set to "MDIO".
4. Tap "Trigger Type MDIO" and select the trigger type to be used for MDIO protocol analysis.
5. If the trigger type "Data" is selected, the frame pattern has to be specified.

For information on how to proceed with the configuration settings, see Chapter 12.14.3.1, "MDIO Trigger Settings", on page 691.

12.14.4 MDIO Label List

Label lists are protocol-specific. A label list file for MDIO contains physical addresses and their symbolic names.

Example: MDIO label list CSV file

```
@PROTOCOL_NAME = mdio
0x0B, KSZ9031MNX
0x0C, KSZ8051MNLU
0x0E, KSZ8721CL
0x0F, KSZ8721SL
0x1A, KSZ8721BL
0x1B, KSZ8721BT
```

MDIO Label List

Physical Address [hex]	Symbolic Label
[hex] 0B	KSZ9031MNX
[hex] 0C	KSZ8051MNLU
[hex] 0E	KSZ8721CL
[hex] 0F	KSZ8721SL
[hex] 1A	KSZ8721BL
[hex] 1B	KSZ8721BT

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 441.

Remote command:

- `BUS<m>:MDIO:WORD<n>:SYMBol?` on page 1468

12.14.5 MDIO Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Example

An example test waveform consisting of six frames is shown in Figure 12-89. The corresponding "Decode results" table for these frames can be seen in the foreground. The upper part of the screen, behind the table, represents the waveform in a honeycomb display, along with the binary decode results. In the lower part of the screen is a zoom into frame #2, which is a "Write" frame, containing PRE, ST, OP, PRTAD, DEVAD, TA and DATA fields. The zoom shows both the honeycomb display and the binary decode results of that second frame.

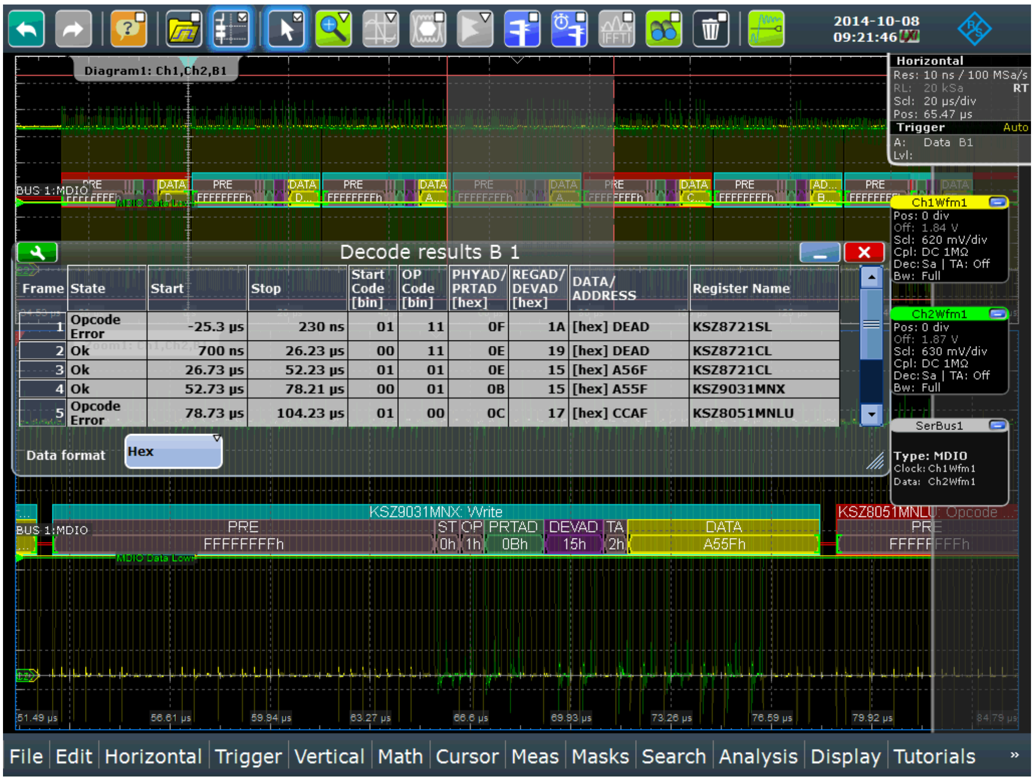


Figure 12-89: Decoded and binary MDIO signal trace, and decode results table

green brackets [...]	= start and end of frame
blue frame	= frame ok
red frame	= frame containing an error
grey	= preamble (PRE), start pattern (ST), operation code (OP = frame type), or turnaround (TA) fields
dark green	= PHY address or port address (depending on clause)
dark purple	= register address or device address field (depending on clause)
yellow	= data field or address field (depending on clause)

Table 12-17: Content of the "Decode results" table in the previous figure

Column	Description
Frame	Number of the acquired frame
State	State of frame, available messages are: • OK • OPcode error • Length error • Incomplete frame • Unsynchronized bits
Start	Start time of the frame
Stop	Stop time of the frame

Column	Description
ST	Start of frame code, 2 bits ● "01" (Clause 22) ● "00" (Clause 45)
OP	Operation code (= Frame type), 2 bits ● "00" = Address frame (in Clause 45, only) ● "01" = Write frame (in Clause 22 or Clause 45) ● "10" = Read frame (in Clause 22) or Post Read frame (in Clause 45) ● "11" = Read frame (in Clause 45)
PHYAD/PRTAD	Address field, shown as 2 hex characters (corresponding to 5 binary bits) ● PHY address (in Clause 22) ● Port address (in Clause 45)
REGAD/DEVAD	Address field, shown as 2 hex characters (corresponding to 5 binary bits) ● Register address (in Clause 22) ● Device address (in Clause 45)
DATA/ADDRESS	Payload data field (in Clause 22 or Clause 45), or Address field (in Clause 45, only), shown as 4 hex characters or 16 binary bits (see Figure 12-90).
Register Name	Displays a translation of the PHYAD/PRTAD address label in textual form

In the decode results table, the contents of column "DATA/ADDRESS" can also be displayed in alternative numerical formats, e.g. in binary format, as shown in Figure 12-90.

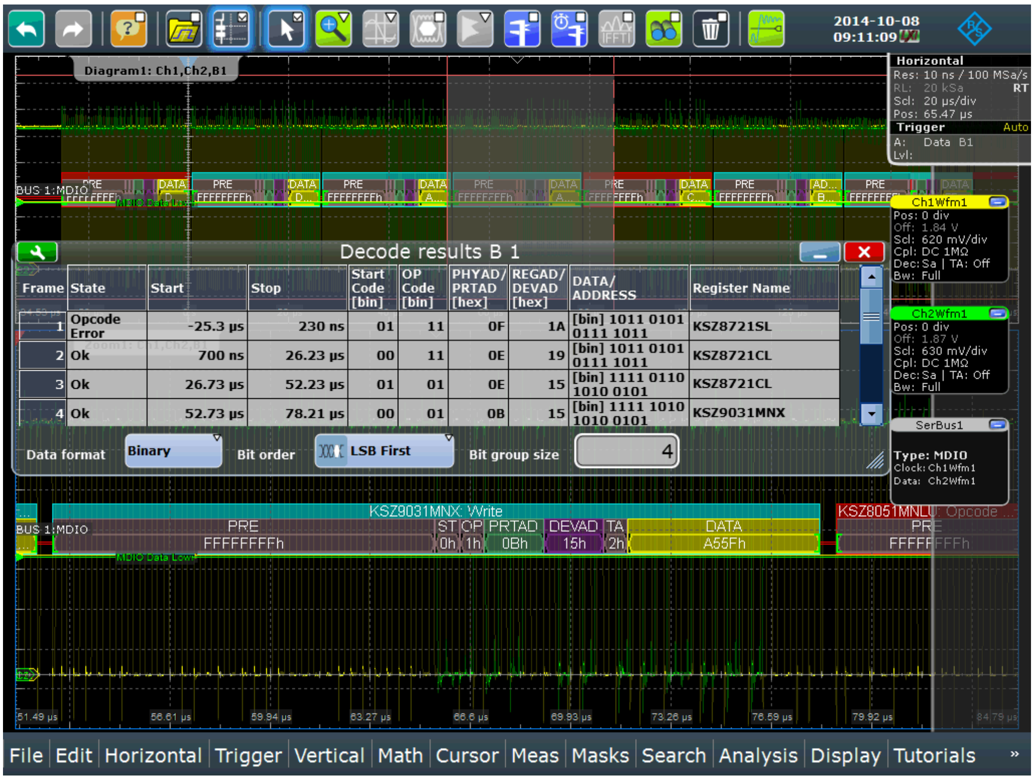


Figure 12-90: The same signal trace and decode results table as in the previous figure, but only with "DATA" in binary format

To configure the numerical format of the content in column "DATA/ADDRESS", either use the button "Data format" in the "Decode results" table, as shown in Figure 12-90, or the same button in the "Display" tab of the "Protocol" dialog, as shown in Figure 12-91. Available data formats are "Hex", "Octal", "Binary", "Ascii", "Signed", and "Unsigned". If the binary format is selected, additional data format options are "Binary bit order", and "Binary bit group size". This defines if the data word is displayed most significant bit (MSB) or least significant bit (LSB) first, and in which size of groups the bits are displayed. This feature is also described in Chapter 12.1.2, "Display", on page 440.

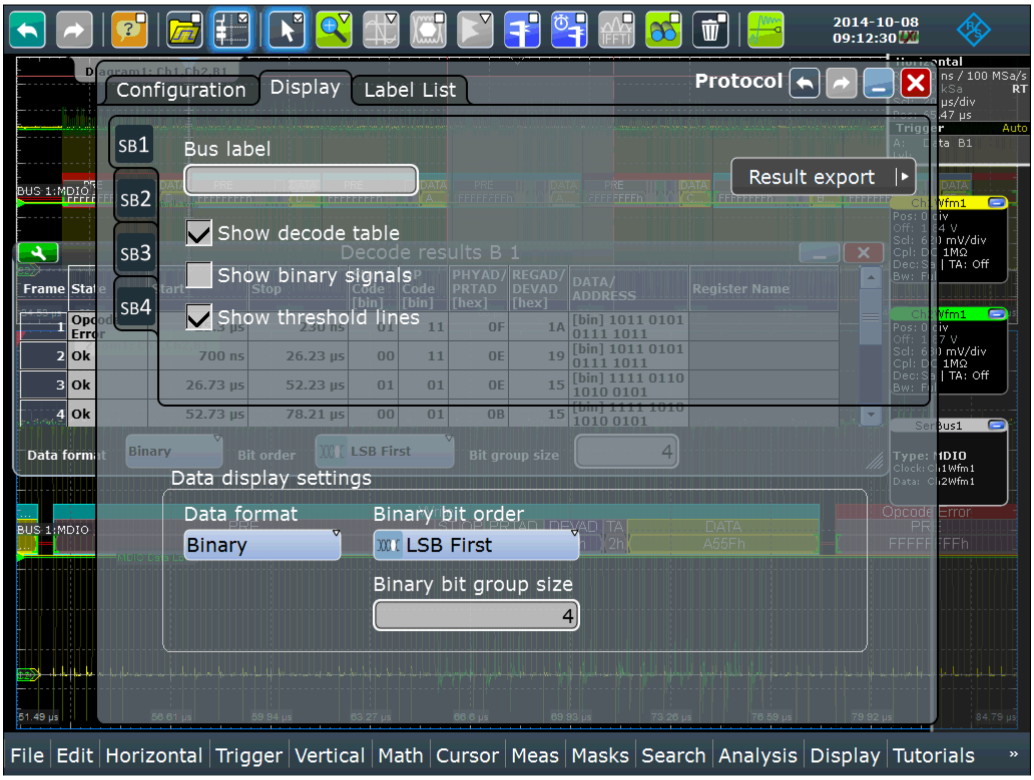


Figure 12-91: The Data display settings can be configured in the Display tab of the Protocol dialog

The following commands are used to retrieve decode results in remote control.

Remote commands:

- BUS<m>:MDIO:WCOunt? on page 1465
- BUS<m>:MDIO:WORD<n>:STATe? on page 1467
- BUS<m>:MDIO:WORD<n>:STARt? on page 1466
- BUS<m>:MDIO:WORD<n>:STOP? on page 1467
- BUS<m>:MDIO:WORD<n>:ST? on page 1466
- BUS<m>:MDIO:WORD<n>:TYPE? on page 1468
- BUS<m>:MDIO:WORD<n>:PHYS? on page 1465
- BUS<m>:MDIO:WORD<n>:REGI? on page 1466
- BUS<m>:MDIO:WORD<n>:DATA? on page 1465
- BUS<m>:MDIO:WORD<n>:SYMBol? on page 1468

12.14.6 Search on Decoded MDIO Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 376.

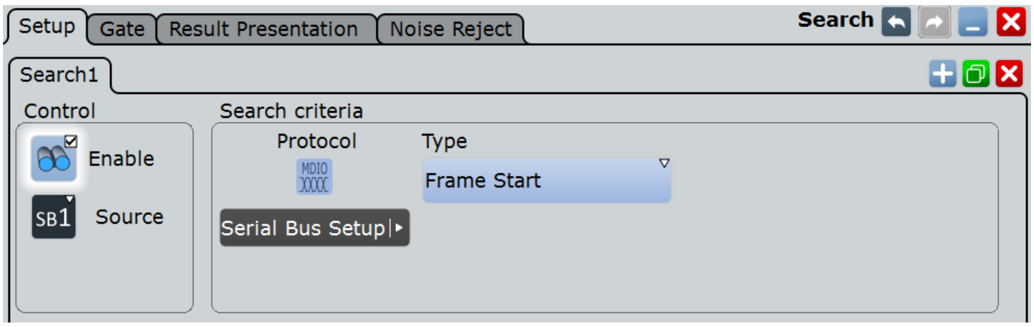
If you need information on how to get started with searching MDIO data, see Chapter 12.14.6.3, "Searching MDIO Data", on page 702. Otherwise proceed with the MDIO search setup.

12.14.6.1 MDIO Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for MDIO

Search criteria

Use the "Search criteria" dialog to define the event types to be searched.



Available event types are "Frame Start", "Frame Stop", and "Data".

Only if search criteria type "Data" is selected, individual search parameters can be specified in the tabs below the "Search criteria" dialog. For these parameters, see "ST" on page 700, "OP" on page 700, "PHYAD/PRTAD" on page 701, "REGAD/DEVAD" on page 701, and "DATA/ADDRESS" on page 701.

Remote command:
`SEARch:TRIGger:MDIO:TYPE` on page 1470

ST

Selects the start of frame code of the frame pattern; available only in search criteria type "Data". Permissible frame patterns are: Clause 22, Clause 45, or Any

Remote command:
`SEARch:TRIGger:MDIO:ST` on page 1470

OP

Selects the Type of Frame code (or OP code, OpCode, operation code); available only in search criteria type "Data". Available frame types are: Address, Write, Read, Post Read, or Any

Remote command:
`SEARch:TRIGger:MDIO:FRAMetype` on page 1469

PHYAD/PRTAD
Sets the physical address or port address (5 bits) of the frame pattern; available only in search criteria type "Data".

Remote command:
`SEARch:TRIGger:MDIO:PHYS` on page 1469

REGAD/DEVAD
Sets the register address or device address (5 bits) of the frame pattern; available only in search criteria type "Data".

Remote command:
`SEARch:TRIGger:MDIO:REGI` on page 1470

DATA/ADDRESS
Defines the payload data pattern or address pattern (16 bits); available only in search criteria type "Data".

Remote command:
`SEARch:TRIGger:MDIO:DATA` on page 1469

12.14.6.2 MDIO Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394

Remote commands:

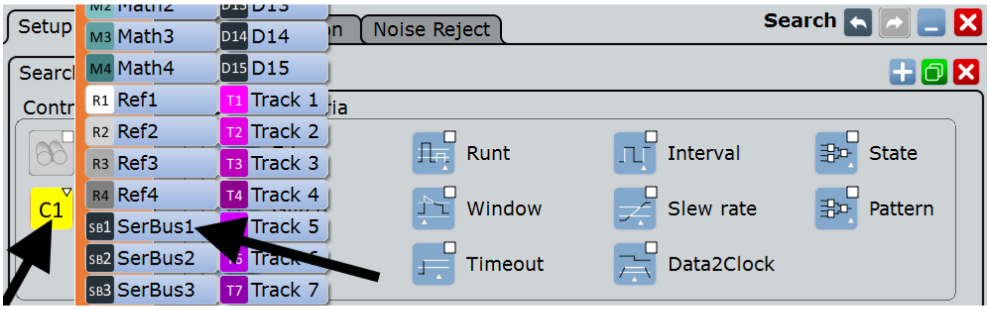
- `SEARch:RESult:MDIO:WCOunt` on page 1475
- `SEARch:RESult:MDIO:WORD<m>:STATe?` on page 1473
- `SEARch:RESult:MDIO:WORD<m>:STARt?` on page 1473
- `SEARch:RESult:MDIO:WORD<m>:STOP?` on page 1474
- `SEARch:RESult:MDIO:WORD<m>:ST?` on page 1472
- `SEARch:RESult:MDIO:WORD<m>:TYPE?` on page 1474
- `SEARch:RESult:MDIO:WORD<m>:PHYS?` on page 1472
- `SEARch:RESult:MDIO:WORD<m>:REGI?` on page 1472
- `SEARch:RESult:MDIO:WORD<m>:DATA?` on page 1471
- `SEARch:RESult:MDIO:WORD<m>:SYMBol?` on page 1474

12.14.6.3 Searching MDIO Data

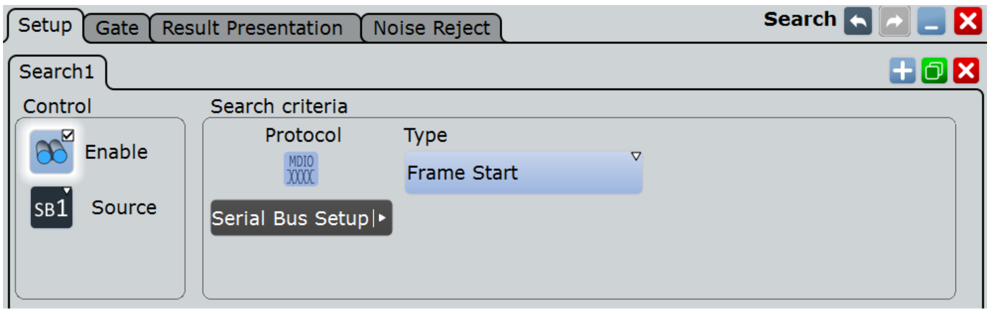
Prerequisite: A serial bus is configured for the MDIO signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 391.
3. Tap "Source" and select the serial bus that is set to MDIO (e.g. "SerBus1", unless already selected).



The search dialog for MDIO protocol analysis is opened.

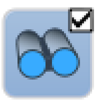


There are no additional search criteria to be specified.

4. To acquire a waveform, press RUN N× SINGLE.

   The R&S RTE performs a MDIO decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).

5. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:



The R&S RTE displays the "Search Results" box that lists the detected events.

For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 397 and "Navigating search results" on page 378.

12.15 USB (Option R&S RTE-K60)

R&S RTE-K60 is a firmware option that enables the R&S RTE to analyse Universal Serial Bus (USB) protocols, by triggering and decoding them. The option is compatible with the standards USB 1.0, USB 1.1, USB 2.0 and USB HSIC (High-Speed Inter-Chip). R&S RTE-K60 supports the data rates "Low Speed" (1.5 Mbit/s), "Full Speed" (12 Mbit/s) and "High Speed" (480 Mbit/s, available in USB 2.0 and HSIC).

12.15.1 The USB Protocol

The USB protocol was developed, starting in 1996, by the nonprofit organization USB Implementers Forum, Inc. (USB-IF), formed by Compaq, Hewlett-Packard, Intel, Lucent Technologies, Microsoft, NEC, and Philips. The purpose was to provide a common "plug-and-play" solution to replace a multitude of interfaces for the communication between computers and devices. It should allow even unskilled users to easily connect many devices to a PC. USB was originally used for devices that feature low signalling rates (up to 1.5 Mbit/s), especially human interface devices like mouse, joystick or keyboard. With the release of USB 2.0 in April 2000, devices such as printers, cameras and mass storage media were enabled to exchange data at faster rates (up to 480 Mbit/s). Additionally, the high speed protocol HSIC (High Speed Inter Chip) is used for the communication between on-board devices.

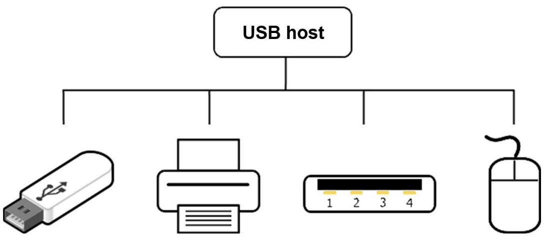


Figure 12-92: USB Topology: mass storage device, printer, USB hub, and mouse (human interface device) connected to a USB host

More information, including the USB specification, is available online within the web domain http://usb.org.

This chapter provides an overview of protocol characteristics, data transfer, packet structure, address and endpoint formats of USB as well as trigger possibilities of R&S®RTx-K60.

USB characteristics

Main characteristics of USB are:

- Four-wire design: USB requires a shielded cable containing four wires. Two of them, called D+ and D-, form a twisted pair (for low speed, they may not be twisted). These data lines transmit differential data signals and single-ended signal states, both referenced to a third wire: the GND or ground. The fourth wire, called VBUS (voltage bus), carries a nominal 5 V supply, which may be used to power a device.
- Host-to-device communication: in USB's "speak-when-spoken-to" protocol, communication is always initiated by the host. Consequently, there is no direct communication between USB devices, apart from very few exceptions.
- Addressing scheme: a maximum of 127 connected devices can be distinguished, because a packet's address field length is limited to 7 bits. USB devices have up to 16 OUT endpoints (from host to device) and up to 16 IN endpoints (from device to host).
- USB transactions consist of two or three packets: token, data, and typically handshake
- Packet type: a packet identifier (PID) is sent as a first byte within the packet and specifies the different packet types.
- NRZI (Non Return to Zero Inverted): a zero (0) is encoded as a transition of the physical level, whereas a one (1) has no transition, thus it is represented by a steady level.

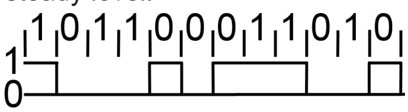


Figure 12-93: Example of an NRZI sequence

- Bit stuffing: a zero (0) is inserted after every 6 consecutive ones (111111). This ensures sufficient transitions to keep the phase-locked loop (PLL) synchronized and locked onto the data stream.
- Little Endian scheme: both multiple bits and multiple bytes are transmitted with the least significant bit/byte (LSB) sent first, while the most significant bit/byte (MSB) is sent last.
- HSIC (High-Speed Inter-Chip): an industry standard for USB chip-to-chip interconnection with a 2-signal (strobe, data) source synchronous serial interface, using 240 MHz DDR signaling to provide only high-speed (480 Mbps) data rate.

Table 12-18: Simplified symbolic representation from the USB standard

Bus State	Protocol	Levels
Differential **"1"**		D+ High, D- Low
Differential **"0"**		D+ Low, D- High
Data **"J"** State	Low speed	D+ Low, D- High (differential **"0"**)
	Full speed	D+ High, D- Low (differential **"1"**)

Bus State	Protocol	Levels
Data **"K"** State	Low speed	D+ High, D- Low (differential **"1"**)
	Full speed	D+ Low, D- High (differential **"0"**)

In the example in Table 12-18, High speed can be assumed to be like Full speed. For a complete overview of bus states as well as for an electrical definition of High and Low speed, refer to chapter 7 of the USB specification.

Data transfer

In contrast to a conventional bus, USB is more like a network protocol, using target addresses and endpoints. However, USB features a bus master, called the host. It transmits packets of data to all devices or hubs connected to the host (or connected to a device or hub, which is in turn connected to the host). All connected devices receive each data packet, but disregard it unless it carries the correct address. In reply, only the addressed device (one at a time) can send data upstream, to the host.

The USB architecture supports four different kinds of data transfer: control, bulk, interrupt or isochronous transfer. For example, a "bulk OUT" transfer (from host to device) would look like this:

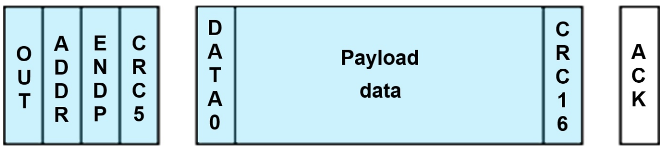


Figure 12-94: Example of a bulk OUT transfer. Blue: host speaks, white: device speaks

Packet structure

All packets must start with a **SYNC** field, also called **SOP** (start of packet), which indicates data transmission. It consists of "KJ" pairs, followed by one "KK". At low speed and full speed (USB 1.x), it is 8 bits long, encoded as "KJKJKJKK". At high speed (USB 2.0 and HSIC), it is up to 32 bits long, encoded as "KJKJKJKJKJKJ...KK".

The SYNC field is used to synchronize the clock of the receiver with that of the transmitter. The final 2 bits ("KK") indicate where the PID fields starts.

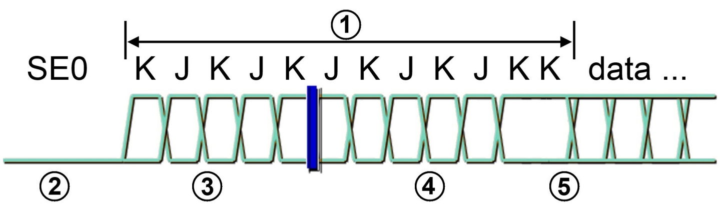


Figure 12-95: Start of a high speed packet: after an SE0, the packet starts with a SYNC field (or SOP), followed by the data packet

SE0 = Single-ended zero, both D+ and D- wire are on low level
1 = High-speed SYNC field (or SOP), length up to 32 bits
2 = Receiver-squelched differential envelope, below 100 mV

3 = Differential envelope exceeds 150 mV, reception enabled with 4 symbol times
4 = Clock recovery must lock in time to detect end of SYNC
5 = End of SYNC detected, receiver begins data recovery

After the SYNC (or SOP), USB data packets consist of (in this order):

- **PID** (packet identifier): specifies the type of packet. Examples are:
  - Token packets (IN, OUT, SETUP) are always the first packet in a USB transaction, containing the address of the device and its endpoint.
  - Token SOF packets (start of frame) are there to schedule a data transfer.
  - Handshake packets provide the status of the transaction.
  - Data packets are dedicated for the data transfer payload.
  - Various special packets provide special characteristics: for instance, SPLIT packets are used to communicate with low or full speed devices on a high speed link.

  The PID's length is 8 bit, beginning (LSB) with the fields PID0, PID1, PID2 and PID3. Those 4 bits are repeated in PID4, PID5, PID6 and PID7, but in complementary form (for integrity checking). The PID is the only part of a packet not to be covered by the CRC (see below). Packets with invalid or non-supported PID fields are rejected. For valid PIDs, see Table 12-19.
- **ADDR** (address): contains the USB address of the target device. The length of this field is 7 bits, resulting in addresses 0 through 127 (with 0 reserved as the default address after reset).
- **ENDP** (endpoint): number of the endpoint. The length of this field is 4 bits, resulting in a maximum of 16 different endpoints.
- **Frame number**: this field with a length of 11 bits specifies the current frame number from 0 through 2047. It is only sent in SOF packets.
- **Data field** (or "payload data"): the length of this field is not fixed, it can contain between 0 and 1024 bytes.
- **CRC** (cyclic redundancy check): Finally, the CRC field ensures that the received data is correct. If an error is detected in the CRC calculation, the packet is rejected. Packets (in this case: IN, OUT, SOF, SETUP, PING, SPLIT) are followed by a CRC5 (which is 5 bits long) over ADDR and ENDP (or the frame number field, in case of SOF); data packets (DATA0, DATA1, MDATA, DATA2) are followed by a CRC16 (which is 16 bits long) over the data field. No CRC is used for handshake packets.
- **EOP** (end of package): the devices determine the length of the data field by means of the EOP signal, which indicates the end of a packet. In low and full speed, it consists of two SE0 bits, followed by a J state. In case of high speed, the current state is inverted and kept for seven bit times, leading to a Bitstuff error that is used as an EOP indicator. This corresponds to the bit sequence 01111111 ahead of NRZI; in case of the SOF token, the bit sequence 0111111111111111111111111111111111111111 is transmitted (five NRZI bytes), which is used to recognize disconnects (since high-speed devices normally do not apply voltage to D+/D-). If no device is present, a higher voltage is measured. After that, the idle state (SE0) is occupied.

Table 12-19: Valid PIDs for different packet types

Packet type	Name	PID value	Meaning
Token	OUT	0xE1	Starts data transfer towards a device
	IN	0x69	Starts data transfer towards the host
	SOF	0xA5	Indicates start of frame
	SETUP	0x2D	Starts a setup transfer and sends information on this to the device
Data	DATA0	0xC3	Data packet with data-toggle bit 0
	DATA1	0x4B	Data packet with data-toggle bit 1
	DATA2	0x87	Data packet for high speed IN isochronous transfers that require high bandwidth
	MDATA	0x0F	Data packet for high speed OUT isochronous transfers that require high bandwidth
Handshake	ACK	0xD2	Acknowledgement of a packet received without error
	NAK	0x5A	Data not accepted, typically equivalent with some type of EAGAIN, meaning that the data should be re-sent at a later time
	STALL	0x1E	A severe error has occurred, the target endpoint can not be addressed until it is explicitly cleared again
	NYET	0x96	Only used in high speed transfers, meaning ACK, but in the next interval no data can be received, therefore the host should first apply a PING
Special	PRE	0x3C	Starts a low speed transfer via a full speed bus
	ERR	0x3C	Indicates an error in a SPLIT transaction (using the same PID as PRE, however, these can not be mistaken for each other)
	SPLIT	0x78	Starts a SPLIT transaction (thus: a low speed or full speed transfer via a high speed bus)
	PING	0xB4	Used for monitoring high speed data flow

- Token packets (IN, OUT, SETUP) and PING packets have the following format:

SYNC	PID	ADDR	ENDP	CRC5	EOP

- Start of frame packets (SOF) have the following format:

SYNC	PID	Frame number	CRC5	EOP

- Data packets have the following format:

SYNC	PID	Data	CRC16	EOP

- Handshake packets have the following format:

SYNC	PID	EOP

- SPLIT packets have the following format:

SYNC	PID	ADDR	SC	PORT	S	E	ET	CRC5	EOP

Trigger possibilities

Signals on the input channels CH1 - CH4 of the R&S RTE can be triggered by the option R&S®RTx-K60. The following trigger types are available:

- ANY Packet - Packet Sync: Triggering on the first rising slope after transmission of the packet Sync. Various lengths according to standard (in USB 2.0: 32 bit)
- Any token, OUT, IN, SOF, SETUP, AND-ing with user defined PID check, address, endpoint, CRC5: For OUT, IN, SETUP, the endpoint and CRC5 follow from the bit order, therefore such patterns can be recognized.
- Data Selection: DATA0, DATA1, DATA2, MDATA, (for USB 1.x only: AND-ing with user defined PID check, payload and CRC values)
- Handshake Packet Setup: Triggering on handshake packet, trigger with specific settings: ACK, NAK, NYET, STALL or ERR handshake packet
- Protocol Error: Triggering on PID/check error, CRC5 error, CRC16 (for USB 1.x only), frame length error (for USB 1.x only)
- Bus Event: Triggering on reset, resume, or suspend

12.15.2 USB Configuration

If you need information on how to get started with configuring the USB setup, see Chapter 12.15.2.2, "Configuring USB Signals", on page 712. Otherwise proceed with the configuration settings.

12.15.2.1 USB Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol" = *USB*

Make sure that the tab of the correct serial bus is selected on the left side.

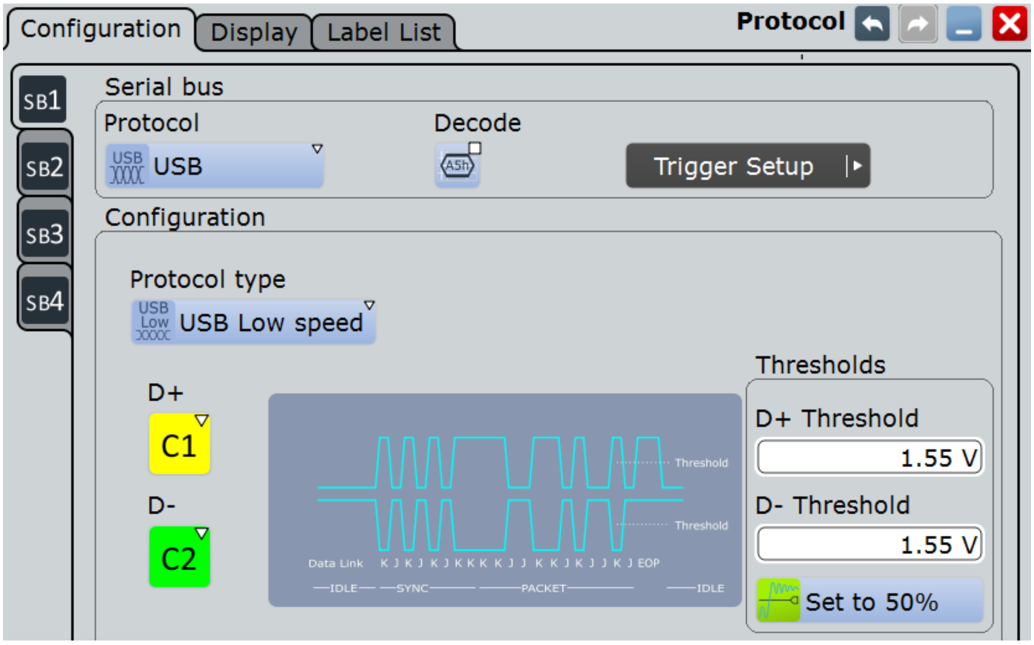


Figure 12-96: Serial bus protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Protocol type

Defines the USB protocol technology and transmission speed.

"USB Low speed"

Selects USB low speed protocol (1.5 Mbit/s).

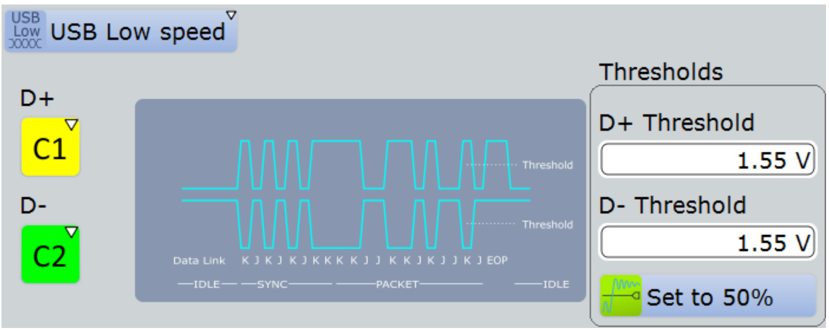


Figure 12-97: USB low speed protocol configuration

Remote command:

`BUS<m>:USB:DPLus:SOURce` on page 1476
`BUS<m>:USB:DMINus:SOURce` on page 1476
`BUS<m>:USB:DPLus:THReshold` on page 1477
`BUS<m>:USB:DMINus:THReshold` on page 1478

"USB Full speed"
Selects USB full speed protocol (12 Mbit/s).

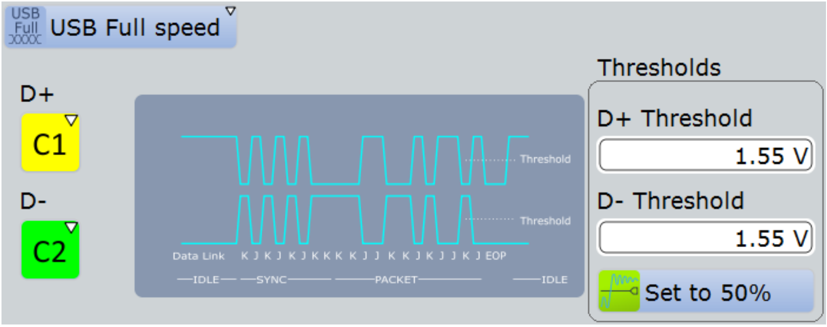


Figure 12-98: USB full speed protocol configuration

Remote command:
BUS<m>:USB:DPLus:SOURce on page 1476
BUS<m>:USB:DMINus:SOURce on page 1476
BUS<m>:USB:DPLus:THReshold on page 1477
BUS<m>:USB:DMINus:THReshold on page 1478

"USB High speed"
Selects USB high speed protocol (480 Mbit/s). As the signal is differential, there is only one source and one threshold to be defined.

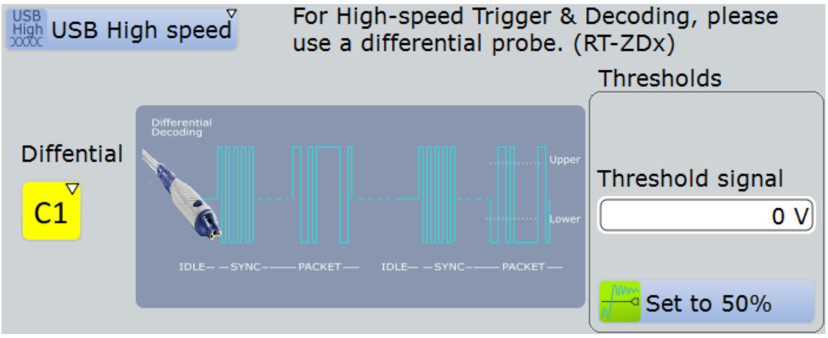


Figure 12-99: USB high speed protocol configuration

Remote command:
BUS<m>:USB:DIFFerential:SOURce on page 1476
BUS<m>:USB:DIFFerential:THReshold on page 1478

"USB HSIC"

Selects USB high speed inter-chip (HSIC) protocol.

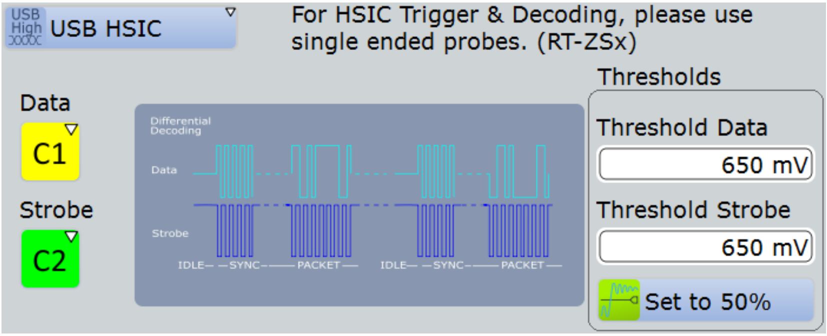


Figure 12-100: USB HSIC protocol configuration

Remote command:
BUS<m>:USB:DATA:SOURce on page 1477
BUS<m>:USB:STRobe:SOURce on page 1477
BUS<m>:USB:DATA:THReshold on page 1478
BUS<m>:USB:STRobe:THReshold on page 1478

Remote command:
BUS<m>:USB:TECHnology on page 1475

D+

Defines the source settings for the D+ data signal (in USB low speed and USB full speed protocol, only). Permitted selections are the analog channels "C1" – "C4".

Remote command:
BUS<m>:USB:DPLus:SOURce on page 1476

D-

Defines the source settings for the D- data signal (in USB low speed and USB full speed protocol, only). Permitted selections are the analog channels "C1" – "C4".

Remote command:
BUS<m>:USB:DMINus:SOURce on page 1476

Differential

Defines the source settings for the differential data signal (in USB high speed protocol, only). Permitted selections are the analog channels "C1" – "C4".

Remote command:
BUS<m>:USB:DIFFerential:SOURce on page 1476

Data

Defines the source settings for the data signal (in USB HSIC protocol, only). Permitted selections are the analog channels "C1" – "C4".

Remote command:
BUS<m>:USB:DATA:SOURce on page 1477

Strobe
Defines the source settings for the strobe signal (in USB HSIC protocol, only). Permitted selections are the analog channels "C1" – "C4".

Remote command:
`BUS<m>:USB:STRobe:SOURce` on page 1477

Thresholds
Sets the threshold value for the digitization of each signal line. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, if the signal value is below the threshold, the signal state is considered low.

There are three ways to set the threshold:

- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Remote command:
`BUS<m>:USB:DPLus:THReshold` on page 1477
`BUS<m>:USB:DMINus:THReshold` on page 1478
`BUS<m>:USB:DIFFerential:THReshold` on page 1478
`BUS<m>:USB:DATA:THReshold` on page 1478
`BUS<m>:USB:STRobe:THReshold` on page 1478

12.15.2.2 Configuring USB Signals

For configuration, assign the lines to the input channels and define the active states and the logical thresholds.

Serial Bus Setup

1. Press the PROTOCOL key on the front panel.
2. At the left hand-side, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Select the "Configuration" tab.
4. Tap "Protocol" and select the protocol: "USB".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Switch to the "Trigger Setup" dialog, tap "Source" and select "Serial bus".

   This prevents to use Math waveforms, Ref waveforms and Tracks as channel signals.

   Note: For triggering on a serial bus, analog input channels are required!
7. Switch back to the "Serial Bus Setup" dialog.
8. Tap "Protocol type" and select the protocol type ("USB Low speed", "USB Full speed", "USB High speed", or "USB HSIC") you want to set up.

9. Depending on the protocol type, select the waveform for each of the available "D+", "D-", "Differential", "Data", and "Strobe" lines.
10. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fields.
11. In the protocol "Configuration" tab, select "Decode" to activate the decode functionality.

For details on configuration settings, see Chapter 12.15.2.1, "USB Configuration Settings", on page 708.

12.15.3 USB Trigger

If you need information on how to get started with triggering on USB signals, see Chapter 12.15.3.2, "Triggering on USB", on page 722. Otherwise proceed with the USB trigger settings.

12.15.3.1 USB Trigger Settings

Access: TRIGGER > "Source = Serial Bus" > select "Serial bus" > "Protocol = USB"

In this section, all trigger settings are described. Their availability on the instrument depends on the selected USB protocol type and trigger type. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to data sheet.

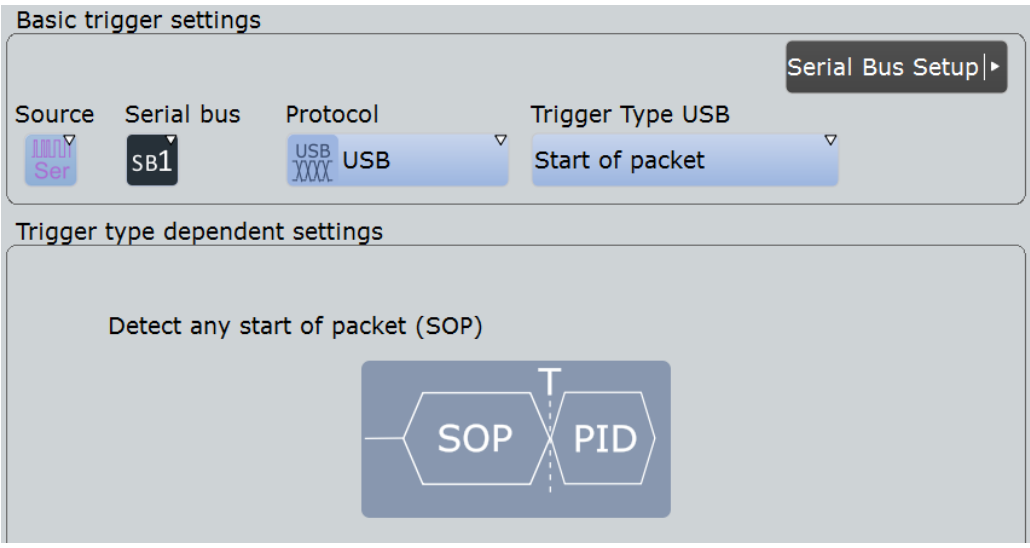


Figure 12-101: USB trigger event settings dialog

Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

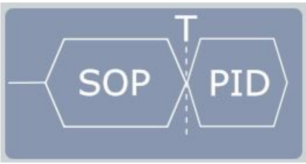
Trigger type USB

Selects the trigger type for USB analysis. The available trigger types depend on the USB protocol type that is selected in the configuration setup, see "Protocol type" on page 709.

Remote command:
`TRIGger<m>:USB:TYPE` on page 1480

Start of packet ← Trigger type USB

Sets the trigger to the SOP (start of packet) field. The start of packet condition is the end of the SYNC field. The trigger instant is the end of the SOP field.



End of packet ← Trigger type USB

Sets the trigger to the EOP (end of packet) field. Not available for USB High Speed and USB HSIC protocol types. The trigger instant is the beginning of the EOP field.

Reset ← Trigger type USB

Sets the trigger to the Reset field. Not available for USB High Speed and USB HSIC protocol types. For more information on the reset condition, see the USB standard. The trigger instant is the end of the 10 ms period after the SE0 field.

Suspend ← Trigger type USB
Sets the trigger to the Suspend field. Not available for USB High Speed and USB HSIC protocol types. For more information on the suspend condition, see the USB standard. The trigger instant will be declared after the defined 3 ms timeout.

Resume ← Trigger type USB
Sets the trigger to the Resume field. Not available for USB High Speed and USB HSIC protocol types. For more information on the resume condition, see the USB standard. The trigger instant will be declared after the defined 20 ms timeout.

Token ← Trigger type USB
Sets the trigger to one out of four different token trigger types: OUT, IN, SOF, or SETUP.

See "Token" on page 716

Data ← Trigger type USB
Sets the trigger to one out of four different data trigger types: DATA0, DATA1, DATA2, or MDATA.

See "Data" on page 716

Handshake ← Trigger type USB
Sets the trigger to one out of four different handshake trigger types: ACK, NAK, STALL, or NYET.

See "Handshake" on page 717

Special PID ← Trigger type USB
Sets the trigger to one out of four different Special PID trigger types: PREamble, ERR, SPLIT, or PING.

See "Special PID" on page 717

Error condition ← Trigger type USB
Sets the trigger to one out of eight different error condition trigger types: Any error, PID error, CRC5 error, CRC16 error, Bitstuffing error, Unexpected PID error, SE1 error, or Glitching error.

See "Error condition" on page 719

Token
Sets the trigger to one out of four different token types:
- "OUT"
- "IN"
- "SOF"
- "SETUP"

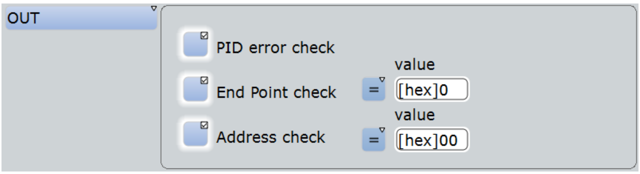
If no additional conditions are set, the trigger instant is after the PID.

If the PID error check is selected, and
- if an error is found in the PID's complementary form, the trigger is set immediately after the 8th bit of the PID
- if no PID error is found, no trigger is set, even if other selected conditions may be met.

Otherwise, the trigger instant is defined by the first occurrence of any of the specified additional condition(s).

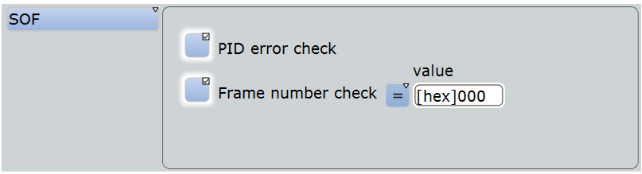
Remote command:
`TRIGger<m>:USB:TOKen` on page 1490

OUT, IN or SETUP ← Token
For the trigger token types "OUT", "IN" or "SETUP", the following conditions can be set:



You can refine the trigger condition:
- See "PID error check" on page 719
- See "End Point check" on page 719
- See "Address check" on page 719

SOF ← Token
For the trigger token type "SOF", the following conditions can be set:



You can refine the trigger condition:
- See "PID error check" on page 719
- See "Frame number check" on page 720

Data
Sets the trigger to one out of four different data types:
- "DATA0"
- "DATA1"
- "DATA2"

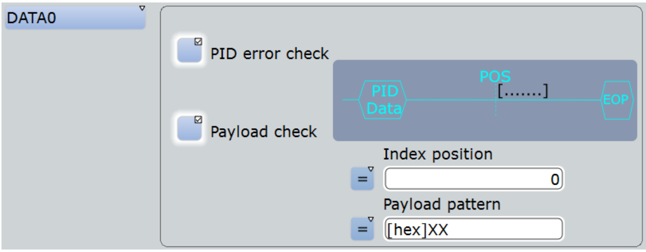
- "MDATA"

If no additional conditions are set, the trigger instant is after the PID.

If the PID error check is selected, and

- if an error is found in the PID's complementary form, the trigger is set immediately after the 8^{th} bit of the PID
- if no PID error is found, no trigger is set, even if other selected conditions may be met.

Otherwise, the trigger instant is defined by the first occurrence of any of the specified additional condition(s).



You can refine the trigger condition:

- See "PID error check" on page 719
- See "Payload check" on page 720

Remote command:

`TRIGger<m>:USB:DATA` on page 1482

Handshake

Sets the trigger to one out of four different handshake types:

- "ACK"
- "NAK"
- "STALL"
- "NYET"

If no handshake condition is set, the trigger instant is after the PID.

If the PID error check is selected, and

- if an error is found in the PID's complementary form, the trigger is set immediately after the 8^{th} bit of the PID
- if no PID error is found, no trigger is set.

See "PID error check" on page 719

Remote command:

`TRIGger<m>:USB:HAND` on page 1486

Special PID

Sets the trigger to one out of four different "Special PID" types:

- "PREamble"
- "ERR"
- "SPLIT"

- "PING"

If no additional conditions are set, the trigger instant is after the PID.

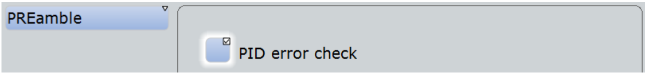
If the PID error check is selected, and
- if an error is found in the PID's complementary form, the trigger is set immediately after the 8th bit of the PID
- if no PID error is found, no trigger is set, even if other selected conditions may be met.

Otherwise, the trigger instant is defined by the first occurrence of any of the specified additional condition(s).

Remote command:
`TRIGger<m>:USB:SPEC` on page 1488

PREamble or ERR ← Special PID

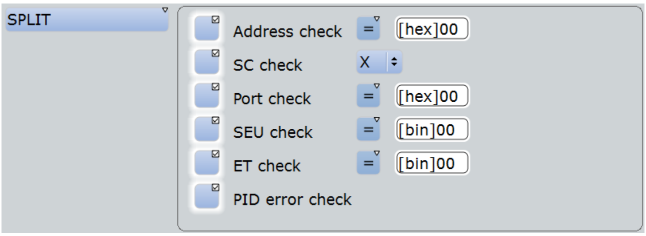
For the Trigger Special Types "PREamble" and "ERR", the following condition can be set:



See "PID error check" on page 719

SPLIT ← Special PID

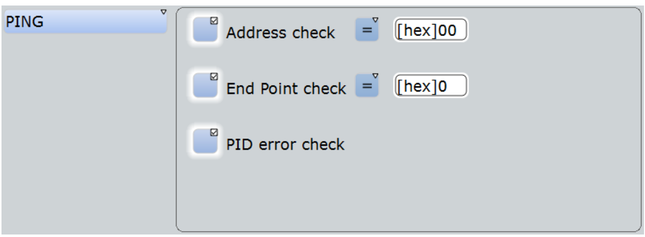
For the Trigger Special Type "SPLIT", the following conditions can be set:



You can refine the trigger condition:
- See "Address check" on page 719
- See "SC check" on page 721
- See "Port check" on page 721
- See "SEU check" on page 721
- See "ET check" on page 721
- See "PID error check" on page 719

PING ← Special PID

For the Trigger Special Type "PING", the following conditions can be set:



You can refine the trigger condition:
- See "Address check" on page 719
- See "End Point check" on page 719
- See "PID error check" on page 719

Error condition

Sets the trigger in case of one of the following eight different error condition types.
- Any error: triggers on any of the errors listed below.
- PID error: triggers on any packet identifier error.
- CRC5 error: triggers on any CRC5 error event
- CRC16 error: triggers on any CRC16 error event
- Bitstuffing error: triggers in the event of an erroneous or missing bit stuffing sequence (see USB standard).
- Unexpected PID error: triggers on any illegal PID. This is a PID that is not allowed in USB low speed and USB full speed protocols, especially PID's announcing packets such as SPLIT, DATA2, MDATA, or other noncompliant packets.
- SE1 error: triggers on the illegal bus state Single Ended 1 (SE1 = both lines high).
- Glitching error: triggers on an error in the bit period (see USB standard for the definition of glitching).

The trigger instant is the first occurrence of the specified error.

Remote command:
`TRIGger<m>:USB:ERRC` on page 1484

PID error check

Defines, whether a packet ID error check is executed or not.

Remote command:
`TRIGger<m>:USB:WPID` on page 1492

End Point check

Defines, whether an endpoint check that meets specific conditions is executed or not.

"Condition" Defining a specific endpoint or an endpoint range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies an endpoint, or sets the start value of an endpoint range.

"Max" Sets the the end value of an endpoint range if "Condition" (`TRIGger<m>:USB:ECONdition`) is set to `INRange` or `OORange`.

Remote command:
`TRIGger<m>:USB:WEND` on page 1491
`TRIGger<m>:USB:ECONdition` on page 1484
`TRIGger<m>:USB:EMIN` on page 1484
`TRIGger<m>:USB:EMAX` on page 1484

Address check

Defines, whether an address check that meets specific conditions is executed or not.

"Condition" Defining a specific address or an address range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies an address, or sets the start value of an address range.

"Max" Sets the the end value of an address range if "Condition" (TRIGger<m>:USB:ACONdition) is set to INRange or OORange.

Remote command:
TRIGger<m>:USB:WADD on page 1491
TRIGger<m>:USB:ACONdition on page 1482
TRIGger<m>:USB:AMAX on page 1482
TRIGger<m>:USB:AMIN on page 1482

Payload check

Defines, whether a payload check that meets specific conditions is executed or not.

"Condition" Sets the operator "any" or "equal" that allows to trigger for payload data at any position or at a specified position.

"Position" Available only if "Condition" (TRIGger<m>:USB:DPOPerator) is set to *equal*. Specifies the position in which a special data pattern is to be triggered within the payload data packet.

"Data Condition" Sets the operator ("equal" or "unequal", TRIGger<m>:USB:DCONdition) to set a specific payload data pattern.

"Payload pattern" Specifies the payload data pattern that is to be triggered.

Remote command:
TRIGger<m>:USB:WPAY on page 1492
TRIGger<m>:USB:DPOPerator on page 1483
TRIGger<m>:USB:DPOSition on page 1483
TRIGger<m>:USB:DCONdition on page 1483
TRIGger<m>:USB:PATT on page 1486

Frame number check

Defines, whether a frame number check that meets specific conditions is executed or not.

"Condition" Defining a specific frame number or a frame number range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies a frame number, or sets the start value of a frame number range.

"Max" Sets the the end value of a frame number range if "Condition" (TRIGger<m>:USB:FCONdition) is set to INRange or OORange.

Remote command:
TRIGger<m>:USB:WFRN on page 1491
TRIGger<m>:USB:FCONdition on page 1485
TRIGger<m>:USB:FMIN on page 1486
TRIGger<m>:USB:FMAX on page 1486

SC check
Defines, whether a Start / Complete SPLIT transaction check is executed or not.

Remote command:
`TRIGger<m>:USB:WSTC` on page 1492
`TRIGger<m>:USB:STCO` on page 1489

Port check
Defines, whether a port check that meets specific conditions is executed or not.

"Condition"	Defining a specific port number or a port number range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies a port number, or sets the start value of a port number range.
"Max"	Sets the the end value of a port number range if "Condition" (`TRIGger<m>:USB:PCONdition`) is set to `INRange` or `OORange`.

Remote command:
`TRIGger<m>:USB:WPOR` on page 1492
`TRIGger<m>:USB:PCONdition` on page 1486
`TRIGger<m>:USB:PMIN` on page 1487
`TRIGger<m>:USB:PMAX` on page 1487

SEU check
Defines, whether an SEU check that meets specific conditions is executed or not. S and E represent the Start and End of a start-split transaction, U represents the reserved/Unused bit of a complete-split transaction. Permissible binary SEU values are 00, 01, 10, and 11.

"Condition"	Defining a specific SEU value or an SEU value range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies an SEU value, or sets the start value of an SEU value range.
"Max"	Sets the the end value of an SEU value range if "Condition" (`TRIGger<m>:USB:SCONdition`) is set to `INRange` or `OORange`.

Remote command:
`TRIGger<m>:USB:WSEU` on page 1492
`TRIGger<m>:USB:SCONdition` on page 1487
`TRIGger<m>:USB:SMIN` on page 1488
`TRIGger<m>:USB:SMAX` on page 1488

ET check
Defines, whether an Endpoint Type (ET) check that meets specific conditions is executed or not.

"Condition"	Defining a specific endpoint type or an ET range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies an ET, or sets the start value of an ET range.
"Max"	Sets the the end value of an ET range if "Condition" (`TRIGger<m>:USB:TCONdition`) is set to `INRange` or `OORange`.

Remote command:
`TRIGger<m>:USB:WETCheck` on page 1491
`TRIGger<m>:USB:TCONdition` on page 1489
`TRIGger<m>:USB:TMIN` on page 1490
`TRIGger<m>:USB:TMAX` on page 1490

12.15.3.2 Triggering on USB

Prerequisite: A bus is configured for the USB signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog (Chapter 12.15.2.1, "USB Configuration Settings", on page 708), tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to USB, e.g.:

   The "Protocol" selection is then automatically set to "USB".
4. Tap "Trigger Type USB" and select the trigger type to be used for USB protocol analysis.
   Available trigger types depend on the USB protocol type that has been activated in "Protocol type" on page 709.
5. Depending on the selected USB protocol type and trigger type, more setup conditions have to be specified.

For information on how to proceed with the configuration settings, see Chapter 12.15.3.1, "USB Trigger Settings", on page 713.

12.15.4 USB Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Examples

The example in Figure 12-102 shows a simulated USB full speed message. A Token OUT packet has been decoded, followed by an ACK packet with an erroneous complementary PID value (PID Error). The next event is a PRE packet, then a DATA1 packet with two bytes of data transmitted, and with a valid CRC16. The trigger instant is at the PID of the DATA1 packet.

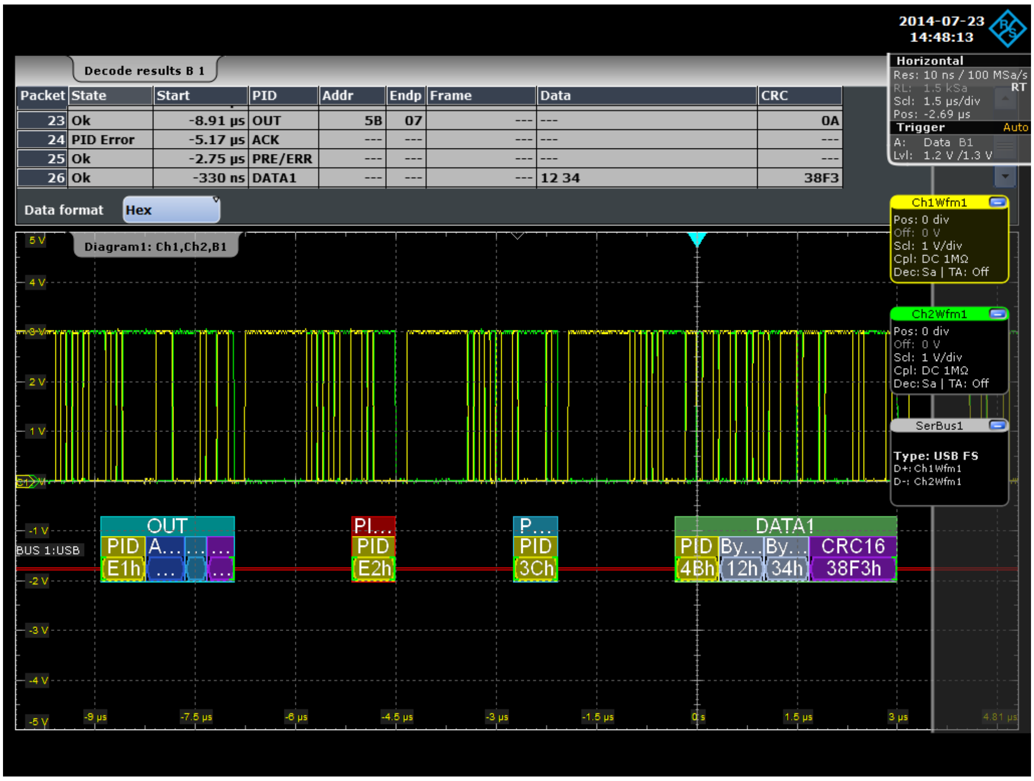


Figure 12-102: USB full speed protocol: decoded and binary signal, and decode results

green brackets [...] = start and end of packet
blue packet = packet ok
green packet = data packet ok
red packet = error condition
yellow = PID
dark blue = address

blue = endpoint
purple = CRC5/16
grey = payload data bytes

The example in Figure 12-103 shows a simulated USB high speed message. A Token SETUP packet has been decoded, which contains a CRC5 error. The next event is a Token IN packet and an incomplete MDATA packet. Note that an incomplete packet is also decoded, as long as sample data are available. In such a case, no error will be shown, since the remaining CRC16 cannot be computed. The trigger instant is on the CRC5 error.

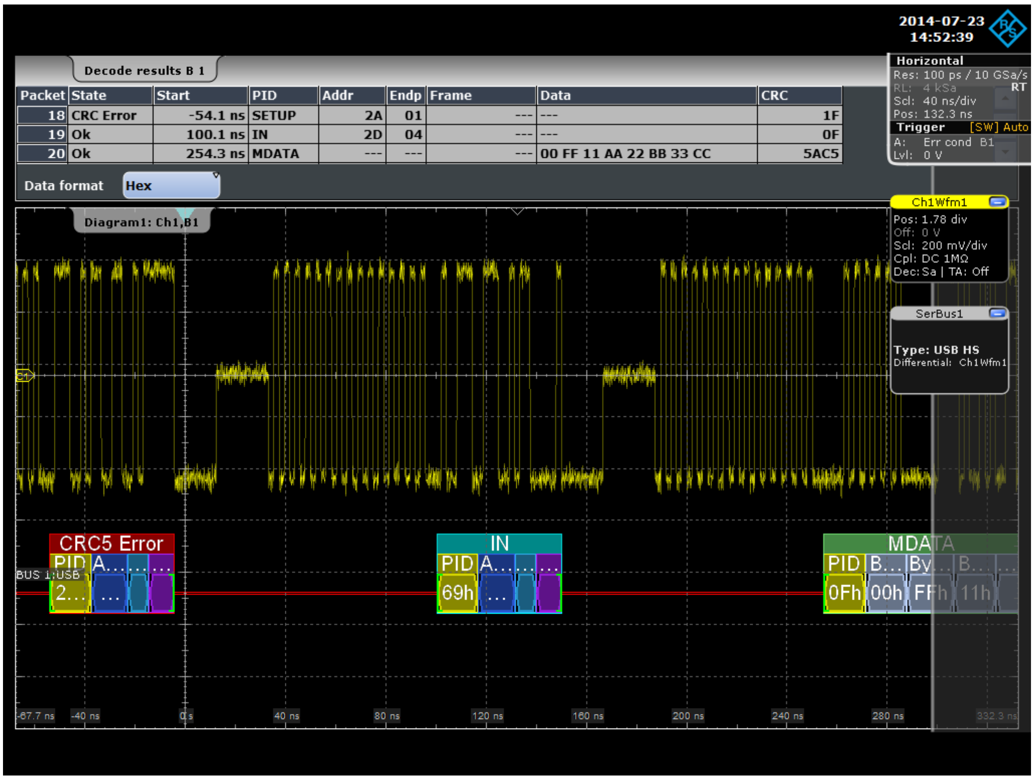


Figure 12-103: USB high speed protocol: decoded and binary signal, and decode results

green brackets [...] = start and end of packet
blue packet = packet ok
green packet = data packet ok
red packet = error condition
yellow = PID
dark blue = address
blue = endpoint
purple = CRC5/16
grey = payload data bytes

The example in Figure 12-104 shows a simulated USB HSIC sequence, in which Data (ch1) and Strobe (ch2) are combined. A Token OUT packet, a DATA0 packet with an erroneous CRC16 value and a STALL packet have been decoded. The next events are a Token SETUP packet with erroneous CRC5 value, and a Token IN packet. In this scenario, the trigger instant is on the SOP (start of packet).

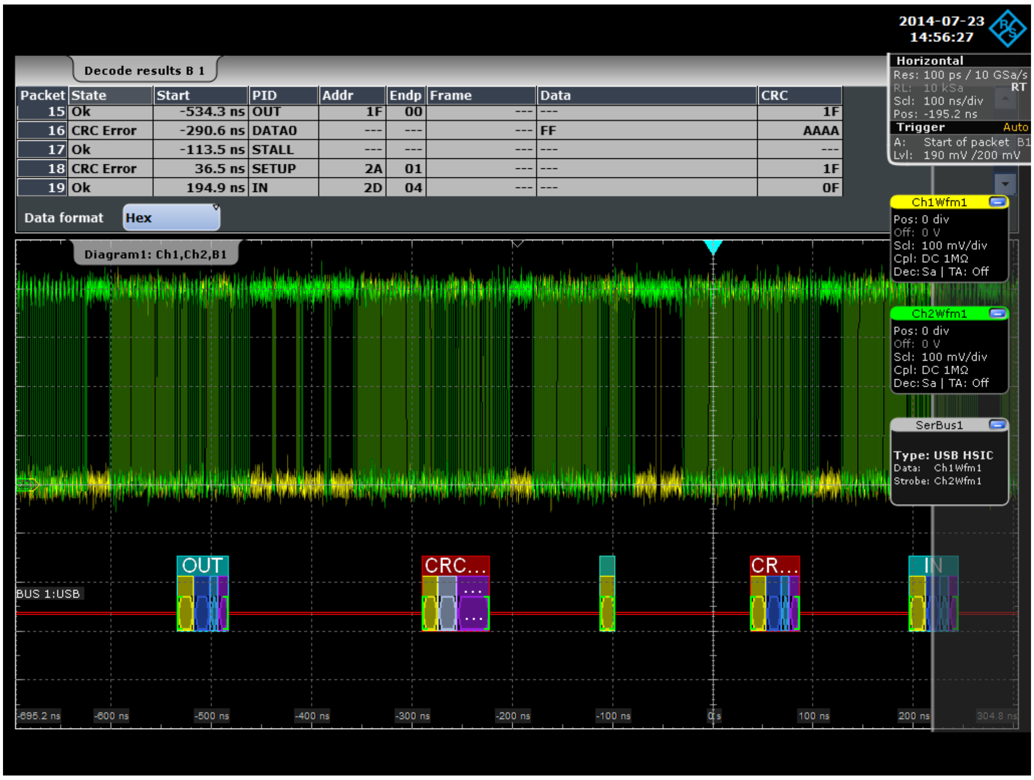


Figure 12-104: USB HSIC protocol: decoded and binary signal, and decode results

green brackets [...] = start and end of packet
blue packet = packet ok
green packet = data packet ok
red packet = error condition
yellow = PID
dark blue = address
blue = endpoint
purple = CRC5/16
grey = payload data bytes

Table 12-20: Content of the "Decode results" table in the previous figures

Column	Description
State	Overall state of the packet: either OK or the relevant error condition (CRC, glitch-ing, ...)
Start	Start time of the packet.
PID	PID type (OUT, IN, DATA0, ...)
Addr	Address of the recipient
Endp	Endpoint of the recipient
Frame	Frame number (in SOF packet)
Data	Values of the payload data bytes. The data format is selected below the table.
CRC	Either CRC5 or CRC16 (data packet PID)

The following commands are used to retrieve decode results in remote control. For an example on how to query the status of a packet, see Chapter 16.17.16.3, "Decode Results", on page 1492.

Remote commands:

- `BUS<m>:USB:PCOunt?` on page 1498
- `BUS<m>:USB:PACKet<n>:STATus?` on page 1497
- `BUS<m>:USB:PACKet<n>:STARt?` on page 1497
- `BUS<m>:USB:PACKet<n>:STOP?` on page 1497
- `BUS<m>:USB:PACKet<n>:PID?` on page 1493
- `BUS<m>:USB:PACKet<n>:ADDRess?` on page 1495
- `BUS<m>:USB:PACKet<n>:ENDPoint?` on page 1495
- `BUS<m>:USB:PACKet<n>:DATA?` on page 1495
- `BUS<m>:USB:PACKet<n>:CRC?` on page 1495
- `BUS<m>:USB:PACKet<n>:ET?` on page 1496
- `BUS<m>:USB:PACKet<n>:FRAMe?` on page 1496
- `BUS<m>:USB:PACKet<n>:PORT?` on page 1496
- `BUS<m>:USB:PACKet<n>:SC?` on page 1496
- `BUS<m>:USB:PACKet<n>:SEU?` on page 1496

12.15.5 Search on Decoded USB Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

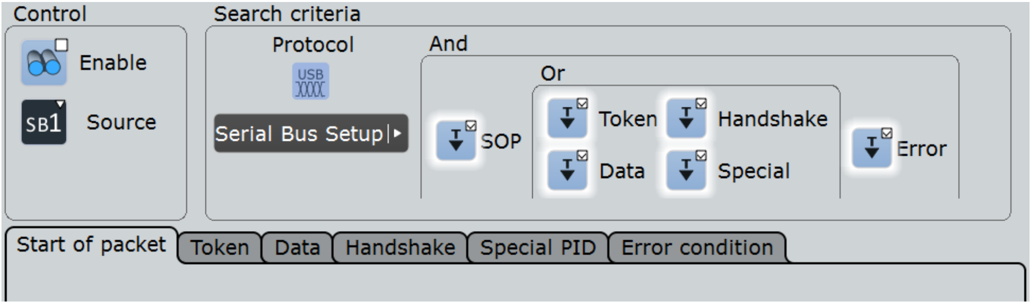
For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 376.

If you need information on how to get started with searching USB data, see Chapter 12.15.5.3, "Searching USB Data", on page 734. Otherwise proceed with the USB search setup.

12.15.5.1 USB Search Setup

Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for USB

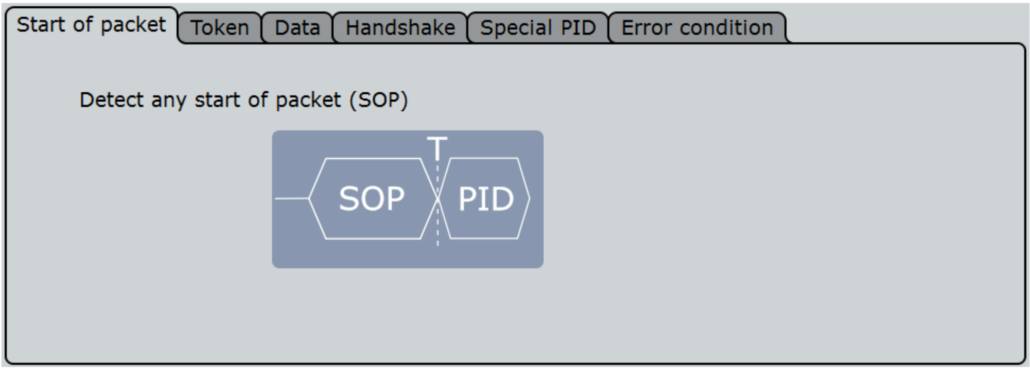
Search criteria
Use the "Search criteria" dialog to define the event types to be searched.



Individual search parameters (which do not depend on the USB protocol type and trigger settings), can be specified in the tabs below the "Search criteria" dialog.

Remote command:
`SEARch:TRIGger:USB:SSOP` on page 1507
`SEARch:TRIGger:USB:STOKen` on page 1509
`SEARch:TRIGger:USB:SDATa` on page 1507
`SEARch:TRIGger:USB:SHANdshake` on page 1507
`SEARch:TRIGger:USB:SSPE` on page 1508
`SEARch:TRIGger:USB:SERRor` on page 1507

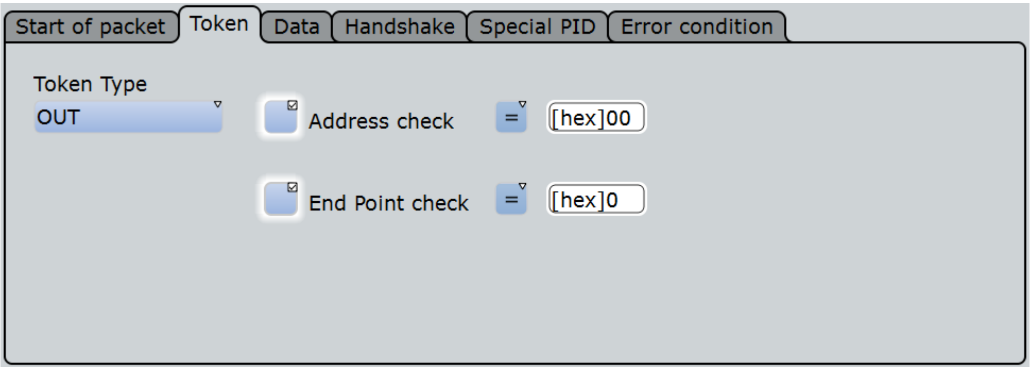
SOP
Searches for any start of packet. There are no additional parameters to be defined.



Token
Searches for four different token types: "OUT", "IN", "SOF", or "SETUP", as well as "Any" token.

For "Any" token, there are no additional parameters to be defined.

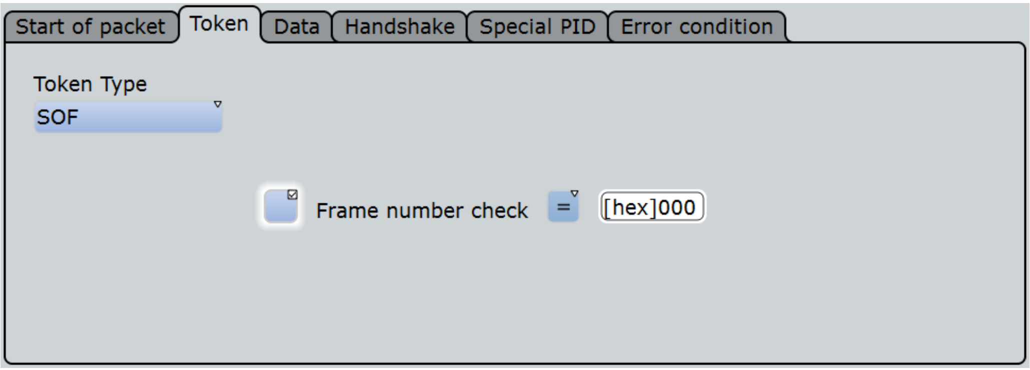
For "OUT", "IN", or "SETUP" tokens, additional search parameters are "Address check" and "End Point check".



You can refine the search condition:

- See "Address check" on page 730
- See "End Point check" on page 731

For "SOF" tokens, the additional search parameter is "Frame number check".



You can refine the search condition:

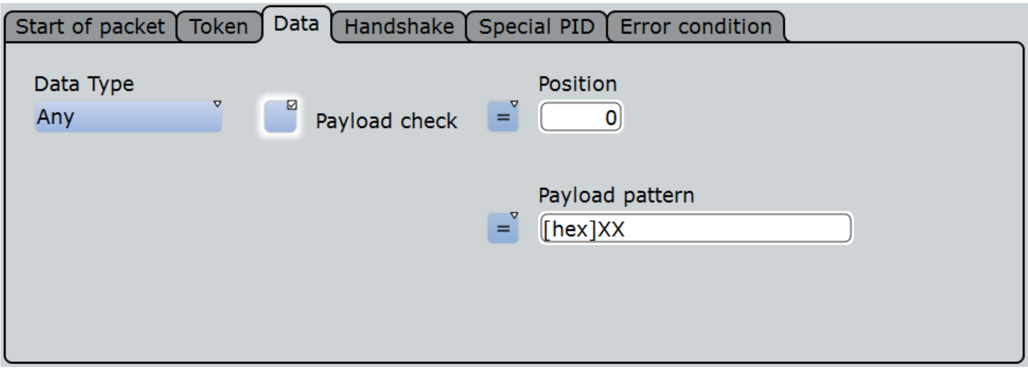
- See "Frame number check" on page 731

Remote command:

`SEARch:TRIGger:USB:TOKen` on page 1510

Data

Searches for data packets of the following types: DATA0, DATA1, DATA2, or MDATA, as well as "Any" data packet.



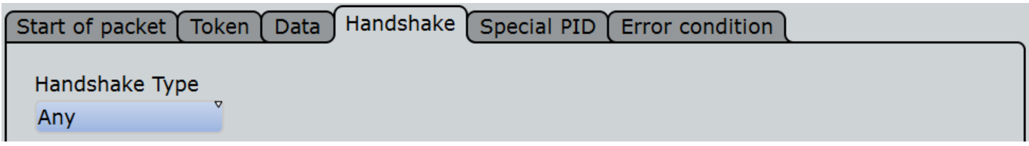
To search for payload in any data packet type, a data pattern and optionally a packet position have to be specified.

You can refine the search condition:

- See "Payload check" on page 731

Remote command:
`SEARch:TRIGger:USB:DATA` on page 1501

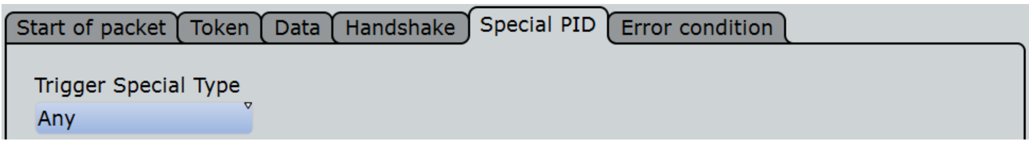
Handshake
Searches for four different handshake packet types: "ACK", "NAK", "STALL", or "NYET", as well as "Any" handshake packet. There are no additional parameters to be defined.



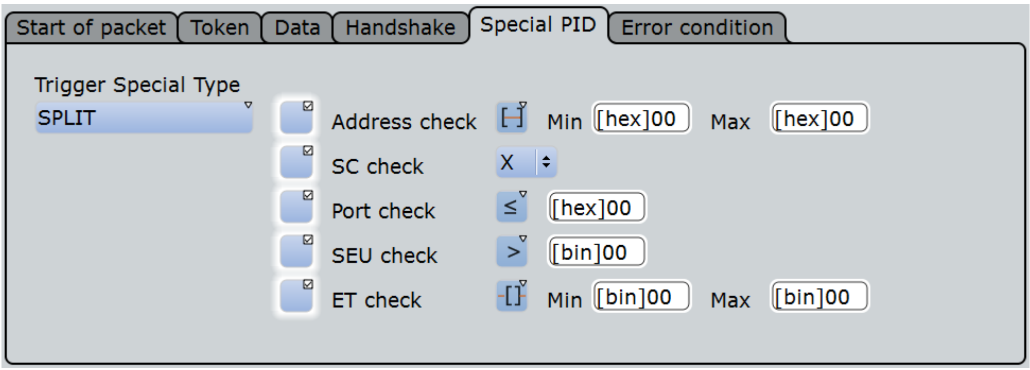
Remote command:
`SEARch:TRIGger:USB:HAND` on page 1504

Special PID
Searches for four different special packet identifier types: "PREamble", "ERR", "SPLIT", or "PING", as well as "Any" special PID.

For "Any", "PREamble", or "ERR", there are no additional parameters to be defined.



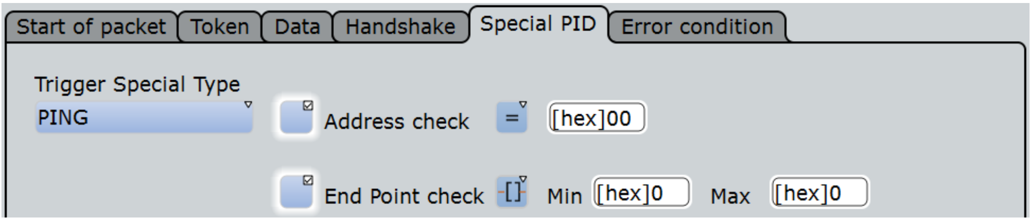
For "SPLIT", additional search parameters are "Address check", "SC check", "Port check", "SEU check", and "ET check".



You can refine the search condition:

- See "Address check" on page 730
- See "SC check" on page 732
- See "Port check" on page 732
- See "SEU check" on page 732
- See "ET check" on page 733

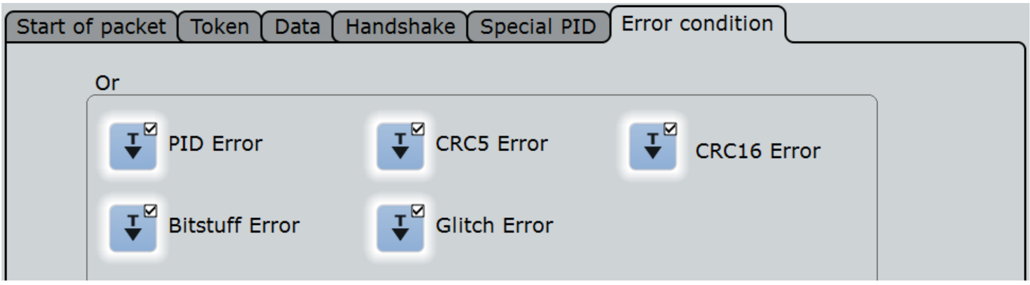
For "PING", additional search parameters are "Address check" and "End Point check".



You can refine the search condition:
- See "Address check" on page 730
- See "End Point check" on page 731

Remote command:
`SEARch:TRIGger:USB:SPEC` on page 1508

Error condition
Searches for the following error conditions:



"PID Error" Searches for packet identifier errors.

Remote command:
`SEARch:TRIGger:USB:PIDerror` on page 1505

"CRC5 Error" Searches for any CRC5 error event.

Remote command:
`SEARch:TRIGger:USB:CRC5error` on page 1500

"CRC16 Error" Searches for any CRC16 error event.

Remote command:
`SEARch:TRIGger:USB:CRC16error` on page 1500

"Bitstuff Error" Searches for bitstuffing errors, thus an erroneous or missing bit stuffing sequence (see USB standard).

Remote command:
`SEARch:TRIGger:USB:BITSterror` on page 1500

"Glitch Error" Searches for glitching errors (errors in the bit period, see USB standard for the definition of glitching).

Remote command:
`SEARch:TRIGger:USB:GLITcherror` on page 1504

Address check
Enables the search for an address that meets specific conditions.

"Condition" Defining a specific address or an address range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies an address, or sets the start value of an address range.

"Max" Sets the the end value of an address range if "Condition" (SEARch:TRIGger:USB:ACONdition) is set to INRange or OORange.

Remote command:
SEARch:TRIGger:USB:WADD on page 1510
SEARch:TRIGger:USB:ACONdition on page 1499
SEARch:TRIGger:USB:AMIN on page 1499
SEARch:TRIGger:USB:AMAX on page 1500

End Point check

Enables the search for an endpoint that meets specific conditions.

"Condition" Defining a specific endpoint or an endpoint range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies an endpoint, or sets the start value of an endpoint range.

"Max" Sets the the end value of an endpoint range if "Condition" (SEARch:TRIGger:USB:ECONdition) is set to INRange or OORange.

Remote command:
SEARch:TRIGger:USB:WEND on page 1511
SEARch:TRIGger:USB:ECONdition on page 1502
SEARch:TRIGger:USB:EMIN on page 1502
SEARch:TRIGger:USB:EMAX on page 1503

Frame number check

Enables the search for a frame number that meets specific conditions.

"Condition" Defining a specific frame number or a frame number range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies a frame number, or sets the start value of a frame number range.

"Max" Sets the the end value of a frame number range if "Condition" (SEARch:TRIGger:USB:FCONdition) is set to INRange or OORange.

Remote command:
SEARch:TRIGger:USB:WFRN on page 1511
SEARch:TRIGger:USB:FCONdition on page 1503
SEARch:TRIGger:USB:FMIN on page 1503
SEARch:TRIGger:USB:FMAX on page 1504

Payload check

Enables the search for a payload data pattern that meets specific conditions.

"Condition"	Sets the operator "any" or "equal" that allows to search for payload data at any position or at a specified position.
"Position"	Available only if "Condition" (SEARch:TRIGger:USB:DPOPerator) is set to *equal*. Specifies the position in which a special data pattern is to be searched within the payload data packet.
"Data Condition"	Sets the operator ("equal" or "unequal", SEARch:TRIGger:USB:DCONdition) to set a specific payload data pattern.
"Payload pattern"	Specifies the payload data pattern that is to be searched.

Remote command:
SEARch:TRIGger:USB:WPAY on page 1511
SEARch:TRIGger:USB:DPOPerator on page 1501
SEARch:TRIGger:USB:DPOSition on page 1502
SEARch:TRIGger:USB:DCONdition on page 1501
SEARch:TRIGger:USB:PATT on page 1504

SC check
Searches for the selected Start (0) or Complete (1) SPLIT transaction endpoint, or X (don't care).

Remote command:
SEARch:TRIGger:USB:WSTC on page 1512
SEARch:TRIGger:USB:STCO on page 1508

Port check
Enables the search for a port that meets specific conditions.

"Condition"	Defining a specific port number or a port number range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies a port number, or sets the start value of a port number range.
"Max"	Sets the the end value of a port number range if "Condition" (SEARch:TRIGger:USB:PCONdition) is set to INRange or OORange.

Remote command:
SEARch:TRIGger:USB:WPOR on page 1512
SEARch:TRIGger:USB:PCONdition on page 1505
SEARch:TRIGger:USB:PMIN on page 1505
SEARch:TRIGger:USB:PMAX on page 1505

SEU check
Enables the search for an SEU that meets specific conditions. (For SEU, see "SEU check" on page 721.)

"Condition" Defining a specific SEU value or an SEU value range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies an SEU value, or sets the start value of an SEU value range.

"Max" Sets the the end value of an SEU value range if "Condition" (SEARch:TRIGger:USB:SCONdition) is set to INRange or OORange.

Remote command:
SEARch:TRIGger:USB:WSEU on page 1512
SEARch:TRIGger:USB:SCONdition on page 1506
SEARch:TRIGger:USB:SMIN on page 1506
SEARch:TRIGger:USB:SMAX on page 1506

ET check

Enables the search for an Endpoint Type (ET) that meets specific conditions.

"Condition" Defining a specific endpoint type or an ET range requires to set the operator to one of the following: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies an ET, or sets the start value of an ET range.

"Max" Sets the the end value of an ET range if "Condition" (SEARch:TRIGger:USB:TCONdition) is set to INRange or OORange.

Remote command:
SEARch:TRIGger:USB:WETCheck on page 1511
SEARch:TRIGger:USB:TCONdition on page 1509
SEARch:TRIGger:USB:TMIN on page 1510
SEARch:TRIGger:USB:TMAX on page 1510

12.15.5.2 USB Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394

Remote commands:

- SEARch:RESult:USB:PCOunt? on page 1517
- SEARch:RESult:USB:PACKet<m>:STATus? on page 1516
- SEARch:RESult:USB:PACKet<m>:STARt? on page 1516

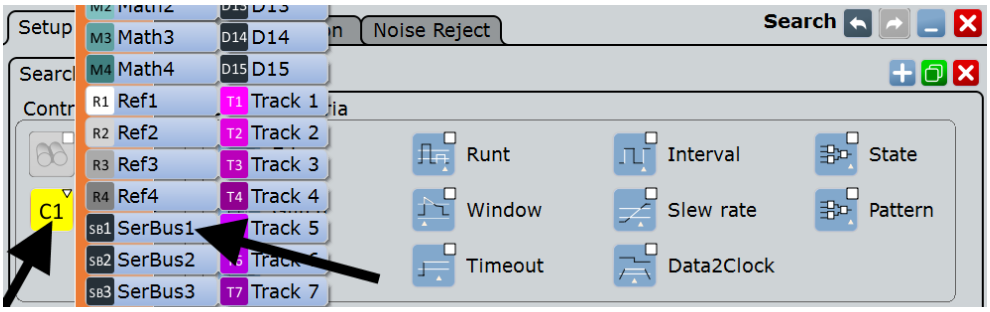
- SEARch:RESult:USB:PACKet<m>:STOP? on page 1516
- SEARch:RESult:USB:PACKet<m>:ADDRess? on page 1513
- SEARch:RESult:USB:PACKet<m>:DATA? on page 1513
- SEARch:RESult:USB:PACKet<m>:CRC? on page 1513
- SEARch:RESult:USB:PACKet<m>:ENDPoint? on page 1514
- SEARch:RESult:USB:PACKet<m>:ET? on page 1514
- SEARch:RESult:USB:PACKet<m>:FRAMe? on page 1514
- SEARch:RESult:USB:PACKet<m>:PID? on page 1514
- SEARch:RESult:USB:PACKet<m>:PORT? on page 1515
- SEARch:RESult:USB:PACKet<m>:SC? on page 1515
- SEARch:RESult:USB:PACKet<m>:SEU? on page 1515

12.15.5.3 Searching USB Data

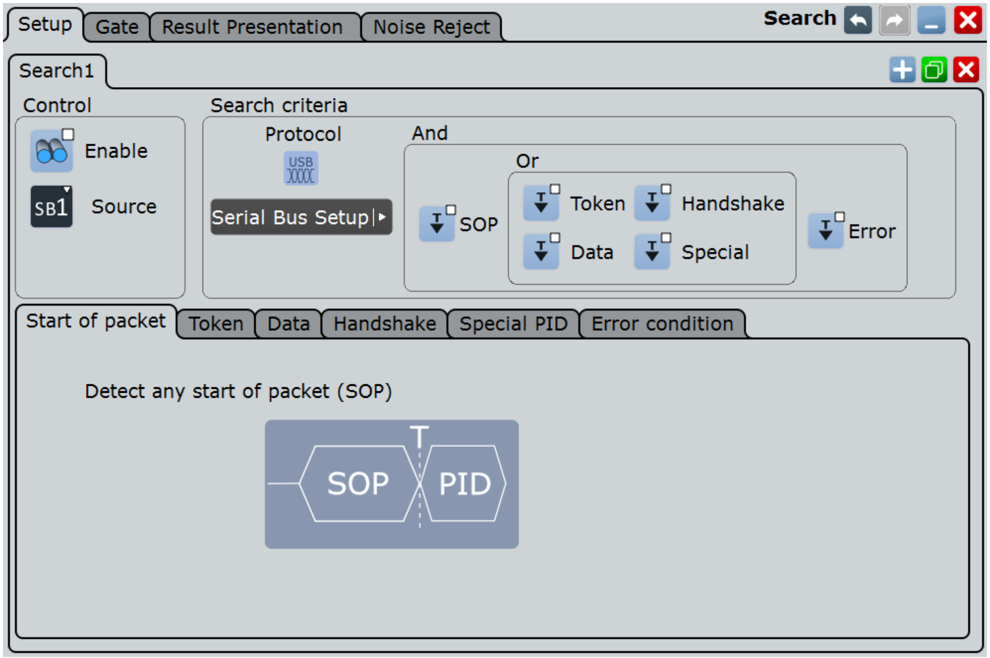
Prerequisite: A serial bus is configured for the USB signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 391.
3. Tap "Source" and select the serial bus that is set to USB (e.g. "SerBus1", unless already selected).

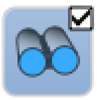


The search dialog for USB protocol analysis is opened.



4. Specify search criteria according to Chapter 12.15.5.1, "USB Search Setup", on page 726.
5. To acquire a waveform, press RUN N× SINGLE.

   The R&S RTE performs a USB decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTE displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 397 and "Navigating search results" on page 378.

12.16 SpaceWire (Option R&S RTE-K65)

The SpaceWire is a communication network standard used for spacecrafts. It is based on the IEEE 1355 standard of comunications and coordinated by the European Space Agency (ESA).

12.16.1 SpaceWire Basic

The SpaceWire links are a Point-toPoint (P2P) connections between a node and another node or a rooter. The link is full-duplex bidirectional serial data link.

The SpaceWire has two type of characters:

- Data characters containing a parity bit, a data control flag and eight bits of data.

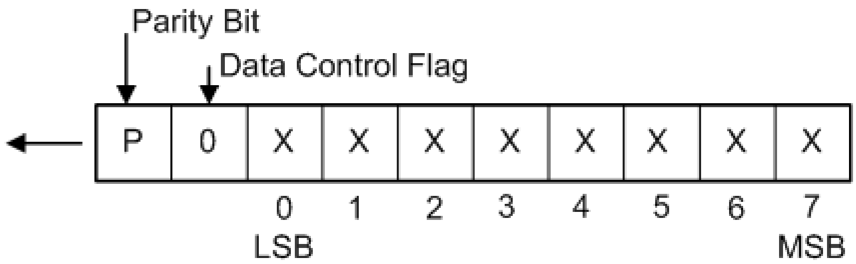


Figure 12-105: SpaceWire data characters

- Control characters containing a parity-bit, a data-control flag and the two-bit control code. The data control flag is set to 1 and indicates that this is a control character.

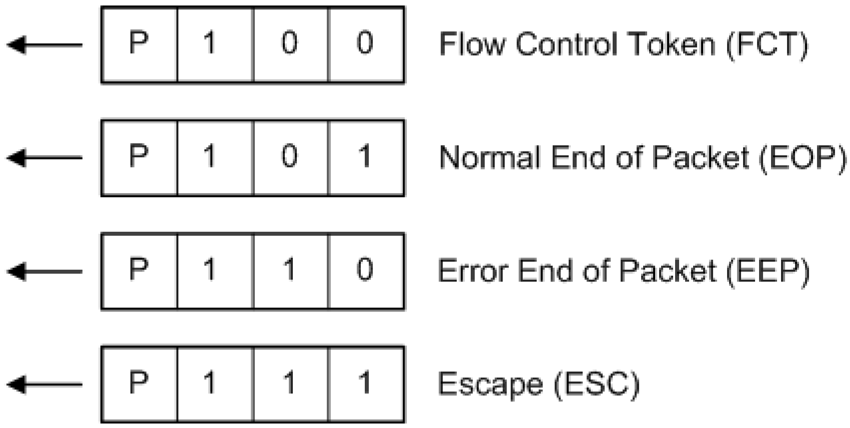


Figure 12-106: SpaceWire control characters

Additionally there are two control codes:

- NULL code consisting of an Escape (ESC) nad a Flow Control Token (FCT)
- Time Code consisting of an ESC followed by a single data character

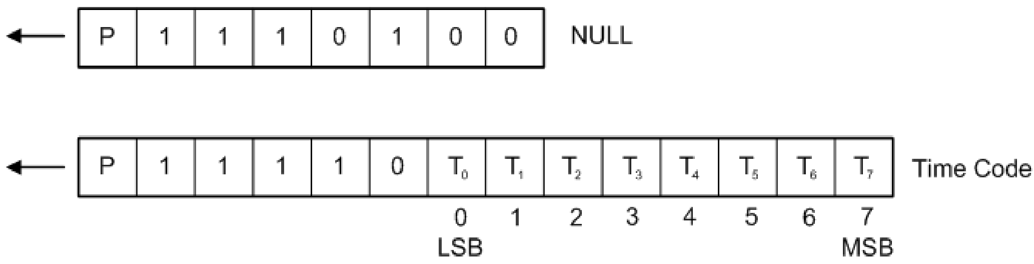


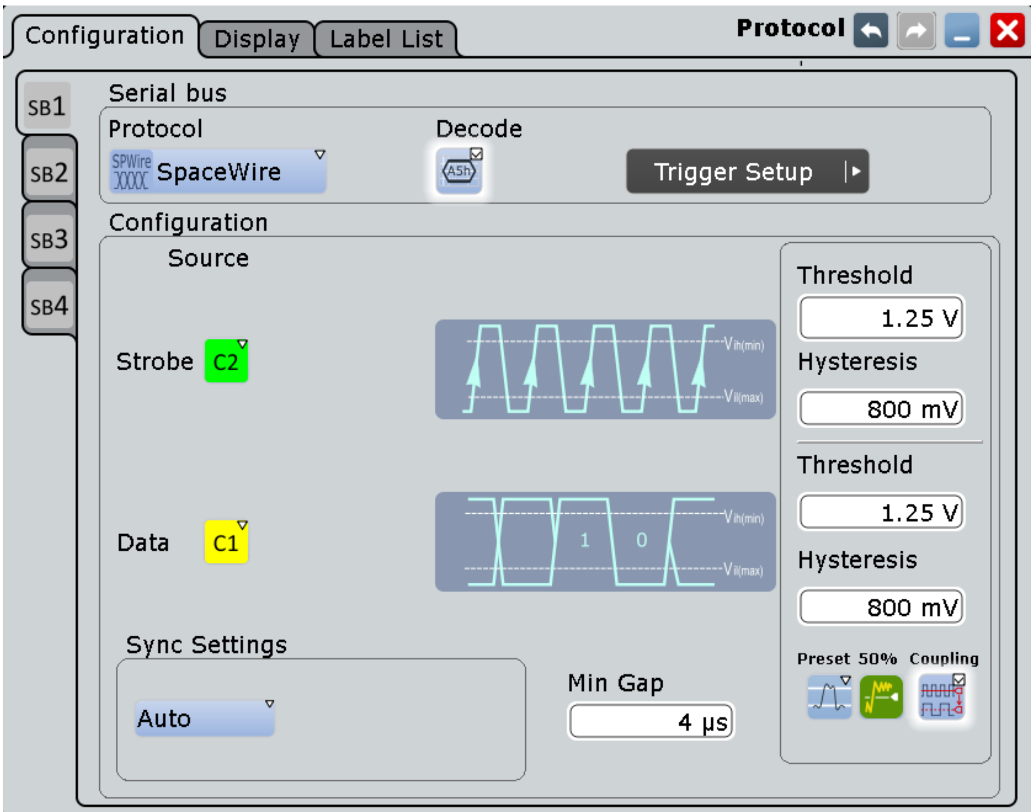
Figure 12-107: SpaceWire control codes

12.16.2 SpaceWire Configuration

12.16.2.1 SpaceWire Configuration Settings

Access: PROTOCOL > "Configuration" tab > "Protocol = SpaceWire"

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Configuration - General Settings", on page 439.

Strobe
Selcts the source for the strobe signal.

Remote command:
BUS<m>:SWIRe:STRBe:SOURce on page 1519

Data
Selcts the source for the data signal.

Remote command:
BUS<m>:SWIRe:DATA:SOURce on page 1518

Threshold
Sets the threshold value for the strobe/data signal.

Remote command:
BUS<m>:SWIRe:STRBe:THReshold on page 1519
BUS<m>:SWIRe:DATA:THReshold on page 1518

Hysteresis
Sets a value for the hysteresis of the strobe/data signal.

Remote command:
BUS<m>:SWIRe:STRBe:HYSTeresis on page 1519
BUS<m>:SWIRe:DATA:HYSTeresis on page 1518

Sync Settings
Sets the mode for the synchronisation of the signal. In the auto mode the decoder will automatically do the packet align. In the manual mode you can set the align point manually with the "Bit Position" setting.

Remote command:
BUS<m>:SWIRe:SYSLect on page 1519

Bit Position ← Sync Settings
Sets the bit position, the align position for the manual synchronisation mode. This can be useful when parity errors exist in the signal, and parity check is the main indicator for the decoder to do packet alignment.

Remote command:
BUS<m>:SWIRe:BPOSition on page 1517

Min Gap
SpaceWire can have idle phases where neither strobe nor data signals are being sent. These "gaps" are identified in order to resume decoding after this idle time.

"Min Gap" sets the minimum duration of a gap. Any inactivity greater than this time will be interpreted as a gap and lead to a resynchronization to the signal.

Remote command:
BUS<m>:SWIRe:MGAP on page 1518

Preset
Presets the threshold and hysteresis values of the strobe and data signal.

The preset values may vary according to the measurement signal:

- 0.1 V - 100 mV Threshold, 10 mv Hysteresis
- 0.3 V - 300 mV Threshold, 30 mV Hysteresis
- 2 V - 1 V Threshold, 200 mV Hysteresis

Remote command:
`BUS<m>:SWIRe:PRESet` on page 1520

Set to 50%
Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Remote command:
`BUS<m>:SETReflevels` on page 1163

Coupling
Enables coupling, i.e. the same threshold and hysteresis value is used for the strobe and data signal.

Remote command:
`BUS<m>:SWIRe:COUPling` on page 1520

12.16.2.2 Configuring the SpaceWire Signals

For configuration, assign the lines to the input channels and define the logical thresholds and the hysteresis.

1. Press the PROTOCOL key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "SpaceWire".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Select the source and polarity for the strobe and data signals.
7. Enter the "Threshold" and the "Hysteresis" for the strobe and data signals.
8. Set the "Sync Settings" and the "Bit Position" if required.
9. Enable "Decode", if available.

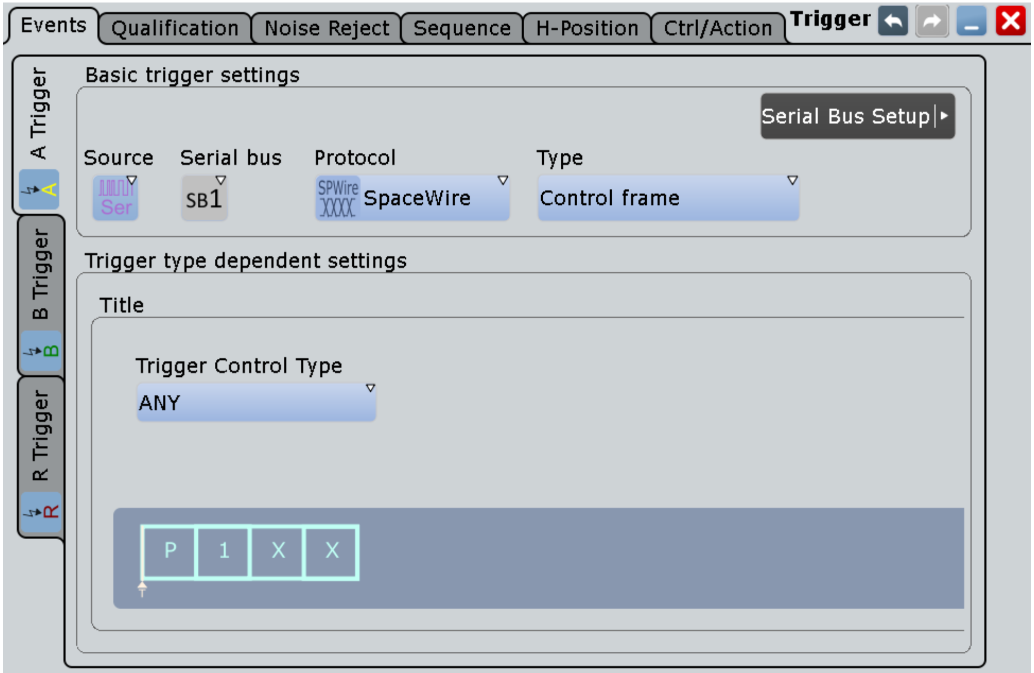
12.16.3 SpaceWire Trigger

12.16.3.1 SpaceWire Trigger Settings

Access: TRIGGER > "Source" = *Serial Bus* and "Protocol" = *SpaceWire*

In this section, all trigger settings are described. Their availability on the instrument depends on the selected USB protocol type and trigger type. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to data sheet.



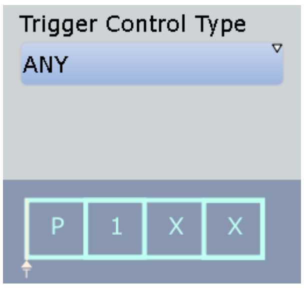
Make sure that:

- The data source(s) of the serial bus are channel signals: PROTOCOL > "Configuration" tab.
- The trigger sequence is set to "A only": TRIGGER > "Sequence" tab.
- The trigger source is "Serial bus": TRIGGER > "Events" tab.
- The correct serial bus is selected: TRIGGER > "Events" tab.
- The correct protocol is selected: TRIGGER > "Events" tab.

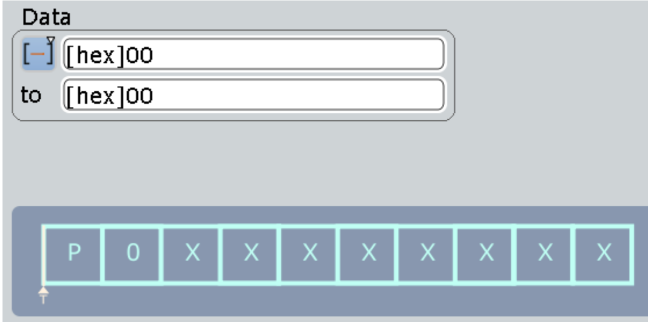
Type

Selects the trigger type for the SpaceWire analysis.

"Control frame" Sets the trigger to the selected control type frame.

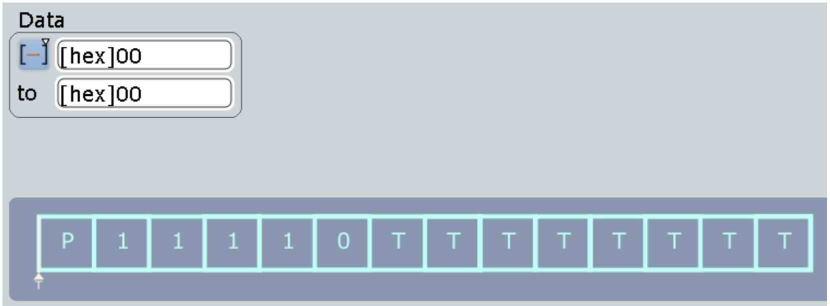


"Data pattern" Sets the trigger to a defined data pattern or pattern range.



"NULL frame" Sets the trigger to a null frame, a frame without usable data.

"Time Code" Sets the trigger to a time-code control code. You can define the data pattern of the time code to be triggered on.



"ERRORs" Triggers on an enabled error type.

Remote command:
TRIGger<m>:SWIRe:TYPE on page 1523

Trigger Control Type
Triggers on a specific control type character.

"ANY" Any control type character

"FCT" Flow Control Token character

"EOP" Normal End of Packet character

"EEP" Error End of Packet character

Remote command:
TRIGger<m>:SWIRe:CTYPe on page 1520

Data (Time Code)
Sets the specified data type for the time code to be triggered on. The data type setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.

"Data Min/ Data" Defines the bit pattern of the data pattern.
In binary format, use the following characters: 1; 0; or X (don't care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:SWIRe:TIME:CONDition` on page 1522
`TRIGger<m>:SWIRe:TIME:MAX` on page 1523
`TRIGger<m>:SWIRe:TIME:MIN` on page 1523

Data(Data Pattern)

Sets the specified data type for the data pattern to be triggered on. The data type setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.

"Data Min/ Data" Defines the bit pattern of the data pattern.
In binary format, use the following characters: 1; 0; or X (don't care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:SWIRe:DATA:CONDition` on page 1521
`TRIGger<m>:SWIRe:DATA:MAX` on page 1521
`TRIGger<m>:SWIRe:DATA:MIN` on page 1521

Parity Error

Checks the parity of every frame and triggers if the parity is even.

Remote command:
`TRIGger<m>:SWIRe:ERRor:PARity` on page 1522

ESC Error

Triggers on a escape error.

Remote command:
`TRIGger<m>:SWIRe:ERRor:ESC` on page 1522

12.16.3.2 Triggering on SpaceWire

Prerequisite: A bus is configured for the SpaceWire signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press TRIGGER or, if coming from the serial bus protocol configuration dialog, tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):

3. Tap "Serial bus" and select the serial bus that is set to SpaceWire, e.g.:

   The "Protocol" selection is then automatically set to "SpaceWire".
4. Select the "Trigger Type" to be used for SpaceWire protocol analysis.
5. To refine the trigger settings, configure additional settings, which are available for some trigger types.
   For details, see Chapter 12.16.3.1, "SpaceWire Trigger Settings", on page 739.

12.16.4 SpaceWire Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 440

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Example

The example in Figure 12-108 shows a decoded signal with ambiguous bits (the earliest, least significant, parity bit among all surviving tracks). In the honeycomb the ambiguous bits are marked in pink. Additionally they are reflected in the result table.

Figure 12-108: Decoded SpaceWire signal with ambiguous bits

The example in Figure 12-109 shows a decoded signal with existing parity errors. The errors are marked with red on the honeycomb and reflected in the results table.

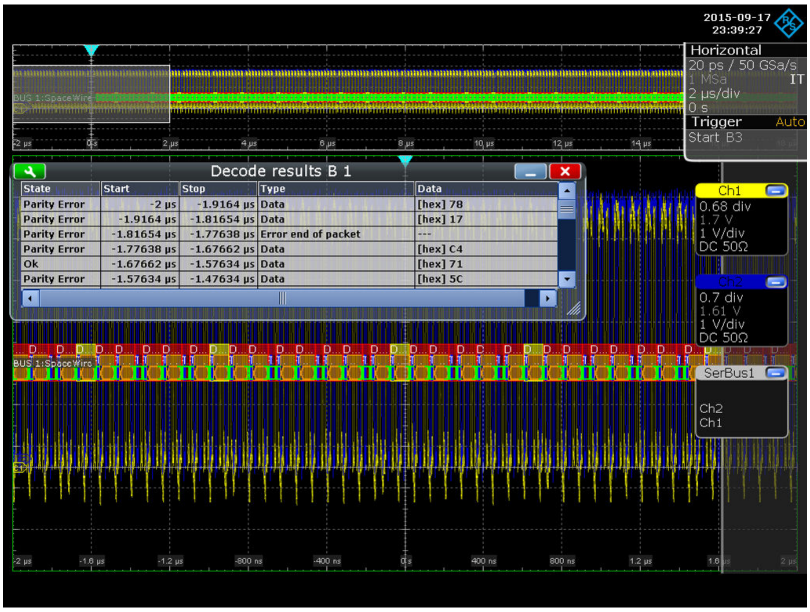


Figure 12-109: Decoded SpaceWire signal with a parity error

Table 12-21: Content of the decode result table

Column	Description
State	Overall state of the frame
Start	Time of frame start in relation to the trigger point
Stop	Time of frame stop in relation to the trigger point

Column	Description
Type	Frame type
Data	Data value

Remote commands:
- BUS<m>:SWIRe:RESults:FCOunt on page 1523
- BUS<m>:SWIRe:RESults:FRAMe<n>:DATA? on page 1524
- BUS<m>:SWIRe:RESults:FRAMe<n>:STARt? on page 1524
- BUS<m>:SWIRe:RESults:FRAMe<n>:STATe? on page 1524
- BUS<m>:SWIRe:RESults:FRAMe<n>:STOP? on page 1525
- BUS<m>:SWIRe:RESults:FRAMe<n>:TYPE? on page 1525

12.16.5 Search on Decoded SpaceWire Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

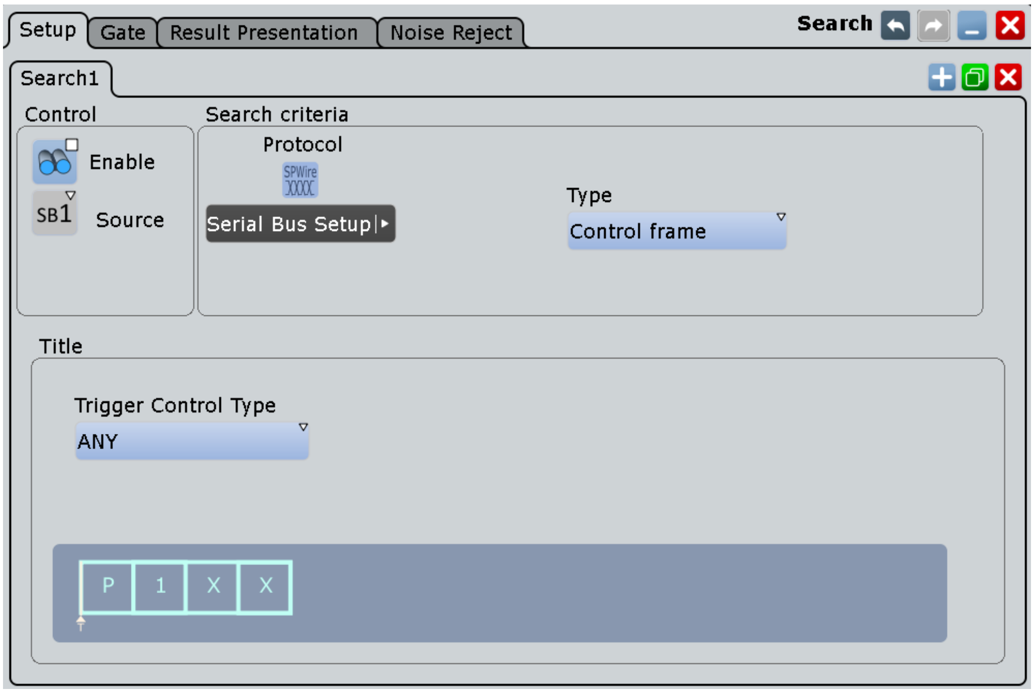
Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 376.

12.16.5.1 SpaceWire Search Setup

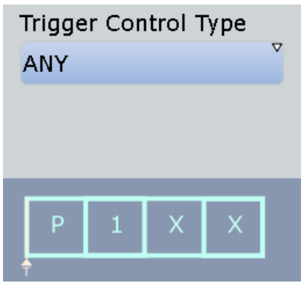
Access: SEARCH > "Setup" tab > "Source" = Serial bus configured for SpaceWire



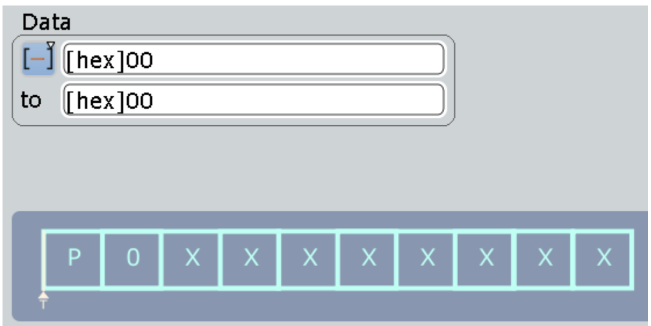
Type

Sets the search type for the SpaceWire analysis.

"Control frame" Searches for the selected control type frame.



"Data pattern" Searches for a defined data pattern or pattern range.



"NULL frame" Searches for a null frame, a frame without usable data.

"Time Code" Searches for a time-code control code. You can define the data pattern of the time code to be searched for.

"ERRORs" Searches for an enabled error type.

Remote command:
SEARch:TRIGger:SWIRe:TYPE on page 1529

Trigger Control Type

Searches for a specific control type character.

"ANY" Any control type character

"FCT" Flow Control Token character

"EOP" Normal End of Packet character

"EEP" Error End of Packet character

Remote command:
SEARch:TRIGger:SWIRe:CTYPe on page 1526

Data (Time Code)

Sets the specified data type for the time code to be searched for. The data type setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.

"Data Min/ Data" Defines the bit pattern of the data pattern.
In binary format, use the following characters: 1; 0; or X (don't care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
SEARch:TRIGger:SWIRe:TIME:CONDition on page 1528
SEARch:TRIGger:SWIRe:TIME:MAX on page 1529
SEARch:TRIGger:SWIRe:TIME:MIN on page 1529

Data(Data Pattern)

Sets the specified data type for the data pattern to be searched for. The data type setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.

"Data Min/ Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (don't care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 445.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:SWIRe:DATA:CONDition` on page 1527
`SEARch:TRIGger:SWIRe:DATA:MAX` on page 1527
`SEARch:TRIGger:SWIRe:DATA:MIN` on page 1527

Parity Error
Checks the parity of every frame and searches for even parity.

Remote command:
`SEARch:TRIGger:SWIRe:ERRor:PARity` on page 1528

ESC Error
Searches for an escape error.

Remote command:
`SEARch:TRIGger:SWIRe:ERRor:ESC` on page 1528

12.16.5.2 SpaceWire Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 377
- Chapter 10.4, "Result Presentation", on page 394

Remote commands:

- `SEARch:RESult:SWIRe:FCOunt` on page 1529
- `SEARch:RESult:SWIRe:FRAMe<m>:DATA?` on page 1530
- `SEARch:RESult:SWIRe:FRAMe<m>:STARt?` on page 1530
- `SEARch:RESult:SWIRe:FRAMe<m>:STATe?` on page 1530
- `SEARch:RESult:SWIRe:FRAMe<m>:STOP?` on page 1531
- `SEARch:RESult:SWIRe:FRAMe<m>:TYPE?` on page 1531

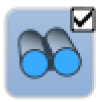
12.16.5.3 Searching SpaceWire

Prerequisite: A serial bus is configured for the SpaceWire signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press SEARCH or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 391.
3. Tap "Source" and select the serial bus that is set to SpaceWire (e.g. "SerBus1", unless already selected).
4. Specify search criteria according to Chapter 12.16.5.1, "SpaceWire Search Setup", on page 745.
5. To acquire a waveform, press RUN N× SINGLE.

   The R&S RTE performs a SpaceWire decode according to the thresholds and protocol settings of the associated serial bus source.
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTE displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 397 and "Navigating search results" on page 378.

13 Mixed Signal Option (MSO, R&S RTE-B1)

The Mixed Signal Option R&S RTE-B1 adds logic analyzer functions to the classical oscilloscope functions. Using the MSO option, you can analyze and debug embedded systems with mixed-signal designs that use analog signals and correlated digital signals simultaneously.

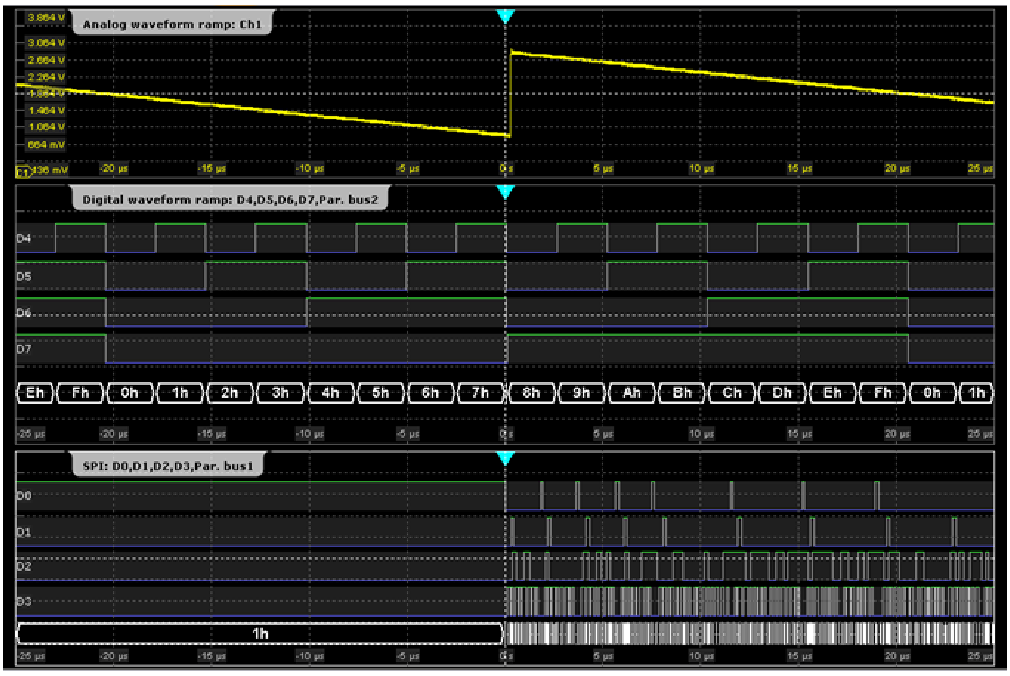
The Mixed Signal Option provides 16 digital channels grouped in two logic probes (pods) with 8 channels each. The instrument ensures that analog and digital waveforms are time-aligned and synchronized so that critical timing interactions between analog and digital signals can be displayed and tested. The automatic alignment compensates the skew between the probe connectors of the analog channels and the probe boxes of the digital channels.

13.1 Digital channels and parallel buses

Each digital channel can be displayed on the screen and used as trigger source. Digital channels may be grouped and displayed as a parallel bus. Up to four parallel buses can be configured; and two bus types are supported: clocked bus and unclocked bus. The clocked bus is available only on parallel bus 1 and 2. Each digital channel can be assigned to one *active* parallel bus only, the instrument disables conflicting buses automatically.

You can display each bus and use it as trigger source, as well. For each active parallel bus, the corresponding signal icon appears on the signal bar and indicates the assigned digital channels. Individual digital channels do not have a signal icon.

If one or more parallel buses are active, the roll mode is not available.

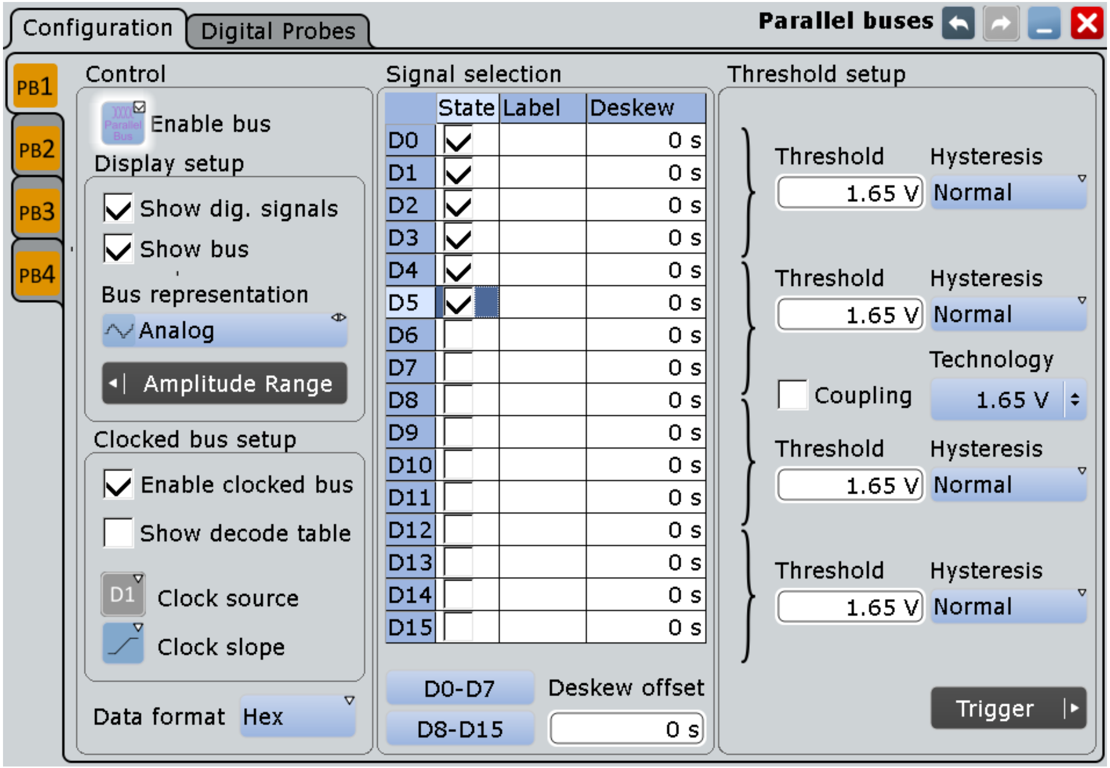


13.1.1 Parallel Buses - Configuration

Access: "Analysis" menu > "Parallel buses"

Digital channels can be displayed individually, and they can be grouped and displayed as a parallel bus. You can configure and enable up to 4 parallel buses. Each digital channel can be assigned to one *active* parallel bus only, the instrument disables conflicting buses automatically.

For clocked buses, you can display the decoded data in a result box.



If you have configured several parallel buses and you want to modify the configuration or display settings, make sure that the tab of the correct bus is selected on the left side, and disable the bus before you change the settings.

Enable bus

Enables the selected parallel bus. The corresponding signal icon appears on the signal bar.

If another *active* bus already uses the same digital channel(s), the instrument disables the other bus and shows a message.

Remote command:

`BUS<m>:PARallel:STATe` on page 1536

Show dig. signals

If enabled, the selected digital channels are shown in the diagram. Each channel is displayed as a logic signal.

Remote command:

`BUS<m>:PARallel:DISPlay:SHDI` on page 1540

Show bus

If enabled, the resulting bus signal and bus values are displayed in the diagram. Select the presentation type for the bus signal with Bus representation.

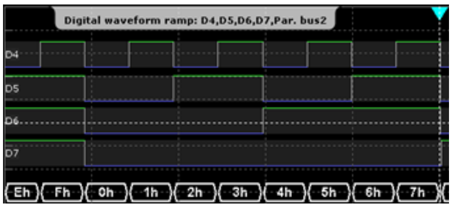
Remote command:

`BUS<m>:PARallel:DISPlay:SHBU` on page 1540

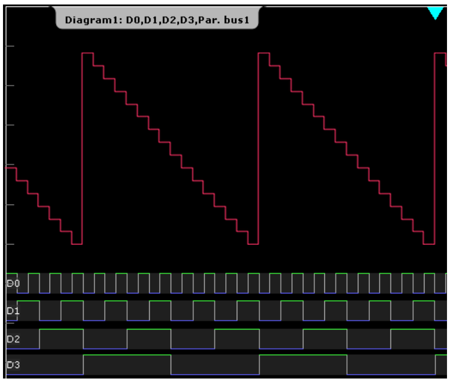
Bus representation

Defines how the parallel bus is displayed:

"Comb" Displays the decoded bus signal with bus values. When at least one digital channel changes its value, the bus value changes too.



"Analog" Displays the bus values as signal amplitudes, similar to an analog waveform. Thus, a quasi-analog waveform is created.

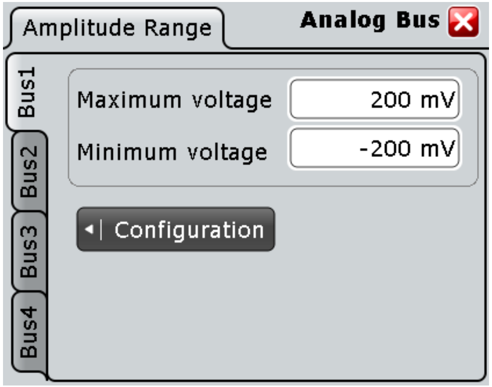


Remote command:

`BUS<m>:PARallel:DISPlay:BTYP` on page 1541

Amplitude Range

If the bus representation is "Analog", the amplitude range defines the voltage range for the display of the analog bus. The highest bus value corresponds to the "Maximum voltage", and the lowest bus value to the "Minimum voltage".



See also: "Bus representation" on page 753

Clocked bus setup

If a bus is a clocked bus, one of the digital channels serves as clock of the bus.

For an unclocked bus, the logical state of the bus is determined for each sample. For a clocked bus, the logical state is determined only at the specified clock edges.

The settings are only available for "Bus1" and "Bus2".

"Enable clocked bus"	Enable this option, if the bus is a clocked bus.
"Show decode table"	The decode table is only available for clocked buses to check the data words. If enabled, a results box opens with decoded values of the bus signal and its time. Each clock edge corresponds to one row in the table.
"Clock source"	Selects the digital channel used as clock.
"Clock slope"	Selects the slope of the clock signal at which all digital channels of the bus are analyzed.

Remote command:
`BUS<m>:PARallel:CLON` on page 1541
`BUS<m>:PARallel:CLOCk` on page 1541
`BUS<m>:PARallel:CLSLope` on page 1542

Data format

Sets the data format of bus values, which are displayed in the decode table and on the comb bus display. Available formats are: Hex, Ascii, Octal, Binary, Signed, and Unsigned.

Signed and Unsigned are integer data types with maximum 16 bit length. Unsigned is used for positive integers. Signed is used for positive and negative integers.

If the target file format is BIN, you can save only signed and unsigned binary data. The data format "Signed" writes signed data; all other formats are saved as unsigned binary data.

Remote command:
`BUSFormat` on page 1164

Signal selection

In the table, you select and configure the digital channels that are used in the selected bus.

"State"	Enables a digital channel, and assigns it to the bus.
"Label"	You can enter a name for each digital channel. The name is displayed in the diagram.
"Deskew"	Sets an individual delay for each digital channel to time-align it with other digital channels. The deskew value compensates delays that are known from the circuit specifics or caused by the different length of cables. The skew between the probe boxes of the digital channels and the probe connectors of the analog channels is automatically aligned by the instrument. You can also set a value that is applied to all digital channels, see "Deskew offset" on page 755.

Remote command:
`BUS<m>:PARallel:BIT<n>[:STATe]` on page 1536 (all buses)
`DIGital<m>:DISPlay` on page 1533 (Bus1)
`BUS<m>:PARallel:BIT<n>:LABel` on page 1540 (all buses)
`DIGital<m>:LABel` on page 1535 (Bus1)
`BUS<m>:PARallel:BIT<n>:DESKew` on page 1539 (all buses)
`DIGital<m>:DESKew` on page 1535 (Bus1)

D0-D7, D8-D15 ← Signal selection

The buttons select or deselect all digital channels of a pod at once.

Deskew offset ← Signal selection

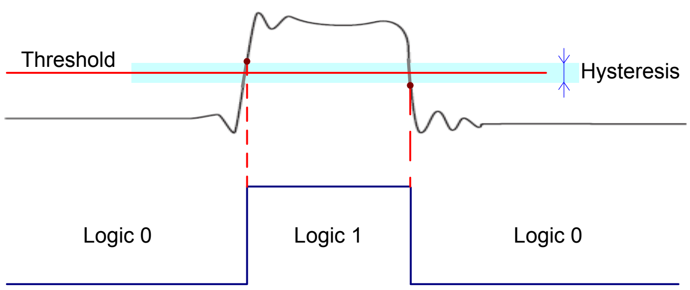
Sets a general delay for all digital channels. The resulting deskew of a digital channel is the sum of the general "Deskew offset" and the individual "Deskew".

Remote command:
`BUS<m>:PARallel:DESoffset` on page 1539

Threshold setup

Sets the logical threshold. For each sample, the instrument compares the input voltage with the threshold value. If the input voltage is above the threshold, the signal state "1" is stored. Otherwise, the signal state "0" is stored if the input voltage is below the threshold.

To avoid the change of signal states due to noise, a hysteresis is considered.



By default, same threshold and hysteresis value is used for all digital channels and all parallel buses: "Coupling" is enabled.

You can also set different thresholds for the individual channel groups: Disable "Coupling" and set the threshold value for each group. As long as the buses are disabled, you can set different thresholds for each bus. Active buses use the same threshold and hysteresis values, the settings of the last activated bus take effect.

The range of threshold levels and the minimum voltage swing are given in the data sheet.

"Threshold" Enter the value directly in the field.

"Technology" Selects the threshold voltage for various types of integrated circuits from a list and applies it to all digital channels. The value is set to "Manual" if a user-defined threshold was entered directly.

"Coupling" Sets the threshold and the hysteresis for all digital channels and all buses to the same value.

"Hysteresis" Defines the size of the hysteresis. Three values are available:

- Normal: the instrument sets a small value suitable for the signal and its settings. Use this setting for clean signals.
- Maximum: the instrument sets the maximum value that is possible and useful for the signal and its settings. Use this setting for noisy signals.

Remote command:
BUS<m>:PARallel:TECHnology on page 1537 (all buses)
DIGital<m>:TECHnology on page 1533 (bus1)
BUS<m>:PARallel:THReshold<n> on page 1537 (all buses)
DIGital<m>:THReshold on page 1533 (bus1)
BUS<m>:PARallel:THCoupling on page 1538 (all buses)
DIGital<m>:THCoupling on page 1534 (bus1)
BUS<m>:PARallel:HYSTeresis<n> on page 1538 (all buses)
DIGital<m>:HYSTeresis on page 1534 (bus1)

13.1.2 Parallel Buses - Digital Probes

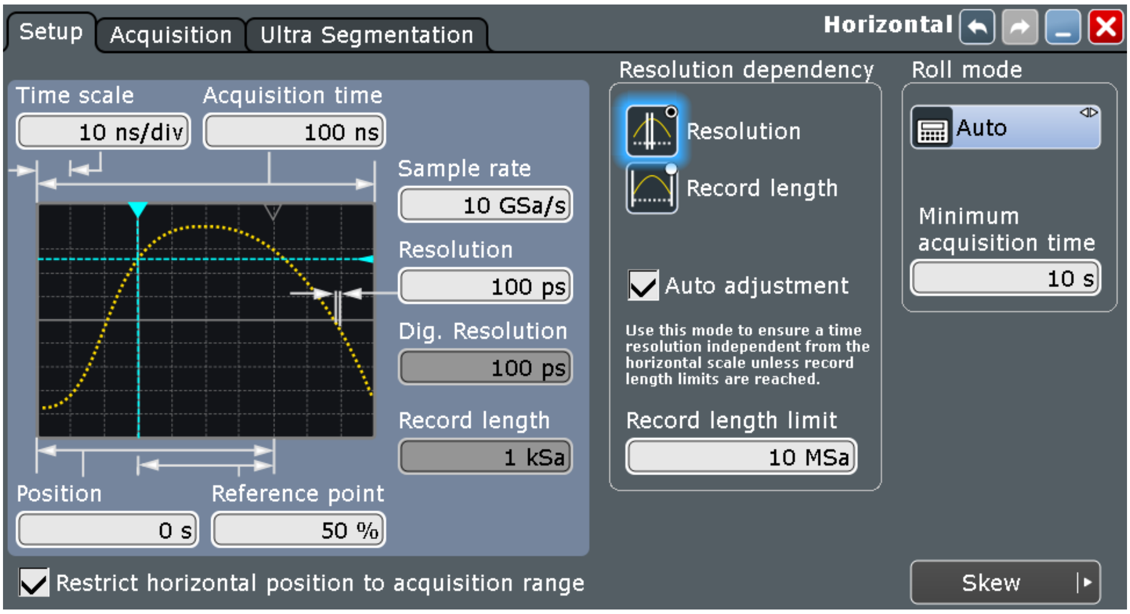
Access: "Analysis" menu > "Parallel buses" > "Digital Probes" tab

Logic probes provided by R&S are recognized by the instrument. The fields show the characteristics of each recognized probe (pod) for information. "Write EEPROM" and "Flash it" are service functions.

13.1.3 Digital Resolution

Access: RES REC LEN key

If an MSO option is installed and at least one digital channel is active, additional information appears on the "Setup" tab of the "Horizontal" dialog box.



Dig. resolution
Shows the current digital resolution of the digital channels. The maximum digital record length is always 200 MSa per digital channel. This number is independent of additionally installed memory.

Remote command:
`ACQuire:DRESolution?` on page 1542

13.1.4 Using Digital Probes

Consider the following guidelines for good probing practices:

- The ground lead from each digital channel group (D15–D8 and D7–D0) should be attached to the ground of the device under test if any channel within the group is being used for data capture. The ground lead improves signal fidelity to the oscilloscope, ensuring accurate measurements.
- For high-speed timing measurements (rise time < 3 ns), each digital channel probe should use its own ground.

1. Connect the digital probe cable to any of the MSO connectors on the rear panel of the instrument as shown on the Documentation Card delivered with the digital probe.
2. Connect the ground lead on each set of channels (each pod) with a probe grabber.
3. Connect a grabber to one of the probe leads.
4. Connect the grabber to a node in the circuit you want to test.
5. For high-speed signals, connect a ground lead to the probe lead, and connect the ground lead to ground in the device under test.

6. Repeat these steps until you have connected all points of interest.

13.1.5 Configuring Digital Channels and Parallel Buses

The configuration of a parallel bus includes the selection and setup of the digital channels, the configuration of the bus display, and, if required, the clock configuration.

For a detailed description of the settings, see Chapter 13.1.1, "Parallel Buses - Configuration", on page 751.

1. On the "Analysis" menu, tap "Parallel buses".
2. In the "State" column of the "Signal selection" table, enable the digital channels to be displayed and included in the bus.
   To enable or disable all channels of a pod at once, tap "D0-D7" or "D8-D15".

   Enabling one or more channels also enables the display of the signals - "Show dig. signals", and enables the parallel bus. If another active bus already uses the same digital channel(s), the instrument disables this bus and shows a message.
   The digital signals are shown in the diagram, and the signal icon of the parallel bus appears on the signal bar. Using this bus icon, you can minimize, arrange, and switch off the bus together with its channels in the same way as you do with any waveform.
3. Optionally, you can enter a "Label" for each digital channel, and a "Deskew" value to time-align the channel.
4. Set the logical thresholds as described in Chapter 13.1.6, "Setting the Logical Thresholds", on page 758.
5. If the bus has a clock signal, enable "Bus clocked" and select the "Clock source" and "Clock slope".

   Now the configuration of the parallel bus is completed.

13.1.6 Setting the Logical Thresholds

For a detailed description of the settings, see "Threshold setup" on page 755. Threshold settings are the same for all *active* parallel buses.

1. On the "Analysis" menu, tap "Parallel buses".
2. To set the thresholds, use one of the following ways:
   - Use the same value for all digital channels and all parallel buses: Enable "Coupling" and set one threshold value, either select a predefined "Technology" value or enter a user-defined value.
   - Set different thresholds for the individual channel groups: Disable "Coupling" and set the threshold value for each group. As long as the buses are disabled, you can set different thresholds for each bus. Active buses use the same threshold and hysteresis values.

3. Set the "Hysteresis" for each threshold to avoid the change of signal states due to noise.

13.2 Display

You can adjust the display of the parallel bus signals and the individual digital channels to optimize the analysis of bus data:

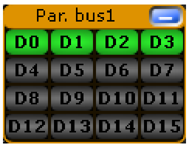
- show the digital channels which are assigned to the bus, drag them to the optimal position, and scale them
- show the decoded bus signal in different ways:
  - comb display with numeric bus values
  - analog display with bus values as amplitudes (quasi-analog waveform)

  You can also drag the bus waveforms on the display and scale them.
- show the result box of the decoded clocked bus signal

Each parallel bus is shown in a separate diagram, and the diagrams can be minimized and arranged as usual.

The signal icon indicates the activities on the digital channels even if they are not displayed in the diagram, of if the acquisition has been stopped:

- blue: channel is low
- green: channel is high
- gray: channel state is changing



The display update rate of the oscilloscope is adapted to the visual perception of human eyes, and it is slower than the acquisition rate. All analog and digital waveforms that are acquired during one display update cycle are overlapped and displayed at once. Thus you can see the cumulative occurance of binary states and edge transitions on the screen at once. Bus signals are not overlapped.

The trigger point is always visible on the display, it cannot be moved outside ("Restrict horizontal position to acquisition range" is enabled automatically).

If digital channels are active, the trigger point is always visible on the display, it cannot be moved outside.

To access and analyze one or more specific acquisitions, you can use the History Viewer in the common way.

Furthermore, you can zoom in digital signals and bus signal in the same way as in analog waveforms.

See also:

- Chapter 6.4, "History", on page 258

- Chapter 6.1, "Zoom", on page 227

13.2.1 Parallel Bus - Decode Table

Decoding is available for clocked parallel buses.

The decode table shows the decoded data words of the bus signal and the corresponding time. Each clock edge corresponds to one row in the table. Below the table, you can select the data format of the bus values.

The results can be saved to a csv or html file, see Chapter 11.2.4, "Numeric Results", on page 423.

13.2.2 Adjusting the Display of Digital Channels and Parallel Buses

The display of digital channels and parallel buses is flexible, you can adjust it to your needs by combining the following settings:

1. Enable "Show bus" if you want to display the bus signal in the diagram. Under "Bus representation", select if you want to display the decoded bus signal with bus values ("Comb"), or show the bus values as amplitudes, similar to an analog waveform ("Analog").
2. Check the signal icon of the bus to monitor the activities on the digital channels even if they are not displayed in the diagram, of if the acquisition has been stopped:
   - blue: channel is low
   - green: channel is high
   - gray: channel state is changing
3. In the diagram, you can change the display order of the digital channels by dragging the individual channels to the required position.
4. To adjust the line height and vertical position of all digital channels at once, tap one of the digital channels and turn the vertical SCALE and POSITION / OFFSET rotary knobs. In the same way, you can move and scale the bus signal.
5. If the bus signal is displayed as quasi-analog waveform, you can doble-tap the waveform to open the "Parallel buses" dialog box.
6. To switch off the display of the digital channels, disable "Show signals".

13.3 Trigger

For digital trigger sources are all trigger types useful that require only one trigger level as trigger condition. This level is the logical threshold. Possible trigger sources are the individual digital channels, parallel bus signals, or any logical combination of digital channels. The following trigger types are available:

Table 13-1: Trigger types and digital trigger sources

Trigger type	Trigger source is		
	Digital channel	Logic combination of digital channels	Parallel bus
Edge	X	X	
Width	X	X	
Timeout	X	X	
Data2Clock	X		X
State		X	X
Pattern (with holdoff)		X	X
Serial Pattern	X	X	

For details, see: Chapter 13.3.1, "Trigger Settings for Digital Signals and Parallel Buses", on page 761.

Additionally, you can define trigger holdoff conditions. See also Chapter 5.4, "Holdoff", on page 216.

13.3.1 Trigger Settings for Digital Signals and Parallel Buses

Depending on the selected source, the instrument provides the appropriate trigger types and the corresponding trigger settings.

The settings in the "Event" tab are:

13.3.1.1 Basic Trigger Settings

The basic trigger settings for MSO are the trigger source and the trigger type. They are selected in the upper part of the "Trigger" dialog box.

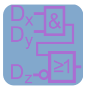
Make sure that the trigger sequence is set to "A only".

Additionally, you can define trigger holdoff conditions. See also Chapter 5.4, "Holdoff", on page 216.

Source
If the Mixed Signal Option is installed, the variety of trigger sources of the A-event setup is enhanced with specific digital trigger sources. You can select as trigger source:

- one of the digital channels "D0" ... "D15"

- a logic combination of digital channels: "Logic"



- one of the parallel buses "Par. bus1" ... "Par. bus4"

Remote command:
`TRIGger<m>:SOURce` on page 942

Type
Depending on the selected source, the instrument provides the appropriate trigger types and the corresponding trigger settings. For mixed signal analysis, the following trigger types are available:

- Edge, see page 762
- Width, see page 763
- Timeout, see page 764
- Data2Clock, see page 765
- State, see page 767
- Pattern, see page 768
- Serial Pattern, see page 770

Remote command:
`TRIGger<m>:PARallel:TYPE` on page 1544

13.3.1.2 Edge

Using the edge trigger, you can also trigger on a single digital channel (a logic bit), and a logical combination of digital channels.

Depending on the selected trigger source, different trigger settings are available. The trigger level is already set - in MSO the logical threshold is used as trigger level.

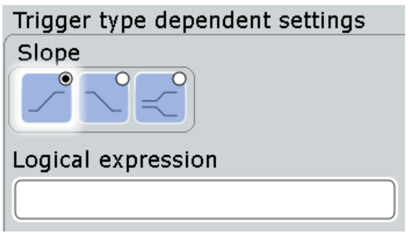


Figure 13-1: Edge trigger settings for trigger source = logical combination of digital channels (Logic)

Slope

Defines the edge - the state transition - of the signal.

"Rising" Means a 0 to 1 transition of the state.

"Falling" Means a 1 to 0 transition of the state.

"Either" Triggers on any activity on the selected trigger source.

Remote command:
`TRIGger<m>:PARallel:EDGE:SLOPe` on page 1545

Logical expression

Defines a logical combination of several digital channels as trigger condition if "Logic" is set for "Source". If the "Slope" is rising, the trigger occurs when the logical expression comes true. If the "Slope" is falling, the trigger occurs when the logical expression comes false.

Remote command:
`TRIGger<m>:PARallel:EDGE:EXPRession[:DEFine]` on page 1545

13.3.1.3 Width

The width trigger detects positive and/or negative pulses of a pulse width (duration) inside or outside of a defined time limit. It can trigger on a single digital channel or a logical combination of digital channels.

The instrument triggers at the end of the detected pulse.

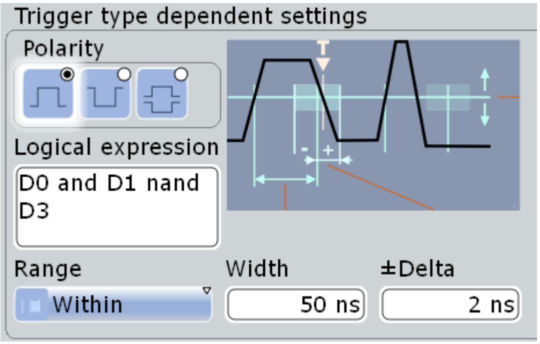


Figure 13-2: Width trigger settings for trigger source = logical combination of digital channels

Range

Selects how the range of a pulse width is defined:

"Within" Triggers on pulses inside a given time range. The time limit is defined by *Width ± Delta*.

"Outside" Triggers on pulses shorter or longer than a given time range. The time limit definition is the same as for "Within" range.

"Shorter" Triggers on pulses shorter than the given "Width".

"Longer" Triggers on pulses longer than the given "Width".

Remote command:
`TRIGger<m>:PARallel:WIDTh:RANGe` on page 1546

Width
For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits "±Delta".

Remote command:
`TRIGger<m>:PARallel:WIDTh:WIDTh` on page 1546

±Delta
Defines a range around the given width value.

The combination "Range" = Within and "±Delta" = 0 triggers on pulses with a pulse width that equals "Width".

The combination "Range" = Outside and "±Delta" = 0 means to trigger on pulse widths ≠ "Width".

Remote command:
`TRIGger<m>:PARallel:WIDTh:DELTa` on page 1546

Polarity
Sets the polarity of a pulse to "Positive", "Negative", or "Both".

When triggering on a positive pulse, the trigger event occurs on the high to low transition of the pulse if the timing condition is true. When triggering on a negative pulse, the trigger event occurs on the low to high transition of the pulse if the timing condition is true.

Remote command:
`TRIGger<m>:PARallel:WIDTh:POLarity` on page 1546

Logical expression
Defines a logical combination of several digital channels as trigger condition if "Logic" is set for "Source". As long as the digital signals match the logical expression (true), the pulse is positive. Otherwise, the pulse is negative.

Remote command:
`TRIGger<m>:PARallel:WIDTh:EXPRession[:DEFine]` on page 1545

13.3.1.4 Timeout

The timeout trigger event checks if the trigger source signal stays above or below the threshold voltage for a specified time lapse. In other words, the event occurs if the state condition remains unchanged for the specified time.

You can use the timeout trigger on a single digital channel, or a logical combination of digital channels.

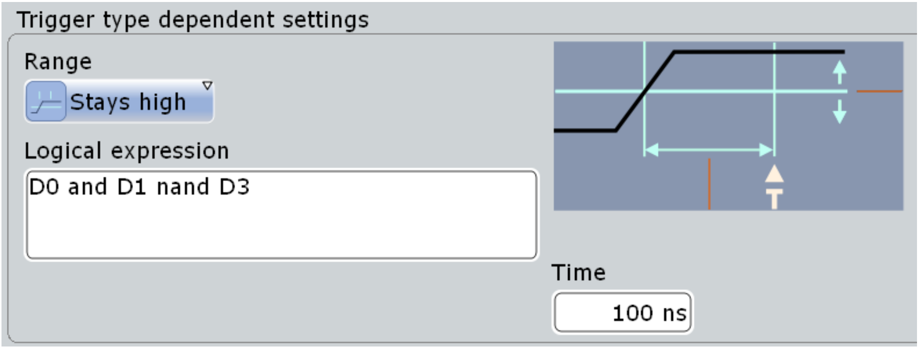


Figure 13-3: Timeout trigger settings for trigger source = logical combination of digital channels

Range

Sets the state condition:

"Stays high"	The level of a digital channel stays above the threshold, or the logical expression for "Logic" trigger source is true.
"Stays low"	The level of a digital channel stays below the threshold, or the logical expression for "Logic" trigger source is false.
"High or low"	The signal state remains unchanged.

Remote command:

TRIGger<m>:PARallel:TIMeout:RANGe on page 1547

Time

Defines the time limit for the timeout at which the instrument triggers.

Remote command:

TRIGger<m>:PARallel:TIMeout:TIME on page 1547

Logical expression

Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

Remote command:

TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine] on page 1545
TRIGger<m>:PARallel:STATe:EXPRession[:DEFine] on page 1545
TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine] on page 1545
TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine] on page 1545

13.3.1.5 Data2Clock

The Data2Clock trigger event occurs when the state of the trigger source signal changes inside a given time before the clock edge (setup time) or after the clock edge (hold time). This trigger type is also known as setup/hold trigger. The trigger event occurs at the clock edge for which the setup and/or hold time was violated.

With Data2Clock trigger, you can trigger on a single digital channel, or a parallel bus to check several digital channels simultaneously. The clock signal is connected to one of the digital channels.

If you configure this trigger type for a parallel bus, the bus configration is adjusted by the instrument if necessary. The bus is defined as clocked bus, and the clock source of the trigger is set as clock source of the bus.

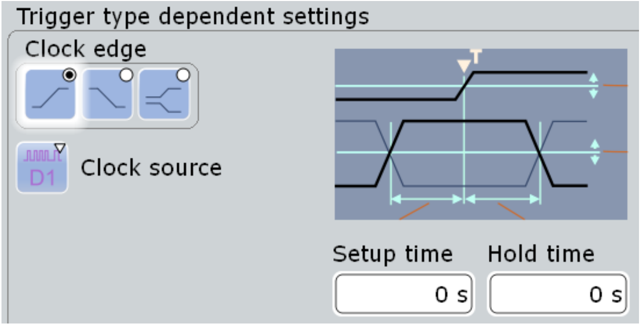


Figure 13-4: Data2clock trigger settings

Clock source

Selects the digital channel of the clock signal.

Remote command:
TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue] on page 1544
TRIGger<m>:PARallel:STATe:CSOurce:VALue on page 1544
TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue] on page 1544

Clock edge

Sets the edge of the clock signal. The crossing of the clock edge and the logical threshold defines the time reference point for the setup and hold time measurement.

Remote command:
TRIGger<m>:PARallel:DATatoclock:CSOurce:EDGE on page 1548

Setup time

Sets the minimum time *before* the clock edge while data should be stable and not change its state.

The setup time can be negative. In this case, the setup interval starts after the clock edge, and the hold time starts after the setup time has expired. Thus, the hold time is always positive. If you change the negative setup time, the hold time is adjusted by the instrument.

Remote command:
TRIGger<m>:PARallel:DATatoclock:STIMe on page 1548

Hold time

Sets the minimum time *after* the clock edge while data should be stable and not change its state.

The hold time can be negative. In this case, the hold time ends before the clock edge, and the setup interval ends when the hold interval starts. Thus, the setup time is always positive. If you change the negative hold time, the setup time is adjusted by the instrument.

Remote command:
TRIGger<m>:PARallel:DATatoclock:HTIMe on page 1548

13.3.1.6 State

The state trigger detects the logical state of several logically combined digital channels at a given clock edge. The trigger source is a logical combination of digital channels or a parallel bus. The trigger occurs at the clock edge at which the state condition is true.

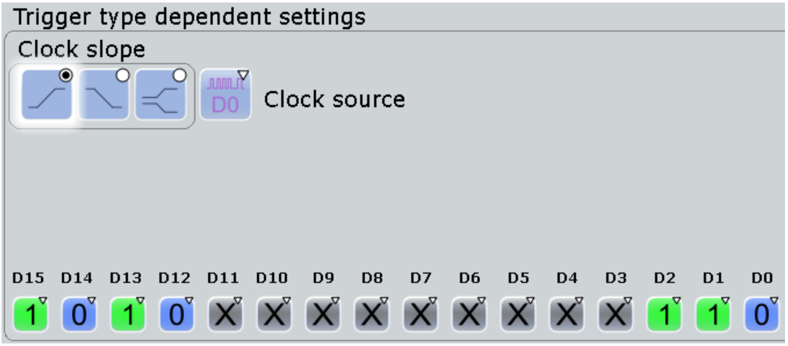


Figure 13-5: State trigger settings for trigger source = parallel bus

Clock source

Selects the digital channel of the clock signal.

Remote command:
`TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue]` on page 1544
`TRIGger<m>:PARallel:STATe:CSOurce:VALue` on page 1544
`TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue]` on page 1544

Clock edge

Sets the edge of the clock signal. The crossing of the clock edge and the logical threshold defines the time at which the logical states and the bus value are analyzed.

Remote command:
`TRIGger<m>:PARallel:STATe:CSOurce:EDGE` on page 1548

Channel states

For each digital channel that is used in the bus, set the required state: 1, 0, or X (don't care).

Remote command:
`TRIGger<m>:PARallel:STATe:BIT<n>` on page 1549

Logical expression

Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

Remote command:
`TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine]` on page 1545
`TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 1545
`TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine]` on page 1545
`TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine]` on page 1545

13.3.1.7 Pattern

The pattern trigger identifies a logical state of several logically combined digital channels (pattern) and a time limitation (holdoff). The pattern definition is defined by the logical expression, if "Logic" is used for trigger source. For a parallel bus trigger source, the pattern is defined by setting the state of each digital channel.

The timing starts when the pattern comes true. The decision level is the logical threshold.

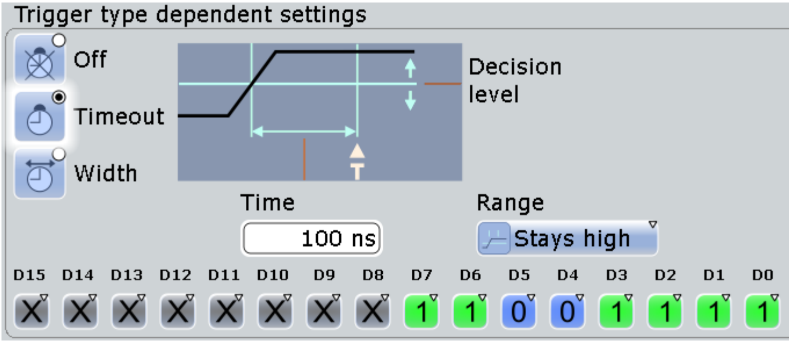


Figure 13-6: Pattern trigger settings for trigger source = parallel bus and timeout

Channel states
For each digital channel that is used in the bus, set the required state: 1, 0, or X (don't care).

Remote command:
`TRIGger<m>:PARallel:PATTern:BIT<n>` on page 1549

Logical expression
Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

Remote command:
`TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine]` on page 1545
`TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 1545
`TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine]` on page 1545
`TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine]` on page 1545

Timing mode: Off, Timeout, Width
Sets the mode of the timing condition.

"Off" No timing condition, only the logical pattern condition is relevant.

"Timeout" Defines a minimum time qualification to avoid triggering on unstable or transitional conditions. Even in best-designed systems, there are slight delays between the signal when digital signals change states. This means that there are always transitional state conditions when signals are switching.
See "Timeout settings" on page 769 for a description of the settings. The trigger event occurs when the pattern stays unchanged for the specified time.

"Width" Sets a pulse width as timing condition, see "Width settings" on page 769. The pulse starts when the pattern comes true, and the trigger event occurs when the pattern comes false during the specified time limit.
Using this mode, you can, for example, trigger exclusively on unstable conditions - if the pattern is present for less than a specified time.

Remote command:
`TRIGger<m>:PARallel:PATTern:MODE` on page 1549

Timeout settings
The timeout settings "Range" and "Time" appear if the timing mode is set to "Timeout".

Range ← Timeout settings
Sets the state condition:

"Stays high" The pattern stays true for the specified time.

"Stays low" The pattern stays false for the specified time.

"High or low" The pattern remains unchanged for the specified time.

Remote command:
`TRIGger<m>:PARallel:PATTern:TIMeout:MODE` on page 1550

Time ← Timeout settings
Defines the time limit for the timeout at which the instrument triggers.

Remote command:
`TRIGger<m>:PARallel:PATTern:TIMeout[:TIME]` on page 1550

Width settings
The width settings "Range", "Width" and "±Delta" appear if the timing mode is set to "Width".

Range ← Width settings
Selects how the range of a pulse width is defined:

"Within" Triggers when the pattern comes false inside a given time range. The time limit is defined by *Width ± Delta*.

"Outside" Triggers when the pattern comes false before or after the given time range. The time limit definition is the same as for "Within" range.

"Shorter" Triggers when the pattern comes false before the given "Width" has expired.

"Longer" Triggers when the pattern comes false after the given "Width" has expired..

Remote command:
`TRIGger<m>:PARallel:PATTern:WIDTh:RANGe` on page 1550

Width ← Width settings
For the ranges "Shorter" and "Longer", the width defines the maximum and minimum time limit, respectively.

For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits "±Delta".

Remote command:
TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh] on page 1551

±Delta ← Width settings
Defines a range around the given width value.

The combination "Range" = Within and "±Delta" = 0 triggers on pulses with a pulse width that equals "Width".

The combination "Range" = Outside and "±Delta" = 0 means to trigger on pulse widths ≠ "Width".

Remote command:
TRIGger<m>:PARallel:PATTern:WIDTh:DELTa on page 1551

13.3.1.8 Serial Pattern

The serial pattern trigger identifies a serial bit string trigger on a single digital channel, or for a logical combination of digital channels. The trigger requires a clocked bus; the bits are read at the specified clock edge. The trigger event occurs at the last clock edge of the serial bit string.

This trigger type allows you to trigger on specific address or data transmissions in serial input and output signals.

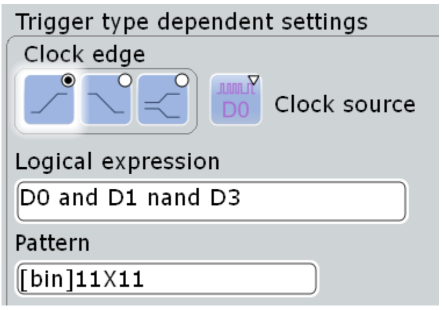


Figure 13-7: Serial pattern trigger settings for trigger source = logical combination of digital channels

Clock edge
Sets the edge of the clock signal. The bit value is determined at the crossing of the clock edge and the logical threshold.

Remote command:
TRIGger<m>:PARallel:SPATtern:CSOurce:EDGE on page 1552

Clock source
Selects the digital channel of the clock signal.

Remote command:
TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue] on page 1544
TRIGger<m>:PARallel:STATe:CSOurce:VALue on page 1544
TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue] on page 1544

Logical expression

Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

Remote command:

`TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine]` on page 1545

`TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 1545

`TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine]` on page 1545

`TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine]` on page 1545

Pattern

Defines the serial bit string on which to trigger. Touch and hold the "Pattern" field to open the "Bit Pattern Editor" where you can enter the pattern in various formats. The pattern has to be defined exactly, X (don't care) is not supported in binary format.

See also: Chapter 12.1.4, "Bit Pattern Editor", on page 445

Remote command:

`TRIGger<m>:PARallel:SPATtern:PATTern` on page 1552

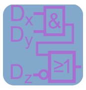
13.3.2 Triggering on Digital Signals and Parallel Buses

For a detailed description of the settings, see Chapter 13.3.1, "Trigger Settings for Digital Signals and Parallel Buses", on page 761.

1. Press the TRIGGER key and select the "Events" tab.
2. Select the trigger "Source":
   - one of the digital channels "D0" ... "D15"

   - a logic combination of digital channels: "Logic"

     
   - one of the parallel buses "Par. bus1" ... "Par. bus4"

3. Select the trigger "Type".
4. Under "Trigger type dependent settings", configure the trigger.
5. For trigger source "Logic", enter the logical expression of the digital channel combination. Tap and hold the "Logical expression" field until the "Qualification Editor" opens. It provides all logic operators that can be used in the expression.

13.4 Measurements on Digital Channels

For measurements on digital channels, the number of measurement categories and types is reduced to applicable measurement types.

These are:

- Period
- Frequency
- Positive and negative pulse
- Pulse count
- Delay
- Phase
- Positive and negative duty cycle
- Burst width
- Edge count

Except for delay measurement, the measurement types have the same settings and results for analog and digital sources.

Delay measurement on digital channels is reduced to measure the time between two subsequent rising or two subsequent falling edges.

See also Chapter 7.2.5, "Amplitude/Time Measurements", on page 294.

13.5 Data export

The data of digital channels and parallel buses can be saved to file in the same way as analog waveform data. One digital channel or bus per file can be saved.

The data format of the stored values is defined with "Analysis" > "Parallel Bus Configuration" > "Data format". If the data is written to XML or CSV files, the selected format is used. If the target file format is BIN, you can save signed and unsigned binary data. The data format "Signed" writes signed data; all other formats are saved as unsigned binary data.

Only y-values are exported, the "Interleaved x/y" setting is not available.

Export of a digital channel

If the data of digital channels is stored in BIN format, one bit is written for each sample. 8 data samples are written in one byte (data word). For example, 100 MSa are written into a 12.5 MByte BIN file. After reading the file, you have to extract the samples from the data words.

If saved to BIN file, the digital channel can be imported as reference waveform.

Export of a parallel bus

A parallel bus can be exported to file if "Enable bus" and "Show bus" are both activated.

All data formats can be saved to XML, CSV, and BIN files. If you save binary format to XML or CSV, you can see the values of each line for each sample.

In BIN files, 4 Bytes are written for each sample.

Importing parallel buses from BIN files is only possible if the bus was saved with quasi-analog bus representation.

See also:

- Chapter 11.2.6, "Saving and Loading Waveform Data", on page 427
- Chapter 11.2.2, "Waveforms - Export Settings", on page 416

Remote commands for export to file:

- EXPort:WAVeform:SOURce on page 1146
  BUSFormat on page 1164
- EXPort:WAVeform:NAME on page 1147
- EXPort:WAVeform:SAVE on page 1148

Remote commands for remote export:

- FORMat[:DATA] on page 887
- BUSFormat on page 1164
- BUS<m>:PARallel:DATA:HEADer? on page 1554
- BUS<m>:PARallel:DATA[:VALues]? on page 1554
- DIGital<m>:DATA:HEADer? on page 1553
- DIGital<m>:DATA[:VALues]? on page 1553

13.6 Mathematics

A parallel bus that is displayed as quasi-analog waveform can be analyzed with FFT. To configure the FFT, use the "Advanced" mode and the formula editor.

13.7 Search

It is also possible to search on digital channels for specified events. Search conditions use the same parameters as the trigger event definition. You can search for edge, width, timeout, and Data2Clock conditions.

14 Power Analysis (Option R&S RTE-K31)

With the R&S RTE and option R&S RTE-K31 you can perform power analysis measurements.

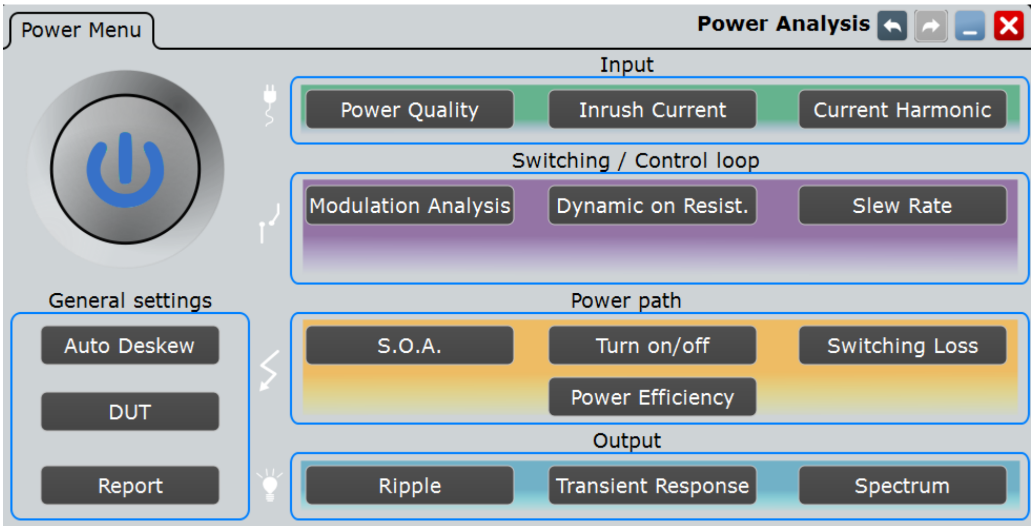
The following power measurements are available:

- Power Quality
- Inrush Current
- Current Harmonic
- Modulation Analysis
- Dynamic On Resistance
- Slew Rate
- Safe Operating Area (S.O.A.)
- Turn On/ Off
- Switching Loss
- Power Efficiency
- Output Ripple
- Transient Response
- Output Spectrum

14.1 Power Measurement Selection

Access: "Analysis"> "Power"

The "Power Menu" is the entry point to all power measurements and the general setting required for them.



The tab has several areas:

- "General Settings": general settings, that can be used by all measurements, like deskewing.
- "Input": measurements for performing input line analysis. They are used to measure the characteristics of the input power as well as the effects the power supply exudes to the input line.
- "Switching and Control Loop": measurements for characterizing the switching properties of a device.
- "Power Path": measurements for analysing the behavior of the devices that control the power flow through the switched-mode power supply (SMPS) circuit, including switching devices and inductors.
- "Output": measurements for characterizing the behavior and quality of the SMPS output voltage.

14.1.1 General Settings

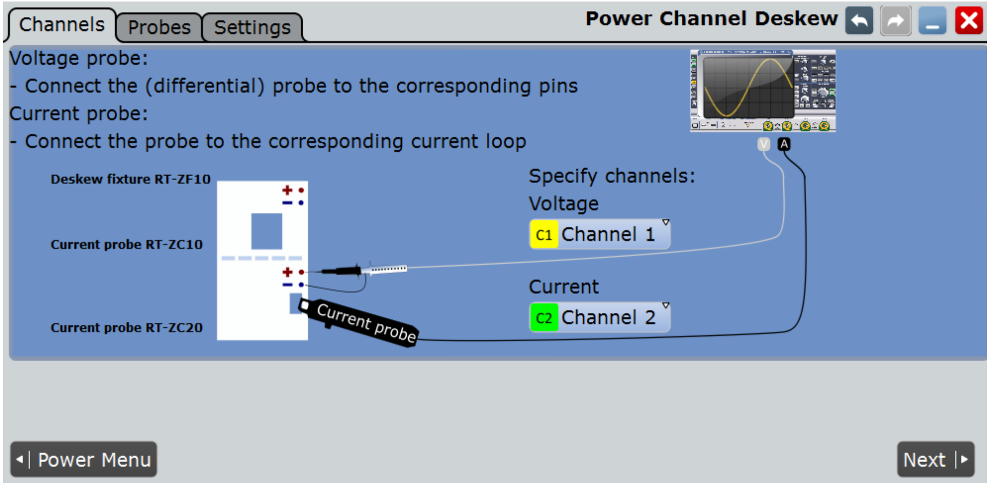
14.1.1.1 Auto Deskew

The "Auto Deskew" dialog box guides you through the auto deskew of your current and voltage probes.

Required equipment:

- R&S RT-ZF20 power deskew fixture
- Rohde & Schwarz voltage probe
- Rohde & Schwarz current probe

1. Select "Analysis" > "Power".
2. Under "General", select "Auto Deskew".
3. Connect the voltage probe and the current probe to the oscilloscope.
4. Connect the probes to the R&S RT-ZF20 power deskew fixture as shown in the "Channels" tab:



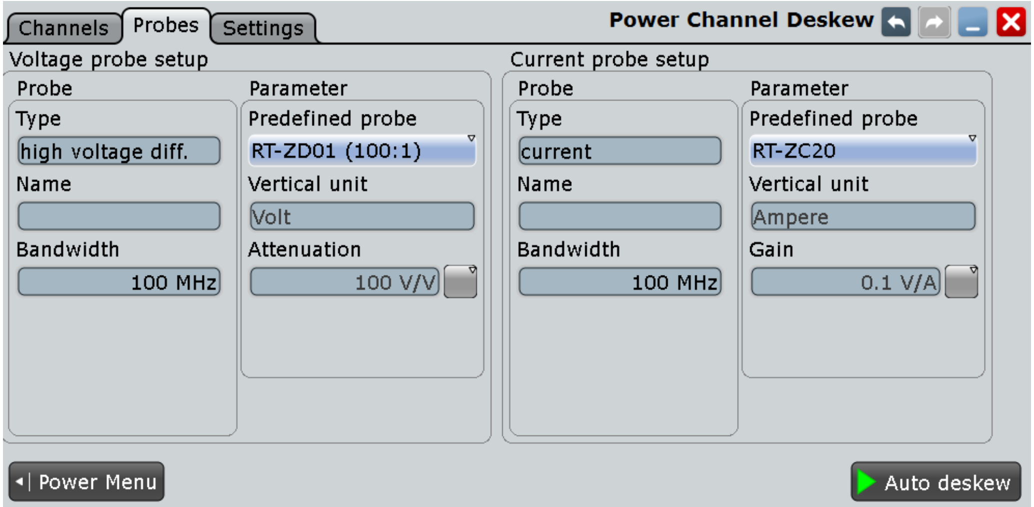
5. Select the correct channels for the "Current Source" and the "Voltage Source".
6. Tap "Next".
7. Check and complete the probe setup in the "Probes" tab.
   Current probes and high-voltage differential probes cannot be automatically detected by the instrument. Tap "Predefined probe" and select the correct probe type.
8. Tap the "Settings" tab.
9. Set the "Overwrite present skew setup" on page 779 and "Activate user defined preset" on page 779 options. These settings define whether the instrument uses the deskew result for user-defined preset and general skew settings.
10. Tap "Auto deskew".

    The probes are deskewed and the measurement can be started.

If no deskew fixture is available, you have to deskew your probes manually, see Chapter 4.7.2, "Skew", on page 182.

Probes

In the "Probes" tab you check and set up your voltage and current probes.



Type, Name, Bandwidth

Many probes are recognized by the instrument. The fields show the characteristics of a recognized probe for information. If the instrument cannot recognize the probe, the "Type" is "None".

Remote command:
`PROBe<m>:SETup:TYPE?` on page 925
`PROBe<m>:SETup:NAME?` on page 925
`PROBe<m>:SETup:BANDwidth?` on page 926
`TRPRobe:SETup:TYPE?` on page 925 (trigger input)
`TRPRobe:SETup:NAME?` on page 925 (trigger input)
`TRPRobe:SETup:BANDwidth?` on page 926 (trigger input)

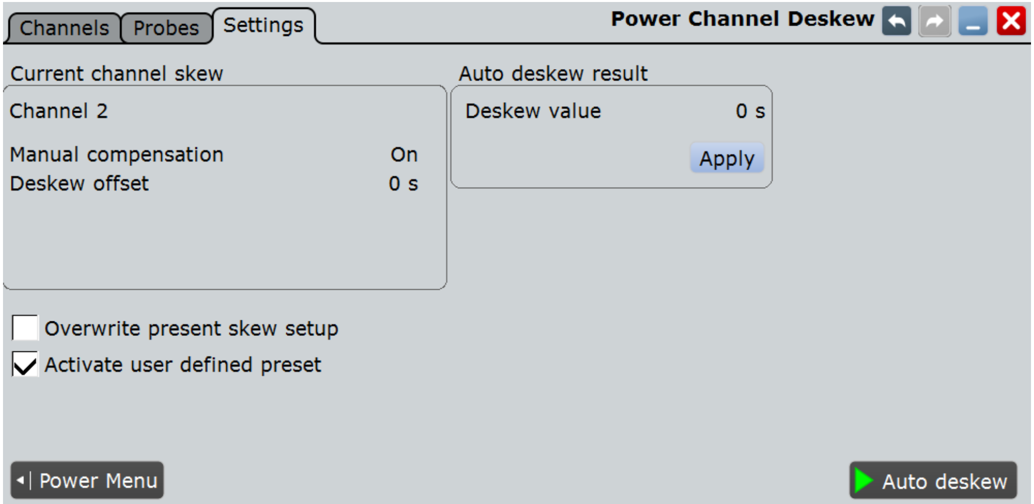
Predefined probe, Vertical unit, Attenuation

Current probes R&S RT-ZCxx, the high voltage active probe R&S RT-ZD01 and the transmission line probe R&S RT-ZZ80 are not recognized automatically but the parameters of these probes are known to the instrument. Select the correct probe type and enter additional parameters if required. The corresponding "Vertical unit" and the "Attenuation" or "Gain" are set.

For an auto deskew, only Rohde & Schwarz probes are supported.

Settings

In this tab you can define the preset behaviour and how the auto deskew results are stored.



Current channel skew

Shows the skew settings of the channel connected to the current probe. Skew settings are defined in the "Horizontal > Skew" dialog box.

See also: Chapter 4.7.2, "Skew", on page 182

Overwrite present skew setup

If disabled, the instrument only stores the result of the auto deskew procedure as a separate value and doesn't use it. This value can be used at a later time for power measurements. The general skew offset under "Current channel skew" remains unchanged.

If enabled, the result of the auto deskew procedure is used for all measurements on the selected channel. It is shown under "Current channel skew".

Remote command:
`POWer:DESKew:RESet` on page 1556

Auto deskew result

Available only if "Overwrite present skew setup" is disabled.

"Deskew value" Result of the auto deskew.

Remote command:
`POWer:DESKew:TIME?` on page 1556

"Apply" Writes the result of the auto deskew to the "Skew offset" of the selected channel.

Remote command:
`POWer:DESKew:CURRent` on page 1556

Activate user defined preset

If enabled, the deskew values are written to a user defined preset file, and the user defined preset is enabled. Thus, the probe setup and deskew values are not influenced by a manual PRESET.

See also: Chapter 11.1.3, "User-defined Preset", on page 404.

Remote command:
`POWer:DESKew:UDPReset` on page 1556

Auto Deskew
Starts an auto deskew.

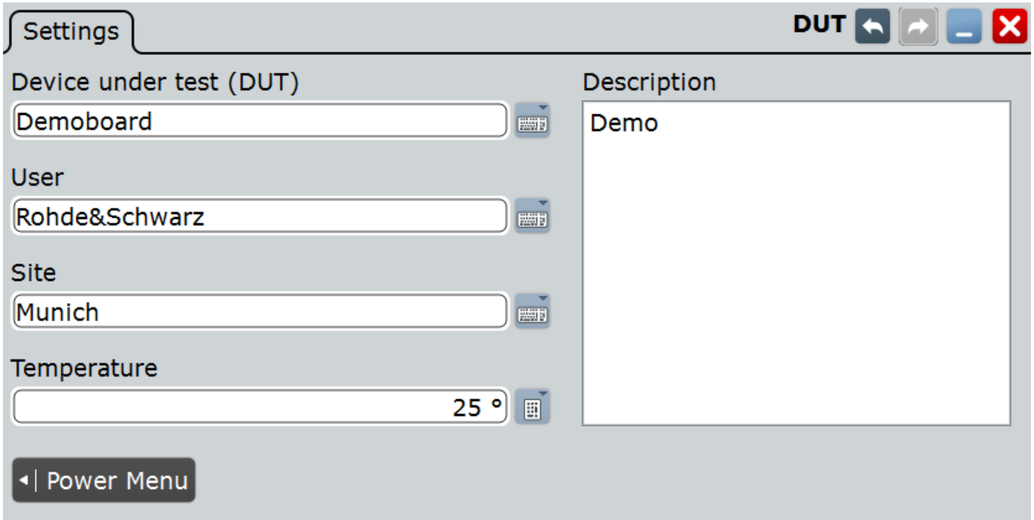
Make sure that the probes are configured correctly before you start the deskewing.

Remote command:
`POWer:DESKew:EXECute` on page 1556

14.1.1.2 DUT

Access: "Analysis" > "Power" > "DUT".

In this dialog you can describe your device under test (DUT). The information set in this dialog can be used on the title page for a report generated from the "Power Analysis" measurements, see "Content" on page 784.



Device under test (DUT)
Enter a name for your DUT.

Remote command:
`POWer:REPort:DUT` on page 1558

User
Enter a user.

Remote command:
`POWer:REPort:USER` on page 1558

Site
Enter a site.

Remote command:
`POWer:REPort:SITE` on page 1558

Temperature

Enter the temperature.

Remote command:

`POWer:REPort:TEMPerature` on page 1558

Description

Enter a description.

Remote command:

`POWer:REPort:DESCription` on page 1558

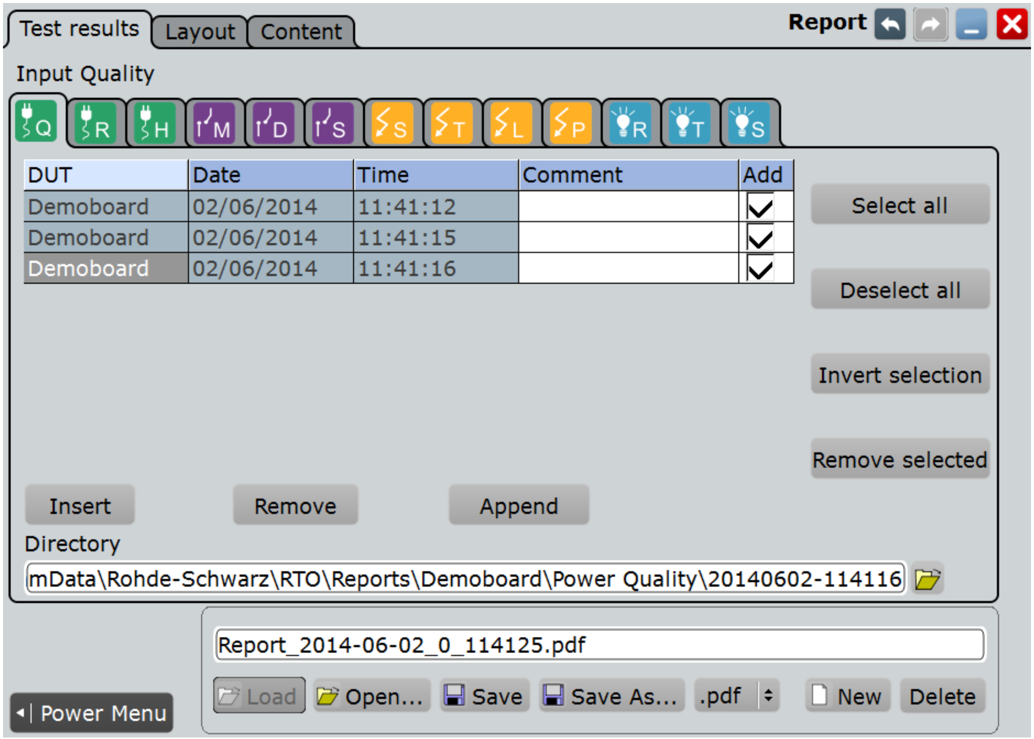
14.1.1.3 Report

Access "Analysis">"Power" > "Report".

Test Results

After executing a measurement, you can press "Add to report" and save the results. In this tab you can manage all saved measurement results.

At the top of the tab you can switch through the different "Power Analysis" measurements.



Report Table

Shows a list of the available measurements.

After you select a Directory you can manage previous report results from this directory.To add a measurement report press "Insert" or "Append". To remove a measurement report press "Remove".

"DUT"	Shows the name of the DUT, see Chapter 14.1.1.2, "DUT", on page 780.
"Date"	Shows the date of the measurement.
"Time"	Shows at what time, the measurement result was added to report.
"Comment"	Enters a comment.
"Add"	Adds the selected measurement to the report.

Remote command:
`POWer:REPort:TEST:ADD` on page 1560
`POWer:REPort:TEST:COMMent` on page 1561
`POWer:REPort:TEST:COUNt` on page 1562
`POWer:REPort:TEST:INSert` on page 1560
`POWer:REPort:TEST:LSENd?` on page 1562
`POWer:REPort:TEST:REMove` on page 1560

Selection
Manages the selection of the result reports.

Select all ← Selection
Selects all result reports.

Remote command:
`POWer:REPort:TEST:SEA` on page 1560

Deselect all ← Selection
Deselects all result reports.

Remote command:
`POWer:REPort:TEST:DSEA` on page 1560

Invert Selection ← Selection
Inverts the selection of all result reports, meaning that all selected result reports are deselected and vice versa.

Remote command:
`POWer:REPort:TEST:ISE` on page 1560

Remove selected ← Selection
Removes the selected result report.

Remote command:
`POWer:REPort:TEST:RSE` on page 1560

Directory
Selects the directory, from which previous report results are inserted into the report table. You can use this directory to insert previously recorded report data into the current report.

Remote command:
`POWer:REPort:TEST:DIRectory` on page 1561

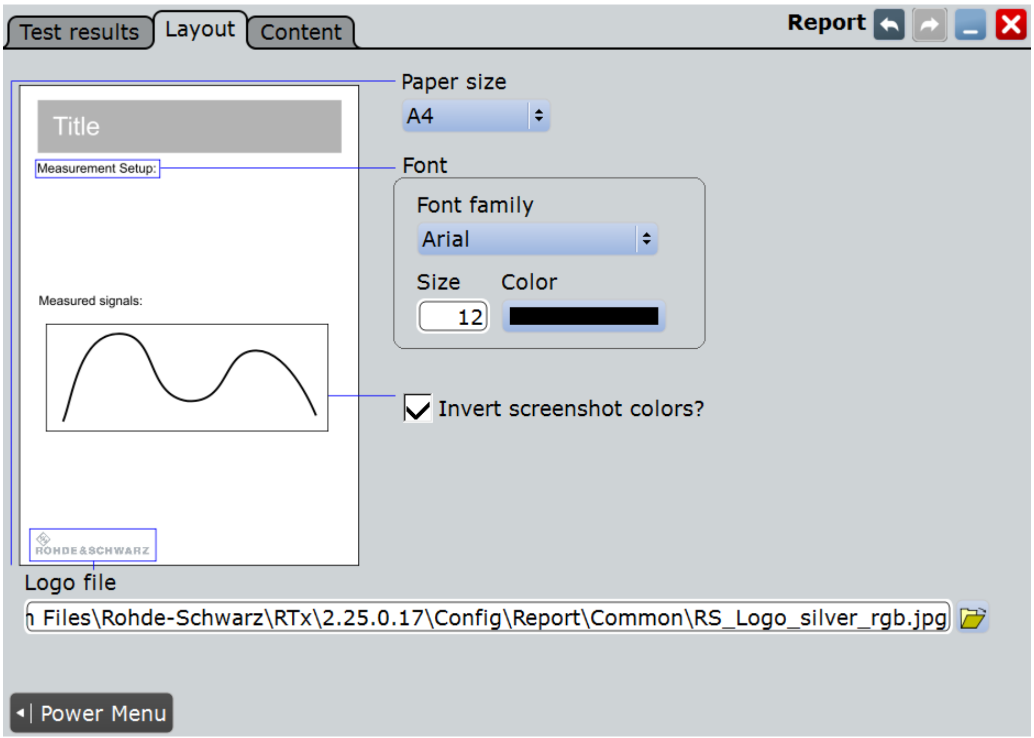
Report Path
Enter the file name to load or to save the report to, and select the file format with the format button on the right.

"Load"	Loads the most recently created report with the Windows default viewer application for the pdf/rtf file format.
"Open"	Opens a file selection dialog box and loads the selected file.
"Save"	Saves the data to the selected file.
"Save As..."	Opens the file selection dialog box and saves the data to the selected file.
".pdf/.rtf"	Selects the file format.
"New"	Creates new file.
"Delete"	Deletes the selected file.

Remote command:
`POWer:REPort:FILE:DELete` on page 1559
`POWer:REPort:FILE:NAME` on page 1559
`POWer:REPort:FILE:NEW` on page 1559
`POWer:REPort:FILE:SAVE` on page 1559

Layout

In this tab you can set up a layout for your report.



Paper size
Selects the paper size.

"A4"	Selects A4.

"US Letter" Selects US Letter.

Remote command:
POWer:REPort:PAPersize on page 1559

Font
Sets the font for the report

Font Family ← Font
Selects the font family.

"Arial" Selects the font Arial.

"Helvetica" Selects the font Helvetica.

Remote command:
POWer:REPort:FONT:FAMI on page 1558

Size ← Font
Sets the font size.

Remote command:
POWer:REPort:FONT:SIZE on page 1558

Color ← Font
Sets the font color.

Remote command:
POWer:REPort:FONT:COLO on page 1558

Invert Screenshot Colors
Inverts the screenshot colors.

Remote command:
POWer:REPort:INVert on page 1560

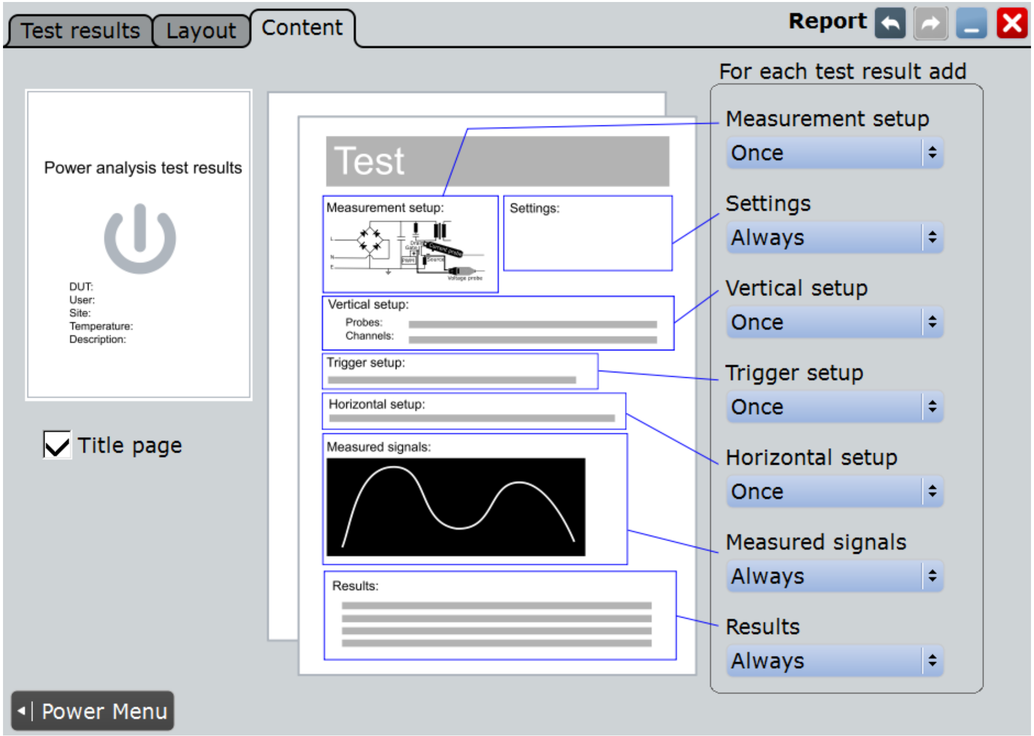
Logo File
Selects a path to a logo picture file.

Remote command:
POWer:REPort:LOGO on page 1559

Content

In this tab you can select the contents of your report. For each content you can select how often it is included in the report:

- "Always": Shows the respective contents for each measurement.
- "Never": Doesn't show the respective contents in the report.
- "Once": Shows the respective contents once at the beginning of the report.



Title Page

Adds a Title page to the report. The contents can be set up in the "DUT" dialog, see Chapter 14.1.1.2, "DUT", on page 780.

Remote command:
`POWer:REPort:CONTent:TITLe` on page 1558

Measurement Setup

Adds a graphic of the measurement setup.

Remote command:
`POWer:REPort:CONTent:MSETup` on page 1557

Settings

Adds the settings of the analysis.

Remote command:
`POWer:REPort:CONTent:SETTings` on page 1557

Vertical Setup

Adds the vertical setup settings.

Remote command:
`POWer:REPort:CONTent:VSETup` on page 1558

Trigger Setup

Adds the trigger setup settings.

Remote command:
`POWer:REPort:CONTent:TSETup` on page 1558

Horizontal Setup
Adds the horizontal setup settings.

Remote command:
`POWer:REPort:CONTent:HSETup` on page 1557

Measured signals
Adds a diagram of the measured signal.

Remote command:
`POWer:REPort:CONTent:MSIGnal` on page 1557

Results
Adds the result box.

Remote command:
`POWer:REPort:CONTent:RESU` on page 1557

14.2 Overview of Power Measurement Setup

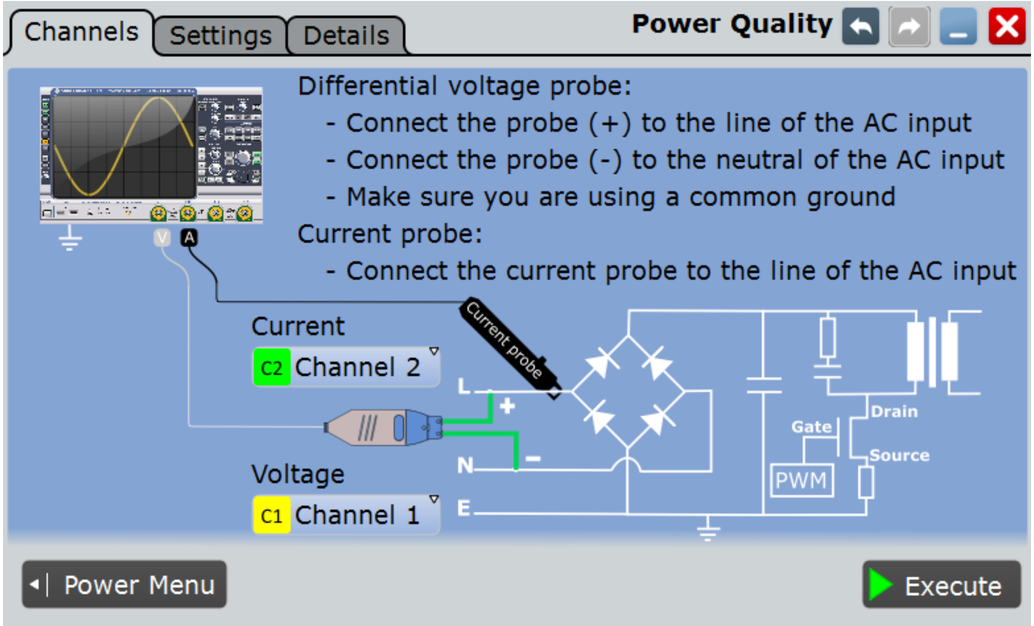
Each power analysis measurement dialog box consists of the following tabs:

- Channels
- Settings
- Details

At the bottom of each tab you can find two buttons. Tapping "Power Menu", you can return to the power analysis measurement selection. "Execute" starts the power measurement.

14.2.1 Channels Tab

In the "Channels" tab you find information on the experimental setup of the selected power measurement. A short description explains what probes are needed and how to connect them. The description is supported by a block diagram of the experimental setup that shows the connection points for the probes.



Depending on the selected power measurement, one or two voltage sources and current sources are required.

Current Source
Sets the channel for the current source.

Remote command:
`POWer:SOURce:CURRent<1..2>` on page 1555

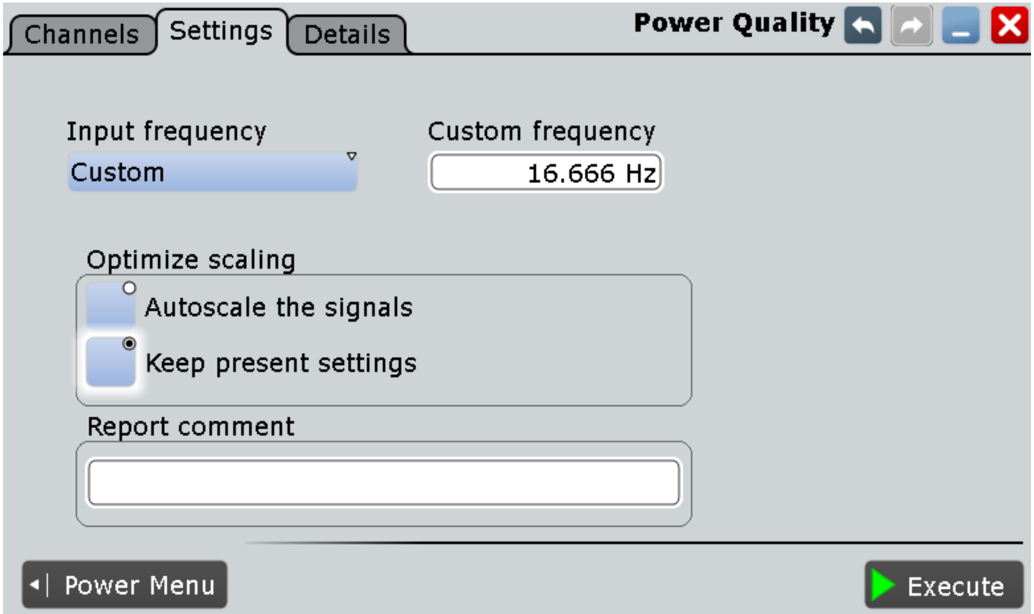
Voltage Source
Sets the channel for the voltage source input.

Remote command:
`POWer:SOURce:VOLTage<1..4>` on page 1555

14.2.2 Settings Tab

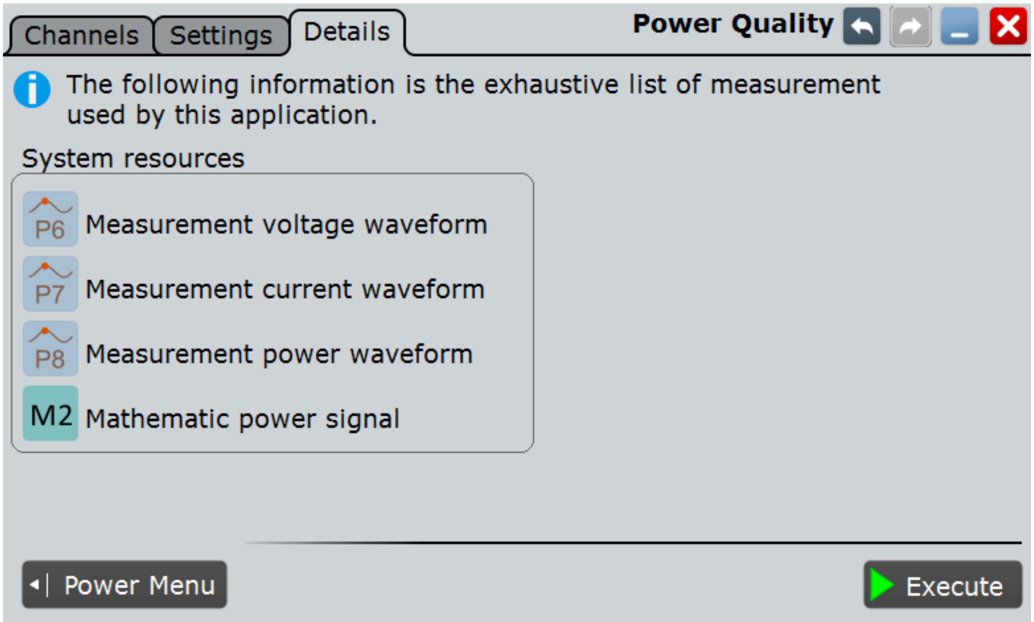
In the "Settings" tab you configure the measurement and display settings. The settings depend on the selected power measurement.

For detailed information, see the "Settings" chapter of the relevant power measurement description.



14.2.3 Details Tab

In the "Details" tab you find information on the measurement resources used by the selected power measurement.



The following resources may be used:
- Measurements
- Mathematic waveforms
- Cursors
- XY-diagrams

The instrument enables the required resources when the power measurement is started.

14.3 Power Quality

In an electric circuit power is a measure for the rate of flow of energy at a certain point of the circuit. The real power of a circuit, or the energy that can be used for work, is the portion of energy that is transferred in one direction over a complete cycle of the AC waveform. In AC circuits, however, inductive and capacitive elements can store energy temporarily. This portion of the power flow known as reactive power is then returned to the source without doing any work.

The "Power Quality" analysis measurements include the real power, the reactive power and the apparent power as well as the power factor. The crest factors and the phase angle between the current and voltage are also measured. These properties describe the power transfer in the system and allow you to characterize the power quality of the system.

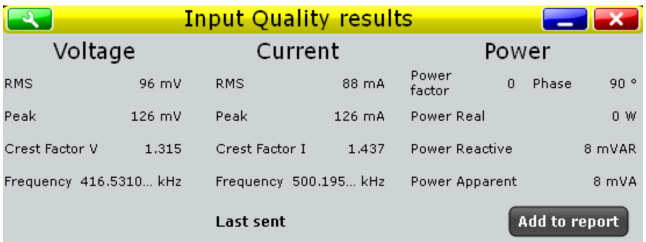
Required probes:

- Differential voltage probe
- Current probe

14.3.1 Power Quality Results

The results of "Power Quality" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage waveform
  - the current waveform
  - the power waveform that is the product of the current and voltage waveforms
- The result box displays the numeric measurement results.



To measure and display the power quality, the instrument uses the following measurements and waveforms:

- "P6" Meas 6 to measure the voltage
- "P7" Meas 7 to measure the current
- "P8" Meas 8 to measure the power
- "M2" Math 2 to calculate the power

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

Voltage and current results

The voltage and current results are defined as follows:

Result	Description
RMS	Square root of the mean of the square of the current or voltage averaged over N cycles
Peak	Highest measured magnitude value of the voltage or current
Crest factor	Peak value / RMS value
Frequency	Frequency of the signal

Power results

The power in a system is described by several physical quantities: real power, reactive power, complex power, and phase angle. In Figure 14-1 you can see how these quantities are related if the voltage and the current are sinusoidal signals.

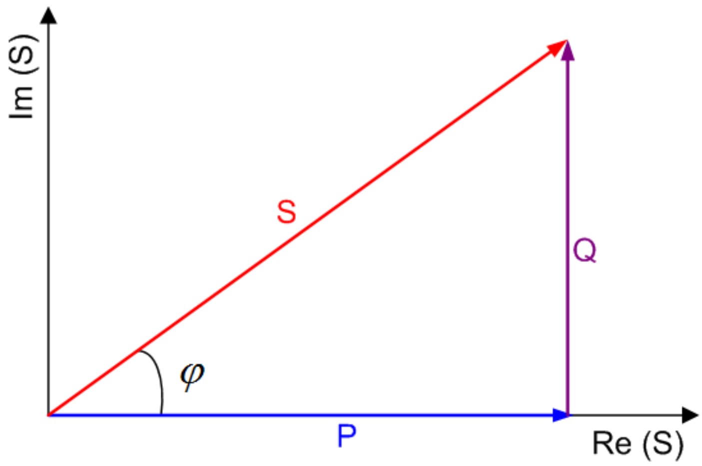


Figure 14-1: Power diagram for sinusoidal signals

P = real power [W]
Q = reactive power [VAR]
S = complex power [VA]
φ = phase angle between the current and the voltage sine waves [°]

The power results are defined as follows:

Result	Unit	Formula	Description
Power factor, P_{Factor}	-	$P_{Factor} = \|P\| / \|S\|$	Measure of the system efficiency. The value varies between -1 and 1.
Phase, φ	°	$\varphi = acos\ (P_{Factor})$	Phase angle between the current and the voltage sine waves.

Real power, P	W	$P = V_{INSTANTENEOUS} \cdot I_{INSTANTENEOUS}$ (averaged over N cycles)	Energy of the system that can be used to do work.
Reactive power, Q	VAR (Volt-Ampere reactive)	$Q = \|S\| \sin\varphi$	Power flow that is temporally stored in a system because of the inductive and capacitive elements.
Apparent power, |S|	VA	$\|S\| = V_{RMS} \cdot I_{RMS}$ (averaged over N cycles)	|S| is the magnitude of the vector sum of real and reactive power (the complex power S).

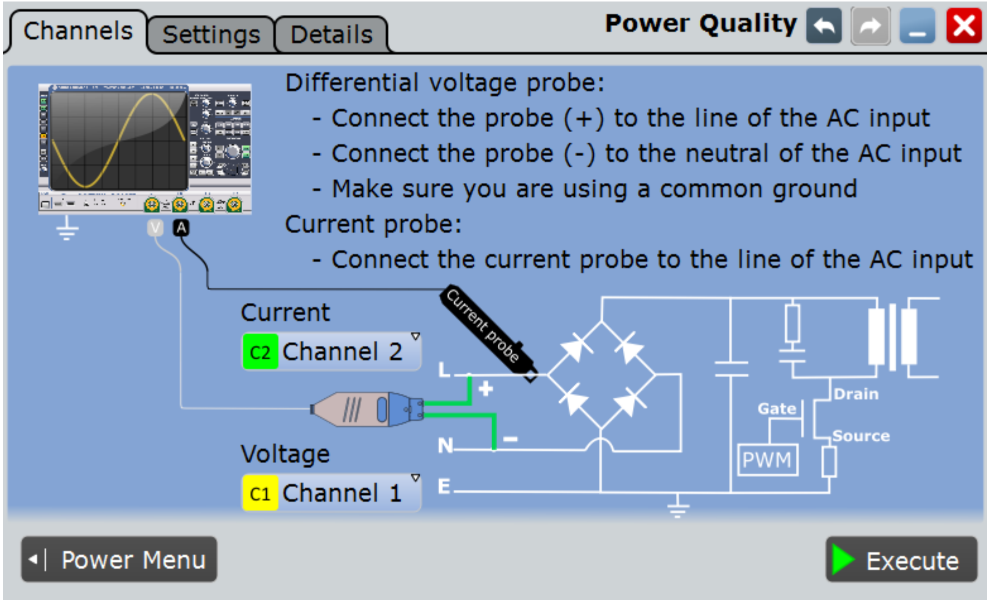
The following remote commands are used for handling the measurement results:

- `POWer:QUALity:RESult:CURRent:CREStfactor?` on page 1563
- `POWer:QUALity:RESult:CURRent:FREQuency?` on page 1563
- `POWer:QUALity:RESult:CURRent:PEAK?` on page 1563
- `POWer:QUALity:RESult:CURRent:RMS?` on page 1563
- `POWer:QUALity:RESult:POWer:APParent?` on page 1563
- `POWer:QUALity:RESult:POWer:PFACtor?` on page 1563
- `POWer:QUALity:RESult:POWer:PHASe?` on page 1563
- `POWer:QUALity:RESult:POWer:REACtive?` on page 1563
- `POWer:QUALity:RESult:POWer:REALpower?` on page 1564
- `POWer:QUALity:RESult:VOLTage:CREStfactor?` on page 1564
- `POWer:QUALity:RESult:VOLTage:FREQuency?` on page 1564
- `POWer:QUALity:RESult:VOLTage:PEAK?` on page 1564
- `POWer:QUALity:RESult:VOLTage:RMS?` on page 1564
- `POWer:QUALity:REPort:ADD` on page 1563

14.3.2 Configuring Power Quality

For details of the configuration settings, see Chapter 14.3.3, "Power Quality Settings", on page 792.

1. Select "Analysis" > "Power".
2. Under "Input", select "Power Quality".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 14.1.1.1, "Auto Deskew", on page 776.
5. Connect the probes to the DUT as shown in the "Channels" tab:



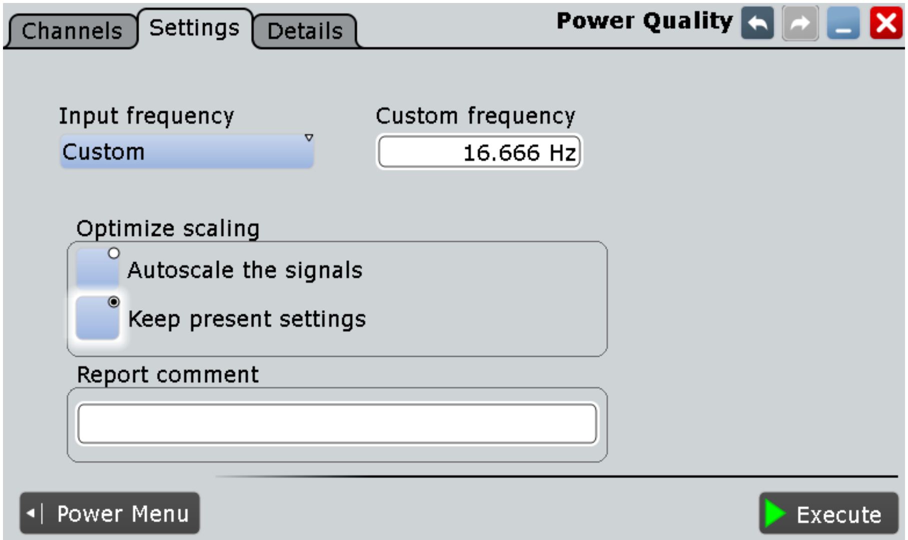
6. Select the correct channels of the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Set the "Input frequency" according to your signal.
9. Select an "Optimize Scaling" option.
10. Tap "Execute".

    On the screen you can see the measurement waveforms of the current, the voltage and the power. Additionally, the result box with numeric measurement results is shown. For details, see Chapter 14.3.1, "Power Quality Results", on page 789.

14.3.3 Power Quality Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 14.2.1, "Channels Tab", on page 786.

In the "Settings" tab you configure the power measurement parameters and display settings.



Input frequency

Selects the input frequency of the source signal.

Remote command:
`POWer:QUALity:FREQ` on page 1563

Custom frequency

Sets the user-defined frequency if the "Input frequency" is set to "Custom".

Remote command:
`POWer:QUALity:FCUS` on page 1563

Optimize scaling

Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:QUALity:AUTO` on page 1562

Report comment

In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute

Starts the "Power Quality" measurement.

Remote command:
`POWer:QUALity:EXECute` on page 1563

14.4 Inrush Current

The "Inrush Current" analysis measures the peak of the input current that is drawn by the device, when the device is first turned on.

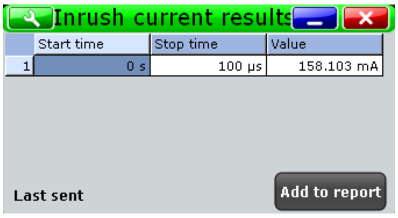
Required probes:

- Current probe

14.4.1 Inrush Current Results

The results of "Inrush Current" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  – the current waveform
- The result box displays the following numeric measurement results:
  – "Start time" / "Stop time" define the time period for the present gate
  – The "Value" stands for the maximum amplitude of the current for the present time period. This is the inrush current for the correspondent gate.



To measure and display the inrush current, the instrument uses the following measurements and waveforms:

- "P1" to "P5": Meas 1 to Meas 5 to measure the inrush current of "Gate 1" to "Gate 5"

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

The following remote commands are used for handling the measurement results:

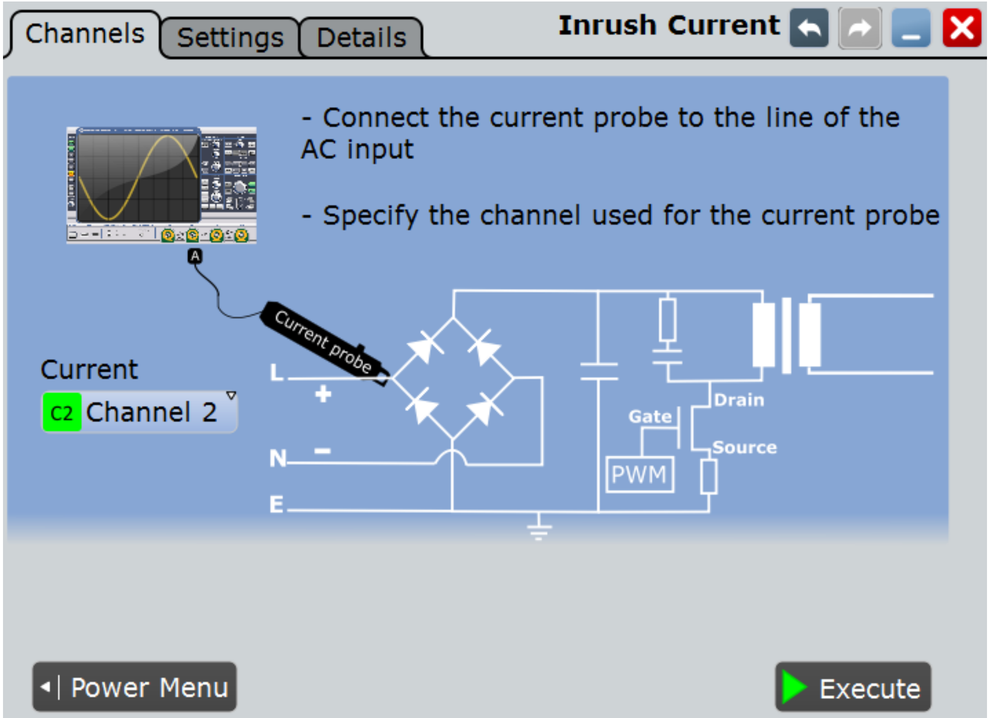
- `POWer:INRush:GATE<m>:VALue` on page 1565
- `POWer:INRush:REPort:ADD` on page 1566

14.4.2 Configuring Inrush Current

For details of the configuration settings, see Chapter 14.4, "Inrush Current", on page 794.

1. Select "Analysis" > "Power".
2. Under "Input", select "Inrush Current".
3. Connect the current probe to the oscilloscope.

4. Select the correct channel for the "Current Source".
5. Select "Vertical" > "Probe Setup" > "Channel" and set your probe parameters.
6. Connect the probes to the DUT as shown in the "Channels" tab:



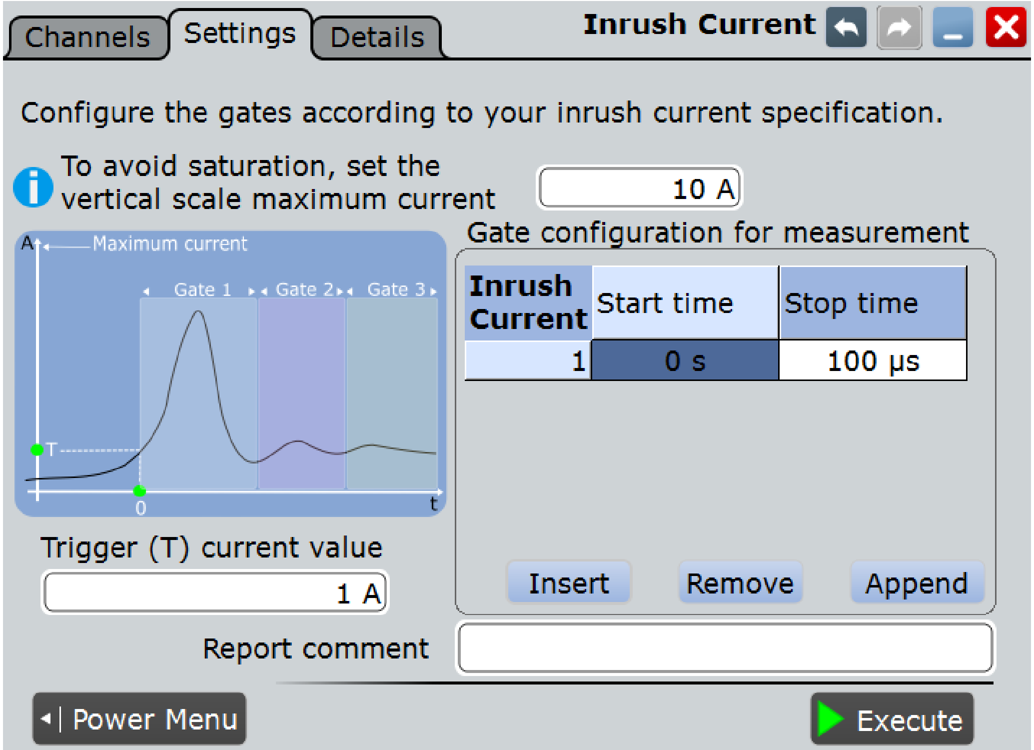
7. Select the "Settings" tab.
8. Set the "Trigger current value".
9. Set the "Maximum current" that shall be displayed in the vertical scale.
10. In the "Gate configuration" table, define the different time periods. You can set up to five different gates.
11. Tap "Execute".
12. Start the DUT.

    On the screen you can see the result box with the inrush current of each gate. For details, see Chapter 14.4.1, "Inrush Current Results", on page 794.

14.4.3 Inrush Current Settings

In the "Channels" tab, you set the current source, see also: Chapter 14.2.1, "Channels Tab", on page 786.

In the "Settings" tab you configure the inrush current measurement parameters and display settings.



Maximum current
Sets the maximum expected current for the vertical scale. Set the value according to your signal in order to avoid saturation.

Remote command:
`POWer:INRush:MAXCurrent` on page 1565

Trigger current value (T)
Sets the current value for the trigger. The measurement starts after the signal of the DUT reaches this current value.

Remote command:
`POWer:INRush:TRIGger` on page 1566

Gate Configuration
In this table you can configure different gates (time periods). You can configure up to five different gates. The time periods of the defined gates may overlap.

To add a gate press "Insert" or"Append". To remove a gate press "Remove".

Remote command:
`POWer:INRush:ADD` on page 1564
`POWer:INRush:INSert` on page 1564
`POWer:INRush:REMove` on page 1564

Inrush current ← Gate Configuration
Shows the index of the gate.

Remote command:
`POWer:INRush:COUNt?` on page 1565

Start time ← Gate Configuration
Sets the start measuring time for the selected gate.

Remote command:
`POWer:INRush:GATE<m>:STARt` on page 1565

Stop time ← Gate Configuration
Sets the stop measuring time for the selected gate.

Remote command:
`POWer:INRush:GATE<m>:STOP` on page 1565

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Inrush Current " measurement.

Remote command:
`POWer:INRush:EXECute` on page 1565

14.5 Current Harmonic

Current harmonics appear in an electric power system due to non linear electric loads. The harmonics can be ejected back into the AC line and disturb other equipment on the grid. In order to avoid this disturbance there are often standards of compliance that consumer or industry end-products should meet.

The "Current Harmonic" analysis tests the devices according to the pre-compliance standards EN 61000-3-2, MIL-STD-1399 and RTCA DO-160F.

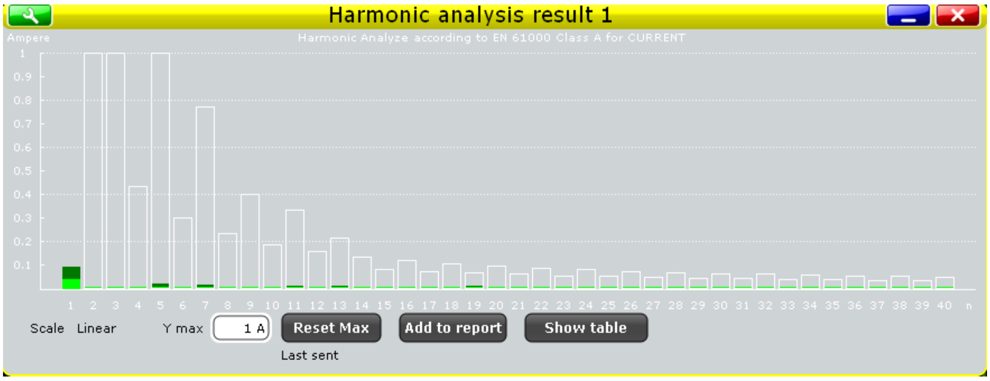
Required probes:

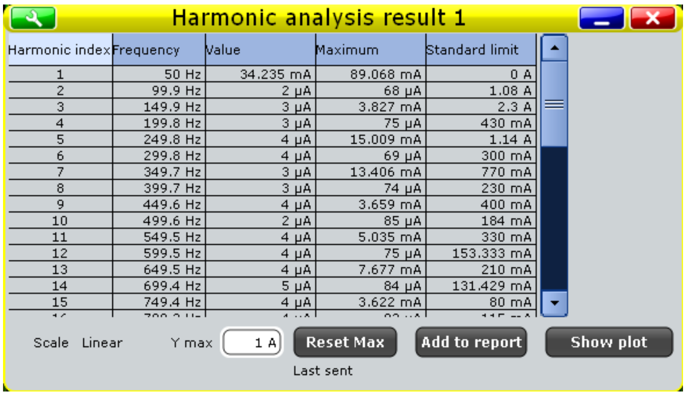
- Differential voltage probe
- Current probe

14.5.1 Current Harmonic Results

The results of "Current Harmonic" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  – the voltage waveform
  – the current waveform
  – the power waveform
- The result box displays a bar chart or a table with the numerical measurement results up to the 40th harmonics.
  To switch the display, tap "Show table" or "Show plot" accordingly





Harmonic index	Frequency	Value	Maximum	Standard limit
1	50 Hz	34.235 mA	89.068 mA	0 A
2	99.9 Hz	2 µA	68 µA	1.08 A
3	149.9 Hz	3 µA	3.827 mA	2.3 A
4	199.8 Hz	3 µA	75 µA	430 mA
5	249.8 Hz	4 µA	15.009 mA	1.14 A
6	299.8 Hz	4 µA	69 µA	300 mA
7	349.7 Hz	3 µA	13.406 mA	770 mA
8	399.7 Hz	3 µA	74 µA	230 mA
9	449.6 Hz	4 µA	3.659 mA	400 mA
10	499.6 Hz	2 µA	85 µA	184 mA
11	549.5 Hz	4 µA	5.035 mA	330 mA
12	599.5 Hz	4 µA	75 µA	153.333 mA
13	649.5 Hz	4 µA	7.677 mA	210 mA
14	699.4 Hz	5 µA	84 µA	131.429 mA
15	749.4 Hz	4 µA	3.622 mA	80 mA

To measure and display the current harmonic, the instrument uses the following measurements and waveforms:

- "P6" Meas 6 to measure the power waveform
- "P7" Meas 7 to measure the spectrum voltage
- "P8" Meas 8 to measure the spectrum current
- "M2" Math 2 to calculate the power
- "M3" Math 3 to calculate the FFT of the voltage
- "M4" Math 4 to calculate the FFT of the current

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

The current harmonic results are defined as follows:

Result Table	Bar Chart Match	Description
Harmonic Index	Value of the X-Axis	The harmonic order
Frequency	-	The frequency value of the signal
Value	Value of the Y-Axis. Shown by a green bar	The present value of the current harmonic
Maximum	Shown by a darkened green bar	The maximum measured value

Result Table	Bar Chart Match	Description
Standard limit	Shown by a white bar	The maxim allowed value according to the selected standard
"Y max"	"Y max"	Sets the upper limit for the display of the Y scale. This value can be reset with the "Reset Max" button

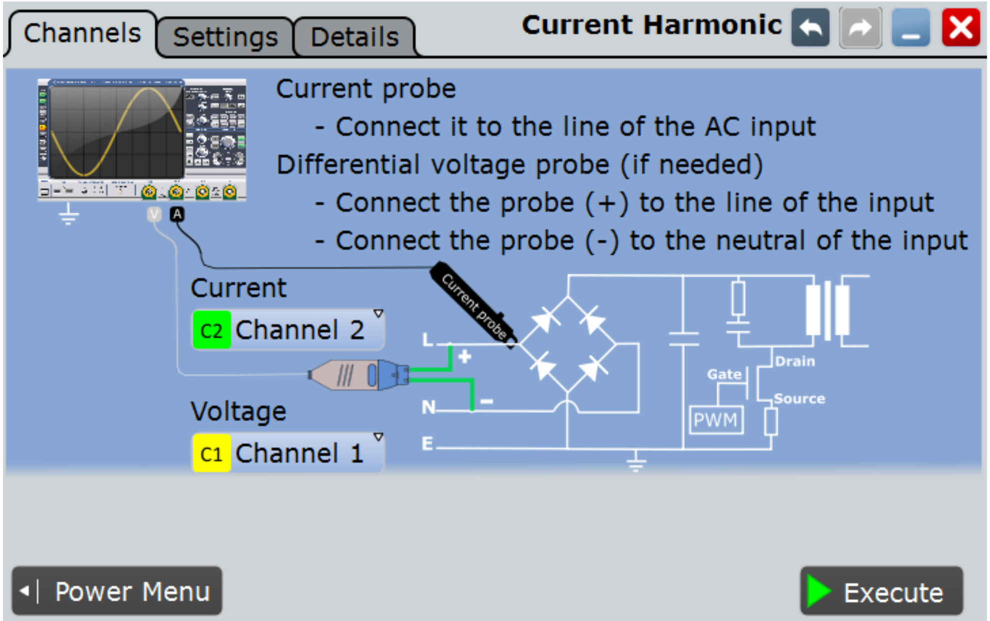
The following remote commands are used for handling the measurement results:

- `POWer:HARMonics:RESult<m>:FREQuency<n>:VALue?` on page 1567
- `POWer:HARMonics:RESult<m>:MAXValue<n>:VALue?` on page 1567
- `POWer:HARMonics:RESult<m>:STDinuse?` on page 1567
- `POWer:HARMonics:RESult<m>:STDValue<n>:VALue?` on page 1567
- `POWer:HARMonics:RESult<m>:VALue<n>:VALue?` on page 1567
- `POWer:HARMonics:REPort:ADD` on page 1567

14.5.2 Configuring Current Harmonic

For details of the configuration settings, see Chapter 14.5.3, "Current Harmonic Settings", on page 800.

1. Select "Analysis">"Power".
2. Under "Power Analysis", select "Current Harmonic".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 14.1.1.1, "Auto Deskew", on page 776.
5. Connect the probes to the DUT as shown in the "Channels" tab:



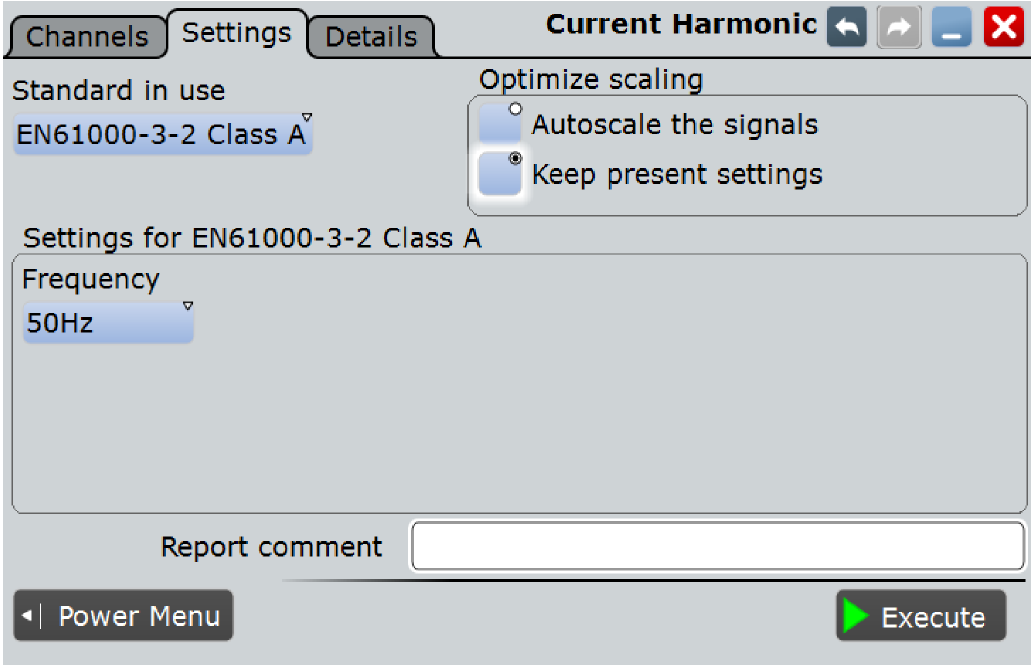
6. Select the correct channels for the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Set the "Standard in use"
9. Set the "Frequency" according to your signal.
10. Select an"Optimize Scaling" option.
11. Tap "Execute".

    On the screen you can see the measurement of the current, the voltage and the power. Additionally there is a table giving information about important measurement parameters. For details, see Chapter 14.5.1, "Current Harmonic Results", on page 797.

14.5.3 Current Harmonic Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 14.2.1, "Channels Tab", on page 786.

In the "Settings" tab you configure the current harmonic measurement parameters and display settings.



Standard in use

Select the standard in use. For a list of the available standards, see Table 14-1.

Table 14-1: Current Harmonic pre-compliance standards

Standard	Application
EN 61000-3-2 Class A	Balanced 3-phase equipment, household appliances (excluding equipment identified as class D), tools (excluding portable tools), dimmers for incandescent lamps, audio equipment
EN 61000-3-2 Class B	Portable tools, not professional arc welding equip-ment
EN 61000-3-2 Class C	Lighting equipment
EN 61000-3-2 Class D	PC, PC monitors, radio, or TV receivers with an input power less than or equal to 600W
MIL-STD-1399	Military shipboard user equipment
RTCA DO-160	Environmental tests of avionics hardware

Remote command:
`POWer:HARMonics:STAN` on page 1568

Frequency

Selects the frequency of the input signal.

Remote command:
`POWer:HARMonics:ENFR` on page 1567
`POWer:HARMonics:MIFR` on page 1567
`POWer:HARMonics:DOFR` on page 1567

Revised Current
Available only for "Standard" > "RTCA DO-160".

Selects how the results are evaluated. Available are the following settings:

- Evaluation with current source only
- Evaluation with voltage source and revised current law
  – Display opposite voltage harmonic result chart
  – Do not display voltage result

Remote command:
`POWer:HARMonics:EVAL` on page 1567
`POWer:HARMonics:VOLT` on page 1568

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:HARMonics:AUTO` on page 1566

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Current Harmonics" measurement.

Remote command:
`POWer:HARMonics:EXECute` on page 1567

14.6 Modulation Analysis

The "Modulation Analysis " measures the control pulse signal to a switching device.

Required probes:

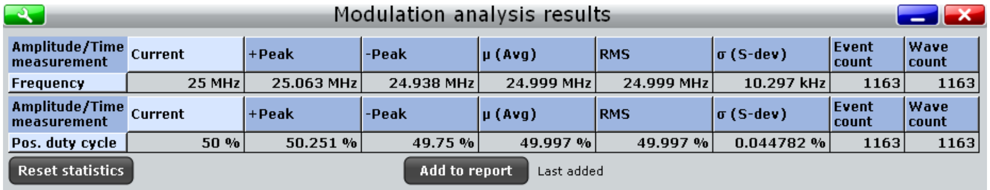
- Differential voltage probe
- Current probe

14.6.1 Modulation Analysis Results

The results of "Modulation Analysis " measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  – the voltage or the current waveform
  – for "Type >Turn on" a track of the frequency and the duty cycle.

- (Optional for "Type > Continuous" measurement) Two histograms display the density distribution of the measurement results in dependance of the frequency and the positive duty cycle.
- The result box displays the numeric measurement results.



To measure and display the power quality, the instrument uses the following measurements and waveforms:

- "P7" Meas 7 to measure the positive duty cycle
- "P8" Meas 8 to measure the frequency

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

Table 14-2: Statistic result parameters

Label	Description
Current	Currently measured value
+Peak	Positive peak value (maximum)
-Peak	Negative peak value (minimum)
µ (Avg)	Average
RMS	Root mean square
σ (S-dev)	Standard deviation
Event count	Number of measured pulses
Wave count	Number of waveforms (acquisitions) the measurement is based on

"Modulation Analysis" is a statistical evaluation that will be reset only if the measurement setup is changed or you reset the statistics.

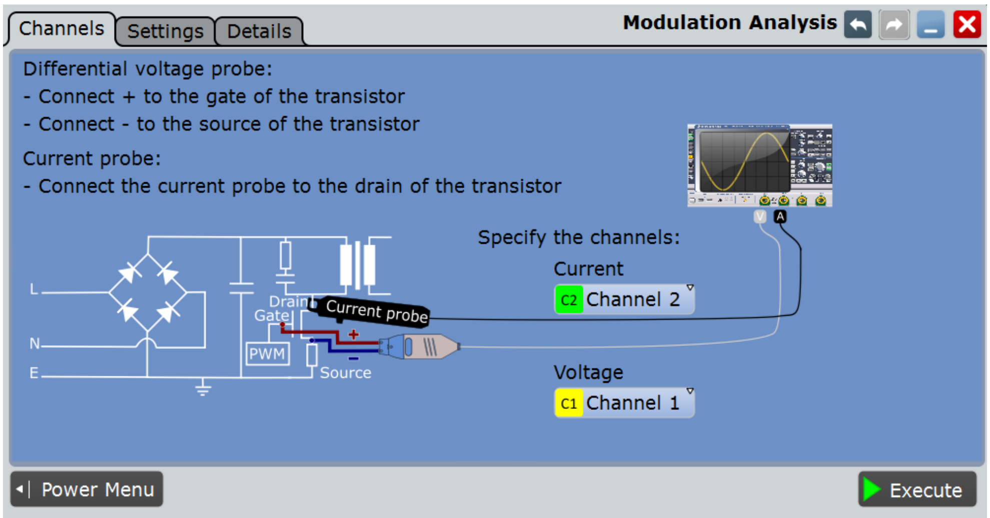
The following remote commands are used for handling the measurement results:

- `POWer:MODulation:RESult:ACTual?` on page 1569
- `POWer:MODulation:RESult:AVG?` on page 1569
- `POWer:MODulation:RESult:EVTCount?` on page 1569
- `POWer:MODulation:RESult:NPEak?` on page 1569
- `POWer:MODulation:RESult:PPEak?` on page 1569
- `POWer:MODulation:RESult:RMS?` on page 1569
- `POWer:MODulation:RESult:STDDev?` on page 1569
- `POWer:MODulation:RESult:WFMCount?` on page 1569
- `POWer:MODulation:REPort:ADD` on page 1569

14.6.2 Configuring Modulation Analysis

For details of the configuration settings, see Chapter 14.6.3, "Modulation Analysis Settings", on page 804.

1. Select "Analysis" > "Power".
2. Under "Switching / Control Loop" select "Modulation Analysis".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 14.1.1.1, "Auto Deskew", on page 776.
5. Connect the probes to the DUT as shown in the "Channels" tab:



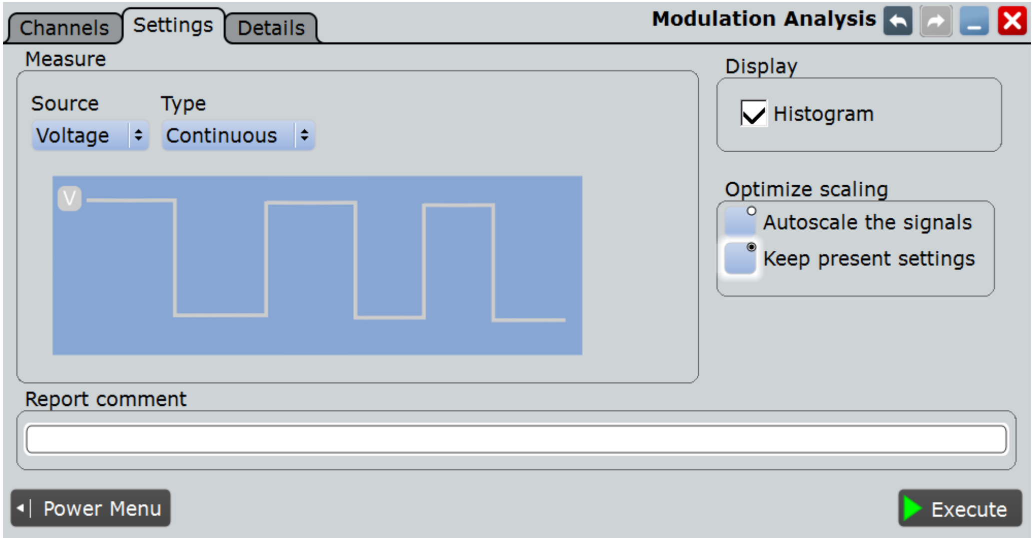
6. Select the correct channels for the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Set the "Source" and the "Type" of measurement.
9. Select an "Optimize Scaling" option.
10. Tap "Execute".

    On the screen you can see the measurement waveforms of the current or the voltage. Additionally, the result box with numeric measurement results is shown. For details, see Chapter 14.6.1, "Modulation Analysis Results", on page 802.

14.6.3 Modulation Analysis Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 14.2.1, "Channels Tab", on page 786.

In the "Settings" tab you configure the modulation analysis parameters and display settings.



Source

Selects the source for the measurement.

Remote command:

`POWer:MODulation:SOURce` on page 1569

Type

Selects the type of signal flow for the measurement

"Continuous" The measurement is running continuously.

"Turn on" The measurement runs once when the DUT is turned on.

Remote command:

`POWer:MODulation:TYPE` on page 1570

Display Histogram

Available only for "Type" > "Continuous".

Enables the display of two histograms after the measurement is executed. The histograms show the density distribution of the measurement results in dependance of the frequency/ duty cycle in a graphic. Thus they illustrate the statistics of the measurements.

Remote command:

`POWer:MODulation:DHIStogram` on page 1569

Optimize scaling

Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:

`POWer:MODulation:AUTO` on page 1568

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Modulation Analysis" measurement.

Remote command:
`POWer:MODulation:EXECute` on page 1569

14.7 Dynamic On Resistance

The "Dynamic ON Resistance" analysis measures the resistance of a switching device, during operation. Because voltage and current may vary in time, the resistance is not constant, thus it is called dynamic ON resistance. It is defined as the ratio dV/dI.

The resistance-related voltage should be measured during a stable part of the switch node waveform, when the undershoot and ringing have decayed, after the high-to-low voltage transition.

Required probes:
- Differential voltage probe
- Current probe

14.7.1 Dynamic On Resistance Results

The results of "Dynamic On Resistance" measurements are provided in two ways:
- The diagram shows the graphical presentation of:
  - the voltage waveform
  - the current waveform
- The result box displays the dynamic on resistance value.

To measure and display the dynamic on resistance, the instrument uses the following measurements and waveforms:
- "P5" Meas 5 to measure the amplitude of the voltage
- "P6" Meas 6 to measure the amplitude of the voltage
- "P7" Meas 7 to measure the amplitude of the current
- "P8" Meas 8 to measure the amplitude of the current
- "C1 " Cursor 1 to measure gate ["t_0" ,"t_1"]
- "C2 " Cursor 2 to measure gate ["t_2" ,"t_3"]

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

The dynamic on resistance displayed as the result is defined as:

$$R = \frac{V(t_2) - V(t_0)}{I(t_3) - I(t_1)}$$

The points "t_0" , "t_1", "t_2" and "t_3" are defined by the cursor lines displayed in the result diagram of the measurement. You can move the cursor lines to define another area of interest.

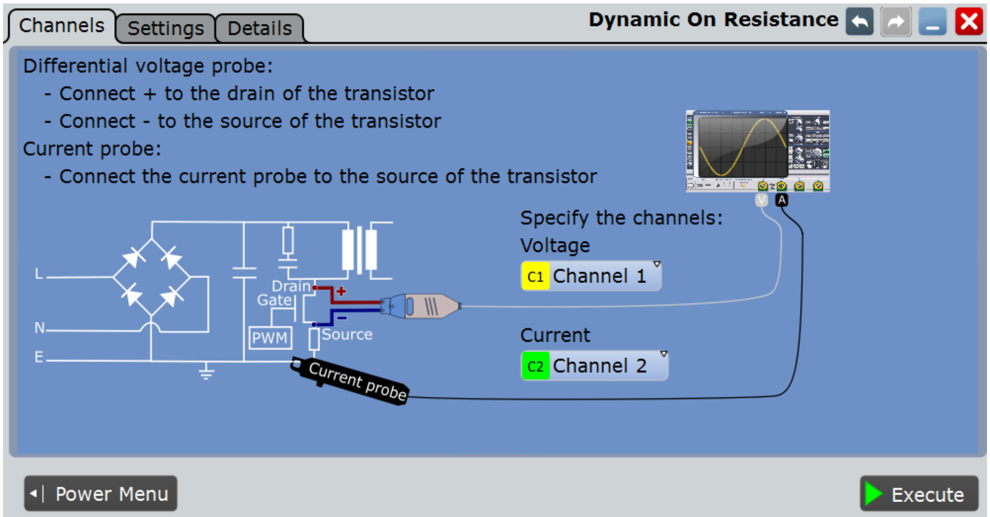
The following remote commands are used for handling the measurement results:

- POWer:DONRes:RESult:RESistance? on page 1571
- POWer:DONRes:GATE<m>:STARt on page 1571
- POWer:DONRes:GATE<m>:STOP on page 1571
- POWer:DONRes:REPort:ADD on page 1571

14.7.2 Configuring Dynamic On Resistance

For details of the configuration settings, see Chapter 14.7.3, "Dynamic On Resistance Settings", on page 808.

1. Select "Analysis" > "Power".
2. Under "Switching / Control Loop" select "Dynamic On Resistance".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 14.1.1.1, "Auto Deskew", on page 776.
5. Connect the probes to the DUT as shown in the "Channels" tab:



6. Select the correct channels for the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.

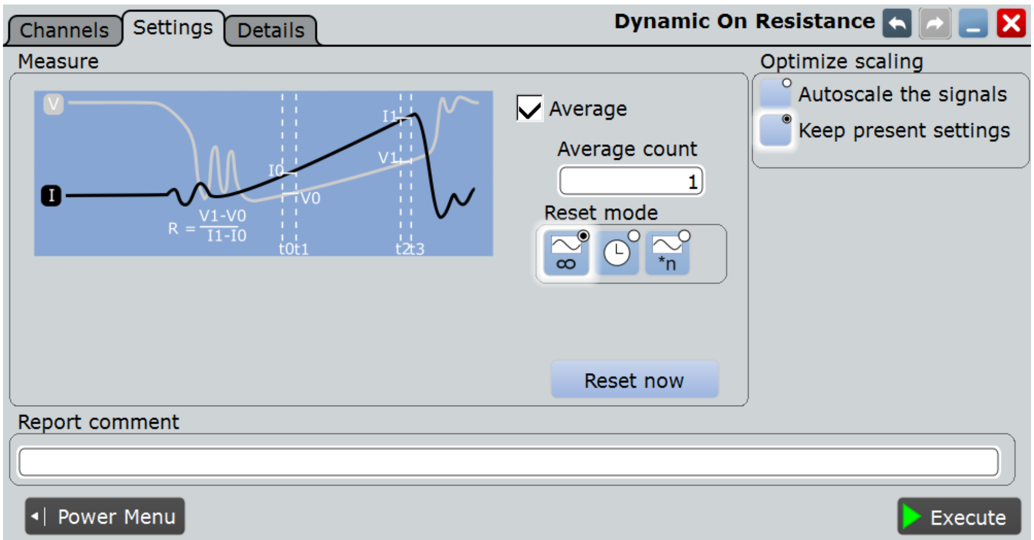
8. If "Average" is selected, enter the "Average count", that is the number of wave-forms used for average calculation.
9. Set the reset condition for the average calculation:
   - If "Time" is selected, enter the "Reset time".
   - If "Waveforms" is selected, enter the "Reset count".
10. Select an "Optimize Scaling" option.
11. Tap "Execute".
12. If needed adjust the cursors manually. You can tap on a cursor and change its position with the NAVIGATION rotary knob.

    On the screen you can see the measurement waveforms of the current and the voltage. Additionally, the result box displays the dynamic on resistance. For details, see Chapter 14.7.1, "Dynamic On Resistance Results", on page 806.

14.7.3 Dynamic On Resistance Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 14.2.1, "Channels Tab", on page 786.

In the "Settings" tab you configure the power measurement parameters and display settings.



Average
Enables the "Average" method for building the resulting waveform. The average is calculated from the data of the current acquisition and a number of acquisitions before. The method reduces random noise and other heterodyne signals. It requires a stable, triggered and periodic signal for correct function. The number of acquisitions for average calculation is defined with "Average count", and the "Reset mode" defines the restart condition.

Remote command:
`POWer:DONRes:AVG` on page 1570

Auto reset mode / Reset mode

Defines when the envelope and average evaluation restarts.

"None" No restart, the number of acquisitions considered by the waveform arithmetics is not limited.

"Time" Restarts the envelope and average calculation after the time defined in "Reset time".

"Waveforms" Restarts the envelope and average calculation after a number of acquired waveforms defined in "Reset count".

Remote command:
`ACQuire:ARESet:MODE` on page 1572
`ACQuire:ARESet:TIME` on page 1572
`ACQuire:ARESet:COUNt` on page 1573

Reset

Forces the immediate restart of the envelope and average calculation for all waveforms.

Remote command:
`ACQuire:ARESet:IMMediate` on page 917

Optimize scaling

Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:DONRes:AUTO` on page 1570

Report comment

In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute

Starts the "Dynamic On Resistance" measurement.

Remote command:
`POWer:DONRes:EXECute` on page 1570

14.8 Slew Rate

The "Slew Rate" analysis measures the rate of change of the voltage or current waveform during the switching of the switching transistor.

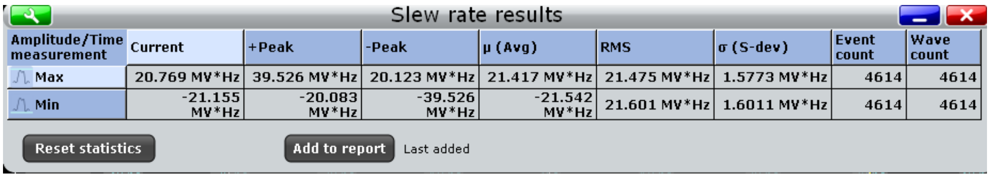
Required probes:

- Differential voltage probe
- Current probe

14.8.1 Slew Rate Results

The results of "Slew Rate" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  – the voltage waveform
  – the current waveform
  – a waveform of the derivative of voltage and current
- The result box displays the numeric measurement results. For a detailed description, see Table 14-2.



To measure and display the slew rate, the instrument uses the following measurements and waveforms:

- "P8" Meas 8 to measure the amplitude of the current or voltage waveform
- "M2" Math 4 to calculate the time derivative of the current or voltage waveform
- "C1" Cursor 1 to determine the measurement area

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

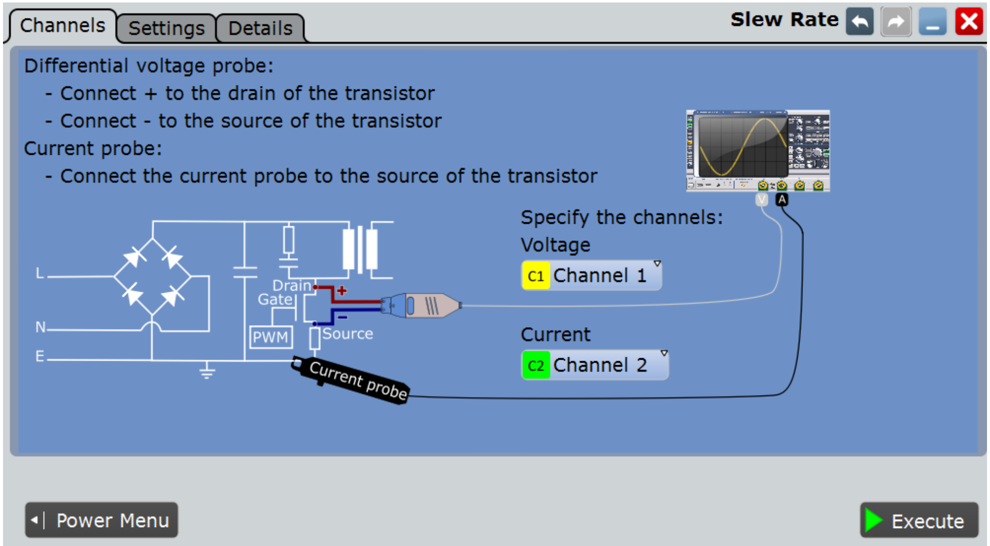
The following remote commands are used for handling the measurement results:

- `POWer:SLEWrate:RESult:ACTual?` on page 1573
- `POWer:SLEWrate:RESult:AVG?` on page 1573
- `POWer:SLEWrate:RESult:EVTCount?` on page 1573
- `POWer:SLEWrate:RESult:NPEak?` on page 1573
- `POWer:SLEWrate:RESult:PPEak?` on page 1573
- `POWer:SLEWrate:RESult:RMS?` on page 1573
- `POWer:SLEWrate:RESult:STDDev?` on page 1573
- `POWer:SLEWrate:RESult:WFMCount?` on page 1573
- `POWer:SLEWrate:REPort:ADD` on page 1573

14.8.2 Configuring Slew Rate

For details of the configuration settings, see Chapter 14.8.3, "Slew Rate Settings", on page 811.

1. Select "Analysis" > "Power".
2. Under "Switching / Control Loop" dialog select "Slew Rate".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 14.1.1.1, "Auto Deskew", on page 776.
5. Connect the probes to the DUT as shown in the "Channels" tab:



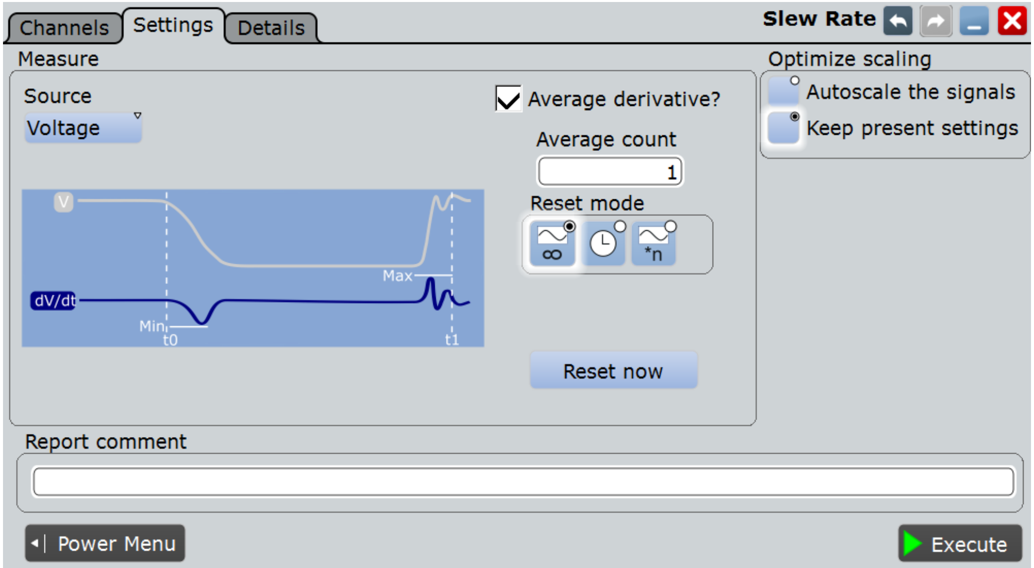
6. Select the correct channels for the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Select the "Source".
9. If "Average" is selected, enter the "Average count", that is the number of waveforms used for average calculation.
10. Set the reset condition for the average calculation:
    - If "Time" is selected, enter the "Reset time".
    - If "Waveforms" is selected, enter the "Reset count".
11. Select an "Optimize Scaling" option.
12. Tap "Execute".

    On the screen you can see the measurement waveforms of the slew rate, the current and the voltage. The result box with numeric measurement results is shown. For details, see Chapter 14.8.1, "Slew Rate Results", on page 810.

14.8.3 Slew Rate Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 14.2.1, "Channels Tab", on page 786.

In the "Settings" tab you configure the slew rate measurement parameters and display settings.



Source

Selects dV/dt or dI/dt as the source of the measurement.

Remote command:
POWer:SLEWrate:SOURce on page 1572

Average

Enables the "Average" method for building the resulting waveform. The average is calculated from the data of the current acquisition and a number of acquisitions before. The method reduces random noise and other heterodyne signals. It requires a stable, triggered and periodic signal for correct function. The number of acquisitions for average calculation is defined with "Average count", and the "Reset mode" defines the restart condition.

Remote command:
POWer:SLEWrate:AVGDeriv on page 1572

Auto reset mode / Reset mode

Defines when the envelope and average evaluation restarts.

"None"	No restart, the number of acquisitions considered by the waveform arithmetics is not limited.
"Time"	Restarts the envelope and average calculation after the time defined in "Reset time".
"Waveforms"	Restarts the envelope and average calculation after a number of acquired waveforms defined in "Reset count".

Remote command:
ACQuire:ARESet:MODE on page 1572
ACQuire:ARESet:TIME on page 1572
ACQuire:ARESet:COUNt on page 1573

Reset
Forces the immediate restart of the envelope and average calculation for all waveforms.

Remote command:
`ACQuire:ARESet:IMMediate` on page 917

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:SLEWrate:AUTO` on page 1572

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Slew Rate" measurement.

Remote command:
`POWer:SLEWrate:EXECute` on page 1572

14.9 Safe Operating Area (S.O.A.)

The safe operating area is defined by the voltage and current conditions over which a power semiconductor device is expected to operate without self-damage. The "Safe Operating Area" analysis provides a diagram of the safe operating conditions of your device.

Required probes:

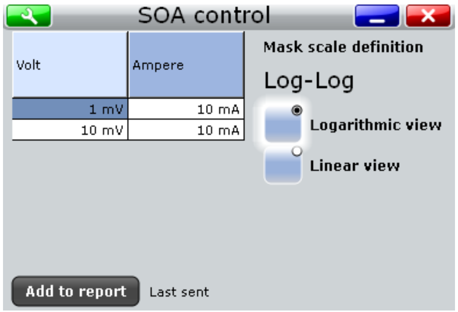
- Differential voltage probe
- Current probe

14.9.1 Safe Operating Area Results

The results of "Safe Operating Area" measurements are provided in the following ways:

- The diagram shows the graphical presentation of:
  - the voltage waveform
  - the current waveform

- A logarithmic or linear XY diagram of the calculated voltage (x-axis) and current (y-axis) waveforms. This curve is a graphical representation of the power handling capability of the device under various conditions.
- The result box displays the numeric measurement results. Additionally, you can see the mask definition and change the scale in the "SOA Control" dialog. If the state of "Enable mask test" is "On" an extra result box appears, see also Table 14-3.



To measure and display the safe operating area, the instrument uses the following measurements and diagrams:

- "XY1" XY Diagram 1 to measure the logarithmic waveform
- "XY2" XY Diagram 2 to measure the linear waveform
- "M1" Math 1 to calculate the voltage signal
- "M2" Math 2 to calculate the current signal

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

The results of the safe operating area mask test are described in Table 14-3.

Table 14-3: Results of the mask test

Result	Description
Acq. completed	Number of tested acquisitions
Acq. remaining	Remaining acquisitions until "Average count / Nx Single count" is reached

Result	Description
State	Shows if the test has been completed. The state is set to "Finished" when "Nx Single count" acquisitions are tested and the number of "Acq. remaining" is 0. As long as the number of tested acquisitions is less the "Nx Single count" number, the state is "Running". If you run the acquisition with RUN CONT, or the number of played history acquisitions exceeds "Nx Single count", the mask testing is performed according to fail criteria settings independently of the test state. The testing is not stopped when the state is set to "Finished".
Sample hits	Number of samples that hit the mask
Acquisition hits	Number of acquisitions that contained at least one sample hit
Fail rate	Ratio of acquisition hits to the number of tested acquisitions
Test result	A test has failed if the number of sample hits or acquisition hits exceeds the limit of "Violation tolerance" hits

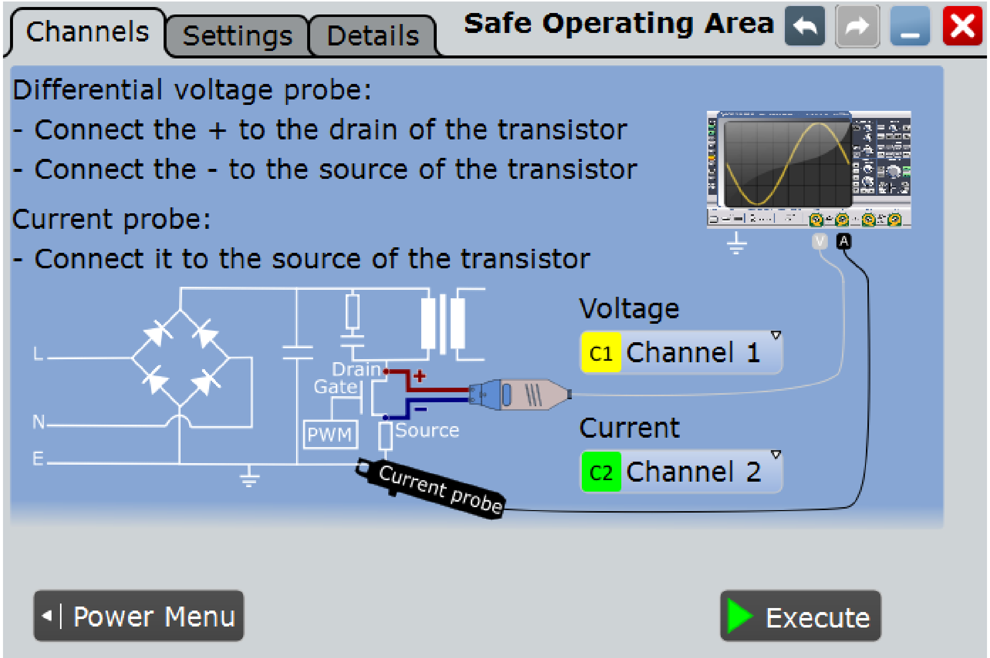
The following remote commands are used for handling the measurement results:

- `POWer:SOA:SWITch` on page 1576
- `POWer:SOA:REPort:ADD` on page 1576

14.9.2 Configuring Safe Operating Area

For details of the configuration settings, see Chapter 14.9.3, "Safe Operating Area Settings", on page 816.

1. Select "Analysis" > "Power".
2. Under "Power Path", select "Safe Operating Area".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 14.1.1.1, "Auto Deskew", on page 776.
5. Connect the probes to the DUT as shown in the "Channels" tab:



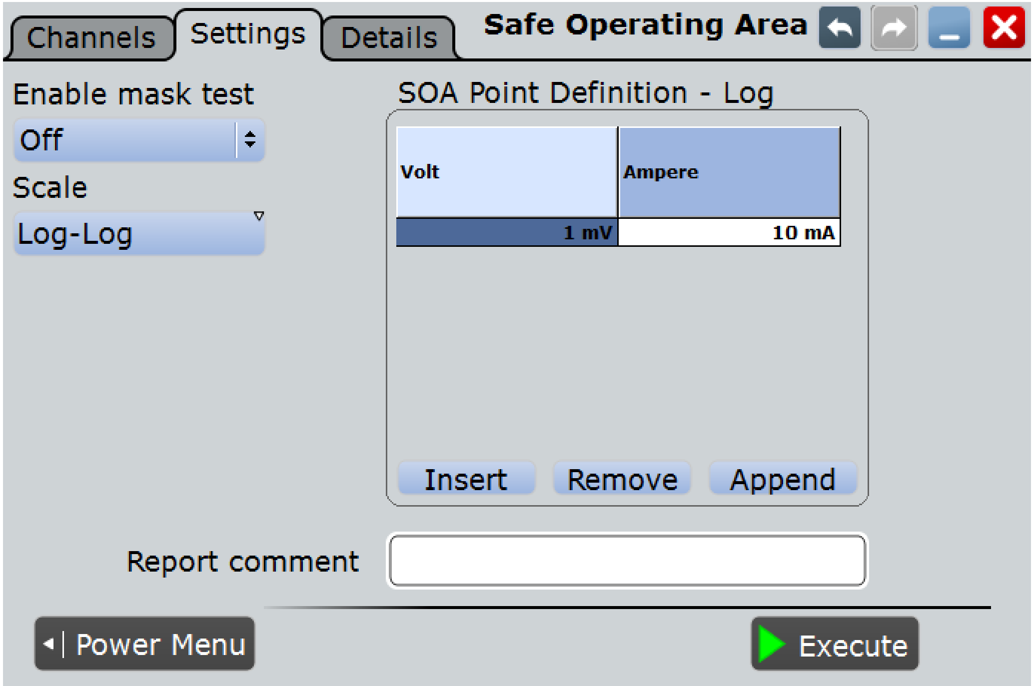
6. Select the correct channels of the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Select the state of the "Enable mask test".
9. Select the "Scale".
10. Define the SOA Points.
11. Tap "Execute".

    On the screen you can see the measurement waveforms of the Additionally, the result box with numeric measurement results is shown. For details, seeChapter 14.9.1, "Safe Operating Area Results", on page 813.

14.9.3 Safe Operating Area Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 14.2.1, "Channels Tab", on page 786.

In the "Settings" tab you configure the safe operating area parameters and display settings.



Enable mask test

Enables a mask test.

Remote command:
POWer:SOA:MASK on page 1576

Scale

Selects the scale for the result diagram.

Remote command:
POWer:SOA:SCALe on page 1576

SOA point definition

In this table you can set voltage-current points to define a mask for the safe point opearing area. If "Enable mask test > On" you can check whether the signal remains within the specified limits.

To add a point press "Insert" or "Append". To remove a point press "Remove".

Remote command:
POWer:SOA:LINear:ADD on page 1574
POWer:SOA:LOGarithmic:ADD on page 1574
POWer:SOA:LINear:COUNt? on page 1574
POWer:SOA:LOGarithmic:COUNt? on page 1574
POWer:SOA:LINear:INSert on page 1575
POWer:SOA:LOGarithmic:INSert on page 1575
POWer:SOA:LINear:REMove on page 1575
POWer:SOA:LOGarithmic:REMove on page 1575

Volt ← SOA point definition

Sets the voltage value of the SOA point.

Remote command:
`POWer:SOA:LINear:POINt<m>:VOLTage` on page 1575

Ampere ← SOA point definition
Sets the current value of the SOA point.

Remote command:
`POWer:SOA:LINear:POINt<m>:CURRent` on page 1575

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Safe Operating Area" measurement.

Remote command:
`POWer:SOA:EXECute` on page 1574

14.10 Turn On/ Off

"Turn On/Off" analysis measures the time that a power supply needs to reach a certain percentage of the steady state output level when initially turned on or turned off.

Common measuring scenarios include:

- Turn on time: measurement of the time it takes for the DC output to reach 90 % of the expected steady state level, after the power supply is initially turned on.
- Turn off time: measurement of the time it takes for the DC output to reach 10 % of the expected steady state level, after the power supply is initially turned off.

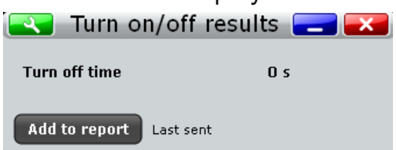
Required probes:

- Differential voltage probe
- Passive or differential voltage probe

14.10.1 Turn On/ Off Results

The results of "Turn On/ Off" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  – the input voltage waveform
  – the output voltage waveform
- The result box displays the "Turn on time" or the "Turn off time".



The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

The"Turn on time" is measured as the time between the trigger point ("Trigger level on" value is reached) and the time the given percentage of the "Steady state level" is reached, see Figure 14-2.

The"Turn off time" is measured as the time between the trigger point, delayed with the set "Time", ("Trigger level on" value is reached) and the time the given percentage of the "Steady state level" is reached, see Figure 14-3.

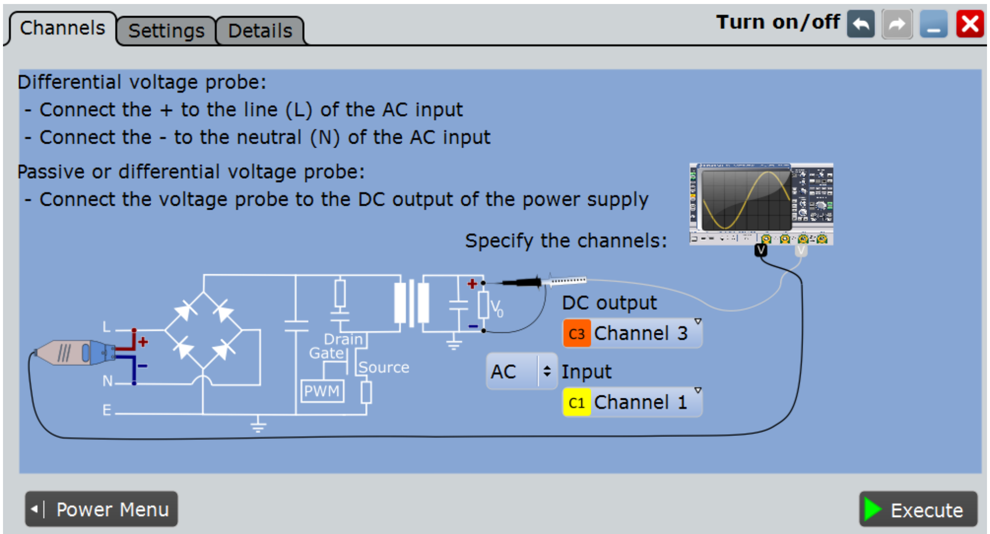
The following remote commands are used for handling the measurement results:

- `POWer:ONOFf:RESult:TOFF?` on page 1578
- `POWer:ONOFf:RESult:TON?` on page 1578
- `POWer:ONOFf:REPort:ADD` on page 1578

14.10.2 Configuring Turn On/ Off

For details of the configuration settings, see Chapter 14.10.3, "Turn On/ Off Settings", on page 820.

1. Select "Analysis">"Power".
2. Under "Power Path", select "Turn On/ Off".
3. Connect the probes to the DUT as shown in the "Channels" tab:



4. Select the correct channels for the "DC output" and the "AC input" or the "DC input".
5. Select the "Settings" tab.
6. Select whether you want to measure "Turn on" or "Turn off".
7. Set the "Steady state level" and the "Trigger level " according to your requirements.

8. Tap "Execute".
9. Turn on/off the DUT.

   On the screen you can see the measurement. Additionally, the result box displays the turn on or the turn off time. For details, see Chapter 14.10.1, "Turn On/ Off Results", on page 818.

14.10.3 Turn On/ Off Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 14.2.1, "Channels Tab", on page 786.

In the "Settings" tab you configure the turn on and the turn off parameters.

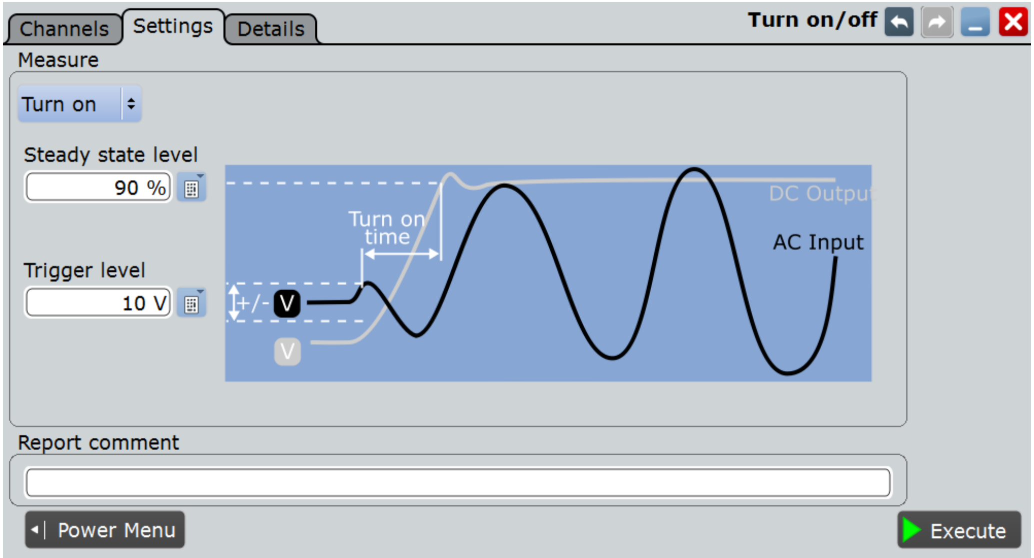


Figure 14-2: Settings turn on time

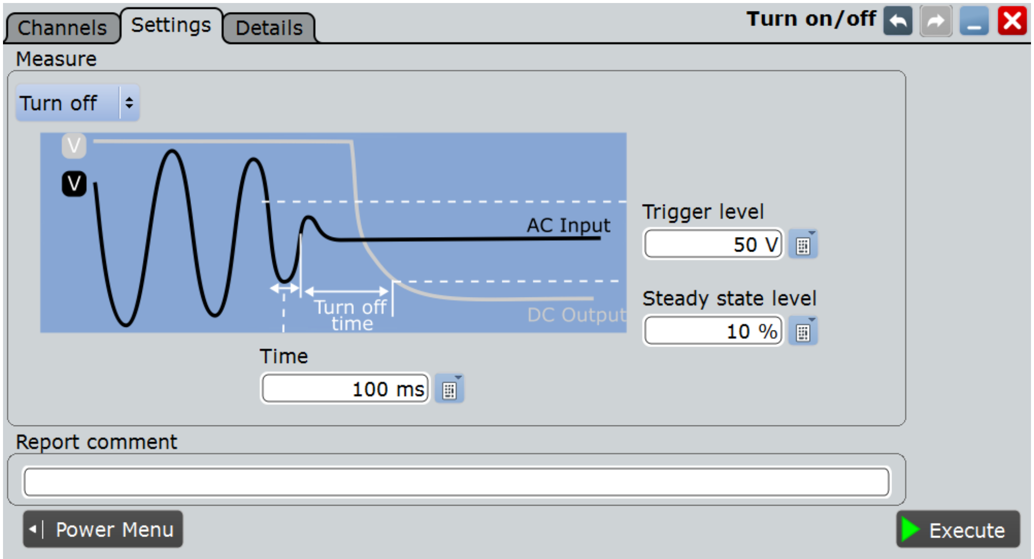


Figure 14-3: Settings turn off time

Input Type

To acces this setting select the "Channels" tab.

Selects the AC or DC input type.

Remote command:

`POWer:ONOFf:INPut` on page 1577

Measurement Type

Selects the"Turn on" or the "Turn off " measurement.

Remote command:

`POWer:ONOFf:TYPE` on page 1578

Turn on

Enables the configuration of the turn on time measurement.

Steady state level-Turn on ← Turn on

Sets the percentage of the steady state level of the DC output that has to be reached.

Remote command:

`POWer:ONOFf:DSON` on page 1577

Trigger level on ← Turn on

Triggers the beginning of the measurements at the moment the AC or DC input voltage reaches the set value.

Remote command:

`POWer:ONOFf:ATON` on page 1577

`POWer:ONOFf:DTON` on page 1577

Turn off

Enables the configuration of the turn off time measurement.

Steady state level- Turn off ← Turn off
Sets the percentage of the steady state level of the DC output that has to be reached.

Remote command:
`POWer:ONOFf:DSOFf` on page 1577

Trigger level ← Turn off
Triggers the beginning of the measurements at the moment the AC or DC input voltage reaches the set value.

Remote command:
`POWer:ONOFf:ATOFf` on page 1577
`POWer:ONOFf:DTOFf` on page 1577

Time ← Turn off
Sets the time the start of the measurement of the turn off time is delay with, after the trigger point.

Remote command:
`POWer:ONOFf:TIME` on page 1578

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Power Quality" measurement.

Remote command:
`POWer:ONOFf:EXECute` on page 1577

14.11 Switching Loss

The "Switching Loss" analysis measures the power and energy losses of a switching device, that occur during the switching phases and the conduction phase of the switching transistor.

Required probes:

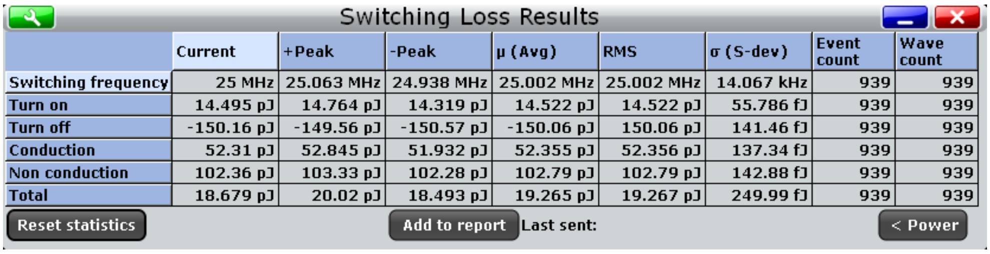
- Differential voltage probe
- Current probe

14.11.1 Switching Loss Results

The results of "Switching Loss" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage waveform
  - the current waveform
  - the power waveform

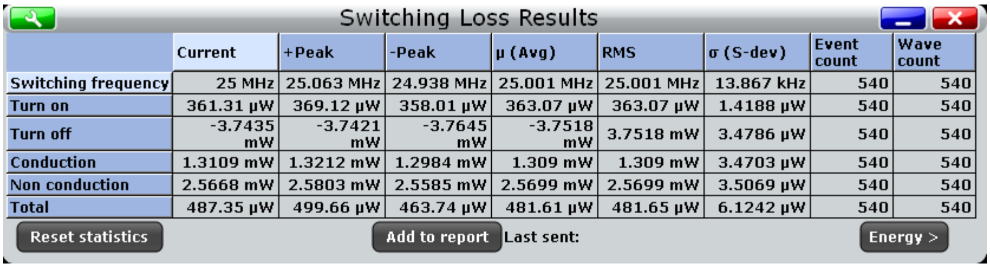
- The result box displays the numeric measurement results for the enabled measurement parameters in dependance of the energy and the power. To switch the display, tap "Energy" or "Power" accordingly.
  For a detailed description, see Table 14-2.



Switching Loss Results

	Current	+Peak	-Peak	μ (Avg)	RMS	σ (S-dev)	Event count	Wave count
Switching frequency	25 MHz	25.063 MHz	24.938 MHz	25.002 MHz	25.002 MHz	14.067 kHz	939	939
Turn on	14.495 pJ	14.764 pJ	14.319 pJ	14.522 pJ	14.522 pJ	55.786 fJ	939	939
Turn off	-150.16 pJ	-149.56 pJ	-150.57 pJ	-150.06 pJ	150.06 pJ	141.46 fJ	939	939
Conduction	52.31 pJ	52.845 pJ	51.932 pJ	52.355 pJ	52.356 pJ	137.34 fJ	939	939
Non conduction	102.36 pJ	103.33 pJ	102.28 pJ	102.79 pJ	102.79 pJ	142.88 fJ	939	939
Total	18.679 pJ	20.02 pJ	18.493 pJ	19.265 pJ	19.267 pJ	249.99 fJ	939	939

Reset statistics | Add to report | Last sent: | < Power



Switching Loss Results

	Current	+Peak	-Peak	μ (Avg)	RMS	σ (S-dev)	Event count	Wave count
Switching frequency	25 MHz	25.063 MHz	24.938 MHz	25.001 MHz	25.001 MHz	13.867 kHz	540	540
Turn on	361.31 μW	369.12 μW	358.01 μW	363.07 μW	363.07 μW	1.4188 μW	540	540
Turn off	-3.7435 mW	-3.7421 mW	-3.7645 mW	-3.7518 mW	3.7518 mW	3.4786 μW	540	540
Conduction	1.3109 mW	1.3212 mW	1.2984 mW	1.309 mW	1.309 mW	3.4703 μW	540	540
Non conduction	2.5668 mW	2.5803 mW	2.5585 mW	2.5699 mW	2.5699 mW	3.5069 μW	540	540
Total	487.35 μW	499.66 μW	463.74 μW	481.61 μW	481.65 μW	6.1242 μW	540	540

Reset statistics | Add to report | Last sent: | Energy >

To measure and display the switching loss, the instrument uses the following measurements and cursors:

- "P3"... "P8": Meas 3 ... Meas 8 to measure the voltage
- "M4" Math 4 to calculate the power
- "C3" Cursor 3 to define time points "t_0" and "t_1"
- "C4" Cursor 4 to define time points "t_2" and "t_3"

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

"Switching Loss" is a statistical evaluation that will be reset only if the measurement setup is changed or you reset the statistics.

The switching loss phases that can be defined during the measurement are shown in Figure 14-4 and described in Table 14-4.

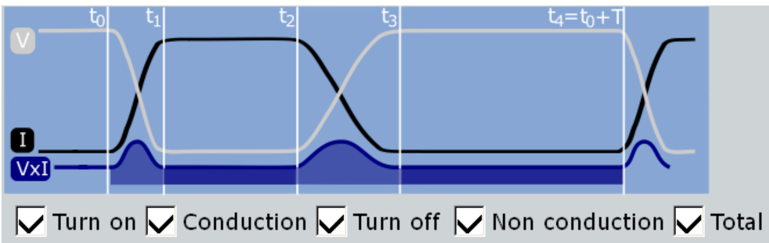


Figure 14-4: Switching loss phases

Table 14-4: Switching loss phases

Phase	Definition Points	Description
Turn on	The area between "t_0" and "t_1"	The time after switching the device, during which the current rises until it reaches the saturation current level.
Conduction	The area between "t_1" and "t_2"	The time during which the voltage is at the transistors saturated minimum and the current flows.
Turn off	The area between "t_2" and "t_3"	The time during which after a short delay time the voltage rises until it reaches its final value.
Non conduction	The area between "t_3" and "t_4"	The time during current doesn't flow. The losses during this period should be theoretically zero.
Total	The area between "t_0" and "t_4"	The period of one switching cycle.

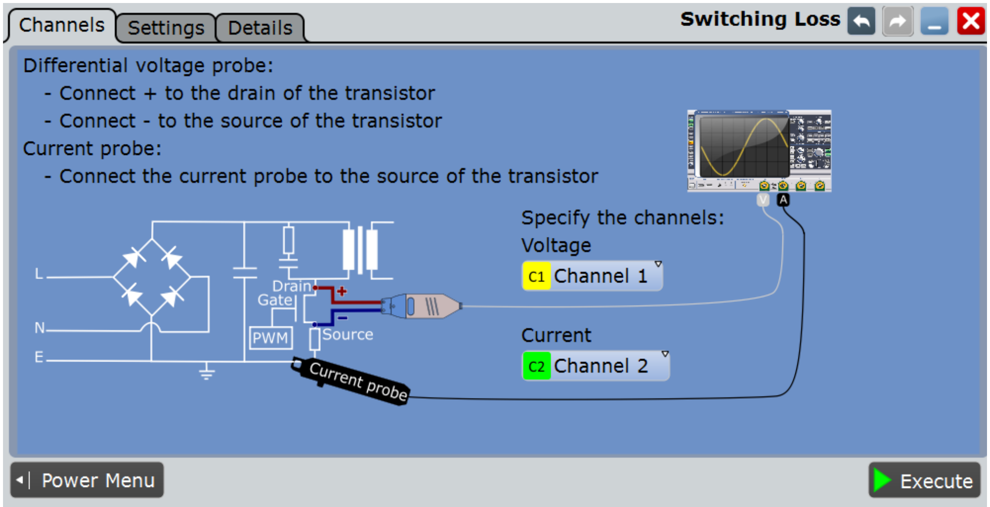
The following remote commands are used for handling the measurement results:

- `POWer:SWITching:GATE:COND:STARt` on page 1580
- `POWer:SWITching:GATE:COND:STOP` on page 1580
- `POWer:SWITching:GATE:NCON:STARt` on page 1580
- `POWer:SWITching:GATE:TOFF:STARt` on page 1580
- `POWer:SWITching:GATE:TOFF:STOP` on page 1580
- `POWer:SWITching:GATE:TON:STARt` on page 1580
- `POWer:SWITching:GATE:TON:STOP` on page 1580
- `POWer:SWITching:RESult:ENERgy:ACTual?` on page 1580
- `POWer:SWITching:RESult:ENERgy:AVG?` on page 1580
- `POWer:SWITching:RESult:ENERgy:EVTCount?` on page 1580
- `POWer:SWITching:RESult:ENERgy:NPEak?` on page 1580
- `POWer:SWITching:RESult:ENERgy:PPEak?` on page 1580
- `POWer:SWITching:RESult:ENERgy:RMS?` on page 1580
- `POWer:SWITching:RESult:ENERgy:STDDev?` on page 1580
- `POWer:SWITching:RESult:ENERgy:WFMCount?` on page 1580
- `POWer:SWITching:RESult:POWer:ACTual?` on page 1581
- `POWer:SWITching:RESult:POWer:AVG?` on page 1581
- `POWer:SWITching:RESult:POWer:EVTCount?` on page 1581
- `POWer:SWITching:RESult:POWer:NPEak?` on page 1581
- `POWer:SWITching:RESult:POWer:PPEak?` on page 1581
- `POWer:SWITching:RESult:POWer:RMS?` on page 1581
- `POWer:SWITching:RESult:POWer:STDDev?` on page 1581
- `POWer:SWITching:RESult:POWer:WFMCount?` on page 1581
- `POWer:SWITching:REPort:ADD` on page 1579

14.11.2 Configuring Switching Loss

For details of the configuration settings, see Chapter 14.11.3, "Switching Loss Settings", on page 825.

1. Select "Analysis" > "Power".
2. Under "Power Path", select "Switching Loss".
3. Connect the differential voltage probe and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 14.1.1.1, "Auto Deskew", on page 776.
5. Connect the probes to the DUT as shown in the "Channels" tab:



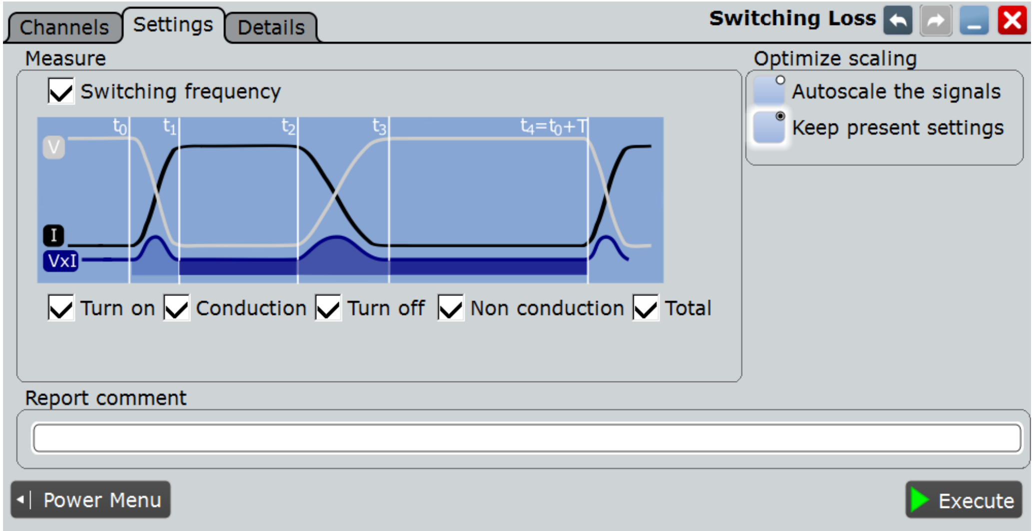
6. Select the correct channels for the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Enable the parameters you want to measure.
9. Select an"Optimize Scaling" option.
10. Tap "Execute".

    On the screen you can see the measurement waveforms of the current, the voltage and the power. Additionally, the result box with numeric measurement results is shown. For details, see Chapter 14.11.1, "Switching Loss Results", on page 822.

14.11.3 Switching Loss Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 14.2.1, "Channels Tab", on page 786.

In the "Settings" tab you configure the switching loss parameters and display settings.



Measure

In this area you can select the parameters that are included in the analysis after executing the measurement.

Switching frequency ← Measure

Enables the measurements of the switching frequency. If disabled you can enter the value of the switching frequency.

Remote command:
`POWer:SWITching:SWIFrequency` on page 1579
`POWer:SWITching:SWIT` on page 1580

Turn on

Enables the measurements during the turn on period.

Remote command:
`POWer:SWITching:TON` on page 1580

Conduction

Enables the measurements during the conduction period.

Remote command:
`POWer:SWITching:COND` on page 1580

Turn off

Enables the measurements during the turn off period.

Remote command:
`POWer:SWITching:TOFF` on page 1580

Non conduction

Enables the measurements during the non conduction period.

Remote command:
`POWer:SWITching:NCON` on page 1580

Total
Enables the measurements of the total period

Remote command:
POWer:SWITching:TOTal on page 1580

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
POWer:SWITching:AUTO on page 1579

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Switching Loss" measurement.

Remote command:
POWer:SWITching:EXECute on page 1579

14.12 Power Efficiency

This measurement requires a 4-channel oscilloscope (R&S RTExxx4).

"Power Efficiency" analysis measures the input and the output power of a power supply. The power efficiency of the power supply is then calculated as the ratio of the output power and the input power.

Required probes:

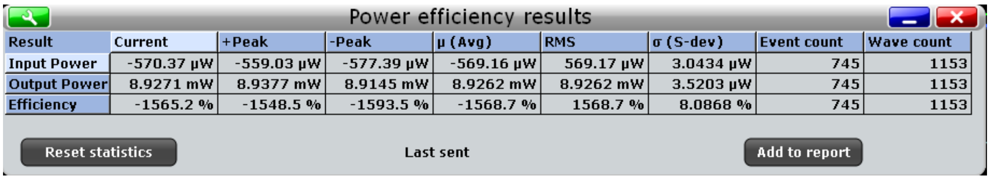
- Two differential voltage probes
- Two current probes

14.12.1 Power Efficiency Results

The results of "Power Efficiency" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  - the voltage input waveform
  - the current input waveform
  - the voltage output waveform
  - the voltage input waveform

  – the power input waveform
  – the power output waveform
- The result box displays the numeric measurement results of the "Input power", "Output power" and the "Efficiency". For a detailed description, see Table 14-2.



Power efficiency results

Result	Current	+Peak	-Peak	µ (Avg)	RMS	σ (S-dev)	Event count	Wave count
Input Power	-570.37 µW	-559.03 µW	-577.39 µW	-569.16 µW	569.17 µW	3.0434 µW	745	1153
Output Power	8.9271 mW	8.9377 mW	8.9145 mW	8.9262 mW	8.9262 mW	3.5203 µW	745	1153
Efficiency	-1565.2 %	-1548.5 %	-1593.5 %	-1568.7 %	1568.7 %	8.0868 %	745	1153

To measure and display the power quality, the instrument uses the following measurements and waveforms:

- "P7" Meas 7 to measure the input power waveform
- "P8" Meas 8 to measure the output power waveform
- "M2" Math 2 to calculate the input power
- "M3" Math 3 to calculate the output power

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

"Power Efficiency" is a statistical evaluation that will be reset only if the measurement setup is changed or you reset the statistics.

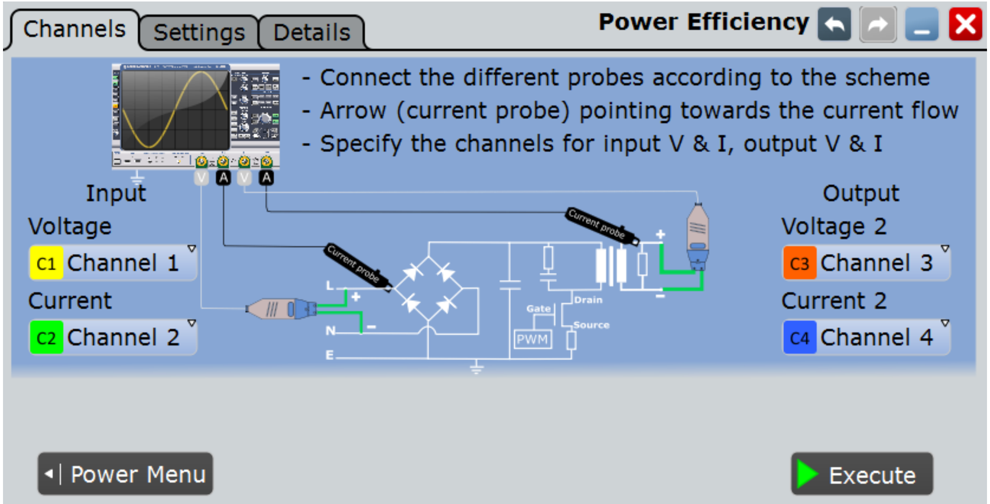
The following remote commands are used for handling the measurement results:

- `POWer:EFFiciency:RESult<m>:ACTual?` on page 1582
- `POWer:EFFiciency:RESult<m>:AVG?` on page 1582
- `POWer:EFFiciency:RESult<m>:EVTCount?` on page 1582
- `POWer:EFFiciency:RESult<m>:NPEak?` on page 1582
- `POWer:EFFiciency:RESult<m>:PPEak?` on page 1582
- `POWer:EFFiciency:RESult<m>:RMS?` on page 1582
- `POWer:EFFiciency:RESult<m>:STDDev?` on page 1582
- `POWer:EFFiciency:RESult<m>:WFMCount?` on page 1582
- `POWer:EFFiciency:REPort:ADD` on page 1582

14.12.2 Configuring Power Efficiency

For details of the configuration settings, see Chapter 14.12.3, "Power Efficiency Settings", on page 829.

1. Select "Analysis" > "Power".
2. Under "Power Path", select "Power Efficiency".
3. Connect the differential voltage probes and the current probes to the oscilloscope.
4. Deskew the probes as described in Chapter 14.1.1.1, "Auto Deskew", on page 776.
5. Connect the probes to the DUT as shown in the graphic of the "Channels" tab:



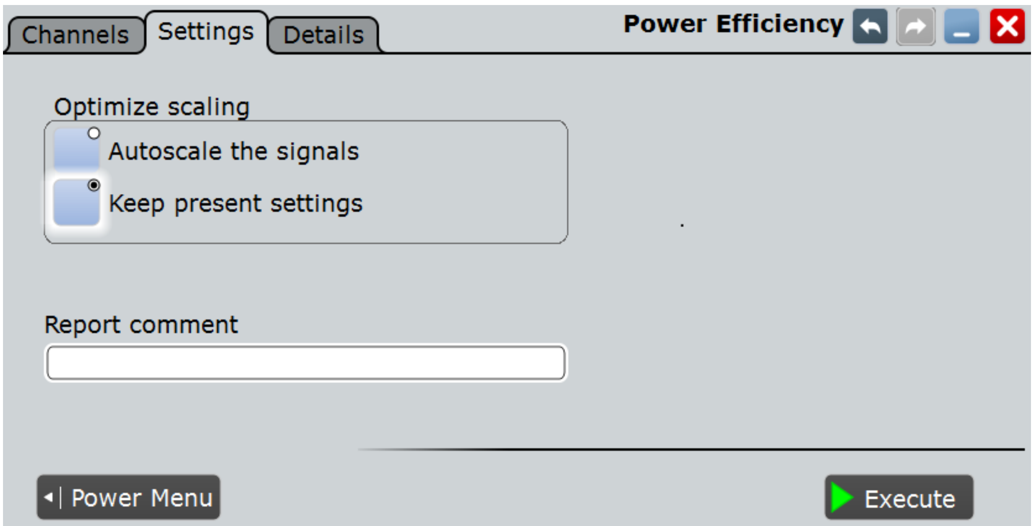
6. Select the correct channels for the "Current Source" and the "Voltage Source" of the input and the output.
7. Select the "Settings" tab.
8. Select an "Optimize Scaling" option.
9. Tap "Execute".

   On the screen you can see the measurement waveforms of the input power and the output power. Additionally, the result box with numeric measurement results is shown. For details, see Chapter 14.12.1, "Power Efficiency Results", on page 827

14.12.3 Power Efficiency Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 14.2.1, "Channels Tab", on page 786.

In the "Settings" tab you configure the power efficience display settings.



Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:EFFiciency:AUTO` on page 1582

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Power Effieciency" measurement.

Remote command:
`POWer:EFFiciency:EXECute` on page 1582

14.13 Output Ripple

The "Output Ripple" analysis measures the ripple of the device output. You can measure the voltage ripple alone or the voltage and the current ripple simultaneously. In this measurement the peak-to peak extremes of the output DC signal are of interest. The measurement also includes the AC-RMS of the output DC signal, that is calculated as a standard derivation.

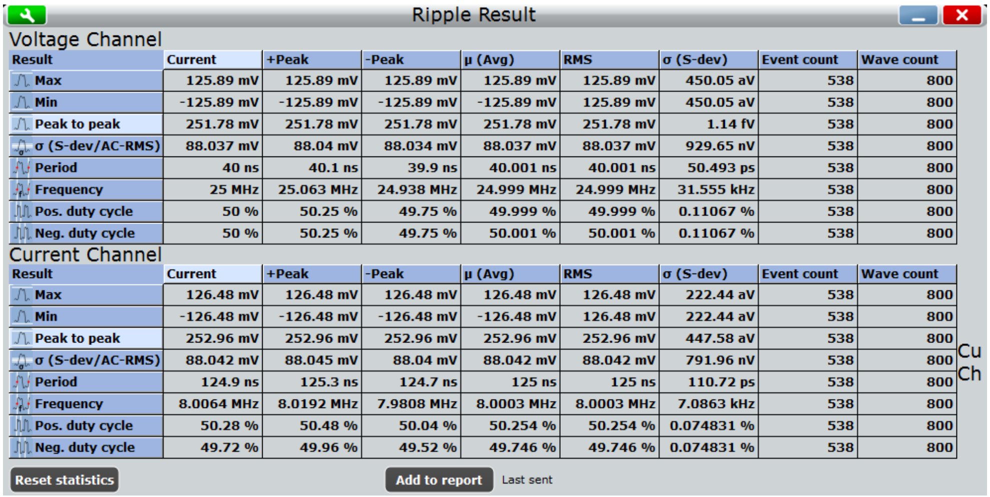
Required probes:

- Voltage probe
- (Optional) Current probe

14.13.1 Output Ripple Results

The results of "Output Ripple" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  – the voltage waveform
  – (optional) the current waveform
- The result box displays the numeric measurement results for the voltage and for the current ripple. For details, see Table 14-5 and Table 14-2.



Voltage Channel

Result	Current	+Peak	-Peak	µ (Avg)	RMS	σ (S-dev)	Event count	Wave count
Max	125.89 mV	125.89 mV	125.89 mV	125.89 mV	125.89 mV	450.05 aV	538	800
Min	-125.89 mV	-125.89 mV	-125.89 mV	-125.89 mV	125.89 mV	450.05 aV	538	800
Peak to peak	251.78 mV	251.78 mV	251.78 mV	251.78 mV	251.78 mV	1.14 fV	538	800
σ (S-dev/AC-RMS)	88.037 mV	88.04 mV	88.034 mV	88.037 mV	88.037 mV	929.65 nV	538	800
Period	40 ns	40.1 ns	39.9 ns	40.001 ns	40.001 ns	50.493 ps	538	800
Frequency	25 MHz	25.063 MHz	24.938 MHz	24.999 MHz	24.999 MHz	31.555 kHz	538	800
Pos. duty cycle	50 %	50.25 %	49.75 %	49.999 %	49.999 %	0.11067 %	538	800
Neg. duty cycle	50 %	50.25 %	49.75 %	50.001 %	50.001 %	0.11067 %	538	800

Current Channel

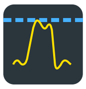
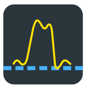
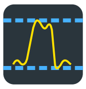
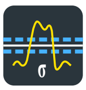
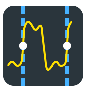
Result	Current	+Peak	-Peak	µ (Avg)	RMS	σ (S-dev)	Event count	Wave count
Max	126.48 mV	126.48 mV	126.48 mV	126.48 mV	126.48 mV	222.44 aV	538	800
Min	-126.48 mV	-126.48 mV	-126.48 mV	-126.48 mV	126.48 mV	222.44 aV	538	800
Peak to peak	252.96 mV	252.96 mV	252.96 mV	252.96 mV	252.96 mV	447.58 aV	538	800
σ (S-dev/AC-RMS)	88.042 mV	88.045 mV	88.04 mV	88.042 mV	88.042 mV	791.96 nV	538	800
Period	124.9 ns	125.3 ns	124.7 ns	125 ns	125 ns	110.72 ps	538	800
Frequency	8.0064 MHz	8.0192 MHz	7.9808 MHz	8.0003 MHz	8.0003 MHz	7.0863 kHz	538	800
Pos. duty cycle	50.28 %	50.48 %	50.04 %	50.254 %	50.254 %	0.074831 %	538	800
Neg. duty cycle	49.72 %	49.96 %	49.52 %	49.746 %	49.746 %	0.074831 %	538	800

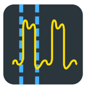
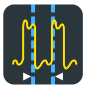
To measure and display the output ripple, the instrument uses the following measurements and waveforms:

- "P7" Meas 7 to measure the current
- "P8" Meas 8 to measure the voltage

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

Table 14-5: Properties output ripple

	Meas. type	Symbol	Description/Result
	Max	X_{Max}	Absolute maximum value of the waveform.
	Min	X_{Min}	Absolute minimum value of the waveform.
	Peak to peak	X_{PkPk}	Peak-to-peak value of the waveform: the difference of maximum and minimum values. $X_{Ampl} = X_{Max} - X_{Min}$
	σ (S-dev/AC-RMS)	σ_X	Standard deviation of the waveform samples
	Period	T_{Period}	Time of the left-most signal period of the waveform - the time difference between two consecutive waveform edges measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible.
	Frequency	f_{Period}	Frequency of the signal, reciprocal value of the period. $f_{Period} = 1 / T_{Period}$

	Meas. type	Symbol	Description/Result
	Pos. duty cycle	R_{PosCyc}	Positive duty cycle: Width of a positive pulse in relation to the period in %. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible. $R_{PosCyc} = \frac{T_{PosPulse}}{T_{Period}} \cdot 100\%$
	Neg. duty cycle	R_{NegCyc}	Negative duty cycle: Width of a negative pulse in relation to the period in %. The measurement requires at least one complete period of a triggered signal. Multiple measurement is possible. $R_{NegCyc} = \frac{T_{NegPulse}}{T_{Period}} \cdot 100\%$

"Ripple" is a statistical evaluation that will be reset only if the measurement setup is changed or you reset the statistics.

The following remote commands are used for handling the measurement results:

- `POWer:RIPPle:RESult:FREQuency:AVG?` on page 1585
- `POWer:RIPPle:RESult:FREQuency:EVTCount?` on page 1585
- `POWer:RIPPle:RESult:FREQuency:NPEak?` on page 1585
- `POWer:RIPPle:RESult:FREQuency:PPEak?` on page 1585
- `POWer:RIPPle:RESult:FREQuency:RMS?` on page 1585
- `POWer:RIPPle:RESult:FREQuency:STDDev?` on page 1585
- `POWer:RIPPle:RESult:FREQuency:WFMCount?` on page 1585
- `POWer:RIPPle:RESult:FREQuency[:ACTual]?` on page 1585
- `POWer:RIPPle:RESult:MAXimum:AVG?` on page 1585
- `POWer:RIPPle:RESult:MAXimum:EVTCount?` on page 1585
- `POWer:RIPPle:RESult:MAXimum:NPEak?` on page 1585
- `POWer:RIPPle:RESult:MAXimum:PPEak?` on page 1585
- `POWer:RIPPle:RESult:MAXimum:RMS?` on page 1585
- `POWer:RIPPle:RESult:MAXimum:STDDev?` on page 1585
- `POWer:RIPPle:RESult:MAXimum:WFMCount?` on page 1585
- `POWer:RIPPle:RESult:MAXimum[:ACTual]?` on page 1585
- `POWer:RIPPle:RESult:MINimum:AVG?` on page 1586
- `POWer:RIPPle:RESult:MINimum:EVTCount?` on page 1586
- `POWer:RIPPle:RESult:MINimum:NPEak?` on page 1586
- `POWer:RIPPle:RESult:MINimum:PPEak?` on page 1586
- `POWer:RIPPle:RESult:MINimum:RMS?` on page 1586
- `POWer:RIPPle:RESult:MINimum:STDDev?` on page 1586
- `POWer:RIPPle:RESult:MINimum:WFMCount?` on page 1586
- `POWer:RIPPle:RESult:MINimum[:ACTual]?` on page 1586
- `POWer:RIPPle:RESult:NDCYcle:AVG?` on page 1586

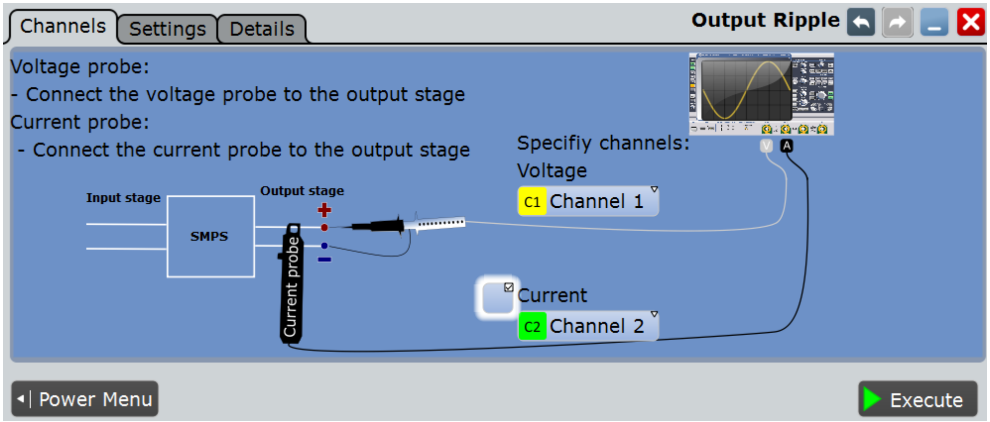
- POWer:RIPPle:RESult:NDCYcle:EVTCount? on page 1586
- POWer:RIPPle:RESult:NDCYcle:NPEak? on page 1586
- POWer:RIPPle:RESult:NDCYcle:PPEak? on page 1586
- POWer:RIPPle:RESult:NDCYcle:RMS? on page 1586
- POWer:RIPPle:RESult:NDCYcle:STDDev? on page 1586
- POWer:RIPPle:RESult:NDCYcle:WFMCount? on page 1586
- POWer:RIPPle:RESult:NDCYcle[:ACTual]? on page 1586
- POWer:RIPPle:RESult:PDCYcle:AVG? on page 1587
- POWer:RIPPle:RESult:PDCYcle:EVTCount? on page 1587
- POWer:RIPPle:RESult:PDCYcle:NPEak? on page 1587
- POWer:RIPPle:RESult:PDCYcle:PPEak? on page 1587
- POWer:RIPPle:RESult:PDCYcle:RMS? on page 1587
- POWer:RIPPle:RESult:PDCYcle:STDDev? on page 1587
- POWer:RIPPle:RESult:PDCYcle:WFMCount? on page 1587
- POWer:RIPPle:RESult:PDCYcle[:ACTual]? on page 1587
- POWer:RIPPle:RESult:PDEL:AVG? on page 1587
- POWer:RIPPle:RESult:PDEL:EVTCount? on page 1587
- POWer:RIPPle:RESult:PDEL:NPEak? on page 1587
- POWer:RIPPle:RESult:PDEL:PPEak? on page 1587
- POWer:RIPPle:RESult:PDEL:RMS? on page 1587
- POWer:RIPPle:RESult:PDEL:STDDev? on page 1587
- POWer:RIPPle:RESult:PDEL:WFMCount? on page 1587
- POWer:RIPPle:RESult:PDEL[:ACTual]? on page 1587
- POWer:RIPPle:RESult:PERiod:AVG? on page 1588
- POWer:RIPPle:RESult:PERiod:EVTCount? on page 1588
- POWer:RIPPle:RESult:PERiod:NPEak? on page 1588
- POWer:RIPPle:RESult:PERiod:PPEak? on page 1588
- POWer:RIPPle:RESult:PERiod:RMS? on page 1588
- POWer:RIPPle:RESult:PERiod:STDDev? on page 1588
- POWer:RIPPle:RESult:PERiod:WFMCount? on page 1588
- POWer:RIPPle:RESult:PERiod[:ACTual]? on page 1588
- POWer:RIPPle:RESult:STDDev:AVG? on page 1588
- POWer:RIPPle:RESult:STDDev:EVTCount? on page 1588
- POWer:RIPPle:RESult:STDDev:NPEak? on page 1588
- POWer:RIPPle:RESult:STDDev:PPEak? on page 1588
- POWer:RIPPle:RESult:STDDev:RMS? on page 1588
- POWer:RIPPle:RESult:STDDev:STDDev? on page 1588
- POWer:RIPPle:RESult:STDDev:WFMCount? on page 1588

- POWer:RIPPle:RESult:STDDev[:ACTual]? on page 1588
- POWer:RIPPle:REPort:ADD on page 1585

14.13.2 Configuring Output Ripple

For details of the configuration settings, see Chapter 14.13.3, "Output Ripple Settings", on page 835.

1. Select "Analysis" > "Power".
2. Under "Output", select "Ripple".
3. Connect the voltage probe to the oscilloscope.
4. If you want to measure the current ripple enable the current channel and connect the current probe to the oscilloscope.
5. If you want to measure both the voltage and the current ripple deskew the probes as described in Chapter 14.1.1.1, "Auto Deskew", on page 776.
6. Connect the probes to the DUT as shown in the "Channels" tab:



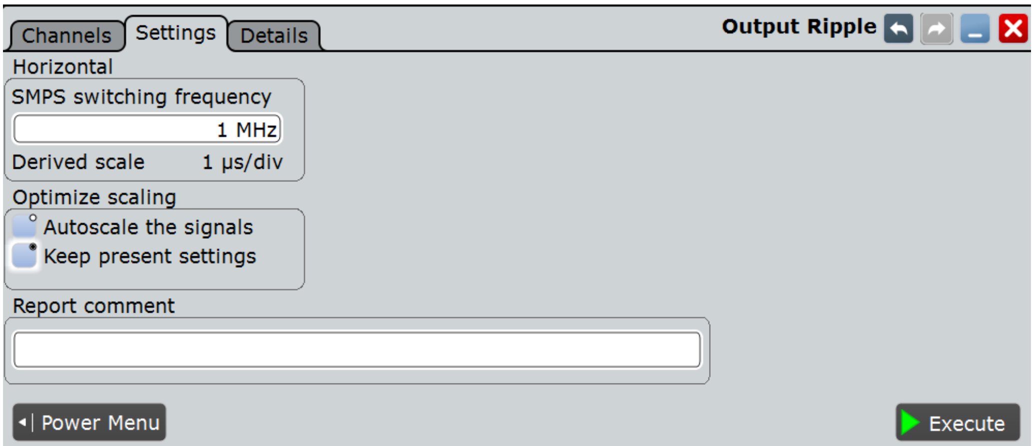
7. Select the correct channels for the "Voltage Source" and the "Current Source".
8. Select the "Settings" tab.
9. Set the "SMPS switching frequency" according to your signal.
10. Select an "Optimize Scaling" option.
11. Tap "Execute".

    On the screen you can see the measurement waveforms of the current and the voltage. Additionally, the result box with numeric measurement results is shown. For details, see Chapter 14.13.1, "Output Ripple Results", on page 830.

14.13.3 Output Ripple Settings

In the "Channels" tab, you set the current source and the voltage source, see also: Chapter 14.2.1, "Channels Tab", on page 786 and `POWer:RIPPle:CURRent` on page 1584)

In the "Settings" tab you configure the ripple parameters and display settings.



Horizontal
Configures the horizontal scale of the result diagram.

SMPS switching frequency ← Horizontal
Sets the SMPS switching frequency. Set the value according to your DUT.

Remote command:
`POWer:RIPPle:FREQuency` on page 1584

Derived scale ← Horizontal
Shows the scale of the the displayed results. This value is calculated as the inverse of the "SMPS switching frequency"

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:RIPPle:AUToscale` on page 1584

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Output Ripple" measurement.

Remote command:
`POWer:RIPPle:EXECute` on page 1584

14.14 Transient Response

The "Transient Response" analysis measures the response of a system to a change from equilibrium. This response is described by different properties like the rise time, the overshoot, the settling time, the peak time and the delay time.

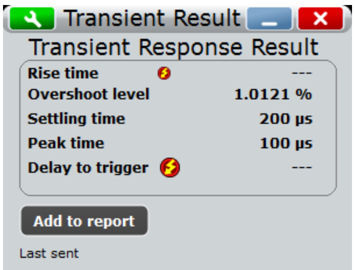
Required probes:

- One or two voltage probes
- Current probe

14.14.1 Transient Response Results

The results of "Power Quality" measurements are provided in two ways:

- The diagram shows the graphical presentation of:
  – the voltage waveform(s)
  – the current waveform
- The result box displays the numeric measurement results.



To measure and display the transient response, the instrument uses the following measurements and waveforms:

- "P8" Meas 8 to measure the rise time, the overshoot and delay to trigger
- "C1" Cursor 3 to measure the peak time
- "C2" Cursor 2 to measure the delay to trigger

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

The results describing the transient response of the system are shown in Figure 14-5 and described in Table 14-6.

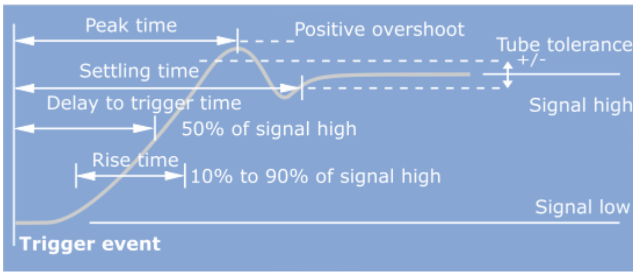


Figure 14-5: Graphical presentation of the transient response properties

Table 14-6: Transient response

Result	Description
Rise time	The time needed for the signal to change from 10% to 90% of the specified signal high.
Overshoot level	The maximum swing level above the signal high.
Settling time	The time elapsed from the trigger event to the time the output enters and remains within the tube tolerance band.
Peak time	The time needed for the response to reach the first peak of the overshoot.
Delay to trigger	The time needed for the response to reach half of the signal high value, after the trigger event.

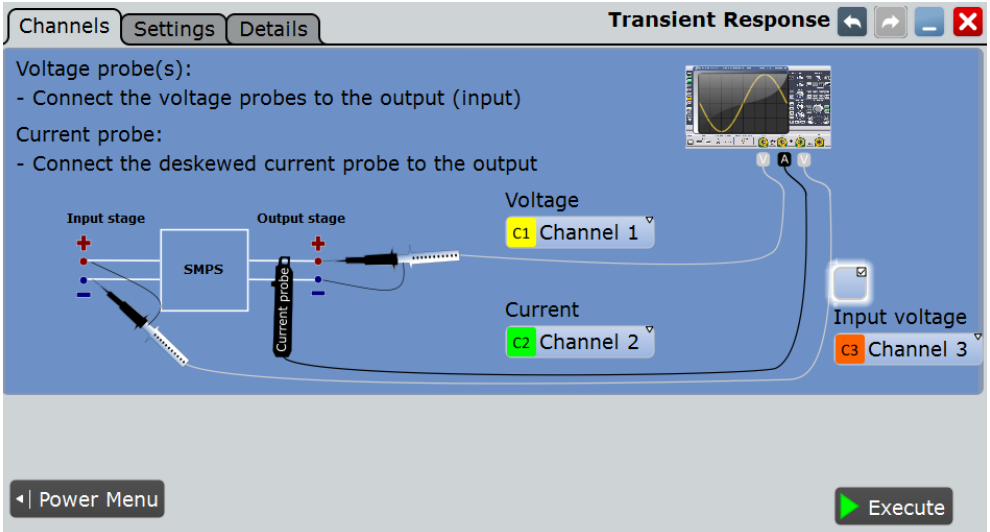
The following remote commands are used for handling the measurement results:

- `POWer:TRANsient:RESult[:ACTual]?` on page 1590
- `POWer:TRANsient:REPort:ADD` on page 1590

14.14.2 Configuring Transient Response

For details of the configuration settings, see Chapter 14.14.3, "Transient Response Settings", on page 838.

1. Select "Analysis" > "Power".
2. Under "Output", select "Transient Response".
3. Connect the voltage probe(s) and the current probe to the oscilloscope.
4. Deskew the probes as described in Chapter 14.1.1.1, "Auto Deskew", on page 776.
5. Connect the probes to the DUT as shown in the "Channels" tab:



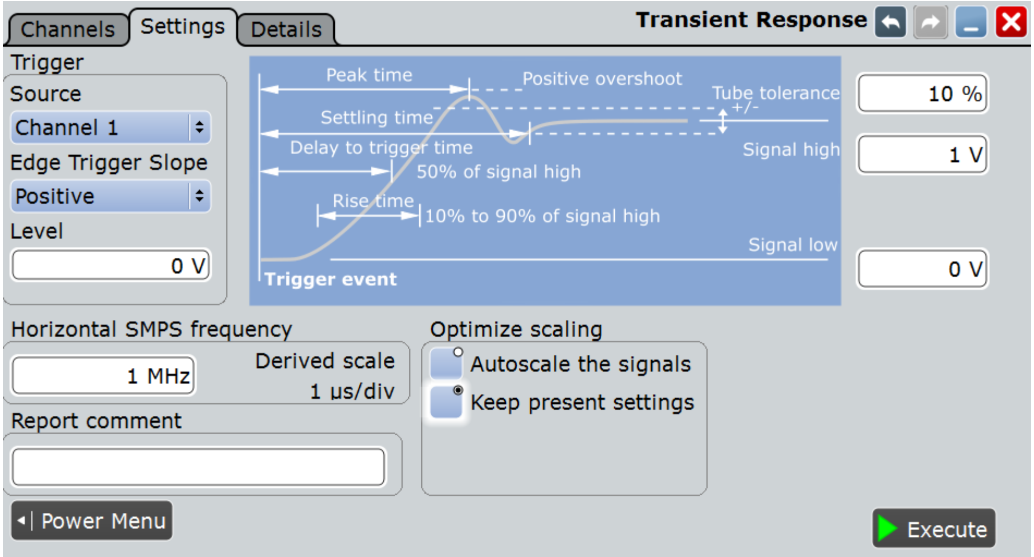
6. Select the correct channels for the "Current Source" and the "Voltage Source".
7. Select the "Settings" tab.
8. Set the "Trigger" settings according to your signal.
9. Set the "Tube tolerance", "Signal high" and "Signal low" according to your requirements.
10. Set the "SMPS switching frequency" according to your device.
11. Select an "Optimize Scaling" option.
12. Tap "Execute".
13. If needed adjust the cursors manually. You can tap on a cursor and change its position with the NAVIGATION rotary knob.

    On the screen you can see the measurement of the current and the voltage . Additionally there is a table giving information about important measurement parameters. For details, see Chapter 14.14.1, "Transient Response Results", on page 836.

14.14.3 Transient Response Settings

In the "Channels" tab, you set the current source and the voltage sources, see also: Chapter 14.2.1, "Channels Tab", on page 786 and `POWer:TRANsient:INPut` on page 1590.

In the "Settings" tab you configure the transient response measurement parameters and display settings.



Trigger
Sets the properties of the trigger.

Source ← Trigger
Sets the source channel of the trigger.

Remote command:
`POWer:TRANsient:TRGChannel` on page 1591

Edge Trigger Slope ← Trigger
Sets the edge type for the trigger event.

"Positive" Selects the rising edge, that is a positive voltage change.

"Negative" Selects the falling edge, that is a negative voltage change.

"Both" Selects the rising as well as the falling edge.

Remote command:
`POWer:TRANsient:TRGSlope` on page 1591

Level ← Trigger
Sets the voltage or current level for the trigger event.

Remote command:
`POWer:TRANsient:TRGLevel` on page 1591

Tube tolerance
Specifies a tolerated error band for the signal level.

Remote command:
`POWer:TRANsient:HYSTeresis` on page 1590

Signal high
Sets the expected signal high voltage value.

Remote command:
`POWer:TRANsient:SIGHigh` on page 1590

Signal low
Sets the expected signal low voltage value.

Remote command:
`POWer:TRANsient:SIGLow` on page 1591

Horizontal
Configures the horizontal scale of the result diagram.

SMPS switching frequency ← Horizontal
Sets the SMPS switching frequency. Set the value according to your DUT.

Remote command:
`POWer:TRANsient:FREQuency` on page 1589

Derived scale ← Horizontal
Shows the scale of the the displayed results. This value is calculated as the inverse of the "SMPS switching frequency"

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:TRANsient:AUToscale` on page 1589

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Transient Response" measurement.

Remote command:
`POWer:TRANsient:EXECute` on page 1589

14.15 Output Spectrum

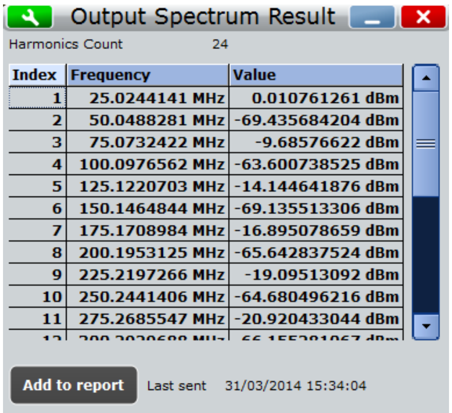
"Output Spectrum" analysis measures the spectrum of the output voltage. The results can be applied to see typical side effect problems of the SMPS application, such as switching frequency components of internal SMPS.

Required probes:
- Voltage probe

14.15.1 Output Spectrum Results

After executing the "Output Spectrum" measurement the following windows are displayed:

The results of "Power Quality" measurements are provided in two ways:
- Two diagrams that shows the graphical presentation of:
  – the voltage waveform
  – the spectrum
- The result box displays the positions of the measured peaks. The peaks are found by an automatic peak search.
  Note: If no results are found, check and correct the FFT settings.



To measure and display the output spectrum, the instrument uses the following measurements and waveforms:
- "M4" Math 4 to calculate the magnitude of the FFT for the voltage source values

The used resources are listed in the "Details" tab. See also: Chapter 14.2.3, "Details Tab", on page 788.

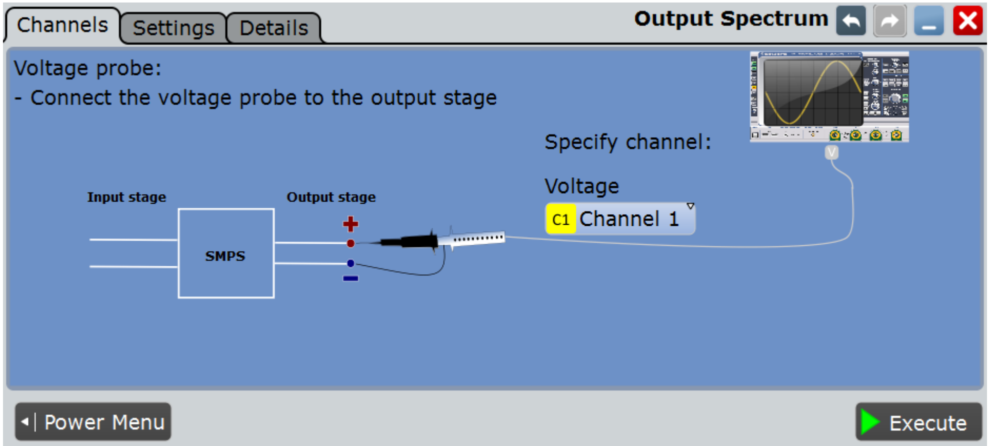
The measured peaks have different origin. Analyzing the frequencies gives information about the influences on the output signal.

The following remote commands are used for handling the measurement results:
- `POWer:SPECtrum:RCOunt?` on page 1592
- `POWer:SPECtrum:RESult<m>:FREQuency?` on page 1592
- `POWer:SPECtrum:RESult<m>:LEVel?` on page 1593
- `POWer:SPECtrum:REPort:ADD` on page 1592

14.15.2 Configuring Output Spectrum

For details of the configuration settings, see Chapter 14.15.3, "Output Spectrum Settings", on page 842.

1. Select "Analysis">"Power".
2. Under "Output", select "Spectrum".
3. Select the "Channels" tab.
4. Connect the probe to the DUT and to the oscilloscope as shown in the graphic:



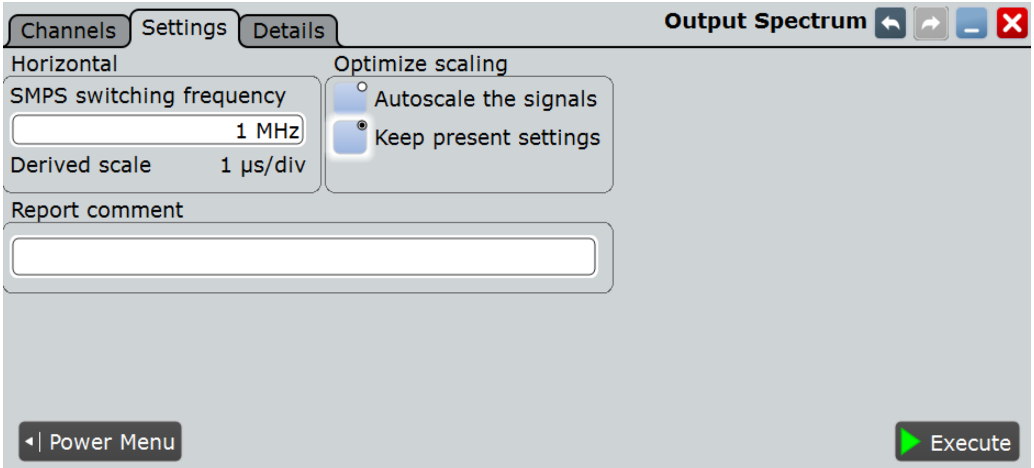
5. Select the correct channel for the "Voltage Source".
6. Select the "Settings" tab.
7. Set the "SMPS switching frequency" according to your signal.
8. Select an "Optimize Scaling"option.
9. Tap "Execute".
10. Set the positions of the cursors according to the measured spectrum. You can tap on a cursor and change its position with the NAVIGATION rotary knob.

    On the screen you can see the measurement of the spectrum. Additionally, the result box shows the position of the peaks. For details, see Chapter 14.15.1, "Output Spectrum Results", on page 841.

14.15.3 Output Spectrum Settings

In the "Channels" tab, you set the voltage source, see also: Chapter 14.2.1, "Channels Tab", on page 786.

In the "Settings" tab you configure the spectrum measurement parameters and display settings.



Horizontal
Configures the horizontal scale of the result diagram.

SMPS switching frequency ← Horizontal
Sets the SMPS switching frequency. Set the value according to your DUT.

Remote command:
`POWer:SPECtrum:FREQuency` on page 1592

Derived scale ← Horizontal
Shows the scale of the the displayed results. This value is calculated as the inverse of the "SMPS switching frequency"

Optimize scaling
Selects the scaling for the display of the results.

"Autoscale the signals"
Automatically selects the most appropriate scale for the display of the results.

"Keep present settings"
The present display settings are not changed.

Remote command:
`POWer:SPECtrum:AUToscale` on page 1592

Report comment
In this field you can write a comment that will be displayed in the measurement report, for example, a measurement description.

Execute
Starts the "Output Spectrum" measurement.

Remote command:
`POWer:SPECtrum:EXECute` on page 1592

15 Network and Remote Operation

This chapter describes the usage of the embedded operating system on the instrument, the setup of network connections, and the interfaces and protocols used for remote control. It also explains how to start a remote control session.

Firmware update

Your instrument is delivered with the latest firmware version.

Firmware updates and the "Release Notes" describing the improvements and modifications are provided on the Internet at www.rohde-schwarz.com/ product/rte.html > "Downloads" > "Firmware".

How to update the firmware is described in the "Release Notes" of the R&S RTE.

Software options

See Chapter 3.6.3, "Activating Options", on page 137

15.1 Operating System

The R&S RTE has a Windows Embedded Standard 7 64 bit operating system.

The operating system has been configured according to the instrument's features and needs. To ensure that the instrument software functions properly, certain rules must be adhered to when using the operating system.

NOTICE

Risk of causing instrument unusability

The instrument is equipped with a Windows operating system. Additional software can therefore be installed on the instrument. The use and installation of additional software may impair instrument function. Thus, run only programs that Rohde & Schwarz has tested for compatibility with the instrument software.

The drivers and programs used on the instrument under Windows have been adapted to the instrument. Existing instrument software must always be modified using only update software released by Rohde & Schwarz.

Changes in the system setup are only required if the network configuration does not comply with the default settings (see Chapter 15.2.1.1, "Connecting the Instrument to the Network", on page 847).

15.1.1 Virus Protection

Take appropriate steps to protect your instruments from infection. Use strong firewall settings and scan any removable storage device used with a Rohde & Schwarz instrument regularly. It is also recommended that you install anti-virus software on the instrument. Rohde & Schwarz does NOT recommend running anti-virus software in the background ("on- access" mode) on Windows-based instruments, due to potentially degrading instrument performance. However, it does recommend running it during non-critical hours.

For details and recommendations, see the Rohde & Schwarz White Paper 1DC01: Malware Protection.

15.1.2 Service Packs and Updates

Microsoft regularly creates security updates and other patches to protect Windows-based operating systems. These are released through the Microsoft Update website and associated update server. Instruments using Windows, especially those that connect to a network, should be updated regularly.

For details and recommendations, see the Rohde & Schwarz White Paper 1DC01: Malware Protection.

15.1.3 Logon

Windows requires that users identify themselves by entering a user name and password in a logon window. You can set up two types of user accounts, either an administrator account with unrestricted access to the computer/domain or a standard user account with limited access.

If the instrument is connected to the network, you are automatically logged on to the network at the same time you log on to the operating system. As a prerequisite, the user name and the password must be identical under Windows and on the network. The instrument provides an auto-logon function that can be configured for user and administrator access. The configuration requires the user name and password. All users except for the administrator are treated as standard user with limited access. See also: "Log on as" on page 109

By default, the user name for the administrator account is "instrument", and the user name for the standard user account is "NormalUser". In both cases the initial password is "894129". You can change the password for the standard user in the Windows configuration :"Start" menu > "Settings > Control Panel > User Accounts". Some administrative tasks require administrator rights, e.g. the configuration of a LAN network.

To configure the auto-logon for admistrator

Starting situation: the auto-logon is configured for a standard user.

1. Press the SETUP key and select the "System" tab.
2. Set "Logon as" to "None".

3. Restart the instrument an log on as administrator.
4. Set the "Logon as" to "Admin autologon" and enter the admistrator's password.

15.1.4 Accessing Windows functionality

All required Windows settings can be changed using the touchscreen and the on-screen keyboard that is part of the Windows system. However, modification is easier if you connect a mouse and/or keyboard to the instrument.

To access Windows

► On the "File" menu, select "Minimize application".

The application is minimized to the task bar and the "Start" menu becomes available.

To access Windows using an external keyboard

1. To open the "Start" menu, press the Windows key or the CTRL + ESC key combination on your keyboard.
2. To access the desktop, press the Windows key + D on your keyboard.

To access Windows settings directly from the firmware

Important Windows settings can be accessed directly from the R&S RTE interface.

1. Press the SETUP key and tap the "System" tab.
2. Select one of the settings buttons to access the corresponding Windows dialog box.

   Once you have opened a Windows dialog box, the task bar and the "Start" menu are also available.

15.2 Operation in a Network

A LAN connection is the prerequisite for all network operations. The LAN connection settings can be configured directly in the Windows operating system, or with LXI (LAN eXtension for Instruments).

Remote operation

The remote desktop connection of Windows Embedded Standard 7 can be used for instrument control and file transfer. Even on computers with non-Windows operating systems, a remote desktop connection is possible using RDP applications.

15.2.1 Setting Up a Network (LAN) Connection

The R&S RTE is equipped with a network interface and can be connected to an Ethernet LAN (local area network). Provided the network administrator has assigned you the appropriate rights and adapted the Windows firewall configuration, you can use the interface, for example:

- To transfer data between a controlling device and the test device, e.g. to run a remote control program.
  See chapter "Remote Control"
- To access or control the measurement from a remote computer using the "Remote Desktop" application (or a similar tool)
- To connect external network devices (e.g. printers)
- To transfer data from a remote computer and back, e.g. using network folders

This section describes how to configure the LAN interface. It includes the following topics:

- Chapter 15.2.1.1, "Connecting the Instrument to the Network", on page 847
- Chapter 15.2.1.2, "Assigning the IP Address", on page 848

LXI

The R&S RTE complies with LXI Class C. LXI gives you direct access to the LAN settings described below.

15.2.1.1 Connecting the Instrument to the Network

There are two methods to establish a LAN connection to the instrument:

- A non-dedicated network (Ethernet) connection from the instrument to an existing network made with an ordinary RJ-45 network cable. The instrument is assigned an IP address and can coexist with a computer and with other hosts on the same network.
- A dedicated network connection (Point-to-point connection) between the instrument and a single computer made with a (crossover) RJ-45 network cable. The computer must be equipped with a network adapter and is directly connected to the instrument. The use of hubs, switches, or gateways is not required, however, data transfer is still performed using the TCP/IP protocol. An IP address has to be assigned to the instrument and the computer, see Chapter 15.2.1.2, "Assigning the IP Address", on page 848.

NOTICE

Risk of network failure

Before connecting the instrument to the network or configuring the network, consult your network administrator. Errors may affect the entire network.

► To establish a non-dedicated network connection, connect a commercial RJ-45 cable to one of the LAN ports.
To establish a dedicated connection, connect a (crossover) RJ-45 cable between the instrument and a single PC.

If the instrument is connected to the LAN, Windows automatically detects the network connection and activates the required drivers.

The network card can be operated with a 10/100/1000 Mbps Ethernet IEEE 802.3u interface.

15.2.1.2 Assigning the IP Address

Depending on the network capacities, the TCP/IP address information for the instrument can be obtained in different ways.

- If the network supports dynamic TCP/IP configuration using the Dynamic Host Configuration Protocol (DHCP), all address information can be assigned automatically.
- If the network does not support DHCP, or if the instrument is set to use alternate TCP/IP configuration, the addresses must be set manually.

By default, the instrument is configured to use dynamic TCP/IP configuration and obtain all address information automatically. This means that it is safe to establish a physical connection to the LAN without any previous instrument configuration.

NOTICE

Risk of network errors

Connection errors can affect the entire network. If your network does not support DHCP, or if you choose to disable dynamic TCP/IP configuration, you must assign valid address information before connecting the instrument to the LAN. Contact your network administrator to obtain a valid IP address.

Assigning the IP address on the instrument

1. Press the SETUP key and select the "System" tab.
2. Tap "Network".
3. Touch and hold (or right-click) "Local Area Connection" and select "Properties".
4. On the "Networking" tab, select "Internet Protocol Version 4 (TCP/IPv4)" and then select "Properties".
5. Select "Use the following IP address" and enter the address information as obtained from the network administrator.
6. If necessary, select "Use the following DNS server addresses" and enter your own DNS addresses.

15.2.1.3 Using Computer Names

In a LAN that uses a DNS server (Domain Name System server), each PC or instrument connected in the LAN can be accessed via an unambiguous computer name instead of the IP address. The DNS server translates the host name to the IP address. This is especially useful when a DHCP server is used, as a new IP address may be assigned each time the instrument is restarted.

Each instrument is delivered with an assigned computer name, but this name can be changed.

The default instrument name is a non-case-sensitive string with the following syntax:

<Type><variant>-<serial_number>

The serial number can be found on the rear panel of the instrument. It is the third part of the device ID printed on the bar code sticker:

To change the computer name

1. Press the SETUP key and select the "System" tab or "LXI" tab.
   The current computer name is displayed and can be edited.
2. Alternatively, tap "System" on the "System" tab.
3. Select "Change", enter the new computer name and confirm the entry.

15.2.1.4 Changing the Windows Firewall Settings

A firewall protects an instrument by preventing unauthorized users from gaining access to it through a network. Rohde & Schwarz highly recommends the use of the firewall on your instrument. Rohde & Schwarz instruments are shipped with the Windows firewall enabled and preconfigured in such a way that all ports and connections for remote control are enabled.

For more details on firewall configuration, see the Rohde & Schwarz White Paper 1DC01: Malware Protection.

Note that changing firewall settings requires administrator rights.

15.2.2 Remote Desktop Connection

Remote Desktop is a Windows application which can be used to access and control the instrument from a remote computer through a LAN connection. While the instrument is in operation, the instrument screen contents are displayed on the remote computer, and Remote Desktop provides access to all of the applications, files, and network resources of the instrument. Thus, remote operation of the instrument is possible.

NOTICE

Risk of Unauthorized Access

If the Windows Remote Desktop application is enabled on the instrument (go to "Start > Settings > Control Panel > System"), any user in the network who knows the computer name and login data can access it. To prevent this, make sure that the Remote Desktop application on the instrument is disabled.

To set up a Remote Desktop connection

1. Enable remote desktop control on the instrument.
2. Connect the instrument and the remote computer to a LAN, see Chapter 15.2.1.1, "Connecting the Instrument to the Network", on page 847.
3. Set up the Remote Desktop connection between the remote computer and the instrument.

Remote Desktop Client

With Windows 7, Remote Desktop Client is part of the operating system and can be accessed via "Start > Programs > Accessories > [Communications >] Remote Desktop Connection.".

For other versions of Windows, Microsoft offers the Remote Desktop Client as an add-on.

Enabling remote desktop control on the instrument

1. Press the SETUP key and select the "System" tab.
2. Select "System" and switch to the "Remote" tab.
3. Under "Remote Desktop", activate the "Allow users to connect remotely to this computer" option.

   Note: Remote Desktop access and firewall settings.
   When you enable or disable the Windows Remote Desktop option (in the "System Properties"), the associated firewall settings are adapted automatically.
4. If necessary, click "Select Remote Users" and select users who are to be given access to the R&S RTE via Remote Desktop. The user account under which configuration is carried out is automatically enabled for Remote Desktop.

Setting up the Remote Desktop connection on the remote computer

1. On the remote computer, select "Start > Programs > Accessories > [Communications >] Remote Desktop Connection."

2. Enter the instrument's name or IP address in the dialog box (see also Chapter 15.2.1.2, "Assigning the IP Address", on page 848).
3. Enter the user ID and password for the instrument, see Chapter 15.1, "Operating System", on page 844.
4. Click "Connect".

   When the connection has been set up, the instrument's screen appears on the remote computer.

For detailed information about Remote Desktop and the connection refer to the Windows Help.

Helpful settings for Remote Desktop

The following settings for the Remote Desktop connection can make working on the remote PC more convenient.

1. When setting up the connection to the instrument, you can configure the connection settings in the "Remote Desktop Connection" dialog box.
   Click the "Options >>" button.

   The dialog box is expanded to display the configuration data.
2. Customize the settings:
   - **On the "Experience" tab:**
     – Select the appropriate connection to optimize the connection speed.
     – To improve the performance, you can deactivate options you do not require under "Allow the following".
   - **On the "Local Resources" tab:**
     – If you need to access drives of the remote PC from the instrument (e.g. in order to store settings or to copy files from the PC to the instrument), activate the "Disk drives" option. Windows 7 will then map drives of the remote PC to the corresponding network drives. When a connection is established, a warning is displayed on the PC indicating that the drives are enabled for access from the instrument.
     – To use printers connected to the remote PC while accessing them from the instrument, activate the "Printers" options. Do not change the remaining settings.
   - **On the "Display" tab:**
     – Under "Remote desktop size", set the size of the R&S RTE window on the desktop of the remote PC.
     – Activate the "Display the connection bar when in full screen mode" option. A bar showing the network address of the instrument is displayed on the screen which you can use to reduce, minimize or close the window.
   - **On the "General" tab:**
     You can save the connection settings for later use using the "Save As" button.

Terminating Remote Desktop Control

A Remote Desktop connection can be terminated either on the R&S RTE or on the remote PC. The connection can be established again any time as long as remote control is enabled on the instrument. Consider the notice above concerning unauthorized access due to Remote Desktop!

► To terminate the connection on the remote PC, close the "Remote Desktop" window, or select "Start > Disconnect".

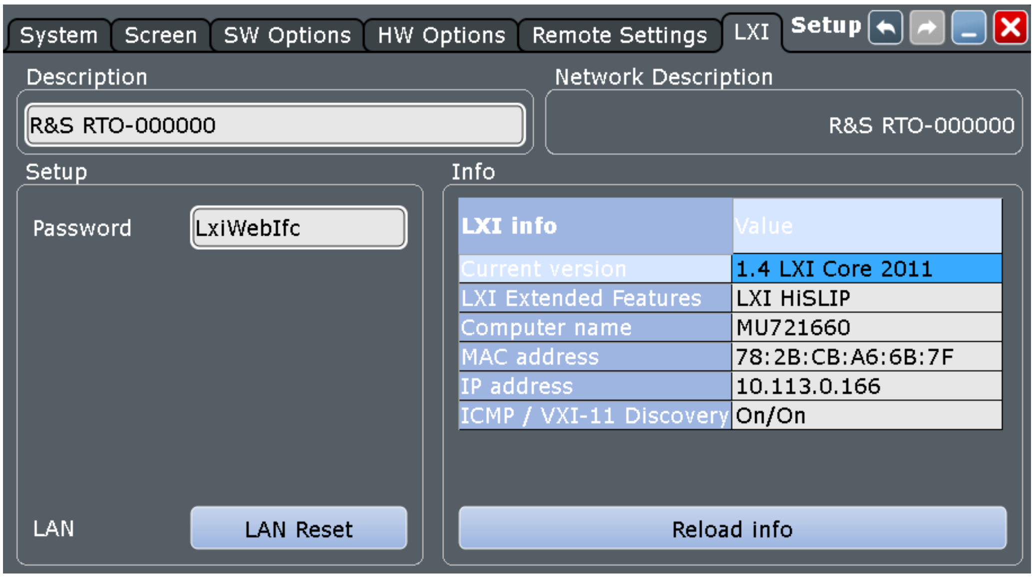
15.2.3 LXI Configuration

LAN eXtensions for Instrumentation (LXI) is an instrumentation platform for measuring instruments and test systems that is based on standard Ethernet technology. LXI is intended to be the LAN-based successor to GPIB, combining the advantages of Ethernet with the simplicity and familiarity of GPIB.

The R&S RTE supports the LXI core features. For information about the LXI standard refer to the LXI website at http://www.lxistandard.org.

15.2.3.1 LXI Settings

The "LXI" tab of the "Setup" dialog box provides core LXI functions and information. LXI allows you to connect your R&S RTE to other devices in a network.



Default state of the network settings

"Reset" initiates the network configuration reset mechanism (LCI) for the instrument.

According to the LXI standard, an LCI must set the following parameters to a default state.

Parameter	Value
TCP/IP Mode	DHCP + Auto IP Address
Dynamic DNS	Enabled
ICMP Ping	Enabled
Password for LAN configuration	LxiWebIfc

The LAN settings are configured using the instrument's LXI Browser Interface, see Chapter 15.2.3.2, "LXI Browser Interface", on page 853.

Description
Instrument description of the R&S RTE.

Password
Password for LAN configuration. The default password is *LxiWebIfc*.

LAN Reset
Resets the LAN configuration to its default settings.

LXI Info
Displays the current LXI information from the R&S RTE.

"Current version"
Current LXI version

"LXI Extended Features" List of extended LXI features that the instrument supports

"Computer name"
Name of the R&S RTE as defined in the operating system

"MAC address" Media Access Control address (MAC address), a unique identifier for the network card in the R&S RTE

"IP address" IP address of the R&S RTE as defined in the operating system.

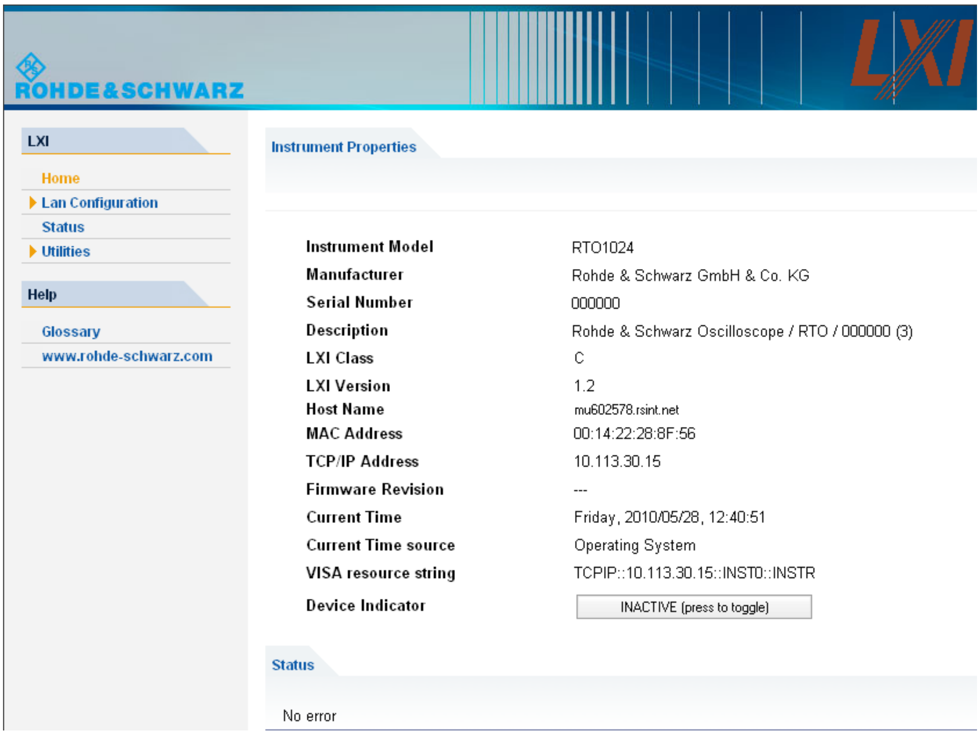
Reload Info
Reloads LXI configuration

15.2.3.2 LXI Browser Interface

The instrument's LXI browser interface works correctly with all W3C compliant browsers.

► Type the instrument's host name or IP address in the address field of the browser on your PC, e.g. "http://10.113.10.203".

The "Instrument Home Page" (welcome page) opens.



The instrument home page displays the device information required by the LXI standard including the VISA resource string in read-only format.

► Press the "Device Indicator" button to activate or deactivate the LXI status icon on the toolbar of the R&S RTE. A green LXI status symbol indicates that a LAN connection has been established; a red symbol indicates an error, for exmaple, that no LAN cable is connected. While a device is connecting to the instrument, the LXI logo is blinking, and the "Host Name" is updated on the LXI home page. The "Device Indicator" setting is not password-protected.

The most important control elements in the navigation pane of the browser interface are the following :

- "LAN Configuration" opens the menu with configuration pages.
- "Status" displays information about the LXI status of the instrument.
- "Help > Glossary" opens a document with a glossary of terms related to the LXI standard.

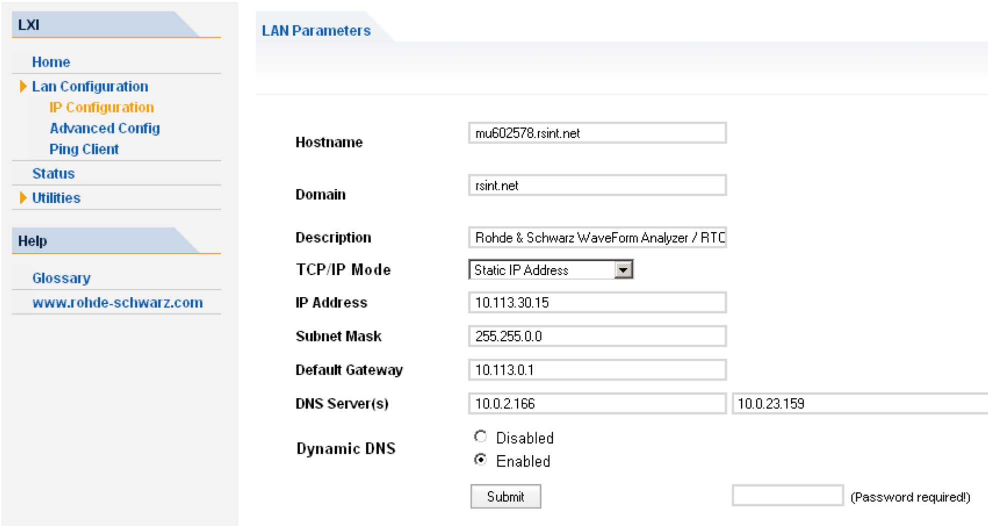
15.2.3.3 LAN Configuration

The LAN configuration consists of three parts:

- "IP configuration" provides all mandatory LAN parameters.
- "Advanced LAN Configuration" provides LAN settings that are not declared mandatory by the LXI standard.
- "Ping Client" provides the ping utility to verify the connection between the instrument and other devices.

IP Configuration

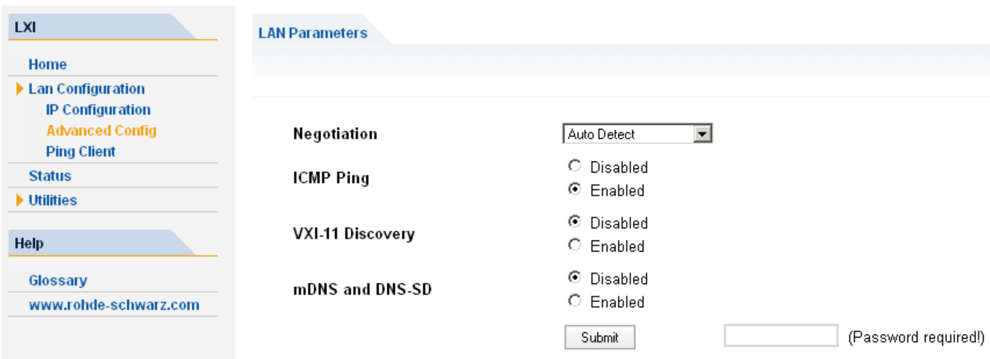
The "LAN Configuration > IP configuration" web page displays all mandatory LAN parameters and allows their modification.



The "TCP/IP Mode" configuration field controls how the IP address for the instrument gets assigned (see also Chapter 15.2.1.2, "Assigning the IP Address", on page 848). For the manual configuration mode, the static IP address, subnet mask, and default gateway are used to configure the LAN. The automatic configuration mode uses DHCP server or Dynamic Link Local Addressing (Automatic IP) to obtain the instrument IP address.

Changing the LAN configuration is password-protected. The password is *LxiWebIfc* (notice upper and lower case characters). This password cannot be changed in the current firmware version.

Advanced LAN Configuration



The "LAN Configuration > Advanced LAN Configuration" parameters are used as follows:

- The "Negotiation" configuration field provides different Ethernet speed and duplex mode settings. In general, the "Auto Detect" mode is sufficient.

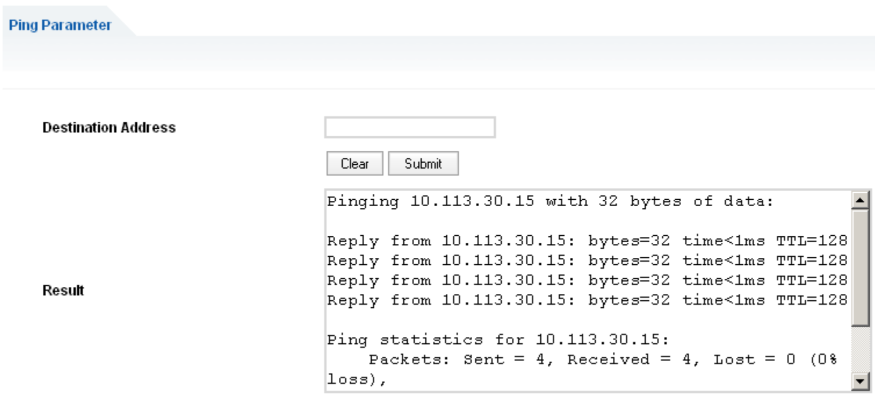
- "ICMP Ping" must be enabled to use the ping utility.
- "VXI-11" is the protocol that is used to detect the instrument in the LAN. According to the standard, LXI devices must use VXI-11 to provide a detection mechanism; other additional detection mechanisms are permitted.
- mDNS and DNS-SD are two additional protocols: Multicast DNS and DNS Service Discovery. They are used for device communication in zero configuration networks working without DNS and DHCP

Ping Client

Ping is a utility that verifies the connection between the LXI-compliant instrument and another device. The ping command uses the `ICMP` echo request and echo reply packets to determine whether the LAN connection is functional. Ping is useful for diagnosing IP network or router failures. The ping utility is not password-protected.

To initiate a ping between the LXI-compliant instrument and a second connected device:

1. Enable "ICMP Ping" on the "Advanced LAN Configuration" page (enabled after an LCI).
2. On the "Ping Client" page, enter the IP address of the second device **without the ping command and without any further parameters** into the "Destination Address" field (e.g. *10.113.10.203*).
3. Click "Submit".



15.3 Remote Control Interfaces and Protocols

The instrument supports different interfaces for remote control. The following table gives an overview.

Table 15-1: Remote control interfaces and protocols

Interface	Protocols, VISA address string	Remarks

Local Area Network (LAN)	**Protocol HiSLIP**
	VISA address string:
	`TCPIP::<host address>::hislip0[,<port>][::INSTR]`
	Protocol VXI-11
	VISA address string:
	`TCPIP::<host address>[::inst0]::[INSTR]`
		The LAN connector is located on rear panel of the instrument.
		The interface is based on TCP/IP and supports various protocols.
		See also:
		• Chapter 15.3.2.2, "VXI-11 Protocol", on page 859
		• Chapter 15.3.2.3, "HiSLIP Protocol", on page 859
		• Chapter 15.3.1, "VISA Libraries", on page 857

GPIB (IEC/ IEEE Bus Interface)	VISA address string: GPIB::primary address[::INSTR] (no secondary address)	The optional GPIB bus interface according to standard IEC 625.1/IEEE 488.1 is located on the rear panel of the instrument. See also: Chapter 15.3.3, "GPIB Interface (IEC/ IEEE Bus Interface)", on page 859.

Within this interface description, the term GPIB is used as a synonym for the IEC/IEEE bus interface.

SCPI (Standard Commands for Programmable Instruments)

SCPI commands - messages - are used for remote control. Commands that are not taken from the SCPI standard follow the SCPI syntax rules. The instrument supports the SCPI version 1999. The SCPI standard is based on standard IEEE 488.2 and aims at the standardization of device-specific commands, error handling and the status registers. The tutorial "Automatic Measurement Control - A tutorial on SCPI and IEEE 488.2" from John M. Pieper (R&S order number 0002.3536.00) offers detailed information on concepts and definitions of SCPI.

15.3.1 VISA Libraries

VISA is a standardized software interface library providing input and output functions to communicate with instruments. Instrument access via VXI11 protocol is usually achieved from high level programming platforms using VISA as an intermediate abstraction layer. VISA encapsulates the low level VXI or even GPIB function calls and thus makes the transport interface transparent for the user.

The I/O channel (LAN or TCP/IP, USB, GPIB,...) is selected at initialization time by means of the channel–specific address string ("VISA resource string") indicated in Table 15-1, or by an appropriately defined VISA alias (short name). A VISA installation is a prerequisite for remote control of R&S RTE.

For more information about VISA refer to the VISA user documentation.

15.3.2 LAN Interface

To be integrated in a LAN, the instrument is equipped with a LAN interface, consisting of a connector, a network interface card and protocols. For remote control via a network, the PC and the instrument must be connected via the LAN interface to a common network with TCP/IP network protocol. They are connected using a commercial RJ45 cable.The TCP/IP network protocol and the associated network services are preconfigured on the instrument. Software for instrument control and the VISA program library for specified protocols must be installed on the controller.

15.3.2.1 IP address

Only the address of the instrument is required to set up the connection. It is part of the "VISA resource string" used by programs to identify and control the instrument. The VISA resource string has the form:

`TCPIP::<host address>::hislip0[,<port>][::INSTR]` for HiSLIP protocol

`TCPIP::<host address>[::inst0][::INSTR]` for VXI-11 protocol

where:

- `host address` identifies the instrument in the network, usually the IP address. If the LAN is supported by a DNS server, the host name can be used instead of the IP address. The DNS server (Domain Name System server) translates the host name to the IP address.
- `hislip0` indicates the HiSLIP protocol
- `inst0` is the default LAN device name. VISA supports several devices running on the instrument. On R&S RTE, only one device is configured, so the LAN device name can be omitted.
- `INSTR` specifies a VISA resource of the type INSTR. By default, the VISA resource name control is set to the INSTR class.

Example: HiSLIP

IP address is *192.1.2.3*: the valid resource string is: `TCPIP::192.1.2.3::hislip0`

Instrument name is *RSRT1*: the valid resource string is: `TCPIP::RSRT1::hislip0`.

DNS host name name is *RTE-123456*: the valid resource string is: `TCPIP::RTE-123456::hislip0`.

Example: VXI-11

IP address is *192.1.2.3*: the valid resource string is: `TCPIP::192.1.2.3`

Instrument name is *RSRT1*: the valid resource string is: `TCPIP::RSRT1`.

DNS host name name is *RTE-123456*: the valid resource string is: `TCPIP::RTE-123456`.

See also:

- Find IP address: SETUP > "System" tab, see "System" on page 108
- Chapter 15.2.1.2, "Assigning the IP Address", on page 848

15.3.2.2 VXI-11 Protocol

The VXI-11 standard is based on the ONC RPC (Open Network Computing Remote Procedure Call) protocol which in turn relies on TCP/IP as the network/transport layer. The TCP/IP network protocol and the associated network services are preconfigured. TCP/IP ensures connection-oriented communication, where the order of the exchanged messages is adhered to and interrupted links are identified. With this protocol, messages cannot be lost.

15.3.2.3 HiSLIP Protocol

The HiSLIP (**Hi**gh **S**peed **L**AN **I**nstrument **P**rotocol) is the successor protocol for VXI-11 for TCP-based instruments specified by the IVI foundation. The protocol uses two TCP sockets for a single connection - one for fast data transfer, the other for non-sequential control commands (e.g. `Device Clear` or `SRQ`).

HiSLIP has the following characteristics:

- High performance as with raw socket network connections
- Compatible IEEE 488.2 support for Message Exchange Protocol, Device Clear, Serial Poll, Remote/Local, Trigger, and Service Request
- Uses a single IANA registered port (4880), which simplifies the configuration of firewalls
- Supports simultaneous access of multiple users by providing versatile locking mechanisms
- Usable for IPv6 or IPv4 networks

Using VXI-11, each operation is blocked until a VXI-11 device handshake returns. However, using HiSLIP, data is sent to the device using the "fire and forget" method with immediate return. Thus, a successful return of a VISA operation such as `viWrite()` does not guarantee that the instrument has finished or started the requested command, but is delivered to the TCP/IP buffers.

For more information see also the application note: 1MA208: Fast Remote Instrument Control with HiSLIP.

15.3.3 GPIB Interface (IEC/IEEE Bus Interface)

To be able to control the instrument via the GPIB bus, the instrument and the controller must be linked by a GPIB bus cable. A GPIB bus card, the card drivers and the program libraries for the programming language used must be provided in the controller. The controller must address the instrument with the GPIB bus address.

Characteristics

- Up to 15 instruments can be connected
- The total cable length is restricted to a maximum of 15 m; the cable lenth between two instruments should not exceed 2m.

- A wired "OR"-connection is used if several instruments are connected in parallel.

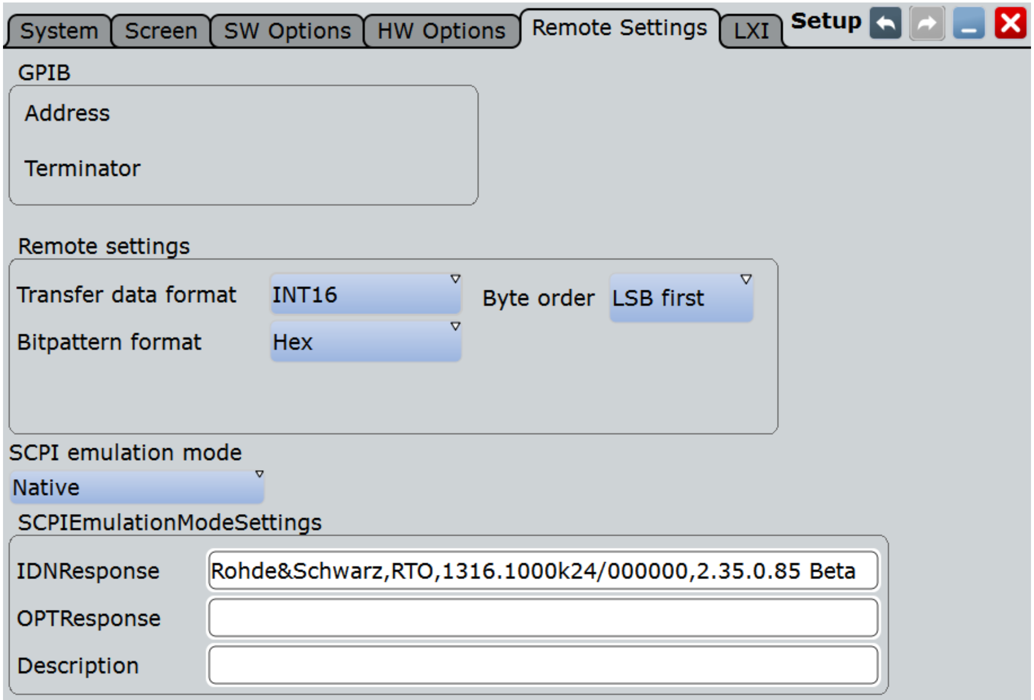
15.3.3.1 GPIB Instrument Address

In order to operate the instrument via remote control, it must be addressed using the GPIB address. The remote control address is factory-set to 20, but it can be changed in the network environment settings. For remote control, addresses 0 through 30 are allowed. The GPIB address is maintained after a reset of the instrument settings.

See also: "Address" on page 860.

15.4 Remote Settings

The settings on this tab are required for remote control of the instrument via a connected computer.



Address

Indicates the GPIB address of the instrument if an optional GPIB bus card is installed.

The address can be edited here. Be aware that changing the address has major effects on the communication to the remote computer. See also: Chapter 15.3.3, "GPIB Interface (IEC/IEEE Bus Interface)", on page 859.

Remote command:
`GPIB:ADDRess` on page 889

Terminator

Specifies the symbol that is used as a terminator in GPIB communication.

Remote command:
`GPIB:TERMinator` on page 890

Transfer data format
Selects the data format that is used for transmission of waveform data from the instrument to the controlling computer.

Waveform data can be retrieved using the following commands:
- `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?`
- `CALCulate:MATH<m>:DATA[:VALues]?`
- `REFCurve<m>:DATA[:VALues]?`

The content of the data stream can be defined with FILE > "Save/Recall > Waveforms > Interleaved X/Y" (or `EXPort:WAVeform:INCXvalues`).

"Ascii"	Data values are returned in ASCII format as a list of comma separated values in floating point format.
"FLOAT"	Binary format. The data is stored as binary data (Definite Length Block Data according to IEEE 488.2).
"INT8"	Signed integer data with length 8 bit.
"INT16"	Signed integer data with length 16 bit. The Byte order can be set using . For details on the formats, refer to the description of the remote command.

Remote command:
`FORMat[:DATA]` on page 887

Byte order
Sets the endianess for INT16 data:
- LSB first: little endian, least significant byte first
- MSB first: big endian, most significant byte first

Remote command:
`FORMat:BORDer` on page 888

Bit pattern format
Sets the format for all bit pattern queries.

Remote command:
`FORMat:BPATtern` on page 889

SCPI emulation
Not available for R&S RTE

15.5 Starting and Stopping Remote Control

15.5.1 Starting a Remote Control Session

When you switch on the instrument, it is always in manual operation state ("local" state) and can be operated via the front panel, the touch screen and external keyboard and/or mouse.

► To start remote control:
- Send a command from the controller.
- VXI-11 protocol (LAN or USB interface): Use `&GTR` interface message.

While remote control is active, the instrument settings are optimized for maximum measurement speed; the display is switched off. Operation via the front panel is disabled.

On the touch screen, two buttons appear in the upper left corner: "Local" and "View".

15.5.2 Using the display during remote control

You can observe the screen while a remote control script is executed. This is helpful for program test purposes but tends to slow down the measurement. Therefore it is recommended that you switch off the display in real measurement applications where a tested program script is to be executed repeatedly.

► To switch on the display, do one of the following:
- Tap the "View" button in the upper left corner of the touch screen.
- Use the `SYSTem:DISPlay:UPDate ON` command.

► To switch off the display, do one of the following:
- Tap the "View" button again.
- Use the `SYSTem:DISPlay:UPDate OFF` command.

15.5.3 Returning to Manual Operation

The instrument switches back to manual operation when the remote connection is closed. Besides, you can return to manual operation manually or via remote control.

► To return to manual operation:
- Tap the "Local" button in the upper left corner of the touch screen.
- VXI-11 protocol: Use `&GTL` interface message.

16 Remote Control Commands

This chapter describes all remote commands available for R&S RTE and provides examples and information how to use the commands.

Further information on remote control:

- Chapter 15.3, "Remote Control Interfaces and Protocols", on page 856
- Chapter 15.5, "Starting and Stopping Remote Control", on page 862
- Chapter B, "Remote Control - Basics", on page 1615
- Chapter C, "Remote Control - Status Reporting System", on page 1629

16.1 Conventions used in Remote Command Description

Note the following conventions used in the remote command descriptions:

- **Command usage**
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.
- **Parameter usage**
  If not specified otherwise, a parameter can be used to set a value and it is the result of a query.

Parameters required only for setting are indicated as **Setting parameters**.
Parameters required only to refine a query are indicated as **Query parameters**.
Parameters that are only returned as the result of a query are indicated as **Return values**.

- **Conformity**
  Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the R&S RTE follow the SCPI syntax rules.
- **Asynchronous commands**
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an **Asynchronous command**.
- **Reset values (*RST)**
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as ***RST** values, if available.
- **Default unit**
  This is the unit used for numeric values if no other unit is provided with the parameter.

16.2 Finding the Appropriate Command

In the following chapters, the commands are sorted according to the menu and dialog structure of the instrument.

A list of all commands in alphabetical order ist given in the "List of Commands" at the end of this documentation.

To find the appropriate command for a setting easily, you can use the context help:

1. Enable the "Tooltip" icon on the toolbar.

2. Tap the parameter for which you need information.

   The tooltip opens.

3. Tap the "Show Help" button in the lower right corner of the tooltip.

   The "Help" window opens and displays the comprehensive description and the corresponding remote command.

4. Tap the remote command link to open the command description.

16.3 Programming Examples

16.3.1 Display

16.3.1.1 Creating Zoom Diagrams

The example creates a zoom diagram, sets the relative size of the zoom area, and removes the zoom diagram.

Command description in: Chapter 16.10.1, "Zoom", on page 986.

```
LAYout:ZOOM:ADD 'Diagram1', VERT, OFF, -10e-9, 20e-9, -0.1, 0.05, 'MyZoom1'
// Create an new zoom diagram for Diagram1
LAYout:ZOOM:HORZ:MODE? 'Diagram1', 'MyZoom1'
<--ABS
// Query the horizontal zoom mode - return value: ABS
LAYout:ZOOM:HORZ:MODE 'Diagram1', 'MyZoom1', REL
// Set horizontal zoom mode to relative
LAYout:ZOOM:HORZ:REL:SPAN 'Diagram1', 'MyZoom1', 10
// Set horizontal zoom span in percent
LAYout:ZOOM:HORZ:REL:POS 'Diagram1', 'MyZoom1', 15
// Set horizontal zoom position in percent
LAYout:ZOOM:REM 'Diagram1', 'MyZoom1'
// Remove zoom diagram
```

16.3.2 Automatic Measurements

16.3.2.1 Setting Reference Levels

Command description in Chapter 16.12.11, "Reference Level", on page 1059

Manual reference level definition using absolute values

The modes, the upper and lower reference level, and the top and bottom distance are set for waveform C1W1 (= suffix 2).

```
REFLevel2:LDETection MANual
REFLevel2:LMODe ABS
REFLevel2:USRLevel UREF
REFLevel2:ABSolute:LLEVel 0.001
REFLevel2:ABSolute:BDIStance 0.02
REFLevel2:ABSolute:ULEVel 0.01
REFLevel2:ABSolute:TDIStance 0.03
REFLevel2:ABSolute:MLEVel 0.005
```

Manual reference level definition using relative values

Reference levels are set to 15%, 50%, and 85% of the high signal level for waveform Ch2 (= suffix 5).

```
REFLevel5:LDETection MANual
REFLevel5:LMODe REL
REFLevel5:RELative:MODE USER
REFLevel5:RELative:LOWer 15
REFLevel5:RELative:MIDDle 50
REFLevel5:RELative:UPPer 85
```

16.3.2.2 Waveform Histograms

Creating and Reading Histograms

The example creates a histogram, activates two measurements (mean and standard deviation measurements of Histogram1), and queries the results of both measure-ments.

Command description in:

- Chapter 16.12.1, "General Settings", on page 1019
- Chapter 16.12.6.2, "Histogram Measurement", on page 1046
- Chapter 16.12.2, "Results", on page 1023

```
LAY:HIST:ADD 'Histogram1', C1W1, -2.5E-007, 2.5E-007, -1.32, 5.35, OFF, VERT

MEAS1 ON
```

```
MEAS1:HIST:SEL 'Histogram1'
MEAS1:CAT HIST
MEAS1:MAIN HME

MEAS2 ON
MEAS2:HIST:SEL 'Histogram1'
MEAS2:CAT HIST
MEAS2:MAIN HSTD

MEAS1:RES:ACT?

MEAS2:RES:ACT?
```

Exporting Histogram Data to File

The example writes the absolute data values of Histogram1 to `C:\Histograms\Hist1.xml` in XML format.

Command description in Chapter 16.16.5, "Waveform Histogram Export to File", on page 1152.

```
EXPort:HISTogram:SELect 'Histogram1'
EXPort:HISTogram:INCidence ABS
EXPort:HISTogram:NAME 'C:\Histograms\Hist1.xml'
EXPort:HISTogram:SAVE
```

Transferring Histogram Data

The example transfers the absolute values of Histogram1 to a controlling computer in ASCII format.

Command description in Chapter 16.16.5, "Waveform Histogram Export to File", on page 1152.

```
EXP:HIST:SEL 'Histogram1'
EXP:HIST:INC ABS
FRM ASC
EXP:HIST:DATA?
<--0,0,0,0,0,2037,5754804,4683496,3100169,2874565,...
```

16.3.2.3 Long Term Measurements

Exporting Long Term Measurement Data to File

The example writes the long term data of Meas1 to `C:\Measurements\Meas1.csv` in CSV format.

Command description in Chapter 16.16.6, "Long Term Measurement Results and Measurement Histogram Export to File", on page 1153.

```
EXPort:MEASurement:SEL MEAS1
EXPort:MEASurement:TYPE LONGTERM
```

```
EXPort:MEASurement:NAME 'C:\Measurements\Meas1.csv'
EXPort:MEASurement:SAVE
```

Transferring Long Term Measurement Data

The example transfers the long term data of Meas1 to a controlling computer in ASCII format.

Command description in Chapter 16.16.6, "Long Term Measurement Results and Measurement Histogram Export to File", on page 1153.

```
MEASurement:LTM ON
MEASurement:STAT ON
EXPort:MEASurement:SELect MEAS1
EXPort:MEASurement:TYPE LONGTERM
FORM ASC
EXPort:MEASurement:DATA?
<--50,0.24901185771,0.24731225296,0.24703557312,0.00069270717936,0,50,....
```

16.3.3 Mask Testing

16.3.3.1 Creating a user mask

Creates a new user mask "MyMask" with one inner segment, and turns the mask test on.

Command description in: Chapter 16.14, "Mask Testing", on page 1085.

```
MTEST:ADD 'MyMask'
MTEST:SEGM:ADD 'MyMask'
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 0, -20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 0, -0.1
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 1, -20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 1, 0.1
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 2, 20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 2, 0.1
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 3, 20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 3, -0.1
MTEST:SEGM:REG 'MyMask', 0, INNER
MTEST:STAT 'MyMask', ON; *OPC?
```

16.3.4 Search

16.3.4.1 Searching for a pulse of specified width

Search for positive pulses with pulse width 12 ± 10 µs (2 µs to 22 µs).

Command description in: Chapter 16.15, "Search", on page 1101.

The usage of asynchronous commands is described in Chapter B.3, "Command Sequence and Synchronization", on page 1626.

```
SEAR:ADD 'MySearch'                    // Create a new search
SEAR:TRIG:WIDT:STAT 'MySearch',1       // Configure search type
SEAR:SOUR 'MySearch',M1                // Configure search source - here Math1
SEAR:TRIG:WIDT:RANG 'MySearch',WITH    // Configure search parameters
SEAR:TRIG:WIDT:WIDT 'MySearch',7e-6    // Configure search parameters
SEAR:TRIG:WIDT:DELT 'MySearch',1e-6    // Configure search parameters
SEAR:RES:LIM 'MySearch',1              // Set number of result lines in table to 1
SEAR:ALL 'MySearch'; *OPC?             // Initiate search for all events, asynchronous command
```

16.3.5 Data Management

16.3.5.1 Saving a Screenshot to File

Saves three display images in bmp format to the files `Print.bmp`, `Print_001.bmp`, and `Print_002.bmp` in the directory `C:\Temp`.

Command description in: Chapter 16.16.7, "Screenshots", on page 1155.

The usage of asynchronous commands is described in Chapter B.3, "Command Sequence and Synchronization", on page 1626.

```
HCOP:DEST 'MMEM'
HCOP:DEV:LANG BMP
MMEM:NAME 'C:\Temp\Print.bmp'
HCOP:IMMediate; *OPC?          \\Asynchronous command
HCOP:IMM:NEXT; *OPC?           \\Asynchronous command
HCOP:IMM:NEXT; *OPC?           \\Asynchronous command
```

16.3.5.2 Exporting Waveform Data to File

Command description in:

- Chapter 16.16.4, "Waveform Data Export to File", on page 1146
- Chapter 16.16.1, "Instrument Settings", on page 1137

- Chapter 16.10.4, "History", on page 1004

Exporting a Single Waveform to XML File

Saves a single analog waveform completely to an XML file. Data logging is off.

The usage of asynchronous commands is described in Chapter B.3, "Command Sequence and Synchronization", on page 1626.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
RUNSingle;*OPC?               \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.xml'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.xml'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.xml'
```

Exporting Raw Data of a Single Waveform to BIN File

Saves the data of a single analog waveform in integer 8 bit format (raw data) to a BIN file. Data logging is off.

Data conversion is described in "Raw (ADC direct)" on page 420.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
RUNSingle; *OPC?             \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.bin'
EXPort:WAVeform:RAW ON
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
```

```
MMEM:DATA? 'C:\Data\DataExportWfm_analog.bin'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.bin'
```

Exporting Raw Data of a Measurement Gate to BIN File

Saves the data of a measurement gate in integer 8 bit format (raw data) to a BIN file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
MEASurement2:CATegory AMPT
MEASurement2:MAIN MEAN
MEASurement2:ENABle 1
MEASurement2:SOURce C1W1
MEASurement2:GATE:MODE ABS
MEASurement2:GATE:ABS:STARt -0.00012
MEASurement2:GATE:ABS:STOP -5e-06
MEASurement2:GATE:STATe On
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe GATE
EXPort:WAVeform:MEAS Meas2
RUNSingle;*OPC?                 \\Asynchronous command
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.bin'
EXPort:WAVeform:RAW ON
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.bin'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.bin'
```

Exporting Interleaved x/y Data of a Single Waveform to CSV File

Saves the x- and y- values of a single analog waveform to a CSV file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
RUNSingle;*OPC?                  \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.csv'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues ON
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.csv'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.csv'
```

Exporting Interleaved x/y Data of a Zoom to CSV File

Saves the x- and y- values that is displayed in a zoom diagram to a CSV file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
LAYout:ZOOM:ADD 'Diagram1',HORIZONTAL,OFF,-0.00012,-5e-06,0.308,-0.092,'ExportAreaZoom'
RUNSingle;*OPC?                  \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe ZOOM
EXPort:WAVeform:ZOOM 'Diagram1', 'ExportAreaZoom'
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.csv'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues ON
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.csv'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.csv'
```

Exporting Multiple Running Acquisitions of a Single Waveform to XML File

Saves the data of 5 subsequent acquisitions of a single analog waveform to an XML file. Data logging is on.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.xml'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues OFF
ACQuire:COUNt 5
EXPort:WAVeform:DLOGging ON
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
RUNSingle;*OPC?                  \\Asynchronous command
MMEM:DATA? 'C:\Data\DataExportWfm_analog.xml'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.xml'
```

Exporting a Single Acquisition of the History to BIN File

Saves the oldest acquisition of the history to a BIN file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.bin'
EXPort:WAVeform:RAW OFF
```

```
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
ACQuire:COUNt 5             \\Acquire 5 waveforms
RUNSingle;*OPC?             \\Asynchronous command
CHANnel1:WAV1:HISTory:STATe ON
CHANnel1:WAV1:HISTory:CURRent -4;*OPC?  \\Oldest waveform of 5 has index -4
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.bin'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.bin'
```

Exporting Multiple Acquisition of the History to XML File

Saves the data of 5 subsequent acquisitions of the history to an XML file. Data logging is on.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.xml'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging ON
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
ACQuire:COUNt 5               \\Acquire 5 waveforms
RUNSingle;*OPC?               \\Asynchronous command
CHANnel1:WAV1:HISTory:STATe ON
CHANnel1:WAV1:HISTory:STARt -4
CHANnel1:WAV1:HISTory:STOP 0
CHANnel1:WAV1:HISTory:REPLay OFF
CHANnel1:WAV1:HISTory:PLAY;*OPC? \\Asynchronous command
MMEM:DATA? 'C:\Data\DataExportWfm_analog.xml'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.xml'
```

16.3.5.3 Exporting Measurement Results to File

See:

- "Exporting Histogram Data to File" on page 867
- "Transferring Histogram Data" on page 867
- "Exporting Long Term Measurement Data to File" on page 867
- "Transferring Long Term Measurement Data" on page 868

16.3.6 Protocol Analysis

16.3.6.1 SENT (Option R&S RTE-K10)

Configuring SENT Bus

```
// Set protocol parameters
//*****************************************************
STOP;*OPC?
BUS:TYPE SENT
BUS:LABel "Bus 1 SENT"
BUS:SENT:DATA:SOURce C1W1
BUS:SENT:DATA:THReshold 2.0
BUS:SENT:CLKPeriod 0.000005
BUS:SENT:CLKTolerance 20.0
BUS:SENT:CRCVersion V2010
BUS:SENT:CRCMethod TLE
BUS:SENT:DNIBbles 5
BUS:SENT:PPULse NPP
BUS ON

//*****************************************************
// Load a label list and switch on
BUS:NEWList 'C:\Protocols\SENT_Labels.xml'
BUS:SYMBols ON
RUNSingle;*OPC?              //asynchronous command

//*****************************************************
// Display all results
BUS:SENT:RDSL ALL

//*****************************************************
// Display the fast channel transmission sequence
BUS:SENT:RDSL TRSQ

//*****************************************************
// Display the short serial message of slow channel
BUS:SENT:RDSL SMSG
```

Triggering on SENT Bus

```
//Set trigger source to serial bus
TRIGger1:SOURce SBUS
TRIGger:MODE NORMal

//Trigger on the fast channel transmission sequence
TRIGger1:SENT:TYPE TSEQ
TRIGger1:SENT:TTYPE STDA
```

```
TRIGger1:SENT:statbit #H2
TRIGger1:SENT:DCONdition INR
BUS1:SENT:DNibbles 5
TRIGger1:SENT:DMIN #H2 //Data MIN = 0010
TRIGger1:SENT:DMAX #H4 //Data MAX = 0100
```

Searching SENT Data

```
// Search for all frames with sync/calibration pulse
SEARch:TRIGger:SENT:CALibration 'Search1', ON
SEARch:ONLIne 'Search1',ON
SEARch:RESult:SORT:ASCending 'Search1', ON
SEARch:RESult:SENT:FCOunt? 'Search1'
SEARch:RESult:SENT:FRAMe1:STAT? 'Search1'
SEARch:RESult:SENT:FRAMe1:STARt? 'Search1'
SEARch:RESult:SENT:FRAMe1:STOP? 'Search1'
SEARch:RESult:SENT:FRAMe1:DATA? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB1:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB2:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:CSValue? 'Search1'
SEARch:RESult:SENT:FRAMe1:SCOM? 'Search1'
SEARch:TRIGger:SENT:CALibration 'Search1', OFF

//****************************************************
// Search Short serial message
SEARch:TRIGger:SENT:SHORt 'Search1', ON
SEARch:RESult:SENT:FCOunt? 'Search1'

SEARch:RESult:SENT:FRAMe1:STAT? 'Search1'
SEARch:RESult:SENT:FRAMe1:IDValue? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB1:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB2:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:CSValue? 'Search1'

SEARch:TRIGger:SENT:SHORt 'Search1', OFF

//****************************************************
// Search Enhanced serial message
SEARch:TRIGger:SENT:ENHanced 'Search1', ON

SEARch:RESult:SENT:FCOunt? 'Search1'

SEARch:RESult:SENT:FRAMe1:STAT? 'Search1'
SEARch:RESult:SENT:FRAMe1:IDValue? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB1:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:NIBB2:VALue? 'Search1'
SEARch:RESult:SENT:FRAMe1:CSValue? 'Search1'

SEARch:TRIGger:SENT:ENHanced 'Search1', OFF
```

16.3.7 Power Analysis (Option R&S RTE-K31)

16.3.7.1 Auto Deskew

Configures the voltage and current probes for power measurements and executes the auto deskew.

Command description in Chapter 16.19.1, "General", on page 1555 and Chapter 16.19.2, "Deskew", on page 1556.

If the instrument refuses to accept `POWer` commands, activate the power mode using `:POWer:ENABle`.

```
*RST; *OPC?
STOP;*OPC?
//Activate two channels
:CHANnel1:STATe 1
:CHANnel2:STATe 1

//Activate power
:POWer:ENABle

//Select current and voltage sources
:POWer:SOURce:VOLTage1 CHANnel1
:POWer:SOURce:CURRent1 CHANnel2

//Configure voltage probe on CH1 manually
//Not necessary if you use an active R&S voltage probe that is recognized by the instrument
:PROBe1:SETup:ATTenuation:MODE Manual
:PROBe:SETup:ATTenuation:DEFProbe ZD01a100
//selected high voltage differential probe 1:100

//Configure current probe on CH2 manually
//Always required because R&S current probes are not recognized automatically
PROBe2:SETup:ATTenuation:MODE Manual
PROBe2:SETup:ATTenuation:DEFProbe ZC20
//select 20MHz current probe ZC10 also possible

//Start deskew
//Overwrites the skew offset of CH2 (current probe), because :POWer:DESKew:RESet? == 1
//writes a user-defined preset file (UserDefinedPreset_AutoDeskew.dfl) and
//activates the user defined preset, because :POWer:DESKew:UDPReset? == 1
:PoWer:DESKew:EXECute;*OPC?

//Check result
CHANnel2:SKEW:MAN?
CHANnel2:SKEW:TIMe?
POWer:DESKew:TIMe?
```

Effect of *RST and loading user-defined preset

Note that `*RST` resets the deskew values.

You can reload the deskew values as follows:

```
*RST;*OPC?
STOP;*OPC?
:POWer:ENABle
//Select voltage and current sources
:POWer:SOURce:VOLTage1 CHANnel1
:POWer:SOURce:CURRent1 CHANnel2
//Reload deskew values
:POWer:DESKew:CURRent
//Load default saveset after FW restart
MMEM:RCL 'C:\Users\Public\Documents\Rohde-Schwarz\RTx\SaveSets
\UserDefinedPreset_AutoDeskew.dfl'
```

16.3.7.2 Transient Response Measurement

Configures and executes a transient response measurement.

Command description in Chapter 16.19.15, "Transient Response", on page 1589.

Make sure to configure and deskew the probes before the measurement, see Chapter 16.3.7.1, "Auto Deskew", on page 876.

```
//Activate power
*RST; *OPC?
:POWer:ENABle

//Expected smps frequency
:POW:TRANsient:FREQ         12500000

:POWer:TRANsient:AUToscale AUTO

:POWer:TRANsient:SIGHigh 0.1
:POWer:TRANsient:SIGLow    0.025
:POWer:TRANsient:HYSTeresis 20

//Trigger channel
:POWer:TRANsient:TRGC CHAN2

//Edge trigger slope
:POWer:TRANsient:TRGS POS

//Trigger level
:POWer:TRANsient:TRGL 0.08

//Run measurement
:POWer:TRANsient:EXECute;*OPC?
```

```
//Query results
:POWer:TRANsient:RESult? SETTling
:POWer:TRANsient:RESult? PEAKtime
:POWer:TRANsient:RESult? DELay
:POWer:TRANsient:RESult? RTIMe
:POWer:TRANsient:RESult? OVERshoot

//Add to report
:Power:TRANsient:REPort:Add
```

16.4 Frequently Used Parameters and Suffixes

This chapter describes in general those parameters and suffixes that are used in several subsystems.

16.4.1 Waveform Suffix

The numeric waveform suffix is used in some commands, for example, to indicate the source waveform number from which the reference level is taken, and to assign color tables to waveforms.

Depending on the command, not all suffix values are supported. For example, in REFLevel commands, only suffixes 2...21 are allowed. The range of supported suffix numbers is indicated in the description of the individual commands.

NOTICE

Suffix 1

Suffix 1 means that no waveform is assigned. The first waveform C1W1 corresponds to suffix number 2.

Waveform number	Description
1	None
2	C1 (channel 1)
3	not available
4	not available
5	C2 (channel 2)
6	not available
7	not available
8	C3 (channel 3)

Waveform number	Description
9	not available
10	not available
11	C4 (channel 4)
12	not available
13	not available
14...17	Math waveforms: M1, M2, M3, M4
18...21	Reference waveforms: R1, R2, R3, R4
22...25	XY-waveforms: XY1, XY2, XY3, XY4
26...33	Measurement results: MRESult1, MRESult2, MRESult3, MRESult4, MRESult5, MRESult6, MRESult7, MRESult8
34...35	not used
36...39	Serial buses: SBUS1, SBUS2, SBUS3, SBUS4
40...55	Digital channels: D0...D15 (option R&S RTE-B1)
56...59	Digital buses: MSO1, MSO2, MSO3, MSO4 (option R&S RTE-B1)
60	not used
61...68	Track waveforms: TRK1, TRK2, TRK3, TRK4, TRK5, TRK6, TRK7, TRK8 Available for audio signals and jitter analysis (options R&S RTE-K5/K12)
69...71	not used
72...75	Spectrograms: SG1, SG2, SG3, SG4 Available for spectrum analysis option R&S RTE-K18
76...83	Timeline spectrums: SG1TL1, SG1TL2, SG2TL1, SG2TL2, SG3TL1, SG3TL2, SG4TL1, SG4TL2 TL1 is timeline 1, TL2 is timeline 2 Available for spectrum analysis option R&S RTE-K18
84...87	not used

16.4.2 Waveform Parameter

Many commands requires one of the waveforms to be specified as source. The following table lists all waveforms. For each command using a waveform parameter, the available waveforms are specified in the command description.

Waveform	Description
C1W1	Channel 1
C2W1	Channel 2
C3W1	Channel 3
C4W1	Channel 4

Waveform	Description
M1 | M2 | M3 | M4	Math waveforms
R1 | R2 | R3 | R4	Reference waveforms
XY1 | XY2 | XY3 | XY4	XY-waveforms
MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8	Measurement results
SBUS1 | SBUS2 | SBUS3 | SBUS4	Serial buses
D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15	Digital channels (option R&S RTE-B1)
MSOB1 | MSOB2 | MSOB3 | MSOB4	Digital buses (option R&S RTE-B1)
TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8	Track waveforms (option R&S RTE-K5 or K12)
CDRSW1 = CDRSw1, CDRSW2 = CDRSw2, CDRHW = CDRHw	Generated clock signals Track waveforms (option R&S RTE-K13)
SG1 | SG2 | SG3 | SG4	Spectrograms (option R&S RTE-K18)

16.4.3 Slope Parameter

The slope parameter is used with several trigger and search condition commands.

Slope	Description
POSitive	Rising edge, that is a positive voltage change.
NEGative	Falling edge, that is a negative voltage change
EITHer	rising as well as the falling edge.

16.4.4 Polarity Parameter

The polarity parameter is used with several trigger and search condition commands.

Polarity	Description
POSitive	Positive going pulses.
NEGative	Negative going pulses.
EITHer	Both positive and negative going pulses.

16.4.5 Event Parameter

The event parameter is used with commands defining an action for mask testing, limit checks and margin checks.

Event	Description
NOACtion	The action is not initiated.
SUCCess	The action is initiated if the operation finished successfully: ● Limits or margins were not exceeded during the entire measurement ● Mask test passed
VIOLation	The action is initiated if the operation finished with error: ● Limits or margins were violated during the measurement ● Mask test failed

16.4.6 Bit Pattern Parameter

Bit pattern parameter are required with commands triggering on address, identifier, or data pattern.

To set the pattern value, you can use either a numeric parameter as defined in the SCPI standard, or a string parameter.

Bit pattern in numeric parameter

In a numeric parameter, the values are listed byte-by-byte, with bytes separated by commas and MSB first. The default numeral format is decimal, other formats can be indicated by a format identifier (#B = binary, #H = hexadecimal, #Q = octal). Currently, no format for signed values is available.

Example: Parameter with three bytes, decimal byte values are 10, 20, 30. The examples are given for CAN, the bit pattern in other commands is defined in the same way.

- `TRIGger:CAN:DMIN 10,20,30`
- `TRIGger:CAN:DMIN #B00001010,#B00010100,#B00011110`
- `TRIGger:CAN:DMIN #H0A,#H14,#H1E`
- `TRIGger:CAN:DMIN #Q012,#Q024,#Q036`

Bit pattern in string parameter

In a string, the complete binary pattern is written without separation of bytes, for example:

`TRIGger:CAN:DMIN '000010100001010000011110'`

Unlike a numeric parameter, the string parameter accepts wildcards for single bits (X = don't care). Whether wildcards can be used or not depends on the remote command. Usually, address and identifier parameter require unique patterns while data parameters may contain wildcards.

Mostly the length of the bit pattern is defined, for example, by the I²C address type, the CAN identifier type, or the data length code. In theses cases, it is recommended that you enter the complete bit pattern. If you enter a shorter pattern, the instrument fills up the pattern with X bits to the right of the defined pattern.

Example: You want to trigger on an 11 bit CAN address and enter the bit pattern '11100011' (8 bits only). The instrument uses the pattern '11100011XXX' for triggering.

Query for a pattern

The pattern format for the return value of a pattern is defined by the `FORMat:BPATtern` command.

16.5 Common Commands

Common commands are described in the IEEE 488.2 (IEC 625-2) standard. These commands have the same effect and are employed in the same way on different devices. The headers of these commands consist of "*" followed by three letters. Many common commands are related to the Status Reporting System.

Available common commands:

***CAL?**

Performs a self-alignment of the instrument and then generates a status response. Return values ≠ 0 indicate an error.

Usage: Query only

***CLS**

Clear status

Sets the status byte (STB), the standard event register (ESR) and the `EVENt` part of the `QUEStionable` and the `OPERation` registers to zero. The command does not alter the mask and transition parts of the registers. It clears the output buffer.

Usage: Setting only

***ESE** <Value>

Event status enable

Sets the event status enable register to the specified value. The query returns the contents of the event status enable register in decimal form.

Parameters:

<Value>	Range:	0 to 255

***ESR?**

Event status read

Returns the contents of the event status register in decimal form and subsequently sets the register to zero.

Return values:

<Contents>	Range:	0 to 255

Usage: Query only

***IDN?**

Identification

Returns the instrument identification.

Return values:

<ID> "Rohde&Schwarz,<device type>,<serial number>,<firmware version>"

<ID> "Rohde&Schwarz,<device type>,<part number>/serial number>,<firmware version>"

Example: `Rohde&Schwarz,RTE,1316.1000k14/200153,1.30.0.25`

Usage: Query only

***IST?**

Individual status query

Returns the contents of the IST flag in decimal form. The IST flag is the status bit which is sent during a parallel poll.

Return values:

<ISTflag> 0 | 1

Usage: Query only

***OPC**

Operation complete

Sets bit 0 in the event status register when all preceding commands have been executed. This bit can be used to initiate a service request. The query form writes a "1" into the output buffer as soon as all preceding commands have been executed. This is used for command synchronization.

***OPT?**

Option identification query

Queries the options included in the instrument. For a list of all available options and their description refer to the data sheet.

Return values:

<Options>	The query returns a list of options. The options are returned at fixed positions in a comma-separated string. A zero is returned for options that are not installed.
Usage:	Query only

***PCB** <Address>

Pass control back

Indicates the controller address to which remote control is returned after termination of the triggered action.

Setting parameters:

<Address>	Range:	0 to 30
Usage:	Setting only	

***PRE** <Value>

Parallel poll register enable

Sets parallel poll enable register to the indicated value. The query returns the contents of the parallel poll enable register in decimal form.

Parameters:

<Value>	Range:	0 to 255

***PSC** <Action>

Power on status clear

Determines whether the contents of the `ENABle` registers are preserved or reset when the instrument is switched on. Thus a service request can be triggered when the instrument is switched on, if the status registers ESE and SRE are suitably configured. The query reads out the contents of the "power-on-status-clear" flag.

Parameters:

<Action> 0 | 1

0
The contents of the status registers are preserved.

1
Resets the status registers.

***RCL** <Number>

Recall

Loads the instrument settings from an intermediate memory identified by the specified number. The instrument settings can be stored to this memory using the command `*SAV` with the associated number.

It also activates the instrument settings which are stored in a file and loaded using `MMEMory:LOAD:STATe`.

***RST**

Reset

Sets the instrument to a defined default status. The default settings are indicated in the description of commands.

Usage: Setting only

***SAV** <Number>

Save

Stores the current instrument settings under the specified number in an intermediate memory. The settings can be recalled using the command `*RCL` with the associated number.

To transfer the stored instrument settings to a file, use `MMEMory:STORe:STATe`.

***SRE** <Contents>

Service request enable

Sets the service request enable register to the indicated value. This command determines under which conditions a service request is triggered.

Parameters:

<Contents> Contents of the service request enable register in decimal form. Bit 6 (MSS mask bit) is always 0.

Range: 0 to 255

***STB?**

Status byte query

Reads the contents of the status byte in decimal form.

Usage: Query only

***TRG**

Trigger

Triggers all actions waiting for a trigger event. In particular, *TRG generates a manual trigger signal. This common command complements the commands of the `TRIGger` subsystem.

Usage: Event

***TST?**

Self-test query

Initiates self-tests of the instrument and returns an error code

Return values:

<ErrorCode> **integer > 0 (in decimal format)**
An error occurred.
(For details see the Service Manual supplied with the instrument).

0
No errors occurred.

Usage: Query only

***WAI**

Wait to continue

Prevents servicing of the subsequent commands until all preceding commands have been executed and all signals have settled (see also command synchronization and `*OPC`).

Usage: Event

16.6 General Remote Settings

This chapter describes commands that have effect on many other remote commands in different applications of the instrument.

FORMat[:DATA] <Format>, [<Length>]

Selects the data type that is used for transmission of waveform data from the instrument to the controlling computer.

Waveform data can be retrieved using the following commands:

- `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?`
- `CALCulate:MATH<m>:DATA[:VALues]?`
- `REFCurve<m>:DATA[:VALues]?`
- `DIGital<m>:DATA[:VALues]?`

The content of the data stream can be defined with `EXPort:WAVeform:INCXvalues`
.

Parameters:

<Format>,[<Length>] ASCii | REAL,32 | INT,8 | INT,16

ASCii
Data values are returned in ASCII format as a list of comma separated values in floating point format. The length can be omitted. It is 0 which means that the instrument selects the number of digits to be returned. The query returns both values (`ASC,0`).

REAL,32
The data is stored as binary data (Definite Length Block Data according to IEEE 488.2). Each waveform value is formatted in 32 Bit IEEE 754 Floating Point Format.
The schema of the result string is as follows:
`#41024<value1><value2>…<value n>` with:
`#4` = number of digits (= 4 in the example) of the following number
`1024` = number of following data bytes (= 1024 in the example)
`<value>` = 4-byte floating point values
If the data exceeds 1 GB, the result string starts with header #0 (unknown length), followed by the data values.

INT,8 | INT,16
Signed integer data with length 8 bit or 16 bit. It defines that `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?` returns the raw sample data of the ADC as integers. If format of the waveform data differs from the defined export format, the instrument converts the data to the required length.
The result string has the same schema as the REAL format.
Fot INT,16 you can set the byte order using the `FORMat:BORDer` command.
Data conversion is described in "Raw (ADC direct)" on page 420.
For digital channel data, math and histogram data, INT formats are not available.
`EXPort:WAVeform:INCXvalues` must be set `OFF`.

*RST: ASCii

Example:
```
FORMat:DATA REAL,32
FORMat:DATA?
REAL,32
```

Usage: SCPI confirmed

FORMat:BORDer <ByteOrder>

Sets the endianess.

The command is only relevant for raw data export in high definition mode (16 bit word length).

Parameters:

<ByteOrder> LSBFirst | MSBFirst

LSB first: little endian, least significant byte first
MSB first: big endian, most significant byte first

*RST: LSBFirst

FORMat:BPATtern <BitPatternFormat>

Sets the number format for all remote bit pattern queries.

Parameters:

<BitPatternFormat> DEC | HEX | OCT | BIN | ASCII | STRG

*RST: HEX

Firmware/Software: V 1.25

SYSTem:DISPlay:UPDate <Enable>

Defines whether the display is updated while the instrument is in the remote state. If the display is switched off, the normal GUI is replaced by a static image while the instrument is in the remote state. Switching off the display can speed up the measurement. This is the recommended state.

See also: Chapter 15.5.2, "Using the display during remote control", on page 862

Parameters:

<Enable> **ON | 1:** Display is shown and updated during remote control
OFF | 0: Display shows static image during remote control

Example: `SYSTem:DISPlay:UPDate 1`
Switch on the display update.

SYSTem:KLOCk <Enable>

Locks or unlocks the local controls of the instrument. This includes the front panel keys, the keyboard, or other local interfaces. except for the "View" button on the display.

Parameters:

<Enable> **ON | 1:** Locks the local keys
OFF | 0: Keys are unlocked

Usage: SCPI confirmed

GPIB:ADDRess <Address>

Sets the GPIB address of the instrument if an optional GPIB bus card is installed. Changing the address has major effects on the communication to the remote computer.

Parameters:

<Address>	Range:	0 to 30
	Increment:	1
	*RST:	20

GPIB:TERMinator <Terminator>

Specifies the symbol that is used as a terminator in GPIB communication.

Parameters:

<Terminator> LFEoi | EOI

*RST: EOI

SYSTem:DISPlay:MESSage:STATe <DispMessageState>

Enables and disables the display of an additonal text in remote control.

To define the text, use `SYSTem:DISPlay:MESSage[:TEXT]`.

Parameters:

<DispMessageState> ON | OFF

*RST: OFF

Firmware/Software: Version 2.70

SYSTem:DISPlay:MESSage[:TEXT] <DisplayMessage>

Defines an additional text that is displayed during remote control operation.

To enable the text display, use `SYSTem:DISPlay:MESSage:STATe` on page 890.

Parameters:

<DisplayMessage> String that contains the text.

Firmware/Software: Version 2.70

16.7 Instrument Setup

This chapter describes commands related to SETUP > "System" and "File" > "Exit". For commands related to SETUP > "Remote Settings", see Chapter 16.6, "General Remote Settings", on page 886.

16.7.1 System Setup

SYSTem:EXIT

Starts the shutdown of the firmware.

Usage: Event

SYSTem:PRESet

Resets the instrument to the factory default settings, to the initial state. Factory settings comprise all instrument settings, including display, intensity and transparency settings. After laoading factory defaults, perform a self-aligment to synchronize the signal data.

Usage: Event

SYSTem:RESet

Resets the instrument settings to defaults appropriate for remote control of the instrument. The last loaded user-defined preset is used. The command is equivalent to `*RST`.

Usage: Event

SYSTem:DATE <Year>, <Month>, <Day>

Sets the date of the internal calendar.

Parameters:

<Year> Year, to be entered as a four-digit number (including the century and millenium information)

<Month> Month, 1 (January) to 12 (December)

<Day> Day, 1 to the maximum number of days in the specified month

*RST: does not affect the date settings

Example: `SYSTem:DATE?`
Returned value: `2011,09,13`

Usage: SCPI confirmed

SYSTem:TIME? <Hour>, <Minute>, <Second>

Returns the UTC (Universal Time Coordinated) of the internal clock. To define the current local time, use the time zone setting of the operating system (SETUP > "Time, date")

Example: `SYSTem:TIME?`
Returned value: `15,09,20`. UTC is 15:09:20.

Usage: Query only
SCPI confirmed

SYSTem:DEVice:ID?

Returns the instrument ID - that is the material number and the serial number

Return values:
<ID> String containing the material number and the serial number

Example: `1316.1000K24-001122-jT`

Usage: Query only

DIAGnostic:SERVice:FWVersion?

Returns the firmware version that is currently installed on the instrument.

Return values:
<FirmwareVersion> Version string

Usage: Query only

DIAGnostic:SERVice:COMPutername <ComputerName>

The query returns the computer name that is currently defined. The computer name is required when configuring a network.

The setting command changes the computer name. The change takes effect after the next reboot of the computer.

Parameters:
<ComputerName> Name string

DIAGnostic:SERVice:PARTnumber <MaterialNumber>

Returns the material number of your instrument. This number is required to order a new option, and in case of service.

Parameters:
<MaterialNumber> Number string

DIAGnostic:SERVice:SERialnumber?

Returns the serial number of your instrument. This number is required to order a new option, and in case of service.

Return values:

<SerialNumber>	Number string
Usage:	Query only

DIAGnostic:SERVice:CHANnelcount?

Queries the number of available channels.

Return values:

<ChannelCount>	Range:	0 to 4
	Increment:	1
	*RST:	0
Usage:	Query only	
Firmware/Software:	V 2.00	

SYSTem:VERSion?

Queries the SCPI version number to which the instrument complies. The instrument complies to the final SCPI version 1999.0.

Usage: Query only
SCPI confirmed

SYSTem:DFPRint [<Path>]

The device footprint contains the configuration of the instrument, installed modules, installed software and software licenses. This information is written in the device footprint xml file might be useful in case of maintenance or support request.

The query returns the information as block data. The setting command saves the device footprint xml file in the specified path.

It is also possible to access the device footprint xml file via the LXI web browser. Therefore, the directory containing the xml file must be enabled for sharing.

Setting parameters:

<Path>	String parameter, specifying the target path of the footprint file.

Return values:

<DeviceFootprint>	Content of the device footprint xml file as block data

SYSTem:ERRor:ALL?

Queries the error/event queue for all unread items and removes them from the queue. The response is a comma separated list of error number and a short description of the error in FIFO order.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error>	List of: Error/event_number,"Error/event_description>[;Device-dependent info]" If the queue is empty, the response is 0,"No error"
Usage:	Query only SCPI confirmed

SYSTem:ERRor[:NEXT]?

Queries the error/event queue for the oldest item and removes it from the queue. The response consists of an error number and a short description of the error.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error>	Error/event_number,"Error/event_description>[;Device-dependent info]" If the queue is empty, the response is 0,"No error"
Usage:	Query only SCPI confirmed

SYSTem:ERRor:CODE:ALL?

Queries the error/event queue for all unread items and removes them from the queue. The response is a comma separated list of error numbers in FIFO order.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error>	If the queue is empty, the response is 0
Usage:	Query only SCPI confirmed

SYSTem:ERRor:CODE[:NEXT]?

Queries the error/event queue for the oldest item and removes it from the queue. The response is the error number.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error> If the queue is empty, the response is 0

Usage: Query only
SCPI confirmed

SYSTem:ERRor:COUNt?

Queries the number of entries in the error queue.

Return values:

<Count> If the queue is empty, the response is 0

Usage: Query only
SCPI confirmed

16.7.2 Display Settings

16.7.2.1 Signal Colors / Persistence

DISPlay:PERSistence[:STATe] <State>

If enabled, each new data point in the diagram area remains on the screen for the duration defined using `DISPlay:PERSistence:TIME`, or as long as `DISPlay:PERSistence:INFinite` is enabled.

If disabled, the signal value is only displayed as long as it actually occurs.

Parameters:

<State> ON | OFF
*RST: ON

DISPlay:PERSistence:INFinite <State>

If persistence is enabled (`DISPlay:PERSistence[:STATe]`), each new data point in the diagram area remains on the screen infinitely until this command is set to "OFF".

Parameters:

<State> ON | OFF

*RST: OFF

DISPlay:PERSistence:TIME <Time>

If persistence is enabled (`DISPlay:PERSistence[:STATe]`), each new data point in the diagram area remains on the screen for the duration defined here.

Parameters:

<Time> Range: 0.05 to 50
Increment: 0.05
*RST: 0.05
Default unit: s

DISPlay:PERSistence:RESet

Resets the display, removing persistent values.

Usage: Event

DISPlay:INTensity <Intensity>

This value determines the strength of the waveform line in the diagram. Enter a percentage between 0 (not visible) and 100% (very strong).

The exact mapping of the cumulative value occurences according to the assigned color table is guaranteed only if the intensity is set to 50% (default). All other intensity values falsify the mapping but may improve the visibility of the signal.

See also: Chapter 3.4.3.1, "Editing Waveform Colors", on page 127.

Parameters:

<Intensity> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

DISPlay:DIAGram:STYLe <Style>

Select the style in which the waveform is displayed.

Parameters:

<Style> VECTors | DOTS

VECTors
The individual data points are connected by a line.

DOTS
Only the individual data points are displayed.

*RST: VECTors

DISPlay:COLor:SIGNal<m>:ASSign <ColorTable>

Assigns the color table to the specified signal.

Suffix:

<m>	1..87 Waveform number, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<ColorTable>	Color table name to be assigned to the signal.

DISPlay:COLor:SIGNal<m>:USE <UseColorTable>

If enabled, the selected waveform is displayed according to its assigned color table.

If this option is disabled, the default color table is used, i.e. the intensity of the specific signal color varies according to the cumulative occurance of the values.

Suffix:

<m>	1..87 Waveform number, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<UseColorTable>	ON | OFF *RST: OFF

16.7.2.2 Color Tables

DISPlay:COLor:PALette:ADD <Name>

Adds a new color table with the specified name.

Setting parameters:

<Name>	color table
Usage:	Setting only

DISPlay:COLor:PALette:REMove <Name>

Removes the specified color table.

Setting parameters:

<Name> color table

Usage: Setting only

DISPlay:COLor:PALette:COUNt?

Queries the number of configured color maps.

Usage: Query only

DISPlay:COLor:PALette:POINt:ADD <PaletteName>

Appends a new row at the end of the color table.

Setting parameters:

<PaletteName> color table

Usage: Setting only

DISPlay:COLor:PALette:POINt:INSert <PaletteName>, <PointIndex>

Inserts the entry at the specified index in the color table.

Setting parameters:

<PaletteName> color table

<PointIndex> row number in the color table

Usage: Setting only

DISPlay:COLor:PALette:POINt:REMove <PaletteName>, <PointIndex>

Removes the entry with the specified index from the color table.

Setting parameters:

<PaletteName> color table

<PointIndex> row number in the color table

Usage: Setting only

DISPlay:COLor:PALette:POINt[:VALue] <ColorTableName>, <ColorTableColorPointIdx>,<Position>, <Color>
DISPlay:COLor:PALette:POINt[:VALue]? <ColorTableName>, <ColorTableColorPointIdx>

Inserts a new entry or queries the specified entry in the specified color table.

Parameters:

<Position>	cumulative occurance value Range: 0 to 100 Increment: 1 *RST: 50 Default unit: %
<Color>	ARGB value of the color to be used for the table entry. ARGB=<Opacity(alpha) value><red value><green value><blue value>, in hexadecimal or decimal format. Range: 0 to 4294967295 Increment: 1 *RST: 0

Parameters for setting and query:

<ColorTableName>	color table to be edited
<ColorTableColorPointIndex>	Index (row number) of the new entry in the color table

DISPlay:COLor:PALette:POINt:COUNt? <PaletteName>

Queries the number of entries in the color table.

Query parameters:

<PaletteName> color table

Usage: Query only

16.7.2.3 Diagram Layout

These settings are user-specific, they are *not* reset by PRESET and `*RST`. You can reset them to default values using FILE > "Save/Recall > User defined preset > Factory defaults" or using the `SYSTem:PRESet` command.

DISPlay:DIAGram:GRID <Show>

If enabled, a grid is displayed in the diagram area.

Parameters:

<Show> ON | OFF

DISPlay:DIAGram:CROSshair <Crosshair>

If selected, a crosshair is displayed in the diagram area. A crosshair allows you to select a specific data point by its co-ordinates.

Parameters:

<Crosshair> ON | OFF

DISPlay:DIAGram:FINegrid <ShowFineScale>

If ON, the crosshair is displayed as a ruler with scale markers. If OFF, the crosshair is shown as dashed lines.

Parameters:

<ShowFineScale> ON | OFF

Firmware/Software: V 1.50

DISPlay:DIAGram:LABels <ShowLabels>

If enabled, labels mark values on the x- and y-axes in specified intervals in the diagram.

Parameters:

<ShowLabels> ON | OFF

DISPlay:DIAGram:TITLe <DiagTitleState>

If enabled, the tab titles of all diagrams are displayed: "Diagram1", "Diagram2" ...

If disabled, the tab titles are not shown except for those in a tabbed diagram. In tabbed diagrams, the tab titles are required to change the tabs.

Parameters:

<DiagTitleState> ON | OFF

DISPlay:DIAGram:YFIXed <YGridFixed>

If enabled, the horizontal grid lines remain in their position when the position of the curve is changed. Only the values at the grid lines are adapted. This reflects the behavior of traditional oscilloscopes.

Parameters:

<YGridFixed>	ON | OFF

DISPlay:GATE:TRANsparency <Transparency>

Sets the transparency of the area that is defined as measurement or search gate.

Parameters:

<Transparency>	Range: 0 to 100 Increment: 1 *RST: 43 Default unit: %

Firmware/Software: FW 3.20

DISPlay:SIGBar[:STATe] <State>

If enabled, the signal bar is displayed in the diagram area.

Parameters:

<State>	ON | OFF

DISPlay:RESultboxes:DEFaultpos <State>

Defines where a new result box opens.

Parameters:

<State> PREV | FLOA

PREV
Preview: The result box opens as a minimized result icon on the signal bar. It shows only two colums and a few rows of the results.

FLOA
Floating: The result box opens as a box similar to a dialog box in front of the diagrams. It can be moved and shows all results.

LAYout:ADD <NodeName>, <ParentType>, <InsertBefore>, <FirstSource>, <DiagramName>

Adds a new diagram with a waveform on the screen, in relation to an existing diagram.

Setting parameters:

<NodeName>	String with the name of the existing diagram

<ParentType>	HORizontal | VERTical | TAB Position of the new diagram in relation to the existing one. **HORizontal** Besides the existing diagram **VERTical** Above or below the existing diagram **TAB** In a new tab in the existing diagram
<InsertBefore>	ON | OFF If on, the new diagram is inserted to the left (for HORizontal), above (for VERTical) or in a tab in front the existing diagram. HOR, ON = left to the existing diagram, defined in <NodeName> HOR, OFF = right to the existing diagram VERT, ON = above the existing diagram VERT, OFF = below the existing diagram
<FirstSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 Waveform to be displayed in the new diagram, see Chapter 16.4.2, "Waveform Parameter", on page 879. Spectrum analysis option R&S RTE-K18: Spectrograms and timeline spectrums are automatically displayed in their own diagrams.
<DiagramName>	String with the name of the new diagram.
Example:	`LAYout:ADD 'Diagram2',TAB,ON,C4W1,'MyDiagram3'` Creates a new diagram 'MyDiagram3' with waveform C4W1 in a new tab that is laid in front of 'Diagram2'.
Usage:	Setting only

LAYout:REMove <DiagramName>

Closes the specified diagram. The waveforms are displayed as minimized waveforms in their signal icons in the signal bar.

Setting parameters:

<DiagramName>	String with the name of the diagram
Usage:	Setting only

LAYout:SHOW <DiagramName>

Selects the specified diagram.

Setting parameters:

<DiagramName> String with the name of the diagram

Usage: Setting only

LAYout:SIGNal:ASSign <DiagramName>, <Source>

Shows the specified waveform in the selected diagram.

Setting parameters:

<DiagramName> String with the diagram name

<Source> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Waveform to be assigned, see Chapter 16.4.2, "Waveform Parameter", on page 879
Spectrum analysis option R&S RTE-K18: Spectrograms and timeline spectrums are automatically displayed in their own diagrams.

Usage: Setting only

LAYout:SIGNal:UNASsign <Source>

Removes the specified waveform from the diagram.

Setting parameters:

<Source> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

See Chapter 16.4.2, "Waveform Parameter", on page 879

Usage: Setting only

DISPlay:SIGBar:POSition <Position>

The signal bar can be placed vertically at the right (default position) or at the left, or horizontally at the top, bottom or center of the diagram to ensure best visibility of the waveforms.

Parameters:

<Position> LEFT | RIGHt

DISPlay:SIGBar:HIDE[:AUTO] <AutoHide>

If enabled, the signal bar disappears automatically after some time, similar to the Windows task bar. With the commands `DISPlay:SIGBar:HIDE:TIME` and `DISPlay:SIGBar:HIDE:TRANsparency`, you can define when and how the signal bar hides.

The signal bar reappears if you tap it, or if an action changes the content of the bar.

Parameters:

<AutoHide> ON | OFF

DISPlay:SIGBar:HIDE:TIME <AutoHideTime>

Sets the time when the signal bar is faded out if `DISPlay:SIGBar:HIDE[:AUTO]` is "ON".

Parameters:

<AutoHideTime> Range: 0.03 to 86.4E+3
Increment: 0.5
Default unit: s

DISPlay:SIGBar:HIDE:HEAD <HideHeadAlso>

If enabled, the "Auto hide" function hides also the horizontal and trigger label at the top of the signal bar.

Parameters:

<HideHeadAlso> ON | OFF

DISPlay:SIGBar:HIDE:TRANsparency <HidingTransparency>

Sets the transparency of the signal bar when the signal bar is faded out with `DISPlay:SIGBar:HIDE[:AUTO]`.

Parameters:

<HidingTransparency> Range: 20 to 70
Increment: 5
Default unit: %

DISPlay:SIGBar:COLor:BORDer <BorderColor>

Defines the color of the signal bar border.

See also: "To change the colors" on page 91.

Parameters:

<BorderColor> ARGB color value

Range: 0 to 4294967295
Increment: 1

DISPlay:SIGBar:COLor:FILL <FillColor>

Define the fill color of the signal bar.

See also: "To change the colors" on page 91.

Parameters:

<FillColor> ARGB color value

Range: 0 to 4294967295
Increment: 1

16.7.2.4 Waveform Labels

To create a new waveform label, use `DISPlay:SIGNal:LABel:ADD`. Using the other `DISP:SIGN:LAB:...` commands, you can query the text and position of a label, and modify the initial settings. The <LabelID> and <Source> parameters identify each label uniquely. Note that it is not possible to query the <LabelID>, or to read it on the user interface.

DISPlay:SIGNal:LABel:ADD <LabelID>, <Source>, <LabelText>, <PositionMode>, <XPositon>, <YPositon>

Creates a new waveform label for the specified source waveform.

Setting parameters:

<LabelID> String with the label identifier. The <LabelID> and <Source> parameters identify each label uniquely, so the label ID must be unique for the given waveform. Note the <LabelID> because it is not possible to query it, or to read it on the user interface.

<Source> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | QUICk | QUICK | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | AEYE1 | AEYE2 | AEYE3 | AEYE4 | SG1 | SG2 | SG3 | SG4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2

Waveform to that the label belongs, see Chapter 16.4.1, "Waveform Suffix", on page 878.

<LabelText>	String with the label text that is shown on the display
<PositionMode>	ABS | REL **ABS** Position in time and voltage values, or in other units depending on the waveform character. Absolute positions move with the waveform display when the scales, the vertical position or offset, or the reference point are changed. **REL** Fixed label position in percent of the screen counting from the upper left corner.
<XPositon>	Horizontal position of the label text. Values, range and unit depend on the position mode, the waveform position and scaling. For relative position mode, the range is 0 to 100 %.
<YPositon>	Vertical position of the label text. Values, range and unit depend on the position mode, the waveform position and scaling. For relative position mode, the range is 0 to 100 %.
Example:	`DISPlay:SIGNal:LABel:ADD 'Label1', C1W1, 'Label on C1', REL, 20, 20` Adds the label text 'Label on C1' to the channel1 waveform at relative position 20% from the upper left corner of the screen. The label ID is 'Label1'.
Example:	`DISPlay:SIGNal:LABel:ADD 'Label2', C2W1, 'Label on C2', ABS, 10e-09, 0.1` Adds the label text 'Label on C2' to the channel2 waveform at absolute position 10 ns and 0.1 V. The label ID is 'Label2'.
Usage:	Setting only

DISPlay:SIGNal:LABel:REMove <LabelID>, <Source>

Deletes the specifies waveform label.

Setting parameters:

<LabelID>	String with the label identifier.
<Source>	All waveforms that can be displayed, see `DISPlay:SIGNal:LABel:ADD`
Example:	`DISPlay:SIGNal:LABel:REMove 'Label1', C1W1`
Usage:	Setting only

DISPlay:SIGNal:LABel:TEXT <LabelID>, <Source>, <LabelText>
DISPlay:SIGNal:LABel:TEXT? <LabelID>, <Source>

Modifies or queries the text of the specified label.

Parameters:

<LabelText>	String with the label text that is shown

Parameters for setting and query:

<LabelID> String with the label identifier.

<Source> All waveforms that can be displayed, see DISPlay:SIGNal:LABel:ADD

DISPlay:SIGNal:LABel:POSMode <Source>, <PositionMode>
DISPlay:SIGNal:LABel:POSMode? <Source>

Modifies or queries the position mode: either relative to the diagram or with absolute values according to the units of the waveform. The position mode applies to all labels of the selected source. For different sources, different position modes can be selected.

Parameters:

<PositionMode> ABS | REL

ABS
Position in time and voltage values, or in other units depending on the waveform character. Absolute positions move with the waveform display when the scales, the vertical position or offset, or the reference point are changed.
Use DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition and DISPlay:SIGNal:LABel:HORizontal:RELative:POSition to set the position.

REL
Fixed label position in percent of the screen counting from the upper left corner.
Use DISPlay:SIGNal:LABel:HORizontal:RELative:POSition and DISPlay:SIGNal:LABel:VERTical:RELative:POSition to set the position.

Parameters for setting and query:

<Source> All waveforms that can be displayed, see DISPlay:SIGNal:LABel:ADD

DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition? <LabelID>, <Source>
DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition? <LabelID>, <Source>

Modifies or queries the absolute horizontal and vertical positiions of the specified label if DISPlay:SIGNal:LABel:POSMode is set to ABS.

Parameters:

<Position> Range: depends on waveform position and scaling
Default unit: s and V, or in other units depending on the waveform character

Parameters for setting and query:

<LabelID> String with the label identifier.

<Source> All waveforms that can be displayed, see DISPlay:SIGNal:LABel:ADD

Example:
```
DISPlay:SIGNal:LABel:HORizontal:ABSolute:
POSition 'Label1', C2W1, 5e-09
DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition
'Label1', C2W1, -0.1
```
Move the label to 5 ns and -0.1 V.

DISPlay:SIGNal:LABel:HORizontal:RELative:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:HORizontal:RELative:POSition? <LabelID>, <Source>
DISPlay:SIGNal:LABel:VERTical:RELative:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:VERTical:RELative:POSition? <LabelID>, <Source>

Modifies or queries the relative horizontal and vertical positiions of the specified label if DISPlay:SIGNal:LABel:POSMode is set to REL.

Parameters:

<Position> Position in percent of the screen counting from the upper left corner.

Range: 0 to 100
Default unit: %

Parameters for setting and query:

<LabelID> String with the label identifier.

<Source> All waveforms that can be displayed, see DISPlay:SIGNal:LABel:ADD

Example:
```
DISPlay:SIGNal:LABel:HORizontal:RELative:
POSition 'Label1', C1W1, 30
DISPlay:SIGNal:LABel:VERTical:RELative:POSition
'Label1', C1W1, 70
```
Move the label to new relative position: horizontal at 30 % and vertical at 70 % of the screen.

16.8 Acquisition and Setup

16.8.1 Starting and Stopping Acquisition

RUNContinous
RUN

Starts the continuous acquisition.

Usage: Event
Asynchronous command

RUNSingle
SINGle

Starts a defined number of acquisition cycles. The number of cycles is set with `ACQuire:COUNt`.

Usage: Event
Asynchronous command

STOP

Stops the running acquistion.

Usage: Event
Asynchronous command

16.8.2 Time Base

TIMebase:SCALe <TimeScale>

Sets the horizontal scale - the time per division on the x-axis - for all channel and math waveforms.

The setting accuracy depends on the current resolution (sample rate).

- No interpolation:
  The resolution is an integer multiple of the ADC sample rate.
- With interpolation:
  Any value for the horizontal scale can be set.

Parameters:

<TimeScale> Range: 25E-12 to 10000 (RTO) | 5000 (RTE)
Increment: 1E-12
*RST: 10E-9
Default unit: s/div

TIMebase:RANGe <AcquisitionTime>

Defines the time of one acquisition, that is the time across the 10 divisions of the diagram: *TimeScale*10*.

Parameters:

<AcquisitionTime> Range: 250E-12 to 100E+3 (RTO) | 50E+3 (RTE)
Increment: 1E-12
*RST: 0.5
Default unit: s

TIMebase:DIVisions?

Queries the number of horizontal divisions on the screen. The number cannot be changed.

Return values:

<HorizDivCount> Range: 4 to 20
Increment: 2
*RST: 10

Usage: Query only

TIMebase:HORizontal:POSition <RescaleCenterTime>

Defines the time distance between the reference point and the trigger point (the zero point of the diagram). The reference point marks the rescaling center of the time scale.

Parameters:

<RescaleCenterTime> Range: -100E+24 to 100E+24
Increment: 1E-12
*RST: 0
Default unit: s

Firmware/Software: V 1.50

TIMebase:REFerence <RescaleCenterPos>

Sets the position of the reference point in % of the screen. The reference point marks the rescaling center of the time scale. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compresses to both sides of the reference point.

Parameters:

<RescaleCenterPos> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

TRIGger<m>:OFFSet:LIMited <State>

If ON, the horizontal position cannot be set outside the visible waveform diagram.

See also: TIMebase:HORizontal:POSition on page 911

Suffix:

<m> 1..3
The numeric suffix is irrelevant.

Parameters:

<State> ON | OFF
*RST: OFF

AUToscale

Performs an autoset process: analyzes the enabled channel signals, and obtains appropriate horizontal, vertical, and trigger settings to display stable waveforms.

Usage: Event
Asynchronous command

ACQuire:POINts:AUTO <RecLengthManual>

Selection to keep constant either the resolution or the record length when you adjust the time scale (`TIMebase:SCALe`) or acquisition time (`TIMebase:RANGe`).

Parameters:

<RecLengthManual> RESolution | RECLength

RESolution
Resolution is kept constant. Set the required resolution value with `ACQuire:RESolution`.

RECLength
The record length is kept constant. Set the required record length value with `ACQuire:POINts[:VALue]`.

*RST: RESolution

ACQuire:POINts:AADJust <AutoAdjust>

Prevents undersampling and ensures a sufficient resolution to acquire the correct waveform if the time scale is changed. The setting takes effect if the changed parameter - resolution or record length - reaches a limit. The instrument automatically keeps this parameter constant at its limit, and changes the other parameter regardless of the `ACQuire:POINts:AUTO` setting.

Parameters:

<AutoAdjust> ON | OFF

*RST: ON

ACQuire:POINts:MAXimum <RecLengthLim>

Sets a limit for the record length to prevent very large records. This value only takes effect if a constant resolution is selected with `ACQuire:POINts:AUTO`. If you increase the time scale, the resolution remains constant and the record length increases until the limit is reached. Further increase of the time scale changes the resolution and keeps the record length limit.

Parameters:

<RecLengthLim>
Range: 1000 to 800 MSa. The actual maximum can be lower depending on the installed options, number of active channels, measurements and math waveforms.
Increment: 2
*RST: 10E+6
Default unit: Sa

ACQuire:POINts:ARATe?

Retrieves the sample rate of the ADC, that is the number of points that are sampled by the ADC in one second.

Return values:

<ADCSampleRate> Range: 10E+9 and 20E+9
*RST: 10E+9
Default unit: Sa/s

Usage: Query only

ACQuire:SRATe <SampleRate>

Defines the sample rate, that is the number of recorded waveform samples per second.

See also: "Sample rate" on page 152.

Parameters:

<SampleRate> Range: 2 to 20E+12
Increment: 1
*RST: 10E+9
Default unit: Sa/s

ACQuire:RESolution <Resolution>

Indicates the time between two waveform points in the record.

Parameters:

<Resolution> A fine resolution with low values produces a more precise waveform record.

Range: 1E-15 to 0.5
Increment: 10E-12
*RST: 100E-12
Default unit: s

ACQuire:POINts[:VALue] <RecordLength>

Indicates the record length, the number of recorded waveform points that build the waveform across the acquisition time. `[:VALue]` can be omitted.

Parameters:

<RecordLength> Number of recorded waveform points.

Range: 1000 to 1000000000
Increment: 2
*RST: 1000
Default unit: Sa

TIMebase:ROLL:ENABle <Mode>

Activates the automatic roll mode.

Parameters:

<Mode>	AUTO | OFF AUTO: the instrument activates the roll mode under specific conditions. See also "Roll mode" on page 153. *RST: AUTO

TIMebase:ROLL:STATe?

Returns the status of the roll mode.

Return values:

<State>	ON | OFF *RST: OFF
Usage:	Query only

TIMebase:ROLL:MTIMe <MinHorizGain>

The roll mode is enabled automatically if the acquisition time exceeds the given value, and if `TIMebase:ROLL:ENABle` is set to AUTO.

Parameters:

<MinHorizGain>	Treshold value for roll mode enabling. Range: 1 to 600 Increment: 1 *RST: 10 Default unit: s

16.8.3 Acquisition

ACQuire:MODE <EnhancementMode>

Selects the method of adding waveform points to the samples of the ADC in order to fill the record length.

See also: "Resolution enhancement" on page 155.

Parameters:

<EnhancementMode>| RTIMe | ITIMe

RTIMe
Real Time Mode: The sampled points of the input signal are used to build the waveform, no waveform points are added.

ITIMe
Interpolated time: Interpolation of waveform points with the method set by the interpolation mode, see `ACQuire:INTerpolate` on page 915.

*RST: ITIMe

ACQuire:INTerpolate <IntpolMode>

Selects the interpolation method-

See also: "Interpolation" on page 156.

Parameters:

<IntpolMode> LINear | SINX | SMHD

LINear
Linear interpolation between two adjacent sample points

SINX
Interpolation by means of a sin(x)/x curve.

SMHD
Sample/Hold causes a histogram-like interpolation.

*RST: SINX

CHANnel<m>[:WAVeform<n>][:STATe] <State>

Activates or deactivates a waveform. `[:STATe]` can be omitted.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Parameters:

<State> ON | OFF

*RST: OFF

CHANnel<m>[:WAVeform<n>]:TYPE <DecimationMode>

Selects the method to reduce the data stream of the ADC to a stream of waveform points with lower sample rate.

See also:"Decimation" on page 156.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 [:WAVeform<n>] is irrelevant, omit it.

Parameters:

<DecimationMode> SAMPle | PDETect | HRESolution | RMS

SAMPle
One of n samples in a sample interval of the ADC is recorded as waveform point.

PDETect
Peak Detect: the minimum and the maximum of n samples in a sample interval are recorded as waveform points.

HRESolution
High resolution: The average of n sample points is recorded as waveform point.

RMS
The waveform point is the root mean square of n sample values.

*RST: SAMPle

ACQuire:CMODode <CoupleAcquSet>

Sets the acquisition mode and the waveform arithmetic of all channels to the last set value.

Parameters:

<CoupleAcquSet> ON | OFF

*RST: ON

Firmware/Software: FW 3.20

CHANnel<m>[:WAVeform<n>]:ARIThmetics <TrArith>

Selects the method to build the resulting waveform from several consecutive acquisitions of the signal. To define the number of acquisitions, use `ACQuire:COUNt`.

See also: "Arithmetic" on page 157.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 [:WAVeform<n>] is irrelevant, omit it.

Parameters:

<TrArith>	OFF | ENVelope | AVERage **OFF** The data of the current acquisition is recorded according to the decimation settings. **ENVelope** Detects the minimum and maximum values in an sample interval over a number of acquisitions. To define the reset method, use ... **AVERage** Calculates the average from the data of the current acquisition and a number of acquisitions before. *RST: OFF

ACQuire:COUNt <MaxAcqCount>

The acquisition and average count has a double effect:

- It sets the number of waveforms acquired with `RUNSingle`.
- It defines the number of waveforms used to calculate the average waveform.

Parameters:

<MaxAcqCount>	Range: 1 to 16777215 Increment: 10 *RST: 1

ACQuire:ARESet:IMMediate

Forces the immediate restart of the envelope and average calculation for all waveforms.

Usage: Event

Firmware/Software: V 1.36

16.8.4 Ultra Segmentation

ACQuire:SEGMented:STATe <State>

Switches the Ultra Segmentation mode on and off.

See also: Chapter 4.2.3, "Ultra Segmentation", on page 158.

Parameters:

<State>	ON | OFF *RST: OFF

ACQuire:SEGMented:MAX <MaxAcquisitions>

The number of acquisitions in a Ultra Segmentation acquisition series depends on the record length.

Parameters:

<MaxAcquisitions> ON | OFF

ON
The maximum possible number of acquisitions in a series is used.

OFF
Acquires the number of acquisitions defined using `ACQuire:COUNt`.

*RST: OFF

ACQuire:SEGMented:AUToreplay <EnabReplayAfterAcq>

If enabled, the instrument starts processing and displaying the data as soon as the acquisition series is captured completely. Depending on the number of acquisitions, it may take some time until the acquisition series is displayed. If the setting is disabled, the instrument only captures the data and stores it in the sample memory.

Parameters:

<ReplayAfterAcq> ON | OFF

*RST: ON

Firmware/Software: FW 1.40

16.8.5 Vertical

CHANNel<m>:STATe <State>

Switches the channel signal on or off.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<State> ON | OFF

*RST: OFF

CHANnel<m>:COUPling <Coupling>

Selects the connection of the indicated channel signal.

Suffix:

<m> 1..4

Selects the input channel.

Parameters:

<Coupling> DC | DCLimit | AC

DC

Direct connection with 50 Ωtermination.

DCLimit

Direct connection with 1 MΩ termination.

AC

Connection through DC capacitor.

*RST: DCLimit

CHANnel<m>:GND <State>

Connects the signal to the ground.

Suffix:

<m> 1..4

Parameters:

<State> ON | OFF

*RST: OFF

CHANnel<m>:SCALe <Scale>

Sets the vertical scale for the indicated channel.

Suffix:

<m> 1..4

Selects the input channel.

Parameters:

<Scale> Scale value, given in Volts per division.

Range: Depends on attenuation factors, coupling, and instrument model. With 1:1 probe and external attenuations and 50 Ω input coupling, the vertical scale (input sensitivity) is minimum 1 mV/div (RTO, RTE 1317.2500) or 0.5 mV/div (RTE 1326.2000) to maximum 1 V/div. For 1 MΩ input coupling, the upper limit is 10 V/div. If the probe and/or external attenuation is changed, multiply the values by the attenuation factors to get the actual scale range.

Increment: Depends on vertical and probe settings

*RST: 0.05

Default unit: V/div

CHANnel<m>:RANGe <Range>

Sets the voltage range across the 10 vertical divisions of the diagram. Use the command alternativly instead of `CHANnel<m>:SCALe`.

Suffix:

<m> 1..4

Selects the input channel.

Parameters:

<Range> Voltage range value

Range: Depends on attenuation factors and coupling. With 1:1 probe and external attenuations and 50 Ω input coupling, the range is 10 mV to 10 V. For 1 MΩ input coupling, it is 10 mV to 100 V. If the probe and/or external attenuation is changed, multiply the range values by the attenuation factors.

Increment: Depends on vertical and probe settings

*RST: 0.5

Default unit: V/div

CHANnel<m>:POSition <Position>

Sets the vertical position of the indicated channel as a graphical value.

Suffix:

<m> 1..4

Selects the input channel.

Parameters:

<Position>	Positive values move the waveform up, negative values move it down. Range: -5 to 5 Increment: 0.01 *RST: 0 Default unit: div

CHANnel<m>:OFFSet <Offset>

The offset voltage is subtracted to correct an offset-affected signal. The offset of a signal is determined and set by the autoset procedure.

See also: "Offset" on page 162

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Offset>	Negative values move the waveform up, positive values move it down. Range: Depends on attenuation factors, input coupling, and the offset compensation range of active probes. The nominal offset range for 1:1 attenuation and probe offset compensation = 0 is specified in the data sheet. Increment: Depends on vertical and probe settings *RST: 0 Default unit: V

CHANnel<m>:INVert <InvertChannel>

Turns the inversion of the signal amplitude on or off. To invert means to reflect the voltage values of all signal components against the ground level. If the inverted channel is the trigger source, the instrument triggers on the inverted signal.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<InvertChannel>	ON | OFF *RST: OFF

Firmware/Software: FW 3.30

CHANnel<m>:BANDwidth <BandwidthLimit>

Selects the bandwidth limit for the indicated channel.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<BandwidthLimit> FULL | B200 | B20

FULL
Use full bandwidth.

B200 | B20
Limit to 200 MHz or 20 MHz.

*RST: FULL

CHANnel<m>:IMPedance <Impedance>

Sets the impedance of the channel for power calculations and measurements.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Impedance>
Range: 1 to 100E+3
Increment: 1
*RST: 50
Default unit: Ohm

CHANnel<m>:OVERload <Overload>

Retrieves the overload status of the specified channel from the status bit. When the overload problem is solved, the command resets the status bit.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Overload> ON | OFF

Use OFF to reset the overload status bit.

*RST: OFF

Example:

`CHANnel2:OVERload?`
Queries the overload status of channel 2.
`CHANnel2:OVERload OFF`
Resets the overload status bit.

16.8.6 Waveform Data

To set the export data format, see FORMat[:DATA] on page 887.

CHANnel<m>[:WAVeform<n>]:DATA:HEADer?

Returns the header of channel waveform data.

Table 16-1: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of one waveform	200000
4	Number of values per sample interval. For most waveforms the result is 1, for peak detect and envelope waveforms it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).	1

If multichannel export is enabled, the number of returned samples is *Record length * Number of exported waveforms*. See also EXPort:WAVeform:MULTichannel.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Example:
```
CHAN1:WAV1:DATA:HEAD?
-9.477E-008,9.477E-008,200000,1
```

Usage: Query only
SCPI confirmed

CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?

Returns the data of the channel waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use FORMat[:DATA].

You can retrieve only Y-values (usually voltage values), or X- and Y-values. Use EXPort:WAVeform:INCXvalues to define this.

If multichannel export is active (EXPort:WAVeform:MULTichannel), the channel suffix is ignored. To select the channels to be exported, use CHANnel<m>:EXPortstate. The Y-values are written in interleaved order, for example, $YCh1_0$; $YCh2_0$; $YCh1_1$; $YCh2_1$... for a 2-channel instrument.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Return values:

<Data> List of values according to the format and content settings.

Example:

```
FORM ASC
EXP:WAV:INCX OFF
CHAN1:WAV1:DATA?
-0.125000,-0.123016,-0.123016,-0.123016,
-0.123016,-0.123016,...
```

Usage: Query only

16.8.7 Probes

16.8.7.1 General Settings and Passive Probes

TRPRobe:SETup:STATe?
PROBe<m>:SETup:STATe?

Queries if the probe at the specified input channel is active (detected) or not active (not detected). To switch the probe on, use `CHANnel<m>:STATe`.

Suffix:

<m>	1..4

Return values:

<State>	DETected | NDETected	
	*RST:	NDETected

Usage: Query only

TRPRobe:SETup:TYPE?
PROBe<m>:SETup:TYPE?

Queries the type of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Type>	String containing one of the following values: – None (no probe detected) – Passive Probe – active single-ended

Usage: Query only

TRPRobe:SETup:NAME?
PROBe<m>:SETup:NAME?

Queries the name of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Name>	Name string

Usage: Query only

TRPRobe:SETup:BANDwidth?
PROBe<m>:SETup:BANDwidth?

Queries the bandwidth of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Bandwidth>	Range: 1E+6 to 20E+9 *RST: 1E+9 Default unit: Hz

Usage: Query only

TRPRobe:SETup:ATTenuation:MODE <ProbeAttMode>
PROBe<m>:SETup:ATTenuation:MODE <ProbeAttMode>

Set the mode to MANual if the instrument does not detect the probe.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ProbeAttMode>	AUTO | MANual *RST: AUTO

TRPRobe:SETup:ATTenuation[:AUTO]?
PROBe<m>:SETup:ATTenuation[:AUTO]?

Queries the attenuation of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<ProbeAttModeAuto>	Range: 1E-3 to 1000 *RST: 1 Default unit: V/V

Usage: Query only

TRPRobe:SETup:ATTenuation:UNIT <ProbeAttUnit>
PROBe<m>:SETup:ATTenuation:UNIT <ProbeAttUnit>

Sets the unit for the connected probe type if `PROBe<m>:SETup:ATTenuation:MODE` on page 926 is set to `MANual`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ProbeAttUnit>	V | A | W Voltage probe (V), current probe (A), power probe (W) *RST: V

TRPRobe:SETup:ATTenuation:MANual <AttManual>
PROBe<m>:SETup:ATTenuation:MANual <AttManual>

Sets the attenuation for the connected probe if `PROBe<m>:SETup:ATTenuation:MODE` on page 926 is set to `MANual`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<AttManual>	Range: 100E-6 to 10000 Increment: 0.1 *RST: 1 Default unit: depends on the selected unit

---

TRPRobe:SETup:GAIN:MANual <GainManual>
PROBe<m>:SETup:GAIN:MANual <GainManual>

Sets the gain of a current probe.

Suffix:

<m>	1..4 Selects the input channel. The number of channels depends on the instrument.

Parameters:

<GainManual>	Range: 100E-6 to 10000 Increment: 100E-6 *RST: 1 Default unit: V/A

TRPRobe:SETup:OFFSet:AZERo
PROBe<m>:SETup:OFFSet:AZERo
PROBe<m>:SETup:OFFSet:USEautozero <UseAutoZeroOffss>

Includes the AutoZero offset in measurement results. The auto zero error is detected with `PROBe<m>:SETup:OFFSet:AZERo`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<UseAutoZeroOffss>	ON | OFF	
	*RST:	OFF

Firmware/Software: Version 2.70

CHANnel<m>:EATScale <ExtAttScale>

Sets the attenuation scale for an external divider.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<ExtAttScale>	LIN | LOG	
	*RST:	LIN

CHANnel<m>:EATTenuation <ExtAtt>

Sets the attenuation of an external voltage divider that is part of the DUT before the measuring point. The external attenuation is included in the measurement, and the instrument shows the results that would be measured before the divider.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<ExtAtt> Values and unit depend on the selected scale (`CHANnel<m>:EATScale`).

Range:	Linear scale: 1E-3 to 1E+6, logarithmic scale: -60 dB to 120 dB
Increment:	0.01
*RST:	1

16.8.7.2 Active Probes R&S RT-ZS and R&S RT-ZD

TRPRobe:SETup:MODE <Mode>
PROBe<m>:SETup:MODE <Mode>

Select the action that is started when you press the micro button on the probe head.

See also: "Micro button action" on page 172.

Suffix:

<m> 1..4

Selects the input channel.

Parameters:

<Mode> RCONtinuous | RSINgle | AUToset | AZERo | SEToffsettomean | PRINt | SITFile | NOACtion | FINDtriglevel | REPort | PROBemode

RCONtinuous
Run continuous: The acquisition is running as long as the probe button is pressed.

RSINgle
Run single: starts one acquisition.

AUTOSET
Starts the autoset procedure.

AZero
AutoZero: performs an automatic correction of the zero error.

SEToffsettomean
Set offset to mean: performs an automatic compensation for a DC component of the input signal.

PRINt
Prints the current display according to the printer set with `SYSTem:COMMunicate:PRINter:SELect<1..2>`.

SITFile
Save Image To File:
Directs the display image to a file. The `MMEMory:NAME` command defines the file name. The file format is defined with `HCOPy:DEVice<m>:LANGuage`.

NOACtion
Nothing is started on pressing the micro button.

FINDtriglevel
Sets the trigger level automatically to*0.5 * (MaxPeak – MinPeak)*. The function is not available for an external trigger source.

REPort
Creates and saves a report of the current results.

PROBemode
Only available for R&S RT-ZM probes. Changes the measurement mode of the probe.

*RST: RCONtinuous

TRPRobe:SETup:CMOFfset <CMOffset>
PROBe<m>:SETup:CMOFfset <CMOffset>

Sets the common-mode offset. The setting is only available for differential probes.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<CMOffset>	Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

TRPRobe:SETup:ZAXV <RTZA15>
PROBe<m>:SETup:ZAXV <RTZA15>

If you use the external attenuator R&S RT-ZA15 together with one of the differential active probes R&S RT-ZD10/20/30, enable it to include the external attenuation in the measurements.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<RTZA15>	ON | OFF *RST: OFF

16.8.7.3 R&S ProbeMeter

TRPRobe:SETup:DISPlaydiff <DisplayDiff>
PROBe<m>:SETup:DISPlaydiff <DisplayDiff>

Selects the input voltages to be measured by the ProbeMeter of an R&S differential active probe.

See also: "Differential Active Probes" on page 149.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<DisplayDiff> DIFFerential | SINGleended

DIFFerential
Measures differential and common mode voltages

SINGleended
Measures the voltage between the positive/negative signal socket and the ground.

*RST: DIFFerential

TRPRobe:PMETer:VISibility <Visibility>
PROBe<m>:PMETer:VISibility <Visibility>

Activates the integrated R&S ProbeMeter of active R&S probes.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Visibility> ON | OFF

*RST: OFF

Firmware/Software: FW 2.25

TRPRobe:PMETer:RESults:SINGle?
PROBe<m>:PMETer:RESults:SINGle?

ProbeMeter measurement result of single-ended active R&S probes

Returns the voltage measured between the probe tip and the ground.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<Result> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

TRPRobe:PMETer:RESults:COMMon?
PROBe<m>:PMETer:RESults:COMMon?

ProbeMeter measurement result of differential active R&S probes

Returns the common mode voltage - the mean voltage between the signal sockets and the ground socket.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<Result> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

TRPRobe:PMETer:RESults:DIFFerential?
PROBe<m>:PMETer:RESults:DIFFerential?

ProbeMeter measurement result of differential active R&S probes

Returns the differential voltage - the voltage between the positive and negative signal sockets.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<Result> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

TRPRobe:PMETer:RESults:NEGative?
PROBe<m>:PMETer:RESults:NEGative?

ProbeMeter measurement result of differential active R&S probes

Returns the voltage that is measured between the negative signal socket and the ground.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<Result>
Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

TRPRobe:PMETer:RESults:POSitive?
PROBe<m>:PMETer:RESults:POSitive?

ProbeMeter measurement result of differential active R&S probes

Returns the voltage that is measured between the negative signal socket and the ground.

Suffix:

<m>
1..4
Selects the input channel.

Return values:

<Result>
Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

16.8.7.4 Predefined Probes

TRPRobe:SETup:ATTenuation:DEFProbe <SelectedPredefinedProbe>
PROBe<m>:SETup:ATTenuation:DEFProbe <PredefinedProbe>

Selects a predefined probe. These are probes that are not recognized automatically but the parameters of the probe are known to the instrument.

Suffix:

<m>
1..4
Selects the input channel.

Parameters:

<PredefinedProbe>	ZC10 | ZC20 | ZC30 | ZD01A100 | ZD01A1000 | ZZ80 | FREE **ZC10 | ZC20 | ZC30** Current probe R&S RT-ZC10, R&S RT-ZC20, or R&S RT-ZC30 **ZD01A100 | ZD01A1000** High voltage differential probe R&S RT-ZD01, attenuation ratio 100:1 or 1000:1 according to the setting on the probe control box **ZZ80** Transmission line passive probe R&S RT-ZZ80 **FREE** Any other probe that is not recognized by the instrument. *RST: FREE
Firmware/Software:	V 1.27

TRPRobe:SETup:OFFSet:TOMean
PROBe<m>:SETup:OFFSet:TOMean

Performs an automatic compensation for a DC component of the specified input signal using the result of a background mean measurement.

Suffix:

<m>	1..4 Selects the input channel.
Usage:	Event

16.8.7.5 Current Probes

To set up R&S RT-ZC10 and R&S RT-ZC20, use `PROBe<m>:SETup:ATTenuation:DEFProbe`.

TRPRobe:SETup:DEGauss
PROBe<m>:SETup:DEGauss

Demagnetizes the core if it has been magnetized by switching the power on and off, or by an excessive input. Always carry out demagnetizing before measurement. The demagnetizing process takes about one second.

Suffix:

<m>	1..4 Selects the input channel.
Usage:	Event

Firmware/Software: FW 2.50

PROBe<m>:SETup:OFFSet:STPRobe

Saves the zero adjust value in the probe box. If you connect the probe to another channel or to another R&S RTx oscilloscope, the value is read out again.

Suffix:

<m> 1..4
Selects the input channel.

Usage: Event

PROBe<m>:SETup:OFFSet:ZADJust <ZeroAdjustValue>

set the waveform to zero position. It corrects the effect of a voltage offset or temperature drift. To set the value by the instrument, use `PROBe<m>:SETup:OFFSet:AZERo`.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<ZeroAdjustValue> Range: -100 to 100
Increment: 0.1
*RST: 0
Default unit: %

Firmware/Software: FW 2.50

16.8.7.6 Probe Attributes

TRPRobe:ID:SWVersion?
PROBe<m>:ID:SWVersion?

Queries the version of the probe firmware.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<Softwareversion> Version number in a string.

Usage: Query only

TRPRobe:ID:PRDate?
PROBe<m>:ID:PRDate?

Queries the production date of the probe.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<ProductionDate> Date in a string.

Usage: Query only

TRPRobe:ID:PARTnumber?
PROBe<m>:ID:PARTnumber?

Queries the R&S part number of the probe.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<PartNumber> Part number in a string.

Usage: Query only

TRPRobe:ID:SRNumber?
PROBe<m>:ID:SRNumber?

Queries the serial number of the probe.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<SerialNo> Serial number in a string.

Usage: Query only

TRPRobe:SETup:CAPacitance?
PROBe<m>:SETup:CAPacitance?

Queries the input capacitance of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<InputCapacity>	Range: 100E-15 to 1E-9 *RST: 10E-12 Default unit: F

Usage: Query only

TRPRobe:SETup:IMPedance?
PROBe<m>:SETup:IMPedance?

Queries the termination of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<InputImpedance>	Range: 100E-15 to 1E+9 *RST: 50 Default unit: Ω

Usage: Query only

16.8.8 Digital Filter

CHANnel<m>:DIGFilter:STATe <State>

Enables the DSP filter for input channels.

Suffix:

<m>	1..4 Irrelevant, omit the suffix. The filter is enabled to all channels.

Parameters:

<State>	ON | OFF *RST: OFF

TRIGger<m>:RFReject <Bandwidth>

Sets the limit frequency for input channels and the trigger source.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

Parameters:

<Bandwidth> Range: 100E+3 to 4E+9
Increment: 1000
*RST: 1E+6
Default unit: Hz

TRIGger<m>:RFSReject <HFRejectTrigger>

Enables the DSP filter for the trigger channel. Frequencies higher than the bandwidth (`TRIGger<m>:RFReject`) are rejected, lower frequencies pass the filter.

Suffix:

<m> 1..3
The suffix is irrelevant.

Parameters:

<HFRejectTrigger> ON | OFF
*RST: OFF

16.8.9 Skew

CHANnel<m>:SKEW:MANual <ManualCompensation>

If enabled, the skew offset value (`CHANnel<m>:SKEW:TIME`) is used for compensation. This improves horizontal and trigger accuracy.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<ManualCompensation> ON | OFF
*RST: ON

CHANnel<m>:SKEW:TIME <Offset>

Sets an delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically. It affects only the selected input channel.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<Offset>	Range: -100E-9 to 100E-9 Increment: 1E-12 *RST: 0 Default unit: s

16.8.10 AUX OUT

CALibration:SOURce:FREQuency <Frequency>

Frequency value and waveform type of the internal calibration source.

Parameters:

<Frequency>	GHZ1 **GHZ1** 1 GHz sine wave generated by the mainboard. *RST: GHZ1

Example:

```
CAL:SOUR:FREQ GHZ1
CAL:SOUR:STAT ON
```

The commands activate the 1 GHz reference frequency.

CALibration:SOURce:STATe <State>

Defines the state of the internal calibration source.

Parameters:

<State>	ON | OFF *RST: OFF

16.8.11 High Definition (Option R&S RTE-K17)

HDEFinition:STATe <State>

Activates the high definition mode of the instrument.

Parameters:

<State>	ON | OFF ON: high definition mode, up to 16 bit digital resolution OFF: normal oscilloscope mode *RST: OFF	

HDEFinition:BWIDth <Bandwidth>

Sets the filter bandwidth for the high definition mode.

Parameters:

<Bandwidth>	Range:	10000 to max. 1 GHz, depending on the instrument bandwidth.
	Increment:	1000
	*RST:	1E+6
	Default unit:	Hz

See "Bandwidth" on page 164 for bandwidth limits.

HDEFinition:RESolution?

Returns the resulting digital resolution in high definition mode.

Return values:

<Resolution>	Range:	0 to 16
	Increment:	0.1
	*RST:	0

Usage: Query only

FORMat:BORDer <ByteOrder>

Sets the endianess.

The command is only relevant for raw data export in high definition mode (16 bit word length).

Parameters:

<ByteOrder>	LSBFirst | MSBFirst LSB first: little endian, least significant byte first MSB first: big endian, most significant byte first *RST: LSBFirst	

16.8.12 Reference Clock

You can select an internal or external reference clock.

SENSe[:ROSCillator]:SOURce <RefOscillatorSrc>

Enables the use of the external reference signal instead of the internal OCXO reference.

Parameters:

<RefOscillatorSrc>	INTernal | EXTernal	
	*RST:	INTernal

SENSe[:ROSCillator]:EXTernal:FREQuency <ExternalRef>

Sets the frequency of an external reference input signal that is connected to the external reference input on the rear panel.

Parameters:

<ExternalRef>	Range:	RTO: 1E+6 to 20E+6. RTE: 10E+6
	Increment:	RTO: 1E+6. RTE: none
	*RST:	10E+6
	Default unit:	Hz

16.9 Trigger

16.9.1 Basic Trigger Settings

DISPlay:TRIGger:LINes <State>

Hides or shows the trigger levels in the diagrams.

Parameters:

<State> ON | OFF

*RST: OFF

TRIGger<m>:SOURce <SourceDetailed>

Selects the source of the trigger signal.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = not available
Available values depend on the selected trigger source. For input channels CHAN1...4, a trigger sequence can be configured.
For all other trigger sources, only suffix 1 is allowed.
See also: `TRIGger<m>:SEQuence:MODE`

Parameters:

<SourceDetailed> CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 | EXTernanalog | LINE | SBUS | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | LOGIC | MSOB1 | MSOB2 | MSOB3 | MSOB4

CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4
Input channels

EXTernanalog
External analog signal connected to the External Trigger Input. For this source, only the analog edge trigger is available.

LINE
The instrument generates the trigger from the AC power input and synchronizes the signal to the AC power frequency.

SBUS
Serial bus

D0...D15
Digital channels (option R&S RTE-B1)
See also: Chapter 16.18.4, "Trigger Settings for Digital Signals and Parallel Buses", on page 1543

LOGIc
Logic combination of digital channels, used as trigger source (option R&S RTE-B1)

MSOB1 | MSOB2 | MSOB3 | MSOB4
Parallel bus (option R&S RTE-B1)

*RST: CHAN1

TRIGger<m>:TYPE <Type>

Selects the trigger type to trigger on analog channels or the external trigger input.

See also: Chapter 5.3, "Trigger Types", on page 191.

To trigger on digital channels and parallel buses, use `TRIGger<m>:PARallel:TYPE`.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = not available
For suffix 2, only the EDGE trigger type is available.
For suffix 3, the following trigger types are availabe: GLITch, WIDTh, RUNT, WINDow, TIMeout, INTerval, SLEWrate.

Parameters:

<Type> EDGE | GLITch | WIDTh | RUNT | WINDow | TIMeout | INTerval | SLEWrate | DATatoclock | STATe | PATTern | ANEDge | SERPattern | TV

Most of the type values are self-explanatory.

DATatoclock
Data2Clock: analyzes the relative timimg between a data signal and the synchronous clock signal. For trigger settings, see Chapter 16.9.10, "Data2Clock Trigger", on page 961.

ANEDge
Edge trigger for external trigger input. Only available if the trigger source is the EXT TRIGGER INPUT on the rear panel. This trigger type uses the analog input signal. For trigger settings, see Chapter 16.9.2, "Edge Trigger", on page 945.
See also: "External trigger input" on page 189

SERPattern
Serial Pattern for signals with serial data patterns in relation to a clock signal. For trigger settings, see Chapter 16.9.13, "Serial Pattern Trigger", on page 968

*RST: EDGE

TRIGger<m>:LEVel<n>[:VALue] <Level>

Sets the trigger level for the specified event and source.

If the trigger source is serial bus, the trigger level is set by the thresholds in the protocol configuration.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = not available

<n> 1..11
Indicates the trigger source:
1...4 = channel 1 to 4
5 = external trigger input
6...9 and 11 = not available
10 = line trigger

Parameters:

<Level> Voltage for the trigger level.

Range: Depends on vertical scale, channel offset and other settings. The trigger level must be within the current display range.
Increment: 1E-3
*RST: 0
Default unit: V

Example:
`TRIG:LEV5 0.01`
Sets the trigger level for the external trigger signal to 10 mV.
`TRIG2:LEV3 0.2`
Sets the trigger level for the B-event and B-trigger source channel 3 to 200 mV.

TRIGger<m>:FINDlevel

Sets the trigger level automatically. The command is only relevant if the trigger source is an analog channel CHAN1...4.

Suffix:
<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = not available

Usage: Event
Asynchronous command

16.9.2 Edge Trigger

TRIGger<m>:EDGE:SLOPe <Slope>

Defines the edge for the edge trigger event.

Suffix:
<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = not available

Parameters:
<Slope> POSitive | NEGative | EITHer
See Chapter 16.4.3, "Slope Parameter", on page 880.
*RST: POSitive

TRIGger<m>:ANEDge:COUPling <Coupling>

Sets the coupling for the external trigger signal.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Coupling> DC | DCLimit | AC

DC
Direct connection with 50 Ω termination, passes both DC and AC components of the trigger signal.

DCLimit
Direct connection with 1 MΩ termination, passes both DC and AC components of the trigger signal.

AC
Connection through DC capacitor, removes DC and very low-frequency components.

*RST: DCLimit

TRIGger<m>:ANEDge:FILTer <Filter>

Sets a filter for the external trigger signal to reject high or low frequencies.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Filter> OFF | LFReject | RFReject

OFF
The trigger signal is not filtered.

LFReject
Frequencies higher than the "Cut-off" frequency are rejected, lower frequencies pass the filter.
You can adjust the "Cut-off" frequency using the `TRIGger<m>:ANEDge:CUToff:LOWPass` command, the default is 50 kHz.

RFReject
Frequencies below the "Cut-off" frequency are rejected, higher frequencies pass the filter.
You can adjust the "Cut-off" frequency using the `TRIGger<m>:ANEDge:CUToff:HIGHpass` command, the default is 50 kHz.

*RST: OFF

TRIGger<m>:ANEDge:CUToff:HIGHpass <AnalogCutOffHP>

Frequencies below the "Cut-off" frequency are rejected, higher frequencies pass the filter.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<AnalogCutOffHP> KHZ5 | KHZ50 | MHZ50

Cut-off frequency

KHZ5
5 kHz

KHZ50
50 kHz

MHZ50
50 MHz

*RST: KHZ50

TRIGger<m>:ANEDge:CUToff:LOWPass <AnalogCutOffLP>

Frequencies higher than the "Cut-off" frequency are rejected, lower frequencies pass the filter.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<AnalogCutOffLP> KHZ5 | KHZ50 | MHZ50

KHZ5
5 kHz

KHZ50
50 kHz

MHZ50
50 MHz

*RST: KHZ50

TRIGger<m>:ANEDge:GND <Ground>

Connects the analog signal to the ground.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Ground> ON | OFF

*RST: OFF

TRIGger<m>:ANEDge:SLOPe <Slope>

Sets the edge for the trigger event.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<Slope> POSitive | NEGative
See Chapter 16.4.3, "Slope Parameter", on page 880.
*RST: POSitive

16.9.3 Glitch Trigger

The glitch trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:GLITch:POLarity <Polarity>

Defines the polarity of a pulse, that is the direction of the first pulse slope.

Suffix:
<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:
<Polarity> POSitive | NEGative | EITHer
See Chapter 16.4.4, "Polarity Parameter", on page 880.
*RST: POSitive

TRIGger<m>:GLITch:RANGe <RangeMode>

Selects which glitches are identified: shorter or longer than the width specified using `TRIGger<m>:GLITch:WIDTh`.

Suffix:
<m> 1 | 3
1 = A-trigger, 2 | 3 = not availabe

Parameters:
<RangeMode> SHORter | LONGer

SHORter
Glitches shorter than the specified width are identified.

LONGer
Glitches longer than the specified width are identified.

*RST: SHORter

TRIGger<m>:GLITch:WIDTh <Width>

Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value, depnding on the `TRIGger<m>:GLITch:RANGe` command.

You need to know the expected pulse widths of the circuit to set the glitch width correctly.

Suffix:

<m>	1 | 3 1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Width>	Range: 100E-12 to 10000 Increment: 100E-6 *RST: 1E-9 Default unit: s

16.9.4 Width Trigger

The width trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:WIDTh:POLarity <Polarity>

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Polarity>	POSitive | NEGative See Chapter 16.4.4, "Polarity Parameter", on page 880. *RST: POSitive

TRIGger<m>:WIDTh:RANGe <RangeMode>

Defines how the range of a pulse width is defined in relation to the width and delta specified using `TRIGger<m>:WIDTh:WIDTh` and `TRIGger<m>:WIDTh:DELTa`, respectively.

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range is defined by the width ±delta.

OUTSide
Triggers on pulses outside a given range. The range is defined by the width ±delta.

SHORter
Triggers on pulses shorter than the given width.

LONGer
Triggers on pulses longer than the given width.

*RST: WITHin

TRIGger<m>:WIDTh:WIDTh <Width>

For the ranges "Within" and "Outside" (defined using `TRIGger<m>:WIDTh:RANGe`), the width defines the center of a range which is defined by the limits "±Delta" (see `TRIGger<m>:WIDTh:DELTa` on page 950).

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Width> Range: 100E-12 to 10000
Increment: 100E-9
*RST: 5E-9
Default unit: s

TRIGger<m>:WIDTh:DELTa <WidthDelta>

Defines a range around the width value specified using `TRIGger<m>:WIDTh:WIDTh`.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<WidthDelta> Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

16.9.5 Runt Trigger

The runt trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:RUNT:POLarity <Polarity>

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Polarity>	POSitive | NEGative | EITHer See Chapter 16.4.4, "Polarity Parameter", on page 880. *RST: POSitive

---

TRIGger<m>:LEVel<n>:RUNT:UPPer <Level>

Sets the upper voltage threshold.

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe
<n>	1..11 Indicates the trigger source: 1...4 = channel 1...4 5...11 = not available

Parameters:

<Level>	Range: -10 to 10 Increment: 1E-3 *RST: 0.1 Default unit: V

TRIGger<m>:LEVel<n>:RUNT:LOWer <Level>

Sets the lower voltage threshold.

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe

<n>	1..11 Indicates the trigger source: 1...4 = channel 1...4 5...11 = not available

Parameters:

<Level>	Range: -10 to 10 Increment: 1E-3 *RST: -0.1 Default unit: V

TRIGger<m>:RUNT:RANGe <Mode>

Defines the time limit of the runt pulse in relation to the `TRIGger<m>:RUNT:WIDTh` and `TRIGger<m>:RUNT:DELTa` settings.

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Mode> ANY | LONGer | SHORter | WITHin | OUTSide

ANY
Triggers on all runts fulfilling the level condition, without time limitation.

LONGer
Triggers on runts longer than the given "Runt width".

SHORter
Triggers on runts shorter than the given "Runt width".

WITHin
Triggers if the runt length is inside a given time range. The range is defined by "Runt width" and "±Delta".

OUTSide
Triggers if the runt length is outside a given time range. The range is defined by "Runt width" and "±Delta".

*RST: ANY

TRIGger<m>:RUNT:WIDTh <Width>

Defines the upper or lower voltage threshold. This command is not available if `TRIGger<m>:RUNT:RANGe` is set to "ANY".

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Width>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 5E-9 Default unit: s

---

TRIGger<m>:RUNT:DELTa <WidthDelta>

Defines a range around the runt width specified using `TRIGger<m>:RUNT:WIDTh`. This command is only available if `TRIGger<m>:RUNT:RANGe` is set to "WITHin" or "OUTSide".

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe

Parameters:

<WidthDelta>	Range: 100E-12 to 864 Increment: 100E-9 *RST: 100E-12 Default unit: s

16.9.6 Window Trigger

The window trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:LEVel<n>:WINDow:UPPer <Level>

Sets the upper voltage limit for the window.

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe
<n>	1..11 Indicates the trigger source: 1...4 = channel 1...4 5...11 = not available

Parameters:

<Level>	Range: -10 to 10 Increment: 1E-3 *RST: 0.1 Default unit: V

TRIGger<m>:LEVel<n>:WINDow:LOWer <Level>

Sets the lower voltage limit for the window.

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe
<n>	1..11 Indicates the trigger source: 1...4 = channel 1...4 5...11 = not available

Parameters:

<Level>	Range: -10 to 10 Increment: 1E-3 *RST: -0.1 Default unit: V

TRIGger<m>:WINDow:RANGe <RangeMode>

Defines the signal run in relation to the window:

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe

Parameters:

<RangeMode> ENTer | EXIT | WITHin | OUTSide

ENTer
Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.

EXIT
Triggers when the signal leaves the window.

WITHin
Triggers if the signal stays between the upper and lower level for a specified time. The time is defined using the `TRIGger<m>:WINDow:TIME` command.

OUTSide
Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is defined using the `TRIGger<m>:WINDow:TIME` command.

*RST: ENTer

TRIGger<m>:WINDow:TIME <TimeRangeMode>

Defines the limit of the window in relation to the time specified using `TRIGger<m>:WINDow:WIDTh` and `TRIGger<m>:WINDow:DELTa`. Time conditioning is available for `TRIGger<m>:WINDow:RANGe`= "WITHin" and "OUTSide".

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<TimeRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width - Delta* and for *Width + Delta* at the most.

OUTSide
"Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width - Delta* or longer than *Width + Delta*.

SHORter
Triggers if the signal crosses vertical limits before the specified "Width" time is reached.

LONGer
Triggers if the signal crosses vertical limits before the specified "Width" time is reached.

*RST: WITHin

TRIGger<m>:WINDow:WIDTh <Width>

For the ranges "Within" and "Outside" (defined using `TRIGger<m>:WINDow:RANGe`), the width defines the center of a time range which is defined by the limits "±Delta" (see `TRIGger<m>:WINDow:DELTa` on page 955).

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Width> Range: 100E-12 to 10000
Increment: 100E-9
*RST: 5E-9
Default unit: s

TRIGger<m>:WINDow:DELTa <WidthDelta>

Defines a range around the "Width" value specified using `TRIGger<m>:WINDow:WIDTh`.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<WidthDelta> Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

16.9.7 Timeout Trigger

The timeout trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:TIMeout:RANGe <TimeoutMode>

Defines the relation of the signal level to the trigger level.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

HIGH
The signal level stays above the trigger level.

LOW
The signal level stays below the trigger level.

EITHer
The signal level stays above or below the trigger level.

*RST: HIGH

TRIGger<m>:TIMeout:TIME <Time>

Defines the time limit for the timeout at which the instrument triggers.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Time> Range: 100E-12 to 10000
Increment: 100E-9
*RST: 100E-9
Default unit: s

16.9.8 Interval Trigger

The interval trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:INTerval:SLOPe <Slope>

Sets the edge for the trigger. You can analyze the interval between positive edges or between negative edges.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Slope> POSitive | NEGative

See Chapter 16.4.3, "Slope Parameter", on page 880.

*RST: POSitive

Firmware/Software: Version 2.70
The command replaces `TRIGger<m>:INTerval:POLarity`.

TRIGger<m>:INTerval:RANGe <RangeMode>

Defines the range of an interval in relation to the interval width specified using `TRIGger<m>:INTerval:WIDTh` and `TRIGger<m>:INTerval:DELTa`.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range is defined by the interval width ±delta.

OUTSide
Triggers on pulses outside a given range. The range is defined by the interval width ±delta.

SHORter
Triggers on pulses shorter than the given interval width.

LONGer
Triggers on pulses longer than the given interval width.

*RST: OUTSide

TRIGger<m>:INTerval:WIDTh <Width>

Defines the time between two pulses.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Width> Range: 100E-12 to 10000
Increment: 100E-9
*RST: 5E-9
Default unit: s

TRIGger<m>:INTerval:DELTa <WidthDelta>

Defines a range around the "Interval width" value specified using `TRIGger<m>:INTerval:WIDTh` on page 957.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<WidthDelta> Range: 0 to 10
Increment: 100E-9
*RST: 0
Default unit: s

16.9.9 Slew Rate Trigger

The slew rate trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:SLEW:SLOPe <Slope>

Selects the edge type for the trigger event.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Slope> POSitive | NEGative | EITHer
See Chapter 16.4.3, "Slope Parameter", on page 880.
*RST: POSitive

TRIGger<m>:LEVel<n>:SLEW:UPPer <Level>

Defines the upper voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe
<n>	1..11 Indicates the trigger source: 1...4 = channel 1...4 5...11 = not available

Parameters:

<Level>	Range: -10 to 10 Increment: 1E-3 *RST: 0.1 Default unit: V

TRIGger<m>:LEVel<n>:SLEW:LOWer <Level>

Defines the lower voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe
<n>	1..11 Indicates the trigger source: 1...4 = channel 1...4 5...11 = not available

Parameters:

<Level>	Range: -10 to 10 Increment: 1E-3 *RST: -0.1 Default unit: V

TRIGger<m>:SLEW:RANGe <RangeMode>

Defines the time limit for the slew rate in relation to the upper or lower trigger level (see `TRIGger<m>:SLEW:RATE` on page 960 and `TRIGger<m>:SLEW:DELTa` on page 960). The time measurement starts when the signal crosses the first trigger level - the upper or lower level depending on the selected slope - and stops when the signal crosses the second level.

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe

Parameters:

<RangeMode> INSRange | OUTRange | LTHan | GTHan

INSRange
Triggers on pulses inside a given range. The range is defined by the slew rate ±delta.

OUTRange
Triggers on pulses outside a given range. The range is defined by the slew rate ±delta.

LTHan
Triggers on pulses shorter than the given slew rate.

GTHan
Triggers on pulses longer than the given slew rate.

*RST: GTHan

TRIGger<m>:SLEW:RATE <Time>

For the ranges "Within" and "Outside", the slew rate defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the slew rate defines the maximum and minimum slew rate limits, respectively. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope (see `TRIGger<m>:SLEW:SLOPe` on page 958).

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Time>
Range: 100E-12 to 10000
Increment: 100E-9
*RST: 100E-12
Default unit: s

TRIGger<m>:SLEW:DELTa <TimeDelta>

Defines a time range around the slew rate specified using `TRIGger<m>:SLEW:RATE`.

Suffix:

<m> 1..3
1 = A-trigger, 2 | 3 = not availabe

Parameters:

<TimeDelta>
Range: 0 to 10
Increment: 100E-9
*RST: 0
Default unit: s

16.9.10 Data2Clock Trigger

The Data2Clock trigger is only available for the A-event (Suffix = 1).

TRIGger<m>:DATatoclock:CSOurce[:VALue] <ClockSource>

Selects the source of the clock signal.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockSource> CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4

CHAN1 = CHANnel1, CHAN2 = CHANnel2, CHAN3 = CHANnel3, CHAN4 = CHANnel4
Input channel of the clock signal

*RST: CHAN1

TRIGger<m>:DATatoclock:CSOurce:EDGE <ClockEdge>

Sets the edge of the clock signal to define the time reference point for the setup and hold time.

Suffix:

<m> 1
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockEdge> POSitive | NEGative | EITHer

See Chapter 16.4.3, "Slope Parameter", on page 880.

*RST: POSitive

TRIGger<m>:DATatoclock:CSOurce:LEVel <ClockLevel>

Sets the voltage level for the clock signal. Both this command and `TRIGger<m>:DATatoclock:CSOurce:EDGE` define the starting point for calculation of the setup and hold time.

Suffix:

<m> 1
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockLevel> Range: -10 to 10
Increment: 1E-3
*RST: 0
Default unit: V

TRIGger<m>:SCOupling <TrigLevSrcCoup>

Sets the trigger levels of all channels to the value of channel 1 for the indicated trigger event.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = not available

Parameters:

<TrigLevSrcCoup> ON | OFF
*RST: OFF

TRIGger<m>:DATatoclock:HTIMe <HoldTime>

Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

The hold time can be negative. In this case, the setup time is always positive. The setup/hold interval starts before the clock edge (setup time) and ends before the clock edge (hold time). If you change the negative hold time, the setup time is adjusted by the intrument.

Suffix:

<m> 1
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<HoldTime> Range: -99.999E-9 to 100E-9
Increment: 1E-9
*RST: 0
Default unit: s

TRIGger<m>:DATatoclock:STIMe <SetupTime>

Sets the minimum time **before** the clock edge while the data signal must stay steady above or below the data level.

The setup time can be negative. In this case, the hold time is always positive. The setup/hold interval starts after the clock edge (setup time) and ends after the clock edge (hold time). If you change the negative setup time, the hold time is adjusted by the instrument.

Suffix:

<m> 1
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<SetupTime>	Range: -99.999E-9 to 100E-9 Increment: 1E-9 *RST: 0 Default unit: s

16.9.11 State Trigger

The state trigger combines the edge trigger settings with trigger qualification. It is not available for the B-event (Suffix = 2).

Use the following commands:

- `TRIGger<m>:EDGE:SLOPe` on page 945
- `TRIGger<m>:LEVel<n>[:VALue]` on page 944
- `TRIGger<m>:SCOupling` on page 962

TRIGger<m>:QUALify<n>:A[:ENABle] <State>
TRIGger<m>:QUALify<n>:B[:ENABle] <State>
TRIGger<m>:QUALify<n>:C[:ENABle] <State>
TRIGger<m>:QUALify<n>:D[:ENABle] <State>

The command is relevant for pattern trigger and for state trigger.

Select the channels to be considered:

- A[:ENABle]: CH1
- B[:ENABle]: CH3
- C[:ENABle]: CH2
- D[:ENABle]: CH4

The trigger source cannot be enabled.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	1..17 Trigger type: 10 = State, 11 = Pattern, all other suffixes are not available

Parameters:

<State>	ON | OFF **ON** The qualification expression is considered. **OFF** The qualification expression is ignored. *RST: OFF

TRIGger<m>:QUALify<n>:A:LOGic <Operator>
TRIGger<m>:QUALify<n>:B:LOGic <Operator>

TRIGger<m>:QUALify<n>:C:LOGic <Operator>
TRIGger<m>:QUALify<n>:D:LOGic <Operator>

Defines the logic for the indicated channel:

- A: CH1
- B: CH3
- C: CH2
- D: CH4

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	1..17 Trigger type: 10 = State, 11 = Pattern, all other suffixes are not available

Parameters:

<Operator>	DIRect | NOT **DIRect** Input value remains unchanged **NOT** Input value is inverted *RST: DIRect

---

TRIGger<m>:QUALify<n>:AB:LOGic <Operator>
TRIGger<m>:QUALify<n>:CD:LOGic <Operator>
TRIGger<m>:QUALify<n>:ABCD:LOGic <Operator>

Defines the logical combination of the indicated channels after evaluating the previous logical operations:

- AB: CH1 and CH3
- CD: CH2 and CH4
- ABCD: result of AB and CD

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	1..17 Trigger type: 10 = State, 11 = Pattern, all other suffixes are not available

Parameters:

<Operator> AND | NAND | OR | NOR

AND
logical AND, conjunctive combination

NAND
logical NOT AND

OR
logical OR, disjunctive combination

NOR
logical NOT OR

*RST: AND

16.9.12 Pattern Trigger

The pattern trigger is only available for the A-event (Suffix = 1).

The pattern is defined using the commands:

- `TRIGger<m>:QUALify<n>:A[:ENABle]` on page 963
- `TRIGger<m>:QUALify<n>:A:LOGic` on page 963
- `TRIGger<m>:QUALify<n>:AB:LOGic` on page 964

These are the commands for channel 1, use the similar commands for channels 2, 3, and 4.

TRIGger<m>:PATTern:MODE <Mode>

Adds additional time limitation to the pattern definition.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Mode> OFF | TIMeout | WIDTh

OFF
No time limitation. The event occurs if the pattern condition is fulfilled.

TIMeout
Defines how long the result of the pattern condition must be true or false. The duration of the timeout is defined using `TRIGger<m>:PATTern:TIMeout[:TIME]`.

WIDTh
Defines a time range for keeping up the true result of the pattern condition. The range is defined using `TRIGger<m>:PATTern:WIDTh:RANGe`.

*RST: OFF

TRIGger<m>:PATTern:TIMeout:MODE <TimeoutMode>

Defines the condition for the timeout.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<TimeoutMode> HIGH | LOW

HIGH
The result stays high.

LOW
The result stays low.

*RST: HIGH

TRIGger<m>:PATTern:TIMeout[:TIME] <Time>

Defines how long the result of the pattern condition must be true or false.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Time> Range: 100E-12 to 10000
Increment: 100E-9
*RST: 100E-9
Default unit: s

TRIGger<m>:PATTern:WIDTh:RANGe <WidthRangeMode>

Defines how the range of a pulse width is defined for keeping up the true result of the pattern condition. The width and delta are specified using `TRIGger<m>:PATTern:WIDTh[:WIDTh]` and `TRIGger<m>:PATTern:WIDTh:DELTa`, respectively.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<WidthRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range is defined by the width ±delta.

OUTSide
Triggers on pulses outside a given range. The range is defined by the width ±delta.

SHORter
Triggers on pulses shorter than the given width.

LONGer
Triggers on pulses longer than the given width.

*RST: WITHin

TRIGger<m>:PATTern:WIDTh[:WIDTh] <Width>

For the ranges "Within" and "Outside" (defined using `TRIGger<m>:PATTern:WIDTh:RANGe`), the width defines the center of a range which is defined by the limits "±Delta" (see `TRIGger<m>:PATTern:WIDTh:DELTa` on page 967).

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Width>
Range: 100E-12 to 10000
Increment: 100E-9
*RST: 5E-9
Default unit: s

TRIGger<m>:PATTern:WIDTh:DELTa <WidthDelta>

Defines a range around the width value specified using `TRIGger<m>:PATTern:WIDTh[:WIDTh]`.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<WidthDelta> Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

16.9.13 Serial Pattern Trigger

The serial pattern trigger is only available for the A-event (Suffix = 1).

TRIGger<m>:SPATtern:CSOurce[:VALue] <ClockSource>

Defines the source of the clock signal.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockSource> CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4

CHAN1 = CHANnel1, CHAN2 = CHANnel2, CHAN3 = CHANnel3, CHAN4 = CHANnel4
Input channel of the clock signal

*RST: CHAN1

TRIGger<m>:SPATtern:CSOurce:EDGE <ClockEdge>

Together with the clock level (see `TRIGger<m>:SPATtern:CSOurce:LEVel` on page 969), the clock edge defines the point in time when the state of the data signal is checked.

Suffix:

<m> 1
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockEdge> POSitive | NEGative | EITHer

See Chapter 16.4.3, "Slope Parameter", on page 880.

*RST: POSitive

TRIGger<m>:SPATtern:CSOurce:LEVel <ClockLevel>

Defines the voltage level for the clock signal.

Suffix:

<m>	1 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockLevel>	Range: -10 to 10 Increment: 1E-3 *RST: 0 Default unit: V

TRIGger<m>:SPATtern:PATTern <Pattern>

The pattern contains the bits of the serial data to be found in the data stream. The maximum length of the pattern is 128 bit.

Suffix:

<m>	1 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Pattern>	Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

16.9.14 TV/Video Trigger

The TV or video trigger requires a channel input as trigger source (`TRIGger<m>:SOURce`). It is only available for the A-event (Suffix = 1).

Make sure to set the trigger level - the threshold of the sync pulse - with `TRIGger<m>:LEVel<n>[:VALue]`.

TRIGger<m>:TV:STANdard <Standard>

Sets the TV standard.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<Standard> CUSTom | PAL | PALM | NTSC | SECam | P480L60HZ | P720L30HZ | P720L50HZ | P720L60HZ | I1080L50HZ | I1080L60HZ | P1080L24HZ | P1080L24HZSF | P1080L25HZ | P1080L30HZ | P1080L50HZ | P1080L60HZ

CUSTom
User-defined signal. Configure the signal using:
`TRIGger<m>:TV:CUSTom:SCANmode`
`TRIGger<m>:TV:CUSTom:STYPe`
`TRIGger<m>:TV:CUSTom:LDURation`
`TRIGger<m>:TV:CUSTom:SDURation`

PAL | PALM | NTSC | SECam
SDTV standards. PALM = PAL-M

PxxxxLyyHZ
HDTV standards using progressive scanning (P). xxxx indicates the number of active lines, yy is the frame rate.

IxxxxLxxHZ
HDTV standards using interlaced scanning (I). xxxx indicates the number of active lines, yy is the field rate.

P1080L24HZSF
1080p/24sF is a HDTV standard using progressive segmented frame scanning.

*RST: PAL

Firmware/Software: FW 1.40

TRIGger<m>:TV:MODE <Mode>

Selects the lines or fields on which the instrument can trigger. Available modes depend on the scanning system.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Mode> ALL | ODD | EVEN | ALINe | LINE

ALL
All fields, triggers on the frame start (progressive scanning) or field start (interlaced and progressive segmented frame scanning)

ODD | EVEN
Only available for interlaced scanning and progressive segmented frame scanning. Triggers on the field start of the odd or even field.

ALINe
All lines, triggers on all line starts.

LINE
Triggers on a specified line. To set the line number, use TRIGger<m>:TV:LINE. For NTSC signals, set also the field with TRIGger<m>:TV:LFIeld.

*RST: ALL

Firmware/Software: FW 1.40

TRIGger<m>:TV:POLarity <Polarity>

Sets the polarity of the *signal*. Note that the sync pulse has the opposite polarity, for example, a positive signal has a negative sync pulse.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Polarity> POSitive | NEGative

*RST: POSitive

Firmware/Software: FW 1.40

TRIGger<m>:TV:LINE <LineNumber>

Specifies the line number to trigger on. The command is relevant if TRIGger<m>:TV:MODE is set to LINe.

Usually the lines of the frame are counted beginning from the frame start. For NTSC signals, the lines are counted per field, not per frame. For these signals, set also the field with TRIGger<m>:TV:LFIeld.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<LineNumber> Range: Depends on the standard, see table below
Increment: 1
*RST: 1

Firmware/Software: FW 1.40

Standard	Minimum value	Maximum value
PAL	1	625
PAL-M	1	525
NTSC	1	263 in odd field 262 in even field
SECAM	1	625
480p/60 (`P480L60HZ`)	1	525
720p/30 (`P720L30HZ`) 720p/50 (`P720L50HZ`) 720p/60 (`P720L60HZ`)	1	750
1080i/50 (`I1080L50HZ`) 1080i/60 (`I1080L60HZ`) 1080p/24 (`P1080L24HZ`) 1080p/24sF (`P1080L24HZSF`) 1080p/25 (`P1080L25HZ`) 1080p/30 (`P1080L30HZ`) 1080p/50 (`P1080L50HZ`) 1080p/60 (`P1080L60HZ`)	1	1125

TRIGger<m>:TV:LFIeld <LineField>

The commands is only relevant for NTSC signals and sets the field in which the line number is counted.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<LineField> FIELD1 | FIELd1 | FIELD2 | FIELd2

FIELD1 = FIELd1 = odd field
FIELD2 = FIELd2 = even field

*RST: FIELD1

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:SCANmode <ScanMode>

Sets the scanning system. Only relevant if `TRIGger<m>:TV:STANdard` is set to `CUSTom`.

See also: "Scan" on page 216.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ScanMode> INTerlaced | PROGressive | SEGMented

SEGMented: Progressive segmented frame uses progressive scanning to capture the frame, and interlaced scanning for transmission and display.

*RST: INTerlaced

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:LDURation <LinePeriod>

Sets the duration of a line, the time between two successive sync pulses. Only relevant if `TRIGger<m>:TV:STANdard` is set to `CUSTom`.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<LinePeriod> Range: 1E-6 to 500E-6
Increment: 100E-9
*RST: 64E-6
Default unit: s

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:STYPe <SyncPulseType>

Sets the type of the sync pulse. Only relevant if `TRIGger<m>:TV:STANdard` is set to `CUSTom`.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<SyncPulseType> BILevel | TRILevel

BILevel
Bi-level sync pulse, usually used in SDTV signals

TRILevel
Tri-level sync pulse, used in HDTV signals

*RST: BILevel

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:SDURation <SyncPulseDuration>

Sets the width of the sync pulse. Only relevant if `TRIGger<m>:TV:STANdard` is set to `CUSTom`.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<SyncPulseDuration> Range: 100E-9 to 100E-6
Increment: 100E-9
*RST: 4.7E-6
Default unit: s

Firmware/Software: FW 1.40

16.9.15 Holdoff

TRIGger<m>:HOLDoff:MODE <Mode>

Selects the method to define the holdoff condition.

The trigger holdoff defines when the next trigger after the current will be recognized. Thus, it affects the next trigger to occur after the current one. Holdoff helps to obtain stable triggering when the oscilloscope is triggering on undesired events.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Mode> TIME | EVENts | RANDom | AUTO | OFF

TIME
Defines the holdoff directly as a time period. The next trigger occurs only after the "Holdoff time" has passed (defined using `TRIGger<m>:HOLDoff:TIME`).

EVENts
Defines the holdoff as a number of trigger events. The next trigger occurs only when this number of events is reached. The number of triggers to be skipped is defined using `TRIGger<m>:HOLDoff:EVENts`.

RANDom
Defines the holdoff as a random time limited by `TRIGger<m>:HOLDoff:MIN` on page 976 and `TRIGger<m>:HOLDoff:MAX` on page 976. For each acquisition cycle, the instrument selects a new random holdoff time from the specified range.

AUTO
The holdoff time is calculated automatically based on the current horizontal scale.

OFF
No holdoff

*RST: OFF

TRIGger<m>:HOLDoff:TIME <Time>

Defines the holdoff time period. The next trigger occurs only after this time has passed. The setting is relevant if the holdoff mode is set to TIME.

See also:

- `TRIGger<m>:HOLDoff:MODE`

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Time> Range: 100E-9 to 10
Increment: 200E-6
*RST: 1E-3
Default unit: s

Example:

```
TRIGger1:HOLDoff:MODE TIME
TRIGger<m>:HOLDoff:TIME 1ms
```

The holdoff time is set to 1 ms.

TRIGger<m>:HOLDoff:EVENts <Events>

Defines the number of triggers to be skipped. The next trigger only occurs when this number of events is reached. The setting is relevant if the holdoff mode is set to EVENts.

See also:

- `TRIGger<m>:HOLDoff:MODE`

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Events>	Range:	1 to 2147483647
	Increment:	1
	*RST:	1

Example:

```
TRIGger1:HOLDoff:MODE EVENts
TRIGger<m>:HOLDoff:EVENts 5
```

TRIGger<m>:HOLDoff:MIN <RandomMinTime>

Defines the lower limit for the random time holdoff. The setting is relevant if the holdoff mode is set to RANDom.

See also:

- `TRIGger<m>:HOLDoff:MODE`
- `TRIGger<m>:HOLDoff:MAX`

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<RandomMinTime>	Range:	100E-9 to 5
	Increment:	200E-6
	*RST:	1E-3
	Default unit:	s

Example:

```
TRIGger1:HOLDoff:MODE RANDom
TRIGger<m>:HOLDoff:MIN 1ms
TRIGger<m>:HOLDoff:MAX 2ms
```

The holdoff time is set randomly between 1 ms and 2 ms.

TRIGger<m>:HOLDoff:MAX <RandomMaxTime>

Defines the upper limit for the random time holdoff. The setting is relevant if the holdoff mode is set to RANDom.

See also:

- `TRIGger<m>:HOLDoff:MODE`

- TRIGger<m>:HOLDoff:MIN

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<RandomMaxTime>	Range: 100E-9 to 10 Increment: 200E-6 *RST: 2E-3 Default unit: s

---

TRIGger<m>:HOLDoff:AUTotime?

Returns the resulting holdoff time if the holdoff mode is set to AUTO: *Auto time = Auto time scaling * Horizontal scale*. The auto time scaling factor is defined with TRIGger<m>:HOLDoff:SCALing.

See also: TRIGger<m>:HOLDoff:MODE

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Return values:

<AutoTime>	Holdoff time Range: 100E-9 to 10 *RST: 1E-3 Default unit: s

Example:

```
TRIGger1:HOLDoff:MODE AUTO
TRIGger1:HOLDoff:SCALing 0.5
TRIGger<m>:HOLDoff:AUTotime?
1ms
```

Result if the horizontal scale is 1 ns/div

Usage: Query only

TRIGger<m>:HOLDoff:SCALing <AutoTimeScaling>

Sets the auto time scaling factor the horizontal scale is multipied with: *Auto time = Auto time scaling * Horizontal scale*. The setting is relevant if the holdoff mode is set to AUTO.

See also:

- TRIGger<m>:HOLDoff:MODE
- TRIGger<m>:HOLDoff:AUTotime? on page 977

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<AutoTimeScaling>	Range:	1E-3 to 1000
	Increment:	1
	*RST:	0.5

16.9.16 Noise Reject

TRIGger<m>:LEVel<n>:NOISe[:STATe] <HysteresisMode>

Selects how the hysteresis is set.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

<n> 1..11
Indicates the trigger source:
1...4 = channel 1 to 4
5 = external trigger input
6...9 and 11 = not available
10 = line trigger

Parameters:

<HysteresisMode> AUTO | MANual

AUTO
This is the recommended mode. The hysteresis is set by the instrument to reject at least the internal noise of the instrument. You can define a higher minimum value using `TRIGger<m>:LEVel<n>:NOISe:ABSolute`.

MANual
The hysteresis is defined directly with `TRIGger<m>:LEVel<n>:NOISe:ABSolute`.

*RST: AUTO

TRIGger<m>:LEVel<n>:NOISe:MODE <HystSizeMode>

Selects how the hysteresis is set.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

<n> 1..11
Indicates the trigger source:
1...4 = channel 1 to 4
5 = external trigger input
6...9 and 11 = not available
10 = line trigger

Parameters:
<HystSizeMode> ABS | REL

ABS
The hysteresis is set in absolute values (voltage).

REL
The hysteresis is defined in relative values (div).

*RST: ABS

TRIGger<m>:LEVel<n>:NOISe:ABSolute <HystAbs>

Defines a range in absolute values around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:
<m> 1..3
Irrelevant, omit the suffix.

<n> 1..11
Indicates the trigger source:
1...4 = channel 1 to 4
5 = external trigger input
6...9 and 11 = not available
10 = line trigger

Parameters:
<HystAbs>
Range: 0 to the value corresponding to five divisions. The exact maximum value depends on the selected vertical scale.
Increment: 1E-3
*RST: 0
Default unit: V

TRIGger<m>:LEVel<n>:NOISe:RELative <HystRel>

Defines a range in percent around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:
<m> 1..3
Irrelevant, omit the suffix.

<n> 1..11
Indicates the trigger source:
1...4 = channel 1 to 4
5 = external trigger input
6...9 and 11 = not available
10 = line trigger

Parameters:

<HystRel> Range: 0 to 50
Increment: 1
*RST: 0
Default unit: %

TRIGger<m>:ANEDge:NREJect <NoiseReject>

Enables the noise reject for the external trigger input.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<NoiseReject> ON | OFF
*RST: OFF

Firmware/Software: FW 2.25

16.9.17 Trigger Sequence

TRIGger<m>:SEQuence:MODE <Type>

Selects the type of the sequence.

See also: Chapter 5.7, "Sequence", on page 223.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

Parameters:

<Type>	AONLy | AB **AONLy** Triggers only on A-events. Additionally, a holdoff condition can be set. if AONLy sequence is set, all inputs (input channels, serial and parallel buses, digital channels etc.) can be used as trigger source. **AB** Triggers if all conditions of A- and B-events, as well as additional delay and waiting conditions are fulfilled. This trigger sequence requires that analog input channels CHAN1...4 are set as trigger sources for all events. *RST: AONLy

---

TRIGger<m>:SEQuence:DELay <Delay>

Sets the time the instrument waits after an A-event until it recognizes B-events.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<Delay>	Range: 0 to 50 Increment: 1E-12 *RST: 0 Default unit: s

---

TRIGger<m>:SEQuence:COUNt <Events>

Sets the number of B-events to be fulfilled after an A-event. The last B-event causes the trigger.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<Events>	Range: 1 to 2147483647 Increment: 1 *RST: 1

16.9.18 Trigger Control

TRIGger<m>:MODE <TriggerMode>

Sets the trigger mode which determines the behaviour of the instrument if no trigger occurs.

See also: "Trigger mode" on page 220

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

Parameters:

<TriggerMode> AUTO | NORMal | FREerun

AUTO
The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. The time interval depends on the time base.

NORMal
The instrument acquires a waveform only if a trigger occurs.

FREerun
The instrument triggers after a very short time interval - faster than in AUTO mode. Real triggers are ignored

*RST: AUTO

TRIGger<m>:FORCe

If the acquisition is running in normal mode and no valid trigger occurs, forcing the trigger provokes an immediate single acquisition. Thus you can confirm that a signal is available and use the waveform display to determine how to trigger on it.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

Usage: Event

TRIGger<m>:OUT:STATe <State>

Enables/disbales the trigger out signal that is provided to the TRIGGER OUTPUT connector on the rear panel when a trigger occurs.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

Parameters:

<State> ON | OFF

*RST: OFF

TRIGger<m>:OUT:POLarity <Polarity>

Sets the polarity of the trigger out pulse.

Suffix:

<m> 1..3

Irrelevant, omit the suffix.

Parameters:

<Polarity> POSitive | NEGative

*RST: POSitive

TRIGger<m>:OUT:PLENgth <PulseLength>

Sets the length of the trigger out pulse.

Suffix:

<m> 1..3

Irrelevant, omit the suffix.

Parameters:

<PulseLength> Range: 4E-9 to 1E-3

Increment: 20E-9

*RST: 100E-9

Default unit: s

TRIGger<m>:OUT:DELay <Delay>

Sets the delay of the first pulse edge to the trigger point.

The settin gis not available if a mask test or measurement is running and the on-violation event is set to trigger out pulse.

Suffix:

<m> 1..3

Irrelevant, omit the suffix.

Parameters:

<Delay> Range: 800E-9 to 1

Increment: 1E-9

*RST: 800E-9

Default unit: s

16.9.19 Actions on Trigger

TRIGger<m>:EVENt:BEEP <Beep>

Generates a beep sound if the command is set to `TRIGger`.

Suffix:

<m> 1..3
The suffix is irrelevant.

Parameters:

<Beep> NOAction | TRIGger
*RST: NOAction

TRIGger<m>:EVENt:PRINt <Print>

Saves a screenshot at each trigger if the command is set to `TRIGger`.

For screenshot settings, see Chapter 16.16.7, "Screenshots", on page 1155.

Suffix:

<m> 1..3
The suffix is irrelevant.

Parameters:

<Print> NOAction | TRIGger
*RST: NOAction

TRIGger<m>:EVENt:WFMSave <SaveWfm>

Saves the waveform data to file at each trigger if the command is set to `TRIGger`.

For data export settings, see Chapter 16.16.4, "Waveform Data Export to File", on page 1146.

Suffix:

<m> 1..3
The suffix is irrelevant.

Parameters:

<SaveWfm> NOAction | TRIGger
*RST: NOAction

16.9.20 External Trigger Input

To control the external trigger signal, the TRPRobe commands are used. The required commands depend on the used probe type. They work in the same way as the PROBe commands. For details, see Chapter 16.8.7, "Probes", on page 924

TRIGger<m>:EXTern:OVERload <Overload>

The query returns the overload status of the external trigger input.

`:TRIGger:EXTern:OVERload 0` confirms the information in the message box, it has same effect as OK.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Overload>	ON | OFF **ON | 1** Iindicates an overload of the probe **OFF | 0** In a query: no overlaod. Ssetting: confirms the information in the message box *RST: OFF

16.9.21 Acquisition Info

ACQuire:CURRent?

Shows the current number of acquisitions that have been acquired.

Return values:

<CurrAcqCount>	Range: 0 to 4294967295 Increment: 1 *RST: 0

Usage: Query only

16.10 Waveform Analysis

16.10.1 Zoom

LAYout:ZOOM:ADD <NodeName>, <ParentType>, <InsertBefore>, <XStart>, <XStop>, <YStart>, <YStop>, <NewZoomName>

Adds a new zoom diagram based on the specified waveform.

Setting parameters:

<NodeName> String with the name of diagram to be zoomed

<ParentType> VERTical, OFF
The new zoom diagram is displayed below the original one.

<InsertBefore> OFF
Position of the zoom diagram, depending on `ParentType`

<XStart> Defines the x-value at the beginning of the zoom area.

<XStop> Defines the x-value at the end of the zoom area.

<YStart> Defines the y-value at the beginning of the zoom area.

<YStop> Defines the y-value at the end of the zoom area.

<NewZoomName> String with the name of the new zoom diagram.

Example:
```
LAYout:ZOOM:ADD 'Diagram1', VERT, OFF, -10e-9,
20e-9, -0.1, 0.05, 'MyZoom1'
```
Creates the zoom diagram 'MyZoom1' for 'Diagram1'.

Example: See Chapter 16.3.1.1, "Creating Zoom Diagrams", on page 865

Usage: Setting only

LAYout:ZOOM:ADDCoupled <ZoomName>, <XOffset>, <YOffset>, <NewZoomName>

Creates a new zoom diagram based on the settings of an existing zoom area for the same source.

Parameters:

<NewZoomName> Defines the name of the new zoom diagram.

Setting parameters:

<ZoomName> Defines the name of the zoom diagram to be copied.

<XOffset> Defines an offset to the existing zoom area in x direction.

<YOffset> Defines an offset to the existing zoom area in y direction.

LAYout:ZOOM:ONEDiagram <ShowInOne>

Shows all zooms of a diagram in one zoom window. The zoomed areas are overlaid for better comparison of the zoomed waveforms.

The command takes effect on all zoom diagrams.

Parameters:

<ShowInOne> ON | OFF

*RST: OFF

LAYout:ZOOM:POSCoupling <DiagramName>, <ZoomName>, <PositionCoupl>
LAYout:ZOOM:POSCoupling? <DiagramName>, <ZoomName>

Enables or disables the position coupling of coupled zooms. If position coupling is enabled and one zoom area is moved, the other coupled zoom areas are moved, too, and keep their distance.

Parameters:

<PositionCoupl> ON | OFF

*RST: OFF

Parameters for setting and query:

<DiagramName> String with the name of the diagram on which the zoom is based

<ZoomName> String with the name of the zoom diagram

LAYout:ZOOM:HORZ:MODE <DiagramName>, <ZoomName>,<Mode>
LAYout:ZOOM:HORZ:MODE? <DiagramName>, <ZoomName>

Defines whether absolute or relative values are used to specify the x-axis values. Since the zoom area refers to the active signal, relative values ensure that the zoom area remains the same.

Parameters:

<Mode> ABS | REL

Mode used to specify the x-axis values of the zoom area.

*RST: ABS

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

Example: See Chapter 16.3.1.1, "Creating Zoom Diagrams", on page 865

LAYout:ZOOM:HORZ:ABSolute:POSition <DiagramName>, <ZoomName>,<Position>
LAYout:ZOOM:HORZ:ABSolute:POSition? <DiagramName>, <ZoomName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<Position> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:SPAN <DiagramName>, <ZoomName>,<Span>
LAYout:ZOOM:HORZ:ABSolute:SPAN? <DiagramName>, <ZoomName>

Defines the width of the zoom area.

Parameters:

<Span> Range: 0 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:STARt <DiagramName>, <ZoomName>,<Start>
LAYout:ZOOM:HORZ:ABSolute:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the x-axis.

Parameters:

<Start> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:STOP <DiagramName>, <ZoomName>,<Stop>
LAYout:ZOOM:HORZ:ABSolute:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the x-axis.

Parameters:

<Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:HORZ:RELative:POSition <DiagramName>, <ZoomName>,<RelPosi>
LAYout:ZOOM:HORZ:RELative:POSition? <DiagramName>, <ZoomName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<RelPosi> Relative position of the centerpoint (x-value)

Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

Example: See Chapter 16.3.1.1, "Creating Zoom Diagrams", on page 865

LAYout:ZOOM:HORZ:RELative:SPAN <DiagramName>, <ZoomName>,<RelativeSpan>
LAYout:ZOOM:HORZ:RELative:SPAN? <DiagramName>, <ZoomName>

Defines the width of the zoom area.

Parameters:

<RelativeSpan> Range: 1E-15 to 100
Increment: 0.1
*RST: 1
Default unit: %

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

Example: See Chapter 16.3.1.1, "Creating Zoom Diagrams", on page 865

LAYout:ZOOM:HORZ:RELative:STARt <DiagramName>, <ZoomName>,<RelativeStart>
LAYout:ZOOM:HORZ:RELative:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the x-axis.

Parameters:

<RelativeStart> Range: 0 to 100
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:HORZ:RELative:STOP <DiagramName>, <ZoomName>,<RelativeStop>
LAYout:ZOOM:HORZ:RELative:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the x-axis.

Parameters:

<RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:MODE <DiagramName>, <ZoomName>,<Mode>
LAYout:ZOOM:VERTical:MODE? <DiagramName>, <ZoomName>

Defines whether absolute or relative values are used to specify the y-axis values. Since the zoom area refers to the active signal, relative values ensure that the zoom area remains the same.

Parameters:

<Mode> ABS | REL

Mode used to specify the y-axis values of the zoom area.

*RST: ABS

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:POSition <DiagramName>, <ZoomName>,<Position>
LAYout:ZOOM:VERTical:ABSolute:POSition? <DiagramName>, <ZoomName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<Position> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:SPAN <DiagramName>, <ZoomName>,<Span>
LAYout:ZOOM:VERTical:ABSolute:SPAN? <DiagramName>, <ZoomName>

Defines the height of the zoom area.

Parameters:

<Span> Range: 0 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:STARt <DiagramName>, <ZoomName>,<Start>
LAYout:ZOOM:VERTical:ABSolute:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the y-axis.

Parameters:

<Start> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:STOP <DiagramName>, <ZoomName>,<Stop>
LAYout:ZOOM:VERTical:ABSolute:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the y-axis.

Parameters:

<Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:POSition <DiagramName>, <ZoomName>,<RelPosi>
LAYout:ZOOM:VERTical:RELative:POSition? <DiagramName>, <ZoomName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<RelPosi> Relative position of the centerpoint (y-value)

Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:SPAN <DiagramName>, <ZoomName>,<RelativeSpan>
LAYout:ZOOM:VERTical:RELative:SPAN? <DiagramName>, <ZoomName>

Defines the height of the zoom area.

Parameters:

<RelativeSpan>	Range:	1E-15 to 100
	Increment:	0.1
	*RST:	1
	Default unit:	%

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:STARt <DiagramName>, <ZoomName>,<RelativeStart>
LAYout:ZOOM:VERTical:RELative:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the y-axis.

Parameters:

<RelativeStart>	Range:	0 to 100
	Increment:	0.1
	*RST:	0
	Default unit:	%

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:STOP <DiagramName>, <ZoomName>,<RelativeStop>
LAYout:ZOOM:VERTical:RELative:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the y-axis.

Parameters:

<RelativeStop>	Range:	0 to 100
	Increment:	0.1
	*RST:	100
	Default unit:	%

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:REMove <DiagramName>, <ZoomName>

Removes the specified zoom diagram.

Setting parameters:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

Example: See Chapter 16.3.1.1, "Creating Zoom Diagrams", on page 865

Usage: Setting only

16.10.2 Reference Waveforms

16.10.2.1 Reference

REFCurve<m>:SOURce <Source>

Selects the source waveform to be used as a reference.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<Source> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Source of the reference waveform, see Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: C1W1

REFCurve<m>:STATe <State>

If enabled, the reference waveform is displayed in the diagram.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<State> ON | OFF

*RST: OFF

REFCurve<m>:NAME <Name>

Defines the name of the reference waveform file to be loaded, saved or deleted.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<Name> Path and name of the file that contains the reference waveform or to which the reference waveform is to be stored (`.xml` or `.bin` format), enclosed in single quotes.

REFCurve<m>:OPEN

Loads the reference waveform file selected by `REFCurve<m>:NAME` on page 995.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

REFCurve<m>:UPDate

Copies the selected source waveform (see `REFCurve<m>:SOURce` on page 994) with all its settings to the memory of the reference waveform.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

REFCurve<m>:SAVE

Saves the reference waveform to the file selected by `REFCurve<m>:NAME` on page 995.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

REFCurve<m>:DELete

Deletes the reference waveform file selected by `REFCurve<m>:NAME` on page 995.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

REFCurve<m>:CLEar

The selected reference waveform is no longer displayed, its memory is deleted.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

16.10.2.2 Scaling

REFCurve<m>:RESCale:VERTical:STATe <State>

Enables and disables the vertical stretching. Stretching changes the display of the waveform independent of the vertical scale and position.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<State> ON | OFF

*RST: OFF

REFCurve<m>:RESCale:VERTical:OFFSet <Offset>

Moves the reference waveform vertically. Like vertical offset of channel waveforms, the offset of a reference waveform is subtracted from the measured value.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<Offset> Negative values shift the waveform up, positive values shift it down.

Range: -100E+24 to 100E+24
Increment: 1E-6
*RST: 0
Default unit: V

REFCurve<m>:RESCale:HORizontal:STATe <State>

Enables and disables the horizontal stretching.

Stretching changes the display of the waveform independent of the horizontal settings of the source waveform and of the horizontal diagram settings.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<State>	ON | OFF *RST: OFF

REFCurve<m>:RESCale:HORizontal:OFFSet <Offset>

Moves the waveform horizontally. Positive values shift the waveform to the right, negative values shift it to the left.

Suffix:

<m>	1..4 Reference waveform

Parameters:

<Offset>	Range: -100E+24 to 100E+24 Increment: 0.01 *RST: 0 Default unit: s

16.10.2.3 Waveform Data Export

Commands for saving waveform data to file are described in Chapter 16.16.4, "Waveform Data Export to File", on page 1146.Commands for reference waveforms are listed below.

REFCurve<m>:DATA:STYPe?

Returns the signal type of the source of the reference waveform.

Suffix:

<m>	1..4 Reference waveform

Return values:
<SignalType> SOUR | SPEC | CORR | NONE

SOURce = normal signal
SPECtrum = FFT spectrum, specific math signal
CORRelation = correlated signal, specific math signal
NONE = undefined

Usage: Query only
SCPI confirmed

REFCurve<m>:DATA:HEADer?

Returns information on the reference waveform.

Table 16-2: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. For reference waveforms the number is always 1.	1

Suffix:
<m> 1..4
Reference waveform

Example:
```
REFC:DATA:HEAD?
-9.477E-008,9.477E-008,200000,1
```

Usage: Query only
SCPI confirmed

REFCurve<m>:DATA[:VALues]?

Returns the data of the channel waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

You can retrieve only Y-values, or X- and Y-values. Use `EXPort:WAVeform:INCXvalues` to define this.

Suffix:
<m> 1..4
Reference waveform

Return values:
<Data> List of values according to the format and content settings.

Usage: Query only

16.10.2.4 Import of Multichannel Waveform Data

Commands for saving waveform data to file are described in Chapter 16.16.4, "Waveform Data Export to File", on page 1146.Commands for reference waveforms are listed below.

REFCurve<m>:MULTichannel:NAME <MultiChImportPath>

Defines the path and the file to be imported. If not path is given, the default path `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\RefWaveforms` is used.

Suffix:
<m> 1..4
The suffix is irrelevant.

Parameters:
<MultiChImportPath> String with path and filename

Example: See `REFCurve<m>:MULTichannel:IMPort` on page 999.

REFCurve<m>:MULTichannel:IMPort <WfmSelect>

Assigns a waveform from the multichannel file to a reference waveform. To import all waveforms that are in the file, you must assign each waveform to another reference waveform.

Suffix:
<m> 1..4
Selects the reference waveform.

Parameters:
<WfmSelect> NONE | NONE | WF1 | WAFEFORM1 | WF2 | WAFEFORM2 | WF3 | WAFEFORM3 | WF4 | WAFEFORM4

WF1 = WAFEFORM1, WF2 = WAFEFORM2, WF3 = WAFEFORM3, WF4 = WAFEFORM4
Selects the waveform in the export file.

*RST: NONE

Example:

```
REFCurve:MULTichannel:NAME
RefCurve_2016-02-16_01.bin
REFCurve1:MULTichannel:IMPort WF1
REFCurve2:MULTichannel:IMPort WF3
REFCurve3:MULTichannel:IMPort WF4
REFCurve:MULTichannel:OPEN
```

Firmware/Software: FW 3.20

REFCurve<m>:MULTichannel:OPEN

Loads the waveform data to the reference waveforms.

Suffix:

<m> 1..4
The suffix is irrelevant.

Example: See `REFCurve<m>:MULTichannel:IMPort` on page 999.

Usage: Event
Asynchronous command

16.10.3 Mathematics

CALCulate:MATH<m>[:EXPRession][:DEFine] <RemComplExpr>

Defines the math expression to be calculated for the specified math channel.

For an overview of corresponding expressions for the available keys in the formula editor, see Chapter 6.3.3, "Advanced Expressions", on page 248.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<RemComplExpr> String with regular expression for calculation

Example: `CALC:MATH 'Ch1Wfm1*Ch2Wfm1'`
Defines the multiplication of waveforms Ch1Wfm1 and Ch2Wfm1.

Usage: SCPI confirmed

CALCulate:MATH<m>:STATe <State>

Enables the math waveform display.

Suffix:

<m> 1..4
math waveform

Parameters:

<State> ON | OFF

*RST: OFF

Usage: SCPI confirmed

CALCulate:MATH<m>:ENVSelection <EnvelopeCurve>

Selects the upper or lower part of the waveform for mathematic calculation, or a combination of both.

The setting is relevant for waveforms with waveform arithmetic mode "Envelope" or with "Peak detect" decimation. All mathematic operations - except for derivation - can be applied to envelope waveforms and waveforms with "Peak detect" decimation.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<EnvelopeCurve> MIN | MAX | BOTH

*RST: BOTH

Firmware/Software: FW 2.25

CALCulate:MATH<m>:ARIThmetics <Arithmetics>

Selects the method to build the resulting math waveform from consecutive acquisitions. The processing is similar to the waveform arithmetics - instead of the acquired waveforms the results of the mathematic formula are used to create envelope, average and RMS.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<Arithmetics> OFF | ENVelope | AVERage | RMS | MINHold | MAXHold

waveform arithmetic mode

OFF
The math waveform is built according to the mathematic formula.

ENVelope
Detects the minimum and maximum math values in a sample interval over a number of acquisitions.

AVERage
Calculates the average from the math data of the current acquisition and a number of acquisitions before. To define the number of acquisitions, use `ACQuire:COUNt`.

RMS
The resulting math waveform is the root mean square of the current acquisition and a number of acquisitions before. The result is the average power spectrum. Number of acquisitions: `ACQuire:COUNt`

MAXHold
Determines the maximum result for each input value from the math data of the current acquisition and a number of acquisitions before. To define the number of acquisitions, use `ACQuire:COUNt`.

MINHold
Determines the minimum result for each input value from the math data of the current acquisition and a number of acquisitions before. To define the number of acquisitions, use `ACQuire:COUNt`.

*RST: OFF

CALCulate:MATH<m>:VERTical:OFFSet <VerticalOffset>

Sets a voltage offset to adjust the vertical position of the math function on the screen.

Suffix:

<m> 1..4
Math waveform

Parameters:

<VerticalOffset> Negative values move the waveform au, positive values move it down.

Range: -100E+12 to 100E+12
Increment: 0.01
*RST: 0
Default unit: div

CALCulate:MATH<m>:VERTical:RANGe <VerticalRange>

Defines the range of FFT values to be displayed.

Suffix:

<m>	1..4 Math waveform

Parameters:

<VerticalRange>	Range: 0 to 1E+15 Increment: 0.01 *RST: 0 Default unit: div

CALCulate:MATH<m>:VERTical:SCALe <VerticalScale>

Defines the scale of the y-axis in the math function diagram. The value is defined as "V per division", e.g. *50V/div*. In this case, the horizontal grid lines are displayed in intervals of 50 V.

Suffix:

<m>	1..4 Math waveform

Parameters:

<VerticalScale>	Range: 1E-12 to 100E+12 Increment: 10E-6 *RST: 0.5 Default unit: V/div

CALCulate:MATH<m>:DATA:STYPe?

Returns the signal type of the source of the math waveform.

Suffix:

<m>	1..4 Selects the math waveform.

Return values:

<SignalType>	SOUR | SPEC | CORR | MEAS | NONE SOURce = normal signal SPECtrum = FFT spectrum, specific math signal CORRelation = correlated signal, specific math signal MEAsurement = result of a measurement XY = XY-signal SBUS = Serial bus NONE = undefined

Usage: Query only
SCPI confirmed

CALCulate:MATH<m>:DATA:HEADer?

Returns the header of math waveform data. The header contains attributes of the waveform.

Table 16-3: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. For most waveforms the result is 1, for peak detect and envelope waveforms it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).	1

Suffix:
<m> 1..4
Selects the math waveform.

Example:
```
CALC:MATH4:DATA:HEAD
-9.477E-008,9.477E-008,200000,1
```

Usage: Query only
SCPI confirmed

CALCulate:MATH<m>:DATA[:VALues]?

Returns the data of the math waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

You can retrieve only Y-values, or X- and Y-values. Use `EXPort:WAVeform:INCXvalues` to define this.

Suffix:
<m> 1..4
Selects the math waveform.

Return values:
<Data> List of values according to the format and content settings.

Usage: Query only

16.10.4 History

CHANNel<m>[:WAVeform<n>]:HISTory[:STATe] <State>

Enables or disables the history display.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 [:WAVeform<n>] is irrelevant, omit it.

Parameters:

<State>	ON | OFF *RST: OFF

ACQuire:AVAilable?

Returns the number of acquisitions currently saved in the memory. This number of acquisitions is available for history viewing. It is also the number of acquisitions in an Ultra Segmentation acquisition series.

Return values:

<AcqCount>	Range: 0 to 4294967295
Usage:	Query only
Firmware/Software:	V 1.25

CHANNel<m>[:WAVeform<n>]:HISTory:CURRent <CurrAcqIdx>

Accesses a particular acquisition in the memory to display it. The query returns the index of the segment that is shown.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 [:WAVeform<n>] is irrelevant, omit it.

Parameters:

<CurrAcqIdx> History index: the newest segment has the index "0", older segments have a negative index: -(n-1), ... -1 , 0
where n is the number of acquired segments.

Range: 0 to -(n-1)
Increment: 1

Example:
```
CHAN2:HIST:CURR -1
*OPC
```
Displays the acquisition before last from the history.

CHANnel<m>[:WAVeform<n>]:HISTory:STARt <StartAcqIdx>

Sets the index of the oldest history acquisition for the history viewing.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Parameters:

<StartAcqIdx> The start index is always negative.

Range: 0 to -(n-1)
Increment: 1

CHANnel<m>[:WAVeform<n>]:HISTory:STOP <StopAcqIdx>

Sets the index of the latest segment to be displayed in the history viewer.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Parameters:

<StopAcqIdx> Index of the stop acquisition. The newest acquisition always has the index "0".

Range: 0 to -(n-1)
Increment: 1

CHANnel<m>[:WAVeform<n>]:HISTory:TPACq <TimePerAcq>

Sets the display time for one acquisition. The shorter the time, the faster is the replay.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Parameters:
<TimePerAcq> Range: 40E-6 to 10
Increment: 1
*RST: 0.05
Default unit: s

CHANnel<m>[:WAVeform<n>]:HISTory:PLAY

Starts and stops the replay of the history waveforms.

Suffix:
<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Usage: Event
Asynchronous command

CHANnel<m>[:WAVeform<n>]:HISTory:REPLay <AutoRepeat>

If ON, the replay of the history waveform sequence repeats automatically. Otherwise, the replay stops at the stop index set with `CHANnel<m>[:WAVeform<n>]:HISTory:STOP`.

Suffix:
<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Parameters:
<AutoRepeat> ON | OFF
*RST: OFF

Usage: Asynchronous command

CHANnel<m>[:WAVeform<n>]:HISTory:TSDate?

Returns the date of the current acquisition that is shown in the history viewer (`CHANnel<m>[:WAVeform<n>]:HISTory:CURRent`).

Suffix:
<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Return values:
<DateAbsString> String with date of the current acquisition (absolute time)

Usage: Query only

CHANnel<m>[:WAVeform<n>]:HISTory:TSABsolute?

Returns the abolsute daytime of the current acquisition that is shown in the history viewer (`CHANnel<m>[:WAVeform<n>]:HISTory:CURRent`).

Suffix:
<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Return values:
<TimeAbsString> String containing the time and unit

Usage: Query only

CHANnel<m>[:WAVeform<n>]:HISTory:TSRelative?

Returns the relative time of the current acquisition - the time difference to the newest acquisition (index = 0).

See also: (`CHANnel<m>[:WAVeform<n>]:HISTory:CURRent`).

Suffix:
<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Return values:
<TimeRelative> Range: -100E+24 to 100E+24
Default unit: s

Usage: Query only

CHANnel<m>[:WAVeform<n>]:HISTory:TSRReference?

Returns the relative time of the currently selected acquisition and the internal reference time (horizontal alignment) in history view with respect to the acquisition with index 0.

Suffix:
<m> 1..4
Selects the input channel.

<n> 1..3
[:WAVeform<n>] is irrelevant, omit it.

Return values:
<TimeRelativ2IntRef> Range: -100E+24 to 100E+24
Increment: 1
*RST: 0
Default unit: s

Usage: Query only

Firmware/Software: Version 2.70

16.10.5 XY-Diagram

WAVeform<m>:XYCurve:RATio <ConstantXYRatio>

If enabled, the x- and y-axes maintain a constant ratio in the diagram.

Suffix:
<m> 1..4
XY-diagram

Parameters:
<ConstantXYRatio> ON | OFF
*RST: ON

WAVeform<m>:XYCurve:STATe <State>

Activates an XY-waveform.

Suffix:
<m> 1..4
XY-diagram

Parameters:
<State> ON | OFF
*RST: OFF

WAVeform<m>:XYCurve:SWAP

Replaces the source of the x-axis with the source of the y-axis and vice versa.

Suffix:
<m> 1..4
XY-diagram

Usage: Event

LAYout:SIGNal:AXIS <DiagramName>, <Source>, <XSource>

Creates an XY-diagram by adding a second waveform to a diagram with a channel, math or reference waveform.

Setting parameters:

<DiagramName> String with the name of the diagram where the waveform is added.

<Source> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2

Waveform to be added, see Chapter 16.4.2, "Waveform Parameter", on page 879

<XSource> ON | OFF

If on, the added waveform is assigned to the x-axis.
If off, it is assigned to the y-axis.

Usage: Setting only

WAVeform<m>:XYCurve:XSOurce <XYCurveXSource>

Defines the signal source that supplies the x-values of the XY-diagram.

Suffix:

<m> 1..4
XY-diagram

Parameters:

<XYCurveXSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2

Source of x-values, see Chapter 16.4.2, "Waveform Parameter", on page 879

WAVeform<m>:XYCurve:YSOurce <XYCurveYSource>

Defines the signal source that supplies the y-values of the XY-diagram.

Suffix:

<m> 1..4
XY-diagram

Parameters:

<XYCurveYSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2

Source of y-values, see Chapter 16.4.2, "Waveform Parameter", on page 879

16.11 Cursor Measurements

CURSor<m>:AOFF

This command switches all cursors off.

Suffix:

<m> 1..*

The numeric suffix is ignored.

Usage: Event

CURSor<m>:STATe <State>

Switches the indicated cursor on or off.

Suffix:

<m> 1..*

Selects the cursor set. 2 cursor sets are available.

Parameters:

<State> ON | OFF

*RST: OFF

CURSor<m>:FUNCtion <Type>

Defines the type of the indicated cursor set.

Suffix:

<m> 1..*

Selects the cursor set. 2 cursor sets are available.

Parameters:

<Type> HORizontal | VERTical | PAIRed

HORizontal
A pair of horizontal cursor lines.

VERTical
A pair of vertical cursor lines.

PAIRed
Both vertical and horizontal cursor line pairs.

*RST: PAIRed

CURSor<m>:TRACking[:STATe] <TrackCurve>

If set to `ON`, the horizontal cursor lines follow the waveform.

Suffix:

<m> 1..*

Selects the cursor set. 2 cursor sets are available.

Parameters:

<TrackCurve> ON | OFF

*RST: OFF

CURSor<m>:SOURce <CursorSource>

Defines the source of the cursor measurement.

Suffix:

<m> 1..*

Selects the cursor set. 2 cursor sets are available.

Parameters:

<CursorSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | SG1 | SG2 | SG3 | SG4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2

Source of the cursor measurement, see Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: NONE

CURSor<m>:X1Position <XPosition1>

Defines the position of the left vertical cursor line.

Suffix:

<m> 1..*
Selects the cursor set. 2 cursor sets are available.

Parameters:

<XPosition1> Range: 0 to 500
Increment: 0.1
*RST: 0
Default unit: s

CURSor<m>:X2Position <XPosition2>

Defines the position of the right vertical cursor line.

Suffix:

<m> 1..*
Selects the cursor set. 2 cursor sets are available.

Parameters:

<XPosition2> Range: 0 to 500
Increment: 0.1
*RST: 0
Default unit: s

CURSor<m>:XCOupling <Coupling>

Defines the positioning mode of the vertical cursor.

Suffix:

<m> 1..*
Selects the cursor set. 2 cursor sets are available.

Parameters:

<Coupling> ON | OFF

ON

Moving one cursor line moves the other cursor line too. The cursor lines always remain a fixed distance.

OFF

Each cursor line is positioned independently.

*RST: OFF

CURSor<m>:Y1Position <YPosition1>

Defines the position of the lower horizontal cursor line.

If `CURSor<m>:TRACking[:STATe]` is enabled, the query returns the measurement result - the lower vertical value of the waveform.

Suffix:

<m> 1..*

Selects the cursor set. 2 cursor sets are available.

Parameters:

<YPosition1> Range: -50 to 50

Increment: 0.01

*RST: 0

Default unit: The unit depends on the type of the waveform.

CURSor<m>:Y2Position <YPosition2>

Defines the position of the upper horizontal cursor line.

If `CURSor<m>:TRACking[:STATe]` is enabled, the query returns the measurement result - the upper vertical value of the waveform.

Suffix:

<m> 1..*

Selects the cursor set. 2 cursor sets are available.

Parameters:

<YPosition2> Range: -50 to 50

Increment: 0.01

*RST: 0

Default unit: The unit depends on the type of the waveform.

CURSor<m>:YCOupling <Coupling>

Defines the positioning mode of the horizontal cursor. If the horizontal cursor lines track the waveform, the y-coupling is irrelevant (CURSor<m>:MODE TRACk).

Suffix:

<m> 1..*

Selects the cursor set. 2 cursor sets are available.

Parameters:

<Coupling> ON | OFF

ON

Moving one cursor line moves the other cursor line too. The cursor lines always remain a fixed distance.

OFF

Each cursor line is positioned independently.

*RST: OFF

CURSor<m>:X1ENvelope <EnvelopeCurve1>

If the waveform arithmetics are set to envelope curve (see CHANnel<m>[:WAVeform<n>]:ARIThmetics on page 916) and CURSor<m>:TRACking[:STATe] is set to "ON", this setting defines how the first horizontal cursor is positioned.

Suffix:

<m> 1..*

Selects the cursor set. 2 cursor sets are available.

Parameters:

<EnvelopeCurve1> MIN | MAX

MIN

The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope.

MAX

The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope.

*RST: MAX

CURSor<m>:X2ENvelope <EnvelopeCurve2>

If the waveform arithmetics are set to envelope curve (see CHANnel<m>[:WAVeform<n>]:ARIThmetics on page 916) and CURSor<m>:TRACking[:STATe] is set to "ON", this setting defines how the second horizontal cursor is positioned.

Suffix:

<m> 1..*

Selects the cursor set. 2 cursor sets are available.

Parameters:

<EnvelopeCurve2> MIN | MAX

MIN

The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope.

MAX

The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope.

*RST: MIN

CURSor<m>:XDELta[:VALue]?

Queries the delta value (distance) of two vertical cursor lines.

Suffix:

<m> 1..*
Selects the cursor set. 2 cursor sets are available.

Return values:

<Delta> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

CURSor<m>:XDELta:INVerse?

Queries the inverse value of the delta value (distance) of the two vertical cursor lines.

Suffix:

<m> 1..*
Selects the cursor set. 2 cursor sets are available.

Return values:

<DeltaInverse> Range: -100E+24 to 100E+24
*RST: 0
Default unit: Hz

Usage: Query only

CURSor<m>:YDELta[:VALue]?

Queries the delta value (distance) of the two horizontal cursor lines.

Suffix:

<m> 1..*
Selects the cursor set. 2 cursor sets are available.

Return values:

<Delta> Range: -100E+24 to 100E+24
*RST: 0

Usage: Query only

CURSor<m>:YDELta:SLOPe <DeltaSlope>

Returns the inverse value of the voltage difference - the reciprocal of the vertical distance of two horizontal cursor lines: *1/ΔV*.

Suffix:

<m> 1..*
Selects the cursor set. 2 cursor sets are available.

Parameters:

<DeltaSlope>	Range:	-100E+24 to 100E+24
	Increment:	0
	*RST:	0

CURSor<m>:FFT:SETCenter

Sets the center frequency to the frequency value that is measured at cursor line c1.

Suffix:
<m> 1..*
The suffix is irrelevant.

Usage: Event

CURSor<m>:FFT:TOCenter

Sets the vertical cursor line c1 to the center frequency.

Suffix:
<m> 1..*
The suffix is irrelevant.

Usage: Event

CURSor<m>:MAXimum[:PEAK]

Sets both cursors to the absolute peak value.

Suffix:
<m> 1..*
Selects the cursor set. 2 cursor sets are available.

Usage: Event

CURSor<m>:MAXimum:LEFT

Sets cursor 2 to the next maximum to the left of the current position.

Suffix:
<m> 1..*
Selects the cursor set. 2 cursor sets are available.

Usage: Event

CURSor<m>:MAXimum:RIGHt

Sets cursor 2 to the next peak to the right (from the current position).

Suffix:
<m> 1..*
Selects the cursor set. 2 cursor sets are available.

Usage: Event

CURSor<m>:MAXimum:NEXT

Sets cursor 2 to the next smaller peak (from the current position).

Suffix:
<m> 1..*
Selects the cursor set. 2 cursor sets are available.

Usage: Event

CURSor<m>:THReshold <Value>

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

Suffix:
<m> 1..*
The suffix is irrelevant.

Parameters:
<Value> Threshold in dBm

Firmware/Software: Version 2.70

CURSor<m>:PEXCursion <Value>

Defines the minimum level by which the waveform must rise or fall so that it will be identified as a maximum or a minimum by the search functions.

Suffix:
<m> 1..*
The suffix is irrelevant

Parameters:
<Value> Range: 0 to 100
Increment: 1
*RST: 5
Default unit: dB

16.12 Automatic Measurements

This chapter contains all remote commands to set up automatic measurements and to analyze the measurement results.

Measurement selection: MEASurement<m>

With R&S RTE you can configure up to eight simultaneous measurements. In manual operation, these eight measurements are represented as subtabs "Meas 1" to "Meas

8" in the "Measurements" dialog box. For remote operation, the measurement is indicated by the suffix MEAS<m>, containing the number of the measurement.

Measurement suffix	Measurement
1 to 8	"Meas 1" to "Meas 8"
9 and 10	Not used

16.12.1 General Settings

MEASurement<m>[:ENABle] <State>

Switches the indicated measurement on or off.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<State>	ON | OFF *RST: OFF

MEASurement<m>:SOURce <SignalSource>, [<SignalSource2>]

Defines the source of the measurement. Depending on the selected source type, only suitable measurement types are available.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<SignalSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Source of the measurement, see Chapter 16.4.2, "Waveform Parameter", on page 879
Digital channels are provided with option R&S RTE-B1.
Serial bus SBUS1 | SBUS2 | SBUS3 | SBUS4 is available as measurement source if an audio bus is configured (option R&S RTE-K5)

<SignalSource2> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Digital channels are only available if <SignalSource> is a digital channel.

MEASurement<m>:FSRC <MeasSrc>

Defines the first measurement source.

The command is an alternative to `MEASurement<m>:SOURce`.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<MeasSrc> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Source of the measurement, see Chapter 16.4.2, "Waveform Parameter", on page 879

SBUS1 ... SBUS4
Serial bus is available as measurement source if an audio bus is configured (option R&S RTE-K5)

D0 ... D15
Digital channels are provided with option R&S RTE-B1.

Firmware/Software: FW 2.00

MEASurement<m>:SSRC <MeasSource2>

Defines the second measurement source.

the command is an alternative to `MEASurement<m>:SOURce`.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<MeasSource2> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Second source of the measurement, see Chapter 16.4.2, "Waveform Parameter", on page 879
Digital channels are only available if a digital channel is set as first measurement source using `MEASurement<m>:FSRC`.

Firmware/Software: V 2.00

MEASurement<m>:CATegory <Category>

Defines the measurement category.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<Category> AMPTime | EYEJitter | SPECtrum | HISTogram | PROTocol

AMPTime
Amplitude and time measurements

JITTer
Jitter measurements, only available isf option R&S RTE-K12 is installed

EYEJitter
Eye diagram mesurements

SPECtrum
Spectrum measurements

HISTogram
Histogram measurements

PROTocol
Protocol measurements (track and trend)

*RST: AMPTime

Example: See "Creating and Reading Histograms" on page 866

MEASurement<m>:MAIN <MeasType>

Defines the measurement type of the selected measurement.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<MeasType> **Amplitude/time measurements**
HIGH | LOW | AMPLitude | MAXimum | MINimum | PDELta | MEAN | RMS | STDDev | POVershoot | NOVershoot | AREA | RTIMe | FTIMe | PPULse | NPULse | PERiod | FREQuency | PDCYcle | NDCYcle | CYCarea | CYCMean | CYCRms | CYCStddev | PULCnt | DELay | PHASe | BWIDth | PSWitching | NSWitching | PULSetrain | EDGecount | SHT | SHR | DTOTrigger | PROBemeter
See Chapter 16.12.3, "Amplitude/Time Measurement", on page 1026.
*RST value for amplitude/time measurements: `AMPLitude`.

Eye diagram measurements
ERPercent | ERDB | EHEight | EWIDth | ETOP | EBASe | QFACtor | RMSNoise | SNRatio | DCDistortion | ERTime | EFTime | EBRate | EAMPlitude | PPJitter | STDJitter | RMSJitter
See Chapter 16.12.4, "Eye Diagram Measurements", on page 1034
*RST value for eye/jitter measurements: `ERPercent`.

Spectrum measurements
CPOWer | OBWidth | SBWidth | THD | THDPCT | THDA | THDU | THDR | HAR | PLISt
See Chapter 16.12.5, "Spectrum", on page 1035.
*RST value for spectrum measurements: `CPOWer`.

Histogram measurements
WCOunt | WSAMples | HSAMples | HPEak | PEAK | UPEakvalue | LPEakvalue | HMAXimum | HMINimum | MEDian | MAXMin | HMEan | HSTDdev | M1STddev | M2STddev | M3STddev | MKPositive | MKNegative
See Chapter 16.12.6.2, "Histogram Measurement", on page 1046.
*RST value for histogram measurements: `WCOunt`.

Example: See "Creating and Reading Histograms" on page 866

MEASurement<m>:CLEar

Deletes the statistic results of the indicated mesurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Usage: Event

MEASurement<m>:MULTiple <MultiMeas>

The measurement is performed repeatedly if the measured parameter occurs several times inside the defined gate.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<MultiMeas>	ON | OFF *RST: OFF

MEASurement<m>:MNOMeas <MaxNoOfMeas>

Sets the maximum number of measurements per acquisition if multiple measurement is enabled (`MEASurement<m>:MULTiple` is `ON`).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<MaxNoOfMeas>	Range: 2 to 1000000 Increment: 1 *RST: 1000

16.12.2 Results

MEASurement<m>:ARES?

Returns the results of the selected measurement. If multiple measurements and/or statistics are enabled, the instrument returns all results.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Return values:

<Data>	Result string

Example:
```
:MEASurement:ARES?
1.225296442688e-001
```

Example:
```
:MEASurement:ARNames 1
:MEASurement:ARES?
High: 1.225296442688e-001
```

Example:
```
:MEASurement:MULTiple 1
:MEASurement:ARNames 1
:MEASurement:ARES?
High:
1.225296442688e-001,1.225296442688e-001,
1.225296442688e-001,1.225296442688e-001,
1.225296442688e-001,3.785715534183e-015,3893,
3893
```

Example:
```
:MEASurement:ARNames 1
:MEASurement:STATistics:ENABle 1
:MEASurement:ARES?
High:
1.225296442688e-001,1.225296442688e-001,
1.225296442688e-001,1.225296442688e-001,
1.225296442688e-001,1.673196471220e-014,176656,
176656
Results: current, peak+, peak-, average, RMS,
standard deviation, event count, waveform count
```

Usage: Query only

MEASurement<m>:ARNames <Identifier>

Enables a prefix that indicates the measurement type in the result string of the `MEASurement<m>:ARES?` command.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<Identifier> ON | OFF
*RST: OFF

Example:

```
:MEASurement:ARNames 1
:MEASurement:ARES?
Amplitude: 2.371541501976e-001
```

Firmware/Software: FW 2.25

MEASurement<m>:RESult[:ACTual]? [<MeasType>]
MEASurement<m>:RESult:AVG? [<MeasType>]
MEASurement<m>:RESult:EVTCount? [<MeasType>]
MEASurement<m>:RESult:NPEak? [<MeasType>]
MEASurement<m>:RESult:PPEak? [<MeasType>]
MEASurement<m>:RESult:RMS? [<MeasType>]
MEASurement<m>:RESult:WFMCount? [<MeasType>]
MEASurement<m>:RESult:STDDev? [<MeasType>]

Return the statistic results of the selected measurement.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

For a detailed description of the results see "Measurement selection: MEASurement<m>" on page 1018.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Query parameters:

<MeasType> | Not relevant, omit it

Example: See "Creating and Reading Histograms" on page 866

Usage: Query only

MEASurement<m>:RESult:STARt? [<MeasType>]
MEASurement<m>:RESult:STOP? [<MeasType>]

Return the start and stop times of the selected measurement.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Query parameters:

<MeasType> | Not relevant, omit it

Usage: Query only

MEASurement<m>:RESult:COUNt?

Returns the number of result groups that are returned by MEASurement:RESult:ACTual? HAR.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Return values:

<MeasType> HAR
The command is only relevant for harmonic search.

Example:

```
:MEASurement:RESult:ACTual? HAR
99.9;-6.000139236;199.8;-80.701713562;299.7;-15.528377533;
:MEASurement:RESult:COUNt? HAR
4
```

Usage: Query only

Firmware/Software: Version 2.70

16.12.3 Amplitude/Time Measurement

The following table lists the <MeasType> parameter values with a short description.

The type suffixes are not relevant for R&S RTE.

For a detailed description, see Chapter 7.2.5.1, "Amplitude/Time Measurement Types", on page 294.

Table 16-4: Amplitude and time measurement types

<MeasType> parameter value	Meas. type	Description, result	Type suffix
HIGH	High	High signal level	1
LOW	Low	Low signal level	2

<MeasType> parameter value	Meas. type	Description, result	Type suffix
AMPLitude	Amplitude	Amplitude of the signal	3
MAXimum	Max	Maximum value of the waveform	4
MINimum	Min	Minimum value of the waveform	5
PDELta	Peak to peak	Peak-to-peak value of the waveform	6
MEAN	Mean	Mean value of the waveform	7
RMS	RMS	RMS (Root Mean Square) value of the voltage	8
STDDev	σ (S-dev)	Standard deviation of the waveform	9
POVershoot	Pos. overshoot	Positive overshoot of a square wave	10
NOVershoot	Neg. overshoot	Negative overshoot of a square wave	11
AREA	Area	Area beneath the waveform (integral)	12
RTIMe	Rise time	Rise time of the left-most rising edge of the waveform.	13
FTIMe	Fall time	Falling time of the left-most falling edge of the waveform.	14
PPULse	Pos. pulse	Width of a positive pulse – a rising edge followed by a falling edge. The measurement requires at least one complete period of a triggered signal.	15
NPULse	Neg. pulse	Width of a negative pulse – a falling edge followed by a rising edge. The measurement requires at least one complete period of a triggered signal.	16
PERiod	Period	Length of the left-most signal period of the waveform	17
FREQuency	Frequency	Frequency of the signal. The result is based on the period measurement.	18
PDCYcle	Pos. duty cycle	Positive duty cycle. The measurement requires at least one complete period of a triggered signal.	19
NDCYcle	Neg. duty cycle	Negative duty cycle. The measurement requires at least one complete period of a triggered signal.	20
CYCarea	Cycle area	Area (integral) beneath one cycle	21
CYCMean	Cycle mean	Mean value of one cycle	22
CYCRms	Cycle RMS	The RMS (Root Mean Square) value of one cycle	23
CYCStddev	Cycle σ (S-dev)	Standard deviation of one cycle	24
PULCnt	Pulse count	Number of positive or negative pulses of the waveform, or both	25
DELay	Delay	Time difference between the any edges of two measurement sources at any reference level. The measurement result is negative if the edge of the second source comes before the edge of the first source.	26
PHASe	Phase	Phase difference between two waveforms	27
BWIDth	Burst width	Duration of one burst, measured from the first edge to the last	28

<MeasType> parameter value	Meas. type	Description, result	Type suffix
PSWitching	Pos. switching	Settling time at rising edges	29
NSWitching	Neg. switching	Settling time at falling edges	30
PULSetrain	Pulse train	Duration of N positive pulses, measured from the rising edge of the first pulse to the falling edge of the N-th pulse. N has to be configured.	31
EDGecount	Edge count	Number of positive or negative edges of the waveform, or both	32
SETup	Setup time	Parameters to query the setup and hold times. Use these parameters only in following queries: • MEASurement<m>:ARES? • MEASurement<n>:RESult:.. commands	33
HOLD	Hold time		
SHT	Setup/Hold time	Setting parameter to enable Setup/Hold time measurements. Use this parameter only as setting in: • MEASurement<m>:MAIN on page 1022	35
SHR	Setup/Hold ratio	Setup/Hold ratio measurement. Setup/Hold ratio is the ratio of the setup time to the sum of hold and setup time: $T_{Setup} / (T_{Setup} + T_{Hold})$ Use this parameter as setting to activate the Setup/Hold ratio measurement in: • MEASurement<m>:MAIN on page 1022 It is also used in the following queries: • MEASurement<m>:ARES? • MEASurement<n>:RESult:.. Used also in queries with and commands.	36
DTOTrigger	Delay to trigger	Time between the trigger event and a following signal slope. High accuracy even if the trigger event is outside the acquisition data.	46
PROBemeter	Trig. ProbeMeter	DC voltage measured by the connected active R&S probe	47

MEASurement<m>:ENVSelect <EnvelopeCurve>

The command is only relevant for measurements on envelope waveforms. It selects the envelope to be used for measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<EnvelopeCurve>	MIN | MAX | BOTH MIN: measures on the lower envelope MAX: measures on the upper envelope BOTH: the envelope is ignored and the waveform measured as usual *RST: BOTH

Firmware/Software: V 1.25

MEASurement<m>:DETThreshold <SignDetectThres>

Defines the value above which measurement results are displayed. Values beneath the threshold are considered to be noise and they are ignored.

Suffix:

<m>	1..10 irrelevant

Parameters:

<SignDetectThres>	Range: 0 to 50 Increment: 1 *RST: 5 Default unit: %

MEASurement<m>:AMPTime:ALEVel <AreaLevel>

Defines the reference level used to integrate the waveform.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<AreaLevel>	Range: -100E+24 to 100E+24 Increment: 0 *RST: 0 Default unit: V

MEASurement<m>:AMPTime:PFSLope <PeriodSlope>

Selects the slope direction for frequency and period measurements.

Suffix:

<m> 1..9
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<PeriodSlope> FIRSt | POSitive | NEGative | EITHer

POSitive | NEGative
Measures the time between rising or falling edges, respectively.

EITHer
In multiple measurements, the time is measured both between rising edges and between falling edges.
In single measurements. the first edge is taken for the measurement.

FIRSt
Time is measured either between rising edges or between falling edges. The first edge is taken for the measurement. In single measurements, it works the same way as "Either".
Only available for analog measurement sources.

*RST: FIRSt (analog source), POSitive (digital source)

MEASurement<m>:AMPTime:PSLope <PulsesSlope>

Sets the first slope of the pulses to be counted. The setting is only relevant for pulse count measurement (`MEASurement<m>:MAIN PULCnt` or `MEASurement<m>:ADDitional PULCnt,ON`).

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<PulsesSlope> POSitive | NEGative | EITHer

Count either positive or negative pulses, or both.

*RST: POSitive

MEASurement<m>:AMPTime:DELay<n>:DIRection <EdgeCountDirection>

Selects the direction for counting slopes for each source: from the beginning of the waveform, or from the end.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

<n> 1..2
Selects the source number.

Parameters:
<EdgeCountDirection> FRFI | FRLA

FRFI - FRom FIrst, counting starts with the first edge of the waveform.
FRLA - FRom LAst, counting starts with the last edge of the waveform.

*RST: FRFI

MEASurement<m>:AMPTime:DELay<n>:ECOunt <EdgeIndex>

Sets the number of the edge that is relevant for delay measurement for each source.

Suffix:
<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

<n> 1..2
Selects the source number.

Parameters:
<EdgeIndex> Edge number

Range: 1 to 100000
Increment: 1
*RST: 1

MEASurement<m>:AMPTime:DELay<n>:LSELect <DelayLevSelection>

Selects the reference level on which the time is measured for each source.

Suffix:
<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

<n> 1..2
Selects the source number.

Parameters:
<DelayLevSelection> UPPer | MIDDle | LOWer

*RST: MIDDle

MEASurement<m>:AMPTime:DELay<n>:SLOPe <Slope>

Sets the edge of each source, between which the delay is measured.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.
<n>	1..2 Selects the source number.

Parameters:

<Slope>	POSitive | NEGative | EITHer *RST: POSitive

MEASurement<m>:AMPTime:PTCount <PulseCount>

Sets the number of positive pulses for the pulse train measurement. It measures the duration of N positive pulses from the rising edge of the first pulse to the falling edge of the N-th pulse.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<PulseCount>	Range: 1 to 2147483647 Increment: 1 *RST: 1

MEASurement<m>:AMPTime:ESLope <EdgesSlope>

Sets the edge direction to be counted: rising edges, falling edges, or both. The setting is only relevant for edge count measurement (`MEASurement<m>:MAIN EDGecount` or `MEASurement<m>:ADDitional EDGecount,ON`).

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<EdgesSlope>	POSitive | NEGative | EITHer *RST: POSitive

MEASurement<m>:AMPTime:CSLope <SetupHoldClockSlope>

Sets the edge of the clock from which the setup and hold times are measured.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<SetupHoldClockSlope>	POSitive | NEGative | EITHer **EITHer** The clock edges next to the data edge are considered regardless of the clock slope. *RST: POSitive

---

MEASurement<m>:AMPTime:CLCK<n>:LSELect <ClockLevel>

Selects the reference level of the clock on which the time is measured. Reference level and clock slope define the time point for setup and hold measurements.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.
<n>	1..2 The suffix is irrelevant, omit it.

Parameters:

<ClockLevel>	UPPer | MIDDle | LOWer *RST: MIDDle

MEASurement<m>:AMPTime:DATA<n>:LSELect <DataLevel>

Selects the reference level of the data on which the setup and hold time are measured.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.
<n>	1..2 The suffix is irrelevant, omit it.

Parameters:

<DataLevel>	UPPer | MIDDle | LOWer *RST: MIDDle

MEASurement<m>:AMPTime:DTOTrigger<n>:SLOPe <Slope>

Sets the edge direction to be used for delay measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.
<n>	1..2 The suffix is irrelevant.

Parameters:

<Slope> POSitive | NEGative | EITHer

*RST: POSitive

MEASurement<m>:AMPTime:DTOTrigger<n>:LSELect <RefLevel>

Selects the reference level of the measurement source on which the delay is measured.

Suffix:

<m> 1..10

See "Measurement selection: MEASurement<m>" on page 1018.

<n> 1..2

The suffix is irrelevant.

Parameters:

<RefLevel> UPPer | MIDDle | LOWer

*RST: MIDDle

16.12.4 Eye Diagram Measurements

The following table lists the <MeasType> parameter values with a short description.

There are no specific commands for eye diagram measurements. The type suffixes are not relevant for R&S RTE.

For a detailed description, see Chapter 7.2.6.1, "Eye Diagram Measurement Types", on page 304.

Table 16-5: Eye diagram measurement types

<MeasType> parameter value	Meas. type	Description/Result	Type suffix
ERPercent	Extinction ratio (%)	Eye base / Eye top *100 Prerequisite: Eye base > 0 and Eye top > 0	2
ERDB	Extinction ratio (dB)	10*log (Eye top / Eye base)	3
EHEight	Eye height	Vertical eye opening	4
EWIDth	Eye width	Horizontal eye opening	5
ETOP	Eye top	Mean of the upper vertical histogram	6
EBASe	Eye base	Mean of the lower vertical histogram	7
QFACtor	Q factor	(Eye top – Eye base) / (σtop + σbase)	10
RMSNoise	Noise (RMS)	Quadratic mean of the noise of eye top and eye base	14
SNRatio	S/N ratio	Signal-to-noise ratio 10 * log (Eye amplitude / Noise RMS)	15

<MeasType> parameter value	Meas. type	Description/Result	Type suffix
DCDistortion	Duty cycle distortion	20 * log (Eye amplitude / Noise RMS)	16
ERTime	Eye rise time	Duration for signal to rise from 10% to 90% of the high signal level	17
EFTime	Eye fall time	Duration for signal to fall from 90% to 10% of the high signal level	18
EBRate	Eye bit rate	Frequency between two crossings	19
EAMPlitude	Eye amplitude	Eye top - Eye base	20
PPJitter	Jitter (peak to peak)	Average of the jitter for both crossing points (σcrossing1 + σcrossing2) / 2	28
STDJitter	Jitter (6*σ)	Jitter *6	29
RMSJitter	Jitter (RMS)	Quadratic mean of the jitter at both crossing points	30

16.12.5 Spectrum

The following table lists the <MeasType> parameter values with a short description.

The type suffixes are not relevant for R&S RTE.

For a detailed description, see Chapter 7.2.7.1, "Spectrum Measurement Types", on page 306.

Table 16-6: Spectrum measurement types

<MeasType> parameter value	Meas. type	Description/Result	Type suffix
CPOWer	Channel power	Power integrated over the sample values defined by a center frequency and a bandwidth; based on a defined impedance; the result is given in mW	1
		not used	2
OBWidth	Occupied band-width	From the defined center frequency, symmetric sam-ple value pairs to the left and right are integrated until a user-defined percentage of the total power is reached	3
SBWidth	Bandwidth	n dB down Bandwidth; the samples to the left and right of the peak value are analyzed until the n dB threshold is exceeded; the frequencies at which the threshold is exceeded define the limits of the requested bandwidth	4
		not used	5
		not used	6
THD	Total harmonic dis-tortion in dB	Power sum of the harmonic waves divided by the power of the fundamental wave.	7

<MeasType> parameter value	Meas. type	Description/Result	Type suffix
THDPCT	Total harmonic distortion in %	Power sum of the harmonic waves divided by the power of the fundamental wave.	8
THD_A	Total harmonic distortion of amplitudes	Sum of all amplitudes of the harmonic waves in relation to the amplitude of the fundamental waveform	9
THD_U	Total harmonic distortion in relation to fundamental waveform	Root mean square of the power sum of harmonic waves in relation to the power of the fundamental waveform	10
THD_R	Total harmonic distortion in relation to all waveforms	Root mean square of the power sum of harmonic waves in relation to the power of all waveforms	11
PLISt	Peak list	List of frequency and peak power value pairs	12
HAR	Harmonic search	Returns the measured harmonics. For each harmonic, the frequency and the value is listed. To get the number of result pairs (= harmonics), use `MEASurement<m>:RESult:COUNt?`.	13

MEASurement<m>:SPECtrum:CPOWer:BANDwidth <ChPowBandwidth>

Defines the bandwidth over which the channel power is calculated.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<ChPowBandwidth> Range: 0 to 4E+9
Increment: 1
*RST: 0
Default unit: Hz

MEASurement<m>:SPECtrum:OBANdwidth <OccupiedBW>

Defines the percentage of the total power used to determine the occupied bandwidth.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<OccupiedBW> Range: 0.1 to 99.9
Increment: 1
*RST: 20
Default unit: %

MEASurement<m>:SPECtrum:CPOWer:CFRequency <CenterFreq>

Defines the center frequency from which the channel power is calculated over the specified bandwidth.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<CenterFreq> Range: 0 to 6E+9
Increment: 1
*RST: 0
Default unit: Hz

MEASurement<m>:SPECtrum:NDBDown <NDbDown>

Defines the threshold until which the samples to the left and right of the peak value are analyzed in order to determine the "N dB down bandwidth".

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<NDbDown> Range: 0 to 100
Increment: 1
*RST: 20
Default unit: dB

MEASurement<m>:SPECtrum:PEXCursion <Value>

Defines a relative threshold, the minimum level value by which the waveform must rise or fall to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

Suffix:

<m>	1..10 The suffix is irrelevant.

Parameters:

<Value>	Range: 0 to 100 Increment: 1 *RST: 5 Default unit: dB

Firmware/Software: Version 2.70

MEASurement<m>:SPECtrum:ATHReshold <Value>

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<Value>	numeric value Default unit: dBm

Firmware/Software: Version 3.30
The command replaces `MEASurement<m>:SPECtrum:THReshold`.

MEASurement<m>:RESult:MAXCount <MeasType>,<Number>
MEASurement<m>:RESult:MAXCount? <MeasType>

Defines the maximum number of results that are returned for the specified measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<Number>

Parameters for setting and query:

<MeasType> CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR

For other measurement types, this command returns an error.

PLISt
Defines the maximum number of peaks that are listed in the peak list and labeled in the diagram.

HAR
Defines the maximum number of harmonics to be measured.

MEASurement<m>:RESult:INVerse <MeasType>, <State>
MEASurement<m>:RESult:INVerse? <MeasType>

Displays labels with black font on white background using the "Full frame" label type (if `MEASurement<m>:RESult:LAFRame=ON`).).

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<State> ON | OFF

Parameters for setting and query:

<MeasType> CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR

For other measurement types, this command returns an error.

PLISt
Peaklist

Example: Display labels.
```
MEAS:RES:SHL PLIS,ON
```
Select inverted labels.
```
MEAS:RES:INV PLIS,ON
```
Query the type of labels for peak lists.
```
MEAS:RES:INV? PLIS
//Result: ON
```

MEASurement<m>:RESult:LAFRame <MeasType>, <FrameType>
MEASurement<m>:RESult:LAFRame? <MeasType>

Defines the layout of the labels (if `MEASurement<m>:RESult:LAFRame=ON`).

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:
<FrameType> NOFRAME | UNDERLINE | FULL

NOFRAME
No frame

UNDERLINE
The label is underlined.

FULL
The label is surrounded by a frame.

Parameters for setting and query:
<MeasType> CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR

For other measurement types, this command returns an error.

PLISt
Peaklist

Example: Display labels.
```
MEAS:RES:SHL PLIS,ON
```
Select framed labels.
```
MEAS:RES:LAFR PLIS,FULL
```
Query the type of labels for peak lists.
```
MEAS:RES:LAFR? PLIS
//Result: FULL
```

MEASurement<m>:RESult:SHFRequency <MeasType>, <State>
MEASurement<m>:RESult:SHFRequency? <MeasType>

Includes the frequency of the detected peak in the diagram labels (if `MEASurement<m>:RESult:LAFRame=ON`).

Suffix:
<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:
<State> ON | OFF

Parameters for setting and query:
<MeasType> CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR

For other measurement types, this command returns an error.

PLISt
Peaklist

Example: Display labels.
`MEAS:RES:SHL PLIS,ON`
Show frequency in labels.
`MEAS:RES:SHFR PLIS,ON`
Query the type of labels for peak lists.
`MEAS:RES:SHFR? PLIS`
`//Result: ON`

MEASurement<m>:RESult:SHLabels <MeasType>, <State>
MEASurement<m>:RESult:SHLabels? <MeasType>

Defines whether a description (label) is displayed for each detected peak in the spectrum diagram.

The layout of the label is defined by `MEASurement<m>:RESult:LAFRame`.

Suffix:
<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:
<State> ON | OFF

Parameters for setting and query:
<MeasType> CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR

For other measurement types, this command returns an error.

PLISt
Peaklist

Example: Display labels.
`MEAS:RES:SHL PLIS,ON`

16.12.6 Histograms

See also: Chapter 16.16.5, "Waveform Histogram Export to File", on page 1152

16.12.6.1 Histogram Display

LAYout:HISTogram:ADD <HistogramName>, <Source>, <XStart>, <XStop>, <YStart>, <YStop>, <Relative>, <Orientation>

Defines and displays a new histogram for the specified source.

Note: To define the mode of the histogram (vertical or horizontal), use the `LAYout:HISTogram:MODE` command.

Setting parameters:

<HistogramName> String defining the histogram name which is used to refer to the histogram by other functions.

<Source> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | AEYE1 | AEYE2 | AEYE3 | AEYE4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2

Data source of the histogram, see Chapter 16.4.2, "Waveform Parameter", on page 879

<XStart> Defines the start value of the x-value range.

<XStop> Defines the stop value of the x-value range.

<YStart> Defines the start value of the y-value range.

<YStop> Defines the stop value of the y-value range.

<Relative> ON | OFF

Defines whether relative or absolute values are used for the value range definition.

<Orientation> VERTical | HORizontal

Example: See "Creating and Reading Histograms" on page 866

Usage: Setting only

LAYout:HISTogram:SOURce <HistogramName>,<HistogramSource>
LAYout:HISTogram:SOURce? <HistogramName>

Defines the source of the histogram. Any analog input signal, math or reference waveform and measurement can be selected.

Parameters:

<HistogramSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | AEYE1 | AEYE2 | AEYE3 | AEYE4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2

Waveform source of the histogram, see Chapter 16.4.2, "Waveform Parameter", on page 879.

Parameters for setting and query:

<HistogramName> String parameter

LAYout:HISTogram:MODE <HistogramName>,<Mode>
LAYout:HISTogram:MODE? <HistogramName>

Defines or queries the type of histogram.

Parameters:

<Mode> VERTical | HORizontal

VERTical
Amplitude histogram (horizontal bars across amplitude)

HORizontal
Time or frequency histogram (vertical bars over time/frequencies)

*RST: VERTical

Parameters for setting and query:

<HistogramName> The name of the histogram as defined using `LAYout:HISTogram:ADD` on page 1042.

LAYout:HISTogram:HORZ:MODE <HistogramName>,<Mode>
LAYout:HISTogram:HORZ:MODE? <HistogramName>

Defines or queries whether the value range limits are entered as absolute or relative values.

Parameters:

<Mode> ABS | REL

*RST: ABS

Parameters for setting and query:

<HistogramName>

LAYout:HISTogram:HORZ:ABSolute:STARt <HistogramName>,<Start>
LAYout:HISTogram:HORZ:ABSolute:STARt? <HistogramName>

Defines the horizontal start value of the histogram.

Parameters:

<Start> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<HistogramName>

LAYout:HISTogram:HORZ:ABSolute:STOP <HistogramName>,<Stop>
LAYout:HISTogram:HORZ:ABSolute:STOP? <HistogramName>

Defines the horizontal stop value of the histogram.

Parameters:

<Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<HistogramName>

LAYout:HISTogram:HORZ:RELative:STARt <HistogramName>,<RelativeStart>
LAYout:HISTogram:HORZ:RELative:STARt? <HistogramName>

Defines the horizontal start value of the histogram.

Parameters:

<RelativeStart> Range: 0 to 100
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:

<HistogramName>

Usage: SCPI confirmed

LAYout:HISTogram:HORZ:RELative:STOP <HistogramName>,<RelativeStop>
LAYout:HISTogram:HORZ:RELative:STOP? <HistogramName>

Defines the horizontal stop value of the histogram.

Parameters:

<RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<HistogramName>

Usage: SCPI confirmed

LAYout:HISTogram:VERTical:MODE <HistogramName>,<Mode>
LAYout:HISTogram:VERTical:MODE? <HistogramName>

Defines or queries whether the value range limits are entered as absolute or relative values.

Parameters:

<Mode> ABS | REL

*RST: ABS

Parameters for setting and query:

<HistogramName>

LAYout:HISTogram:VERTical:ABSolute:STARt <HistogramName>,<Start>
LAYout:HISTogram:VERTical:ABSolute:STARt? <HistogramName>

Defines the vertical start value of the histogram.

Parameters:

<Start> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<HistogramName>

LAYout:HISTogram:VERTical:ABSolute:STOP <HistogramName>,<Stop>
LAYout:HISTogram:VERTical:ABSolute:STOP? <HistogramName>

Defines the vertical stop value of the histogram.

Parameters:

<Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<HistogramName>

LAYout:HISTogram:VERTical:RELative:STARt <HistogramName>,<RelativeStart>
LAYout:HISTogram:VERTical:RELative:STARt? <HistogramName>

Defines the vertical start value of the histogram.

Parameters:

<RelativeStart> Range: 0 to 100
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:

<HistogramName>

Usage: SCPI confirmed

LAYout:HISTogram:VERTical:RELative:STOP <HistogramName>,<RelativeStop>
LAYout:HISTogram:VERTical:RELative:STOP? <HistogramName>

Defines the vertical stop value of the histogram.

Parameters:
<RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:
<HistogramName>

Usage: SCPI confirmed

LAYout:HISTogram:RESet <HistogramName>

Resets the values to begin a new histogram.

Setting parameters:
<HistogramName>

Usage: Setting only

LAYout:HISTogram:REMove <Name>

Removes the specified histogram.

Setting parameters:
<Name>

Usage: Setting only

16.12.6.2 Histogram Measurement

This chapter lists commands to set up measurements on histograms.

See also: "Creating and Reading Histograms" on page 866.

The following table lists the <MeasType> parameter values with a short description.

The type suffixes are not relevant for R&S RTE.

For a detailed description, see Table 7-7.

Table 16-7: Histogram measurement types

<MeasType> parameter value	Meas. type	Description/Result	Type suffix
WCOunt	Waveform count	Number of acquisitions (waveforms) the histogram is based on	1
WSAMples	Waveform samples	Number of samples from the most recent acquisition included in the current histogram	2
HSAMples	Histogram samples	Number of samples from all acquisitions included in the current histogram	3
HPEak	Histogram peak	Maximum sample value in the histogram	4
PEAK	Peak value	Signal value at the histogram peak	5
UPEakvalue	Upper peak value	Signal value at the maximum sample value in the upper half of the histogram	6
LPEakvalue	Lower peak value	Signal value at the maximum sample value in the lower half of the histogram	7
HMAXimum	Maximum	Highest signal value with a probability > 0	8
HMINimum	Minimum	Lowest signal value with a probability > 0	9
MEDian	Median	Signal value for which half the samples lie above, the other half below in the histogram	10
MAXMin	Max - Min	Range of signal values with a probability > 0	11
HMEan	Mean	Weighted arithmetic average of the histogram	12
HSTDdev	σ (S-dev)	Standard deviation of the sample numbers	13
M1STddev	Mean ±σ	Range between (mean value + standard deviation) and (mean value - standard deviation)	14
M2STddev	Mean ±2*σ	Range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)	15
M3STddev	Mean ±3*σ	Range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)	16
MKPositive	Marker + Probability %	Marker value (according to the selected probability domain marker type) plus the defined limit. Note that the value is restricted to the histogram range.	17
MKNegative	Marker - Probability %	Marker value (according to the selected probability domain marker type) minus the defined limit. Note that the value is restricted to the histogram range.	18

MEASurement<m>:HISTogram:SELect <HistogramName>

Selects the histogram on which the measurement is based.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<HistogramName> String with the name of the histogram

Example: See "Creating and Reading Histograms" on page 866

MEASurement<m>:HISTogram:PROBability:TYPE <Marker>

Defines the marker reference in the probability domain.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<Marker> PEAK | UPPK | LWPK | MAXimum | MINimum | MEDian | MEAN

PEAK
The y-value with the maximum sample value in the histogram

UPPK
The y-value at the maximum sample value in the upper half of the histogram

LWPK
The y-value at the maximum sample value in the lower half of the histogram

MAXimum
The highest y-value with a probability > 0

MINimum
The lowest y-value with a probability > 0

MEDian
The y-value for which half the samples lie above, the other half below in the histogram

MEAN
The weighted arithmetic average of the histogram

*RST: PEAK

MEASurement<m>:HISTogram:PROBability:LIMit <Limit>

Defines a range around the probability marker.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<Limit>	Range: 0 to 100 Increment: 10 *RST: 10 Default unit: %

16.12.7 Display

MEASurement<m>:DISPlay:LEVels <DisplayLevels>

If enabled, the reference levels used for the measurement are displayed in the diagram.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<DisplayLevels>	ON | OFF *RST: OFF

MEASurement<m>:DISPlay:RESults <DisplayResult>

If enabled, the intermediate result lines required to obtain the measurement result (e.g. signal thresholds) are displayed in the measurement diagram.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<DisplayResult>	ON | OFF *RST: OFF

MEASurement<m>:DISPlay:STYLe <DisplayStyle>

Selects the style in which the measurement waveform is displayed.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<DisplayStyle> LINE | MARKer

LINE
The individual data points are connected by a line.

MARKer
Only the individual data points are displayed as markers.

*RST: LINE

MEASurement<m>:DISPlay:HISTogram <DispHistg>

Displays a histogram for the source of the selected measurement.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<DispHistg> ON | OFF

*RST: OFF

16.12.8 Statistics and Long-term Measurements

See also: Chapter 16.16.6, "Long Term Measurement Results and Measurement Histogram Export to File", on page 1153.

MEASurement<m>:STATistics[:ENABle] <StatisticsState>

Enables statistics calculation for the measurement.

For details on the statistics results, see ."Statistics" on page 317

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<StatisticsState>	ON | OFF *RST: OFF

MEASurement<m>:STATistics:HISTogram <ShowHistogram>

Displays a histogram of the statistical results. Enabling the histogram enables also the calculation and display of statistics for the measurement results if statistics were disabled. the histogram shows the cumulative occurence distribution of mean measurement results in a graphic.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<ShowHistogram>	ON | OFF *RST: OFF

MEASurement<m>:STATistics:HBINs <HistogramBins>

Sets the number of bins - the number of vertical bars that build the histogram.

If `MEASurement<m>:VERTical:CONT` is ON, the instrument determines the number of bins automatically based on the time base, the current measurements, and other settings.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<HistogramBins>	Range: 2 to 1000 Increment: 10 *RST: 1000

Options: FW 2.50

MEASurement<m>:STATistics:MODE <ResetMode>

Defines when the statistics for long term measurements are reset.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<ResetMode> TIME | WFMS | MEAS

TIME
Sets one long term measurement point after the time defined using `MEASurement<m>:STATistics:RTIMe`.

WFMS - Waveforms
Sets one long term measurement point after a number of acquired waveforms defined using `MEASurement<m>:STATistics:RCOunt`.

MEAS
Sets one long term measurement point after a number of measurement results.

*RST: TIME

MEASurement<m>:STATistics:RCOunt <RstWfmCount>

Defines the number of measured waveforms from which one point of the long term measurement is created (reset of statistics).

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<RstWfmCount>

Range: 1 to 65535
Increment: 10
*RST: 1000

MEASurement<m>:STATistics:RMEascount <RstMeasCount>

Defines the number of measurement results from which one point of the long term measurement is created.

This setting is only available if `MEASurement<m>:STATistics:MODE` is set to `MEAS`.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<RstMeasCount>

Range: 1 to 65535
Increment: 10
*RST: 1000

MEASurement<m>:STATistics:RTIMe <ResetTime>

Defines the time or period after which the statistics are reset.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<ResetTime> Range: 0.1 to 2.14748E+9
Increment: 1E-3
*RST: 0.2
Default unit: s

MEASurement<m>:STATistics:RESet

Resets the histogram, the long term measurement and the statistics.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Usage: Event

MEASurement<m>:VERTical:CONT <AutoScale>

If enabled, automatic vertical scaling is performed whenever the waveform does not fit in the diagram during the long term measurement period.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<AutoScale> ON | OFF
*RST: ON

Firmware/Software: V 1.50

MEASurement<m>:VERTical:AUTO

If enabled, vertical scaling is adapted to the current measurement results automatically during the long term measurement period.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Usage: Event
SCPI confirmed

MEASurement<m>:VERTical:OFFSet <VerticalOffset>

Defines a vertical offset for the long term measurement.

Suffix:
<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:
<VerticalOffset> Range: -100E+24 to 100E+24
Increment: 1E-6
*RST: 0
Default unit: div

Usage: SCPI confirmed

MEASurement<m>:VERTical:SCALe <VerticalScale>

Defines the vertical scaling per division, so that the scaling can be adapted automatically during the long term measurement period.

Suffix:
<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:
<VerticalScale> Range: 10E-24 to 100E+24
Increment: 10E-6
*RST: 0.5
Default unit: V/div

Usage: SCPI confirmed

MEASurement<m>:LTMeas[:STATe] <ShowDiagram>

Enables long term measurement for a defined number of measurement points (see `MEASurement<m>:LTMeas:COUNt` on page 1055) or a specified time (see`MEASurement<m>:LTMeas:TIME` on page 1055).

Suffix:
<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:
<ShowDiagram> ON | OFF
*RST: OFF

MEASurement<m>:LTMeas:COUNt <MeasCount>

Defines the total number of points to be measured during the long term measurement.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<MeasCount>	Range: 1000 to 200000 Increment: 10 *RST: 1000

MEASurement<m>:LTMeas:TIME <MeasurementTime>

Defines the total duration of the long term measurement.

This setting is only available if `MEASurement<m>:STATistics:MODE` is set to "Time".

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<MeasurementTime>	Range: 0.01 to 2.14748E+9 Increment: 1 *RST: 200 Default unit: s

16.12.9 Track and Trend

MEASurement<m>:TRACk[:STATe] <State>

Enables the track functionality and displays the track.

The track functionality requires at least one option, see "Enable (Track)" on page 321.

Suffix:

<m>	1..10 See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<State> ON | OFF

*RST: OFF

MEASurement<m>:TRACk:DATA:HEADer?

Returns the header of the track.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Usage: Query only

MEASurement<m>:TRACk:DATA:STYPe?

Returns the data type: TRK (track)

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Usage: Query only

MEASurement<m>:TRACk:DATA[:VALues]?

Returns the data of track points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Usage: Query only

16.12.10 Gating

MEASurement<m>:GATE[:STATe] <State>

Considers the gating settings of the source waveform for the measurement.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<State> ON | OFF
*RST: OFF

MEASurement<m>:GATE:MODE <Mode>

Defines whether the gate settings are configured using absolute or relative values.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<Mode> ABS | REL
*RST: ABS

MEASurement<m>:GATE:ABSolute:STARt <Time>
MEASurement<m>:GATE:ABSolute:STOP <Time>

Define the absolute start and end values for the gate.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<Time> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Usage: SCPI confirmed

MEASurement<m>:GATE:RELative:STARt <RelativeStart>
MEASurement<m>:GATE:RELative:STOP <RelativeStop>

Define the relative start and end values for the gate, respectively.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

MEASurement<m>:GATE:NOISe <NoiseEvalArea>

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<NoiseEvalArea> UPPer | LOWer
*RST: LOWer

MEASurement<m>:GATE:CURSor <Cursorset>

Selects the cursor set to be used for measurement gating. The gate area is defined by the cursor lines.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<Cursorset> CURSOR1 | CURSor1 | CURSOR2 | CURSor2 | CURSOR3 | CURSor3 | CURSOR4 | CURSor4
CURSOR1 = CURSor1, CURSOR2 = CURSor2, CURSOR3 = CURSor3, CURSOR4 = CURSor4
*RST: CURSOR1

MEASurement<m>:GATE:CCOupling <CursorCoupling>

Enables the cursor coupling for automatic measurements.

Select the cursor set to be used with `MEASurement<m>:GATE:CURSor`.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<CursorCoupling> ON | OFF

*RST: OFF

MEASurement<m>:GATE:ZCOupling <ZoomCoupling>

If enabled, the gate area is defined identically to the zoom area for the zoom diagram.

If enabled, define the zoom area to be used as gate with `MEASurement<m>:GATE:ZDIagram`.

Suffix:

<m> 1..10

See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<ZoomCoupling> ON | OFF

*RST: OFF

MEASurement<m>:GATE:ZDIagram <DiagramName>, <ZoomName>
MEASurement<m>:GATE:ZDIagram? <DiagramName>

If `MEASurement<m>:GATE:ZCOupling` is enabled, the gate area is defined identically to the zoom area for the selected zoom diagram.

Suffix:

<m> 1..10

See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<ZoomName> String with the name of the zoom diagram

Parameters for setting and query:

<DiagramName> String with the name of the diagram on which the zoom is based

Example: `:MEASurement:GATE:ZDIagram "Diagram1","Zoom1"`

16.12.11 Reference Level

16.12.11.1 General Reference Level Settings

REFLevel<m>:LDETection <LevelDetection>

Defines whether the reference level is configured manually or automatically.

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<LevelDetection> AUTO | MANual

*RST: AUTO

Example: `REFLevel2:LDETection MANual`
Sets manual level configuration for Ch1. C1W1 corresponds to suffix number 2.

Example: See: Chapter 16.3.2.1, "Setting Reference Levels", on page 866

REFLevel<m>:LMODe <LevelMode>

Defines whether the reference is configured using absolute or relative values.

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<LevelMode> ABS | REL

*RST: REL

Example: `REFLevel2:LMODe ABS`
Sets definition of reference levels to absolute values for Ch1. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using relative values" on page 866

REFLevel<m>:RELative:MODE <RelativeLevels>

The lower, middle and upper reference levels, defined as percentages of the high signal level.

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<RelativeLevels> FIVE | TEN | TWENty | USER

FIVE
5/50/95

TEN
10/50/90

TWENty
20/50/80

USER
Set the reference levels to individual values with `REFLevel<m>:RELative:LOWer`, `REFLevel<m>:RELative:MIDDle`, and `REFLevel<m>:RELative:UPPer`.

*RST: TEN

Example: `REFL2:REL:MODE FIVE`
Reference levels for Ch1: Lower reference level = 5% of high signal level, middle reference level = 50% of high signal level, upper reference level = 95% of high signal level

Example: See: "Manual reference level definition using relative values" on page 866

16.12.11.2 Automatic Configuration

REFLevel<m>:AUTO[:STATe] <HistgAveraging>

Enables averaging over several histograms to determine the reference levels. The number of histograms to consider is defined using `REFLevel<m>:AUTO:COUNt`.

This function is only available in automatic reference level mode (see `REFLevel<m>:LDETection` on page 1060).

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<HistgAveraging> ON | OFF

*RST: OFF

REFLevel<m>:AUTO:COUNt <Weight>

Defines the number of histograms from which the average is calculated.

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<Weight> Range: 2 to 128
Increment: 2
*RST: 128

16.12.11.3 Manual Configuration

User Signal Level

REFLevel<m>:ABSolute:HIGH <SignalHigh>

The signal value that represents a high level.

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<SignalHigh> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Example:

```
REFLevel2:ABSolute:HIGH 0.015
```

Sets the high signal level for Ch1 to 15 mV. C1W1 corresponds to suffix number 2.

REFLevel<m>:ABSolute:LOW <SignalLow>

The signal value that represents a low level.

Suffix:
<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:
<SignalLow> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Example: `REFLevel2:ABSolute:Low 0.0015`
Sets the low signal level forCh1 to 1.5 mV. C1W1 corresponds to suffix number 2.

REFLevel<m>:ABSolute:TDIStance <TopDistance>

The distance between the high signal level and the upper reference level.

Suffix:
<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:
<TopDistance> Range: 0 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Example: `REFLevel2:ABSolute:TDIStance 0.0002`
Sets the top distance for Ch1 to 0.2 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 866

REFLevel<m>:ABSolute:BDIStance <BottomDistance>

The distance between the lower reference level and the low signal value.

Suffix:
<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<BottomDistance> Range: 0 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Example: `REFLevel2:ABSolute:BDIStance 0.0002`
Sets the bottom distance for Ch1 to 0.2 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 866

User Reference Level

REFLevel<m>:ABSolute:ULEVel <UpperLevel>

The upper reference level, required e.g. to determine a rise.

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<UpperLevel> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Example: `REFLevel2:ABSolute:ULEVel 0.01`
Sets the upper reference level for Ch1 to 10 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 866

REFLevel<m>:ABSolute:MLEVel <MiddleLevel>

The middle reference level.

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<MiddleLevel> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Example: `REFLevel2:ABSolute:MLEVel 0.005`
Sets the middle reference level for Ch1 to 5 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 866

REFLevel<m>:ABSolute:LLEVel <LowerLevel>

The lower reference level, required e.g. to determine a fall.

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<LowerLevel> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Example: `REFLevel2:ABSolute:LLEVel 0.001`
Sets the lower reference level for Ch1 to 1 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 866

REFLevel<m>:RELative:UPPer <UppRefLevRel>

Sets the upper relative reference level if `REFLevel<m>:RELative:MODE` is set to `USER`.

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<UppRefLevRel> Percentage of the high signal level.

Range: -100 to 200
Increment: 1
*RST: 90
Default unit: %

Example: `REFLevel8:RELative:LOWer 85`
Sets the upper reference level for Ch3 to 85 %. Ch3 corresponds to suffix number 8.

Example: See: "Manual reference level definition using relative values" on page 866

REFLevel<m>:RELative:MIDDle <MiddleRefLevRel>

Sets the middle relative reference level if `REFLevel<m>:RELative:MODE` is set to `USER`.

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<MiddleRefLevRel> Percentage of the high signal level.

Range: -100 to 200
Increment: 1
*RST: 50
Default unit: %

Example: `REFLevel8:RELative:MIDDle 50`
Sets the middle reference level for Ch3 to 50 %. Ch3 corresponds to suffix number 8.

Example: See: "Manual reference level definition using relative values" on page 866

REFLevel<m>:RELative:LOWer <LowRefLevRel>

Sets the lower relative reference level if `REFLevel<m>:RELative:MODE` is set to `USER`.

Suffix:

<m> 1..87
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 16.4.1, "Waveform Suffix", on page 878.

Parameters:

<LowRefLevRel> Percentage of the high signal level.

Range: -100 to 200
Increment: 1
*RST: 10
Default unit: %

Example:

```
REFLevel8:RELative:LOWer 15
```

Sets the lower reference level for Ch3 to 15 %. Ch3 corresponds to suffix number 8.

Example:

See: "Manual reference level definition using relative values" on page 866

16.12.11.4 Results

MEASurement<m>:REFLevel:RESult:LOWer?
MEASurement<m>:REFLevel:RESult:MIDDle?
MEASurement<m>:REFLevel:RESult:UPPer?

Return the lower, middle, and upper reference level, respectively.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Return values:

<Level> Range: -100E+24 to 100E+24
*RST: 0

Usage: Query only
SCPI confirmed

MEASurement<m>:REFLevel:RESult:SIGLow?
MEASurement<m>:REFLevel:RESult:SIGHigh?

Return the signal value that represents a low or high level, respectively.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Return values:

<Level> Range: -100E+24 to 100E+24
*RST: 0

Usage: Query only
SCPI confirmed

MEASurement<m>:REFLevel:RESult:BINNer?

Returns the area above the low signal level which is still considered to be low level.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Return values:

<BottomInner> Range: -100E+24 to 100E+24
*RST: 0

Usage: Query only

MEASurement<m>:REFLevel:RESult:BOUTer?

Returns the area beneath the low signal level which is still considered to be low level.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Return values:

<BottomOuter> Range: -100E+24 to 100E+24
*RST: 0

Usage: Query only

MEASurement<m>:REFLevel:RESult:TINNer?

Returns the area beneath the high signal level which is still considered to be high level.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Return values:

<TopInner> Range: -100E+24 to 100E+24
*RST: 0

Usage: Query only
SCPI confirmed

MEASurement<m>:REFLevel:RESult:TOUTer?

Returns the area above the high signal level which is still considered to be high level.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Return values:

<TopOuter> Range: -100E+24 to 100E+24
*RST: 0

Usage: Query only
SCPI confirmed

16.13 Spectrum Analysis

16.13.1 Basic FFT

CALCulate:MATH<m>:FFT:LOGScale <XAxisMode>

Defines the scaling method for the frequency (x-)axis of the spectrogram.

This command is only available if the R&S RTE-K18 option is installed.

Suffix:

<m> 1..4

Parameters:

<XAxisMode> LIN | LOG

LOG
Logarithmic scaling

LIN
Linear scaling

*RST: LIN

CALCulate:MATH<m>:FFT:STARt <StartFreq>

Defines the start frequency of the displayed frequency span.

Suffix:

<m> 1..4
math waveform

Parameters:

<StartFreq> start frequency

Range: 0 to 5E+9
Increment: 1
*RST: 2E+9
Default unit: Hz

CALCulate:MATH<m>:FFT:STOP <StopFreq>

Defines the stop frequency of the displayed frequency span.

Suffix:

<m> 1..4
math waveform

Parameters:

<StopFreq> stop frequency

Range: 0 to 5E+9
Increment: 1
*RST: 2E+9
Default unit: Hz

CALCulate:MATH<m>:FFT:CFRequency <CenterFreq>

Defines the position of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The width of the range is defined using the `CALCulate:MATH<m>:FFT:SPAN` command.

Suffix:

<m> 1..4
math waveform

Parameters:

<CenterFreq> center frequency

Range: 0 to 2E+12
Increment: 1
*RST: 2.5E+9
Default unit: Hz

CALCulate:MATH<m>:FFT:FULLspan

Performs FFT calculation for the full frequency span.

Suffix:

<m> 1..4
math waveform

Usage: Event

CALCulate:MATH<m>:FFT:SPAN <FreqSpan>

The span is specified in Hertz and defines the width of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The position of the span is defined using the `CALCulate:MATH<m>:FFT:CFRequency` command.

Suffix:

<m> 1..4
Math waveform

Parameters:

<FreqSpan> Frequency span

Range: 1 to 4E+12
Increment: 1
*RST: 5E+9
Default unit: Hz

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:ADJusted?

Queries the effective resolution bandwidth.

Suffix:

<m> 1..4
Math waveform

Return values:

<AdjResBW> effective resolution bandwidth

Range: 0.01 to 2E+12
*RST: 0
Default unit: Hz

Usage: Query only

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO <State>

Couples the frequency span to the RBW.

Suffix:

<m> 1..4
math waveform

Parameters:

<State> ON | OFF

*RST: ON

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:RATio <SpanRBWRatio>

This command defines the ratio of span (Hz) / resolution bandwidth (Hz).

Suffix:

<m> 1..4
math waveform

Parameters:

<SpanRBWRatio> ratio span / resolution bandwidth

Range: 1 to 1000
Increment: 1
*RST: 100

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution][:VALue] <ResolutionBW>

This command defines the resolution bandwidth.

Suffix:

<m>	1..4 math waveform

Parameters:

<ResolutionBW>	resolution bandwidth Range: 0.01 to 2E+6 Increment: 0.01 *RST: 2E+6 Default unit: Hz

CALCulate:MATH<m>:FFT:WINDow:TYPE <WindowType>

Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

Various different window functions are provided in the R&S RTE to suit different input signals. Each of the window functions has specific characteristics, including some advantages and some trade-offs. These characteristics need to be considered carefully to find the optimum solution for the measurement task.

Suffix:

<m>	1..4 math waveform

Parameters:

<WindowType> RECTangular | HAMMing | HANN | BLACkharris | GAUSsian | FLATTOP2 | FLATtop2 | KAISerbessel

RECTangular
The rectangular window has the best frequency resolution, but a poor amplitude accuracy and is recommended for separating two tones with almost equal amplitudes and a small frequency distance.

HAMMing
The Hamming window is bell shaped and has a good frequency resolution and fair amplitude accuracy. It is recommended for frequency response measurements as well as sine waves, periodic signals and narrow-band noise

HANN
The Hann window is bell shaped and has a slightly worse frequency resolution but smaller sidelobe level than the Hamming window. The applications are the same.

BLACkharris
The Blackman window is bell shaped and has a poor frequency resolution, but very good amplitude accuracy. It is recommended mainly for signals with single frequencies to detect harmonics.

GAUSsian
Good frequiency resolution and best magnitude resolution, recommended for weak signals and short duration

FLATTOP2 = FLATtop2
The flattop window has a poor frequency resolution, but the best amplitude accuracy and the sharpest side lobe. It is recommended for accurate single-tone amplitude measurements.

KAISerbessel
The Kaiser-Bessel window has a fair frequency resolution and good amplitude accuracy, and a very high sidelobe level. It is recommended for separating two tones with differing amplitudes and a small frequency distance.

*RST: BLACkharris

Firmware/Software: Version 3.35 and higher: Use FLATTOP2 or FLATtop2 instead of FLAT2

CALCulate:MATH<m>:FFT:FRAMe:ARIThmetics <Arithmetics>

The arithmetic mode defines how the final FFT result is calculated from the individual frame results.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:
<Arithmetics> OFF | ENVelope | AVERage | RMS | MINHold | MAXHold
See "FFT Segment Arithmetics" on page 340
*RST: OFF

CALCulate:MATH<m>:FFT:FRAMe:COVerage?

Due to the restriction of the number of frames (see `CALCulate:MATH<m>:FFT:FRAMe:MAXCount` on page 1075), the waveform may only be analyzed partially. This command queries the percentage of the trace that was analyzed, i.e. which part of the trace was included in the frame calculation.

Suffix:
<m> 1...4
math waveform

Return values:
<FrameCoverage> Range: 0 to 100
*RST: 100
Default unit: %

Usage: Query only
SCPI confirmed

CALCulate:MATH<m>:FFT:FRAMe:MAXCount <MaxFrameCount>

Restricts the maximum number of frames to be calculated. Due to the other parameter settings, the required number of frames may become very high, thus slowing performance. By restricting the number of frames, you can avoid performance loss without changing the other parameters.

Suffix:
<m> 1...4
math waveform

Parameters:
<MaxFrameCount> Range: 1 to 10000
Increment: 10
*RST: 1000

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:FRAMe:OFACtor <OverlapFactor>

Defines the minimum factor by which two neighboring frames overlap. If the required number of frames to cover the input values allows for more overlap, the factor is increased.

The higher the overlap factor, the more frames are used. This leads to more individual results and improves detection of transient signal effects. However, it also extends the duration of the calculation.

Suffix:

<m> 1...4
math waveform

Parameters:

<OverlapFactor> Range: 0 to 90
Increment: 1
*RST: 50
Default unit: %

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:GATE:COUPling <GateRBWCoupling>

Defines the behaviour of the record length or RBW value in dependancy to the other FFT parameters.

See also:

- "Record Length/RBW Coupling" on page 343
- Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 328

Suffix:

<m> 1...4
math waveform

Parameters:

<GateRBWCoupling> LENGth | RBW

LENGth
The record length remains constant. If not enough samples are available for the selected RBW, the RBW will be decreased.

RBW
The RBW is not adapted, i.e. remains as defined by the user. The required acquisition time for this RBW is indicated. If necessary and possible, the record length is extended to acquire the required number of samples.

*RST: RBW

Usage: SCPI confirmed

TIMebase:RACTime?

Queries the required acquisition time. If FFT gating is used and the resolution BW is set to constant, record length can be extended to acquire the required number of samples. In this case, the required acquisition time differs from the adjusted acquisition time (`TIMebase:RANGe`).

Return values:

<RequiredAcqTime> Required acquisition time for FFT

Range: 250E-12 to 100E+3
*RST: 0.5
Default unit: s

Usage: Query only

CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt <Start>

Defines the starting value for the gate.

Suffix:

<m> 1...4
math waveform

Parameters:

<Start> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP <Stop>

Defines the end value for the gate.

Suffix:

<m> 1...4
math waveform

Parameters:

<Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:GATE:MODE <Mode>

Defines whether the gate settings are configured using absolute or relative values.

Suffix:

<m> 1...4
math waveform

Parameters:

<Mode> ABS | REL
*RST: ABS

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:GATE:RELative:STARt <RelativeStart>

Defines the starting value for the gate in percent.

Suffix:

<m> 1..4
math waveform

Parameters:

<RelativeStart>	Range:	0 to 100
	Increment:	0.1
	*RST:	0
	Default unit:	%

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:GATE:RELative:STOP <RelativeStop>

Defines the end value for the gate in percent.

Suffix:

<m> 1..4
math waveform

Parameters:

<RelativeStop>	Range:	0 to 100
	Increment:	0.1
	*RST:	100
	Default unit:	%

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:GATE:ZCOupling <ZoomCoupling>

If enabled, the gate area is defined identically to the zoom area for the zoom diagram.

Suffix:

<m> 1...4
math waveform

Parameters:

<ZoomCoupling> ON | OFF
*RST: OFF

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:GATE[:STATe] <State>

Enables FFT gating.

Suffix:

<m> 1...4
math waveform

Parameters:

<State> ON | OFF
*RST: OFF

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:MAGNitude:LEVel <VerticalMax>

Defines the reference level for dB scaling.

Suffix:
<m> 1..4
Math waveform

Parameters:
<VerticalMax> Range: -100E+24 to 1E+15
Increment: 0.01
*RST: 0
Default unit: div

CALCulate:MATH<m>:FFT:MAGNitude:RANGe <Range>

Defines the vertical value range in spectrum mode.

Suffix:
<m> 1...4
math waveform

Parameters:
<Range> Range: 1 to 500
Increment: 1
*RST: 100
Default unit: dB

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:MAGNitude:SCALe <MagnitudeScale>

Defines the scaling of the y-axis. The display values are valid for 50Ω termination impendance.

For details on the available scaling modes, see "Magnitude unit" on page 344.

Suffix:
<m> 1..4
math waveform

Parameters:
<MagnitudeScale> LINear | DBM | DB | DBUV | DBMV | DBV | DBPS | DBNS | DBUS | DBMS | DBS | DBHZ | DBKHZ | DBKHz | DBMHZ | DBMHz | DBGHZ | DBGHz | DBA | DBMA | DBUA

LINear
Linear scaling; displays the RMS value of the voltage

*RST: DBM

Usage: SCPI confirmed

Table 16-8: Logarithmic scaling values

DBM	dBm
DB	dB (related to reference level)
DBUV	dBµV
DBMV	dBmV
DBV	dBV
DBPS	dBps
DBNS	dBns
DBUS	dBµs
DBMS	dBms
DBS	dBs
DBHZ	dBHz
DBKHZ = DBKHz	dBkHz
DBMHZ = DBMHz	dBMHz
DBGHZ = DBGHz	dBGHz
DBA	dBA
DBMA	dBmA
DBUA	dBµA

CALCulate:MATH<m>:FFT:PHASe:SCALe <PhaseScale>

Defines the scaling unit for phase display.

Suffix:
<m> 1...4
math waveform

Parameters:
<PhaseScale> DEGRees | RADians
*RST: DEGRees

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:PHASe:SUPPression <Suppression>

Enables noise suppression. Phase calculation is restricted to frequencies with a minimum magnitude, the threshold value (see `CALCulate:MATH<m>:FFT:PHASe:THReshold` on page 1081).

Suffix:
<m> 1...4
math waveform

Parameters:

<Suppression> ON | OFF

*RST: OFF

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:PHASe:THReshold <SupprThres>

Defines the minimum frequency magnitude for which phases are calculated. This setting is only available if `CALCulate:MATH<m>:FFT:PHASe:SUPPression` is set to "ON".

Suffix:

<m> 1...4
math waveform

Parameters:

<SupprThres> Range: -180 to 180
Increment: 0.1
*RST: 0
Default unit: dBm

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:PHASe:UNWRap <Unwrap>

If enabled, phase shifts due to a limitation of the value range are eliminated.

Suffix:

<m> 1...4
math waveform

Parameters:

<Unwrap> ON | OFF

*RST: OFF

Usage: SCPI confirmed

CALCulate:MATH<m>:FFT:COUPled:WITH<m2> <MathIndex>

Copies the current FFT settings of the selected math waveform (m) to the other selected math waveform (m2), and couples the two waveforms. This can be repeated for all math waveforms.

If any FFT setting for any of the coupled spectrums is changed, it is changed for all coupled spectrums.

Suffix:

<m>, <m2> 1..4
<m>, <m2> must be distinct

Parameters:

<MathIndex> ON | OFF

*RST: OFF

Example: `CALC:MATH1:FFT:COUP:WITH2 ON`

Couples the math waveforms m1 and m2.

Usage: SCPI confirmed

16.13.2 Waveform Data

CALCulate:MATH<m>:DATA:STYPe?

Returns the signal type of the source of the math waveform.

Suffix:

<m> 1..4

Selects the math waveform.

Return values:

<SignalType> SOUR | SPEC | CORR | MEAS | NONE

SOURce = normal signal
SPECtrum = FFT spectrum, specific math signal
CORRelation = correlated signal, specific math signal
MEAsurement = result of a measurement
XY = XY-signal
SBUS = Serial bus
NONE = undefined

Usage: Query only
SCPI confirmed

CALCulate:MATH<m>:DATA:HEADer?

Returns the header of math waveform data. The header contains attributes of the waveform.

Table 16-9: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns

Position	Meaning	Example
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. For most waveforms the result is 1, for peak detect and envelope waveforms it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).	1

Suffix:
<m> 1..4
Selects the math waveform.

Example: `CALC:MATH4:DATA:HEAD`
`-9.477E-008,9.477E-008,200000,1`

Usage: Query only
SCPI confirmed

CALCulate:MATH<m>:DATA[:VALues]?

Returns the data of the math waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

You can retrieve only Y-values, or X- and Y-values. Use `EXPort:WAVeform:INCXvalues` to define this.

Suffix:
<m> 1..4
Selects the math waveform.

Return values:
<Data> List of values according to the format and content settings.

Usage: Query only

16.13.3 Spectrum Analysis (Option R&S RTE-K18)

In all `CALC:MATH<m>:FFT` commands, the suffix <m> selects the math waveform.

In all `CALC:MATH<m>:FFT:SPEC:TIM` commands, the suffix <m> selects the timeline.

CALCulate:MATH<m>:FFT:SPECtrogram:CMODe <ColorTableName>

Selects the color table mode for the frequency analysis display.

Suffix:
<m> 1..4

Parameters:
<ColorTableMode> INCI | AMPL

INCI
("Incidence") The display color is set depending on the frequency of occurrence of a value.

AMPL
("Amplitude") In the spectrogram and the frequency analysis display, the color is used to indicate the magnitude of the FFT signal. The higher the amplitude the higher the color in the assigned color table.

*RST: INCI

CALCulate:MATH<m>:FFT:USEColtab <UseColorTable>

If enabled, the selected waveform is displayed according to its assigned color table. For information on the available color tables, see Chapter 3.4.2.2, "Color Tables", on page 119.

If this option is disabled, the preset color of the selected channel source is displayed, and the intensity of the specific signal color varies according to the cumulative occurrence of the values.

Suffix:
<m> 1..4

Parameters:
<UseColorTable> ON | OFF

*RST: OFF

CALCulate:MATH<m>:FFT:SPECtrogram:STATe <State>

Enables the spectrogram display for a math waveform.

Suffix:
<m> 1..4

Parameters:
<State> ON | OFF

*RST: OFF

CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:POSition <Position>

Defines the position of one of the two possible time lines in a spectrogram. The time line must be enabled first, using the `CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:STATe` command.

Suffix:
<m> 1..4

<n> 1..2

Parameters:

<Position> The position of the time line is defined by the index of the data acquisition in the history. How many acquisitions are available depends on the history settings.

Range: 0 to 4294967295
Increment: 1
*RST: 0

CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:STATe <State>

Enables one of two possible time lines in a spectrogram diagram. A time line marks a single waveform in the spectrogram, that is: the power vs frequency results for the data acquired at a specific time. After enabling a time line, the results for that time are displayed in the spectrum diagram.

The position of the time line is defined using the `CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:POSition` command.

Suffix:

<m> 1..4

<n> 1..2

Parameters:

<State> ON | OFF

*RST: OFF

16.14 Mask Testing

16.14.1 Mask Test Definition

MTESt:ADD <MaskTestName>

Creates a new mask test definition with the specified name.

Setting parameters:

<MaskTestName> String with the name of the mask test

Example: See Chapter 16.3.3.1, "Creating a user mask", on page 868

Usage: Setting only

MTESt:REMove <MaskTestName>

Deletes the mask test definition with the specified name.

Setting parameters:

<MaskTestName> String with the name of the mask test

Usage: Setting only

MTESt[:STATe] <MaskTestName>,<State>
MTESt[:STATe]? <MaskTestName>

Activates and deactivates the mask test. If the acquisition is running, the test starts immediately. Otherwise, the test starts when acquisition is started.

The testing is stopped when acquisition is stopped, also due to the `MTESt:ONViolation:STOP` command, or if `MASK[:STATe]` is set to "OFF".

The coommand needs `*OPC` command synchronisation, see Chapter B.3, "Command Sequence and Synchronization", on page 1626.

Parameters:

<State> ON | OFF

*RST: OFF

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

Example: `MTEST:STAT 'MyMask', ON; *OPC?`
See Chapter 16.3.3.1, "Creating a user mask", on page 868

MTESt:RST

Clears all totals and results in all "Mask Test" result boxes.

Usage: Event

Firmware/Software: FW 1.35

MTESt:SOURce <MaskTestName>,<MaskTestSource>
MTESt:SOURce? <MaskTestName>

Selects the waveform to be tested against the mask. All channel waveforms can be tested.

Parameters:

<MaskTestSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 Waveform to be tested, see Chapter 16.4.2, "Waveform Parameter", on page 879 *RST: C1W1

Parameters for setting and query:

<MaskTestName>	String containing the name of the mask test

MTESt:CONDition <MaskTestName>,<PassFailMode>
MTESt:CONDition? <MaskTestName>

Sets the first criteria for a failed test, the kind of hits to be considered for test evaluation. A test has failed if the number of sample hits or acquisition hits exceeds the limit defined by `MTESt:TOLerance`.

Parameters:

<PassFailMode>	SAMPles | ACQuisitions **SAMPles** Considers the number of samples that hit the mask. **ACQuisitions** Considers the number of acquisitions that contain at least one sample hit. How many samples hit the mask in that acquisition is not relevant. *RST: SAMPles

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:TOLerance <MaskTestName>,<TolViolCount>
MTESt:TOLerance? <MaskTestName>

Sets the second criteria for a failed test, the number of tolerable sample hits or acquisition hits. Use `MTESt:CONDition` to define which hits are considered for test evaluation.

Parameters:

<TolViolCount>	Range: 0 to 4000000000 Increment: 1 *RST: 0

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:CTYPe <MaskTestName>,<DefinitionType>
MTESt:CTYPe? <MaskTestName>

Sets the method of mask definition.

Parameters:

<DefinitionType> | USER | WFML

USER
The mask segments are created by entering the numerical x- and y-values of the mask points.
See: Chapter 16.14.2, "Mask Definition: User Mask", on page 1089

WFML
The mask is created from the envelope of an existing waveform.
See: Chapter 16.14.3, "Mask Definition: Waveform Mask", on page 1094

*RST: USER

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:FILE:NAME <MaskTestName>, <Path>
MTESt:FILE:NAME? <MaskTestName>

Specifies a file to save the mask test.

Parameters:

<Path> String containing path and file name, format .xml

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:FILE:SAVE <MaskTestName>

Saves the specified mask test. It contains the mask definition, defined actions and fail conditions.

Setting parameters:

<MaskTestName> String with the name of the mask test

Usage: Setting only

MTESt:FILE:OPEN <MaskTestName>

Loads the specified mask test to the instrument.

Setting parameters:

<MaskTestName> String with the name of the mask test

Usage: Setting only

MTESt:FILE:DELete <MaskTestName>

Deletes the specified mask test.

Setting parameters:

<MaskTestName> String with the name of the mask test

Usage: Setting only

16.14.2 Mask Definition: User Mask

The chapter contains commands required for the definition of user masks - `MTESt:CTYPe` is set to `USER`.

Segment and point indices

In remote control, the numbering of segments and points starts from 0. But in manual operation, the numbering starts from 1.

MTESt:SEGMent:STATe <MaskTestName>, <MaskSegmIdx>,<State>
MTESt:SEGMent:STATe? <MaskTestName>, <MaskSegmIdx>

Enables and disables the mask segment. Disabled segments are not considered by running tests.

Parameters:

<State> ON | OFF

*RST: ON

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

MTESt:SEGMent:ADD <MaskTestName>

Creates a new segment in the mask definition.

Setting parameters:

<MaskTestName> String with the name of the mask test

Example: See Chapter 16.3.3.1, "Creating a user mask", on page 868

Usage: Setting only

MTESt:SEGMent:COUNt? <MaskTestName>

Returns the number of segments in the mask definition

Query parameters:

<MaskTestName> String with the name of the mask test

Return values:

<Count> Number of segments

Usage: Query only

MTESt:SEGMent:INSert <MaskTestName>, <MaskSegmIdx>

Inserts a new segment before the specified index in the mask definition.

Setting parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Usage: Setting only

MTESt:SEGMent:REMove <MaskTestName>, <MaskSegmIdx>

Removes the specified segment from the mask definition.

Setting parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Usage: Setting only

MTESt:SEGMent:REGion <MaskTestName>, <MaskSegmIdx>, <Region>
MTESt:SEGMent:REGion? <MaskTestName>, <MaskSegmIdx>

Defines the region of the segment that builds the mask.

Parameters:

<Region> UPPer | LOWer | INNer

UPPer
the segment points are connected to a line, the display area above this line is the mask segment

LOWer
the segment points are connected to a line, the display area below this line is the mask segment

INNer
the segment points form a closed geometrical shape, which is the mask segment

*RST: INNer

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Example: See Chapter 16.3.3.1, "Creating a user mask", on page 868

MTESt:SEGMent:POINt:ADD <MaskTestName>, <MaskSegmIdx>

Adds a new point to the segment definition.

Setting parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Example: See Chapter 16.3.3.1, "Creating a user mask", on page 868

Usage: Setting only

MTESt:SEGMent:POINt:INSert <MaskTestName>, <MaskSegmIdx>, <MaskSegmPointIdx>

Inserts a new point before the specified mask segment point.

Setting parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

<MaskSegmPointIdx> Number of the point. Counting starts from 0.

Usage: Setting only

MTESt:SEGMent:POINt:REMove <MaskTestName>, <MaskSegmIdx>, <MaskSegmPointIdx>

Removes the specified point from the mask segment.

Setting parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

<MaskSegmPointIdx> Number of the point. Counting starts from 0.

Usage: Setting only

MTESt:SEGMent:POINt:COUNt? <MaskTestName>, <MaskSegmIdx>

Returns the number of defined points for the specified mask segment.

Query parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Usage: Query only

MTESt:SEGMent:POINt:X <MaskTestName>, <MaskSegmIdx>, <MaskSegmPointIdx>, <X>
MTESt:SEGMent:POINt:X? <MaskTestName>, <MaskSegmIdx>, <MaskSegmPointIdx>

Defines the x-value of the mask segment point.

Parameters:

<X>
Range: -100E+24 to 100E+24
Increment: 1E-6
*RST: 0
Default unit: s

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

<MaskSegmPointIdx> Number of the point. Counting starts from 0.

Example: See Chapter 16.3.3.1, "Creating a user mask", on page 868

MTESt:SEGMent:POINt:Y <MaskTestName>, <MaskSegmIdx>, <MaskSegmPointIdx>, <Y>
MTESt:SEGMent:POINt:Y? <MaskTestName>, <MaskSegmIdx>, <MaskSegmPointIdx>

Defines the y-value of the mask segment point.

Parameters:

<Y>
Range: -100E+24 to 100E+24
Increment: 1E-6
*RST: 0
Default unit: V

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

<MaskSegmPointIdx> Number of the point. Counting starts from 0.

Example: See Chapter 16.3.3.1, "Creating a user mask", on page 868

MTESt:SEGMent:RESCale:RECalculate <MaskTestName>, <MaskSegmIdx>

Multiplies and adds the given x- and y-factors and offsets to the coordinates of all points of the selected mask segment.

Setting parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Usage: Setting only

MTESt:SEGMent:RESCale:XFACtor <MaskTestName>, <MaskSegmIdx>, <ExpansionFactor>
MTESt:SEGMent:RESCale:XFACtor? <MaskTestName>, <MaskSegmIdx>
MTESt:SEGMent:RESCale:YFACtor <MaskTestName>, <MaskSegmIdx>, <ExpansionFactor>
MTESt:SEGMent:RESCale:YFACtor? <MaskTestName>, <MaskSegmIdx>

Stretches or compresses the selected mask segment in horizontal (XFACtor) or vertical direction (YFACtor). The x- or y-values of all points of the selected mask segment are multiplied with this factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.

Only takes effect after the `MTESt:SEGMent:RESCale:RECalculate` command.

Parameters:

<ExpansionFactor> Range: -100 to 100
Increment: 1
*RST: 1

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

MTESt:SEGMent:RESCale:XOFFset <MaskTestName>, <MaskSegmIdx>, <OffsetX>
MTESt:SEGMent:RESCale:XOFFset? <MaskTestName>, <MaskSegmIdx>

Moves the mask segment horizontally. The specified offset is added to the x-values of all points of the selected mask segment.

Only takes effect after the `MTESt:SEGMent:RESCale:RECalculate` command.

Parameters:
<OffsetX> Range: -50 to 50
Increment: 1E-9
*RST: 0
Default unit: s

Parameters for setting and query:
<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Firmware/Software: V 1.25

MTESt:SEGMent:RESCale:YOFFset <MaskTestName>, <MaskSegmIdx>, <OffsetY>
MTESt:SEGMent:RESCale:YOFFset? <MaskTestName>, <MaskSegmIdx>

Moves the mask segment vertically. The specified offset is added to the y-values of all points of the selected mask segment.

Only takes effect after the `MTESt:SEGMent:RESCale:RECalculate` command.

Parameters:
<OffsetY> Range: -1000 to 1000
Increment: 1E-6
*RST: 0
Default unit: V

Parameters for setting and query:
<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

16.14.3 Mask Definition: Waveform Mask

The chapter contains commands required for the definition of waveform masks - `MTESt:CTYPe` is set to `WFML`.

MTESt:REFWfm <MaskTestName>,<Source>
MTESt:REFWfm? <MaskTestName>

Sets the reference waveform from which the mask is created.

The reference waveform can be created before, or loaded from a file with REFCurve commands, see Chapter 16.10.2, "Reference Waveforms", on page 994.

Parameters:

<Source> REF1 | REFERENCE1 | REF2 | REFERENCE2 | REF3 | REFERENCE3 | REF4 | REFERENCE4

REF1 = REFERENCE1, REF2 = REFERENCE2, REF3 = REFERENCE3, REF4 = REFERENCE4: reference waveforms

*RST: REF1

Parameters for setting and query:

<MaskTestName> String containing the name of the mask test

MTESt:WFMLupdate <MaskTestName>

Creates the upper and lower mask limit from the envelope of the selected reference waveform. If the reference waveform was not defined before, it is created automatically from the mask test source waveform which is set wtih `MTESt:SOURce`.

Setting parameters:

<MaskTestName> String containing the name of the mask test

Usage: Setting only

MTESt:WFMRescale:XWIDth <MaskTestName>,<HorizontalWidth>
MTESt:WFMRescale:XWIDth? <MaskTestName>

Sets the width of the mask in horizontal direction. The specified factor in divisions is added to the positive x-values and subtracted from the negative x-values of the mask limits in relation to the source waveform of the mask.

Parameters:

<HorizontalWidth> Range: 0 to 1000
Increment: 0.01
*RST: 0
Default unit: div

Parameters for setting and query:

<MaskTestName> String containing the name of the mask test

MTESt:WFMRescale:YWIDth <MaskTestName>,<VerticalWidth>
MTESt:WFMRescale:YWIDth? <MaskTestName>

Sets the width of the waveform mask in vertical direction. The specified factor in divisions is added to the y-values of the upper mask limit and subtracted from the y-values of the lower mask limit. Thus, the upper half of the mask is pulled upwards, the lower half is pulled down.

Parameters:

<VerticalWidth> Vertical mask width in divisions

Range: 0 to 1000
Increment: 0.01
*RST: 0
Default unit: div

Parameters for setting and query:

<MaskTestName> String containing the name of the mask test

MTESt:WFMRescale:YPOSition <MaskTestName>,<VertPosi>
MTESt:WFMRescale:YPOSition? <MaskTestName>

Moves the mask vertically within the display.

Parameters:

<VertPosi> Range: -1000 to 1000
Increment: 0.01
*RST: 0
Default unit: div

Parameters for setting and query:

<MaskTestName> String containing the name of the mask test

MTESt:WFMRescale:YSTRetch <MaskTestName>,<VerticalStretch>
MTESt:WFMRescale:YSTRetch? <MaskTestName>

Sets the vertical scaling to stretch the mask in y-direction. The scaling axis is the horizontal line through the lowest value of the lower mask limit.

Parameters:

<VerticalStretch> Scale factor in %
Range: 10 to 1000
Increment: 1
*RST: 100
Default unit: %

Parameters for setting and query:

<MaskTestName> String containing the name of the mask test

16.14.4 Event Actions

MTESt:ONViolation:BEEP <MaskTestName>,<Beep>
MTESt:ONViolation:BEEP? <MaskTestName>

Generates a beep sound for the specified event.

Parameters:

<Beep> NOACtion | SUCCess | VIOLation

See Chapter 16.4.5, "Event Parameter", on page 880

*RST: NOACtion

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:ONViolation:STOP <MaskTestName>,<StopAcq>
MTESt:ONViolation:STOP? <MaskTestName>

Stops data acquisition for the specified event.

Parameters:

<StopAcq> NOACtion | SUCCess | VIOLation

See Chapter 16.4.5, "Event Parameter", on page 880

*RST: NOACtion

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:ONViolation:PRINt <MaskTestName>,<Print>
MTESt:ONViolation:PRINt? <MaskTestName>

Prints a screenshot including the measurement results to the printer defined using `SYSTem:COMMunicate:PRINter:SELect<1..2>` for the specified event.

Parameters:

<Print> NOACtion | SUCCess | VIOLation

See Event Parameter

*RST: NOACtion

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:ONViolation:SAVewaveform <MaskTestName>,<SaveWfm>
MTESt:ONViolation:SAVewaveform? <MaskTestName>

Saves the waveform data.

Parameters:

<SaveWfm> NOACtion | SUCCess | VIOLation

See Chapter 16.4.5, "Event Parameter", on page 880

*RST: NOACtion

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:ONViolation:REPort <MaskTestName>,<Report>
MTESt:ONViolation:REPort? <MaskTestName>

Creates and saves a report of the current settings and results.

Parameters:

<Report> NOACtion | SUCCess | VIOLation

NOACtion
The action is not initiated.

SUCCess
The action is initiated if the limits or margins were not exceeded during the entire measurement.

VIOLation
The action is initiated if the limits or margins are exceeded during the measurement.

*RST: NOACtion

Parameters for setting and query:

<MaskTestName>

MTESt:ONViolation:TRIGgerout <MaskTestName>,<TriggerOutPulse>
MTESt:ONViolation:TRIGgerout? <MaskTestName>

Creates a trigger out pulse on mask violation or successful completion of the test cycle.

Parameters:

<TriggerOutPulse> NOACtion | SUCCess | VIOLation

*RST: NOACtion

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

16.14.5 Mask Display

MTESt:LABel <LabelState>

Switches the display of the mask test name on or off.

To change the name of the mask test, use `MTESt:REName` on page 1098.

Parameters:

<LabelState> ON | OFF

*RST: ON

MTESt:REName <MaskTestName>, <NewName>
MTESt:REName? <MaskTestName>

Changes the name of the mask test.

Parameters:

<NewName>	String with the new mask test name.

Parameters for setting and query:

<MaskTestName>	String with the existing mask test name.

16.14.6 Results

MTESt:RESult:STATe? <MaskTestName>

Shows if the test is running or has finished. The state is set to "Finished" if no acquisitions remain (see `MTESt:RESult:COUNt:REMaining?` on page 1100).

Query parameters:
<MaskTestName>

Return values:

<State>	RUNNing | FINished
	*RST: RUNNing
Usage:	Query only

MTESt:RESult[:RESult]? <MaskTestName>

Returns the test result.

A test has failed if the number of sample hits or acquisition hits exceeds the limit of "Violation tolerance" hits (see `MTESt:TOLerance` on page 1087, `MTESt:RESult:COUNt:FAILures?` on page 1100 and `MTESt:RESult:COUNt:FWAVeforms?` on page 1100).

Query parameters:
<MaskTestName>

Return values:

<TestResult>	PASS | FAIL
	*RST: PASS
Usage:	Query only

MTESt:RESult:COUNt:WAVeforms? <MaskTestName>

Returns the number of tested acquisitions.

Query parameters:
<MaskTestName>

Return values:

<AcqsCompleted>	Range:	0 to 100E+24
	*RST:	0

Usage: Query only

MTESt:RESult:COUNt:REMaining? <MaskTestName>

Remaining acquisitions until "Average count / Nx Single count" is reached.

The value is useful if you test a specified number of acquisitions with action "Stop acquisition" on violation, or if the acquisition has been stopped manually.

See also: Chapter 9.3.4, "Running a Mask Test", on page 373.

Query parameters:
<MaskTestName>

Return values:

<AcqsRemaining>	Range:	0 to 100E+24
	*RST:	0

Usage: Query only

MTESt:RESult:COUNt:FWAVeforms? <MaskTestName>

Returns the number of acquisitions that contained at least one sample hit.

Query parameters:
<MaskTestName>

Return values:

<AcquisitionHits>	Range:	0 to 100E+24
	*RST:	0

Usage: Query only

MTESt:RESult:COUNt:FAILures? <MaskTestName>

Returns the number of sample hits that violated the mask.

Query parameters:
<MaskTestName>

Return values:

<SampleHits>	Range:	0 to 100E+24
	*RST:	0

Usage: Query only

MTESt:RESult:FRATe? <MaskTestName>

Ratio of acquisition hits to the number of tested acquisitions.

Query parameters:
<MaskTestName>

Return values:

<FailRate>	Range:	-100E+24 to 100E+24
	*RST:	0
	Default unit:	%

Usage: Query only

16.15 Search

16.15.1 General Search Settings

SEARch:ADD <SearchName>

Creates a new search definition with the specified name.

Setting parameters:
<SearchName> String with the name of the search

Example: See Chapter 16.3.4.1, "Searching for a pulse of specified width", on page 869

Usage: Setting only

SEARch:CLEar <SearchName>

Clears the search results once to start a new search.

Setting parameters:

<SearchName> Search definition

Usage: Setting only

SEARch:REMove <SearchName>

Deletes the specified search definition.

Setting parameters:

<SearchName> String with the name of the search

Usage: Setting only

SEARch:SOURce <SearchName>,<Source>
SEARch:SOURce? <SearchName>

Defines the source on which the search conditions are applied. The source can be any analog or digital channel, math or reference waveform as well as a serial bus configured for a supported protocol.

Parameters:

<Source> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | SBUS1 | SBUS2 | SBUS3 | SBUS4

Source of the search, see Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: NONE

Parameters for setting and query:

<SearchName> String with the name of the search

Example: See Chapter 16.3.4.1, "Searching for a pulse of specified width", on page 869

SEARch:ONLine <SearchName>,<OnlineState>
SEARch:ONLine? <SearchName>

If enabled, a search is performed repeatedly for each new data acquisition.

Parameters:

<OnlineState> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName> Search definition

SEARch:ALL <SearchName>

Performs a search for all results on the existing data from the selected source.

Setting parameters:

<SearchName> Search definition

Example: See Chapter 16.3.4.1, "Searching for a pulse of specified width", on page 869

Usage: Setting only
Asynchronous command

16.15.2 Basic Trigger Search Conditions

SEARch:TRIGger:DATatoclock[:STATe] <SearchName>,<State>
SEARch:TRIGger:DATatoclock[:STATe]? <SearchName>
SEARch:TRIGger:EDGE[:STATe] <SearchName>,<State>
SEARch:TRIGger:EDGE[:STATe]? <SearchName>
SEARch:TRIGger:GLITch[:STATe] <SearchName>,<State>
SEARch:TRIGger:GLITch[:STATe]? <SearchName>
SEARch:TRIGger:INTerval[:STATe] <SearchName>,<State>
SEARch:TRIGger:INTerval[:STATe]? <SearchName>
SEARch:TRIGger:PATTern[:STATe] <SearchName>,<State>
SEARch:TRIGger:PATTern[:STATe]? <SearchName>
SEARch:TRIGger:RUNT[:STATe] <SearchName>,<State>
SEARch:TRIGger:RUNT[:STATe]? <SearchName>
SEARch:TRIGger:SLEWrate[:STATe] <SearchName>,<State>
SEARch:TRIGger:SLEWrate[:STATe]? <SearchName>
SEARch:TRIGger:STATe[:STATe] <SearchName>,<State>
SEARch:TRIGger:STATe[:STATe]? <SearchName>
SEARch:TRIGger:TIMeout[:STATe] <SearchName>,<State>
SEARch:TRIGger:TIMeout[:STATe]? <SearchName>
SEARch:TRIGger:WIDTh[:STATe] <SearchName>,<State>
SEARch:TRIGger:WIDTh[:STATe]? <SearchName>
SEARch:TRIGger:WINDow[:STATe] <SearchName>,<State>
SEARch:TRIGger:WINDow[:STATe]? <SearchName>

Includes the search conditions for the selected trigger event type in the next search.

Parameters:

<State>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:LEVel[:VALue] <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel[:VALue]? <SearchName>, <SignalSource>

Sets the voltage of the trigger level that is used to determine other parameters.

Parameters:

<Value>	Voltage value

Parameters for setting and query:

<SearchName>	String with the name of the search
<SignalSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 Source of the search, see Chapter 16.4.2, "Waveform Parameter", on page 879

SEARch:TRIGger:DATatoclock:ACOPy <SearchName>
SEARch:TRIGger:EDGE:ACOPy <SearchName>
SEARch:TRIGger:GLITch:ACOPy <SearchName>
SEARch:TRIGger:INTerval:ACOPy <SearchName>
SEARch:TRIGger:PATTern:ACOPy <SearchName>
SEARch:TRIGger:RUNT:ACOPy <SearchName>
SEARch:TRIGger:SLEWrate:ACOPy <SearchName>
SEARch:TRIGger:STATe:ACOPy <SearchName>
SEARch:TRIGger:TIMeout:ACOPy <SearchName>
SEARch:TRIGger:WIDTh:ACOPy <SearchName>
SEARch:TRIGger:WINDow:ACOPy <SearchName>

Copies the trigger event configuration from Trigger A for the selected channel source to the search condition settings.

See Chapter 5.3, "Trigger Types", on page 191.

Setting parameters:

<SearchName> Search definition

Usage: Setting only

SEARch:TRIGger:EDGE:BCOPy <SearchName>

Copies the trigger event configuration from trigger B for the selected channel source to the search condition settings.

Setting parameters:

<SearchName> String with name of the search

Usage: Setting only

16.15.3 Edge Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1104

SEARch:TRIGger:EDGE:SLOPe <SearchName>,<Slope>
SEARch:TRIGger:EDGE:SLOPe? <SearchName>

Selects the edge type.

Parameters:

<Slope> POSitive | NEGative | EITHer

See Chapter 16.4.3, "Slope Parameter", on page 880.

*RST: POSitive

Parameters for setting and query:

<SearchName> Search definition

16.15.4 Glitch Search Conditions

Trigger level setting: SEARch:TRIGger:LEVel[:VALue] on page 1104

SEARch:TRIGger:GLITch:POLarity <SearchName>,<Polarity>
SEARch:TRIGger:GLITch:POLarity? <SearchName>

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

Parameters:

<Polarity> POSitive | NEGative | EITHer

See Chapter 16.4.4, "Polarity Parameter", on page 880.

*RST: POSitive

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:GLITch:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:GLITch:RANGe? <SearchName>

Selects which glitches are identified: shorter or longer than the specified width (see SEARch:TRIGger:GLITch:WIDTh on page 1106).

Parameters:

<RangeMode> SHORter | LONGer

*RST: SHORter

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:GLITch:WIDTh <SearchName>,<Width>
SEARch:TRIGger:GLITch:WIDTh? <SearchName>

Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value (see also SEARch:TRIGger:GLITch:RANGE on page 1106).

You need to know the expected pulse widths of the circuit to set the glitch width correctly.

Parameters:

<Width> Range: 100E-12 to 1E-3
Increment: 100E-6
*RST: 1E-9
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

16.15.5 Interval Search Conditions

Trigger level setting: SEARch:TRIGger:LEVel[:VALue] on page 1104

SEARch:TRIGger:INTerval:SLOPe <SearchName>,<Slope>
SEARch:TRIGger:INTerval:SLOPe? <SearchName>

Sets the edge for the search.

Parameters:

<Slope> POSitive | NEGative | EITHer

See Chapter 16.4.3, "Slope Parameter", on page 880.

*RST: POSitive

Parameters for setting and query:

<SearchName> String parameter, name of the search definition

Firmware/Software: Version 2.70
The command replaces
SEARch:TRIGger:INTerval:POLarity.

SEARch:TRIGger:INTerval:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:INTerval:DELTa? <SearchName>

Defines a range around the "Interval width" value (see SEARch:TRIGger:INTerval:WIDTh on page 1108).

Parameters:

<WidthDelta> Range: 0 to 10
Increment: 100E-9
*RST: 0
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:INTerval:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:INTerval:RANGe? <SearchName>

Selects how the range of an interval is defined based on the interval width and delta (see SEARch:TRIGger:INTerval:WIDTh on page 1108 and SEARch:TRIGger:INTerval:DELTa on page 1107).

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulse intervals inside a given range. The range is defined by "Interv. width" and "±Delta".

OUTSide
Triggers on intervals outside a given range. The range definition is the same as for "Within" range.

SHORter
Triggers on intervals shorter than the given "Interv. width".

LONGer
Triggers on intervals longer than the given "Interv. width".

*RST: OUTSide

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:INTerval:WIDTh <SearchName>,<Width>
SEARch:TRIGger:INTerval:WIDTh? <SearchName>

Defines the time between two pulses.

Parameters:

<Width> Range: 100E-12 to 864
Increment: 100E-9
*RST: 5E-9
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

16.15.6 Runt Search Conditions

SEARch:TRIGger:RUNT:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:RUNT:DELTa? <SearchName>

Defines a range around the given runt width.

Parameters:

<WidthDelta> Range: 100E-12 to 864
Increment: 100E-9
*RST: 100E-12
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:RUNT:POLarity <SearchName>,<Polarity>
SEARch:TRIGger:RUNT:POLarity? <SearchName>

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

Parameters:

<Polarity> POSitive | NEGative | EITHer

See Chapter 16.4.4, "Polarity Parameter", on page 880.

*RST: POSitive

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:RUNT:RANGe <SearchName>,<Mode>
SEARch:TRIGger:RUNT:RANGe? <SearchName>

Selects how the time limit of the runt pulse is defined based on the runt width and delta (see `SEARch:TRIGger:RUNT:WIDTh` on page 1110 and `SEARch:TRIGger:RUNT:DELTa` on page 1108).

Parameters:

<Mode> ANY | LONGer | SHORter | WITHin | OUTSide

ANY
Triggers on all runts fulfilling the level condition, without time limitation.

LONGer
Triggers on runts longer than the given "Runt width".

SHORter
Triggers on runts shorter than the given "Runt width".

WITHin
Triggers if the runt length is inside a given time range. The range is defined by "Runt width" and "±Delta".

OUTSide
Triggers if the runt length is outside a given time range. The range definition is the same as for "Within" range.

*RST: ANY

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:RUNT:WIDTh <SearchName>,<Width>
SEARch:TRIGger:RUNT:WIDTh? <SearchName>

For the ranges "Shorter" and "Longer", the runt width defines the maximum and minimum pulse width, respectively.

For the ranges "Within" and "Outside", the runt width defines the center of a range which is defined by "±Delta".

The range is defined using SEARch:TRIGger:RUNT:RANGe on page 1109.

Parameters:

<Width>	Range:	100E-12 to 864
	Increment:	100E-9
	*RST:	5E-9
	Default unit:	s

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:LEVel:RUNT:LOWer <Key>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:RUNT:LOWer? <Key>, <SignalSource>
SEARch:TRIGger:LEVel:RUNT:UPPer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:RUNT:UPPer? <SearchName>, <SignalSource>

Set the lower and upper voltage threshold, respectively.

Parameters:

<Value> Voltage value

Parameters for setting and query:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Source of the search, see Chapter 16.4.2, "Waveform Parameter", on page 879

16.15.7 Slew Rate Search Conditions

SEARch:TRIGger:SLEWrate:DELTa <SearchName>,<TimeDelta>
SEARch:TRIGger:SLEWrate:DELTa? <SearchName>

Defines a time range around the given slew rate.

Parameters:

<TimeDelta> Range: 0 to 10
Increment: 100E-9
*RST: 0
Default unit: s

Parameters for setting and query:

<SearchName> String with the name of the search

SEARch:TRIGger:SLEWrate:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:SLEWrate:RANGe? <SearchName>

Selects how the time limit for the slew rate is defined. The time measurement starts when the signal crosses the first trigger level - the upper or lower level depending on the selected slope - and stops when the signal crosses the second level.

Parameters:

<RangeMode> INSRange | OUTRange | LTHan | GTHan

INSRange
Triggers on slew rates inside a given time range. The range is defined by "Slew rate" and "±Delta".

OUTRange
Triggers on slew rates outside a given time range. The range definition is the same as for "Within" range.

LTHan
Triggers on slew rates shorter than the given "Slew rate" limit.

GTHan
Triggers on slew rates longer than the given "Slew rate" limit.

*RST: GTHan

Parameters for setting and query:

<SearchName> String with the name of the search

SEARch:TRIGger:SLEWrate:SLOPe <SearchName>,<Slope>
SEARch:TRIGger:SLEWrate:SLOPe? <SearchName>

Selects the edge type.

Parameters:

<Slope> POSitive | NEGative | EITHer

See Chapter 16.4.3, "Slope Parameter", on page 880.

*RST: POSitive

Parameters for setting and query:

<SearchName> String with the name of the search

SEARch:TRIGger:SLEWrate:TIME <SearchName>,<Time>
SEARch:TRIGger:SLEWrate:TIME? <SearchName>

For the ranges "Within" and "Outside", the slew rate defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the slew rate defines the maximum and minimum slew rate limits, respectively.

The range is defined using `SEARch:TRIGger:SLEWrate:RANGe`.

Parameters:

<Time> Range: 100E-12 to 864
Increment: 100E-9
*RST: 100E-12
Default unit: s

Parameters for setting and query:

<SearchName> String with the name of the search

SEARch:TRIGger:LEVel:TRANsition:LOWer <Key>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:TRANsition:LOWer? <Key>, <SignalSource>
SEARch:TRIGger:LEVel:TRANsition:UPPer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:TRANsition:UPPer? <SearchName>, <SignalSource>

Set the lower and upper voltage thresholds, respectively. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Parameters:

<Value> Voltage value

Parameters for setting and query:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Source of the search, see Chapter 16.4.2, "Waveform Parameter", on page 879

16.15.8 Timeout Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1104

SEARch:TRIGger:TIMeout:RANGe <SearchName>,<TimeoutMode>
SEARch:TRIGger:TIMeout:RANGe? <SearchName>

Selects the relation of the signal level to the trigger level:

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

HIGH
The signal level stays above the trigger level.

LOW
The signal level stays below the trigger level.

EITHer
The signal level stays above or below the trigger level.

*RST: HIGH

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:TIMeout:TIME <SearchName>,<Time>
SEARch:TRIGger:TIMeout:TIME? <SearchName>

Defines the time limit for the timeout at which the instrument triggers.

Parameters:

<Time> Range: 100E-12 to 864
Increment: 100E-9
*RST: 100E-9
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

16.15.9 Width Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1104

SEARch:TRIGger:WIDTh:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:WIDTh:DELTa? <SearchName>

Defines a range around the given width value (see also `SEARch:TRIGger:WIDTh:WIDTh` on page 1115).

Parameters:

<WidthDelta> Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

Example: See Chapter 16.3.4.1, "Searching for a pulse of specified width", on page 869

SEARch:TRIGger:WIDTh:POLarity <SearchName>,<Polarity>
SEARch:TRIGger:WIDTh:POLarity? <SearchName>

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

Parameters:

<Polarity> POSitive | NEGative | EITHer

See Chapter 16.4.4, "Polarity Parameter", on page 880.

*RST: POSitive

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:WIDTh:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:WIDTh:RANGe? <SearchName>

Selects how the range of a pulse width is defined in relation to the width and delta (see `SEARch:TRIGger:WIDTh:WIDTh` on page 1115 and `SEARch:TRIGger:WIDTh:DELTa` on page 1113).

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range of the pulse width is defined by "Width" and "±Delta".

OUTSide
Triggers on pulses outside a given range. The range definition is the same as for "Within" range.

SHORter
Triggers on pulses shorter than the given "Width".

LONGer
Triggers on pulses longer than the given "Width".

*RST: WITHin

Parameters for setting and query:

<SearchName> Search definition

Example: See Chapter 16.3.4.1, "Searching for a pulse of specified width", on page 869

SEARch:TRIGger:WIDTh:WIDTh <SearchName>,<Width>
SEARch:TRIGger:WIDTh:WIDTh? <SearchName>

For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

The range is defined using `SEARch:TRIGger:WIDTh:RANGe`.

Parameters:

<Width>	Range: 100E-12 to 864 Increment: 100E-9 *RST: 5E-9 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

Example: See Chapter 16.3.4.1, "Searching for a pulse of specified width", on page 869

16.15.10 Window Search Conditions

SEARch:TRIGger:WINDow:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:WINDow:DELTa? <SearchName>

Defines a range around the "Width" value (see `SEARch:TRIGger:WINDow:WIDTh` on page 1117).

Parameters:

<WidthDelta>	Range: 0 to 432 Increment: 500E-12 *RST: 0 Default unit: s

Parameters for setting and query:

<SearchName>	Search definition

SEARch:TRIGger:WINDow:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:WINDow:RANGe? <SearchName>

Selects how the signal run is compared with the window.

Parameters:

<RangeMode> ENTer | EXIT | WITHin | OUTSide

ENTer
Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.

EXIT
Triggers when the signal leaves the window.

WITHin
Triggers if the signal stays between the upper and lower level for a specified time. The time is defined in various ways by the `SEARch:TRIGger:WINDow:TIMerange` command.

OUTSide
Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is also defined by the `SEARch:TRIGger:WINDow:TIMerange` command.

*RST: ENTer

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:WINDow:TIMerange <SearchName>,<TimeRangeMode>
SEARch:TRIGger:WINDow:TIMerange? <SearchName>

Selects how the time limit of the window is defined. Time conditioning is available for the vertical conditions "WITHin" and "OUTSide" (see `SEARch:TRIGger:WINDow:RANGe` on page 1115).

Parameters:

<TimeRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width - Delta* and for *Width + Delta* at the most.

OUTSide
"Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width - Delta* or longer than *Width + Delta*.

SHORter
Triggers if the signal crosses vertical limits before the specified "Width" time is reached.

LONGer
Triggers if the signal crosses vertical limits before the specified "Width" time is reached.

*RST: WITHin

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:WINDow:WIDTh <SearchName>,<Width>
SEARch:TRIGger:WINDow:WIDTh? <SearchName>

For the ranges "Within" and "Outside", the width defines the center of a time range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

The range is defined using `SEARch:TRIGger:WINDow:RANGe`.

Parameters:

<Width> Range: 100E-12 to 864
Increment: 100E-9
*RST: 5E-9
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:LEVel:WINDow:LOWer <Key>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:WINDow:LOWer? <Key>, <SignalSource>
SEARch:TRIGger:LEVel:WINDow:UPPer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:WINDow:UPPer? <SearchName>, <SignalSource>

Set the lower and upper voltage limits for the window.

Parameters:

<Value> Voltage value

Parameters for setting and query:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Source of the search, see Chapter 16.4.2, "Waveform Parameter", on page 879

16.15.11 Data2Clock Search Conditions

Data level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1104

SEARch:TRIGger:DATatoclock:CEDGe <SearchName>,<ClockEdge>
SEARch:TRIGger:DATatoclock:CEDGe? <SearchName>

Sets the edge of the clock signal to define the time reference point for the setup and hold time.

Parameters:

<ClockEdge> POSitive | NEGative | EITHer

See Chapter 16.4.3, "Slope Parameter", on page 880.

*RST: POSitive

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:DATatoclock:CLEVel <SearchName>,<ClockLevel>
SEARch:TRIGger:DATatoclock:CLEVel? <SearchName>

Sets the voltage level for the clock signal. Both this command and `SEARch:TRIGger:DATatoclock:CEDGe` define the starting point for calculation of the setup and hold time.

Parameters:

<ClockLevel> Range: -10 to 10
Increment: 1E-3
*RST: 0
Default unit: V

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:DATatoclock:CSOurce <SearchName>,<ClockSource>
SEARch:TRIGger:DATatoclock:CSOurce? <SearchName>

Selects the waveform used for the clock signal.

Parameters:

<ClockSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the clock signal, see Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: C1W1

Parameters for setting and query:

<SearchName> Search definition name

SEARch:TRIGger:DATatoclock:HTIMe <SearchName>,<HoldTime>
SEARch:TRIGger:DATatoclock:HTIMe? <SearchName>

Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

The hold time can be negative. In this case, the setup time is always positive. The setup/hold interval starts before the clock edge (setup time) and ends before the clock edge (hold time). If you change the negative hold time, the setup time is adjusted by the intrument.

Parameters:

<HoldTime> Range: -99.999E-9 to 0.1
Increment: 1E-9
*RST: 0
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:DATatoclock:STIMe <SearchName>,<SetupTime>
SEARch:TRIGger:DATatoclock:STIMe? <SearchName>

Sets the minimum time **before** the clock edge while the data signal must stay steady above or below the data level.

The setup time can be negative. In this case, the hold time is always positive. The setup/hold interval starts after the clock edge (setup time) and ends after the clock edge (hold time). If you change the negative setup time, the hold time is adjusted by the intrument.

Parameters:

<SetupTime> Range: -99.999E-9 to 0.1
Increment: 1E-9
*RST: 0
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

16.15.12 Pattern Search Conditions

SEARch:TRIGger:PATTern:A[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:A[:ENABle]? <Searchname>
SEARch:TRIGger:PATTern:B[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:B[:ENABle]? <Searchname>
SEARch:TRIGger:PATTern:C[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:C[:ENABle]? <Searchname>
SEARch:TRIGger:PATTern:D[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:D[:ENABle]? <Searchname>

Enables the channel to be considered in the pattern search. The trigger source channel is selected by default.

- A[:ENABle]: CH1
- B[:ENABle]: CH2
- C[:ENABle]: CH3
- D[:ENABle]: CH4

Digital channels are not available.

Parameters:

<State>	ON | OFF

Parameters for setting and query:

<Searchname>	String with name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:A:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:A:LOGic? <Searchname>
SEARch:TRIGger:PATTern:B:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:B:LOGic? <Searchname>
SEARch:TRIGger:PATTern:C:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:C:LOGic? <Searchname>
SEARch:TRIGger:PATTern:D:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:D:LOGic? <Searchname>

Defines the logic for the indicated channel:

- A: CH1
- B: CH2
- C: CH3
- D: CH4

Parameters:

<Operator> DIRect | NOT

DIRect
Input value remains unchanged

NOT
Input value is inverted

Parameters for setting and query:

<Searchname> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:AB:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:AB:LOGic? <Searchname>
SEARch:TRIGger:PATTern:CD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:CD:LOGic? <Searchname>
SEARch:TRIGger:PATTern:ABCD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:ABCD:LOGic? <Searchname>

Defines the logical combination of the indicated channels after evaluating the previous logical operations:

- AB: CH1 and CH2
- CD: CH3 and CH4
- ABCD: result of AB and CD

Parameters:

<Operator> AND | NAND | OR | NOR

AND: logical AND, conjunctive combination
NAND:logical NOT AND
OR:logical OR, disjunctive combination
NOR: logical NOT OR

Parameters for setting and query:

<Searchname> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:MODE <SearchName>,<Mode>
SEARch:TRIGger:PATTern:MODE? <SearchName>

Adds additional time limitation to the pattern definition.

Parameters:

<Mode> OFF | TIMeout | WIDTh

OFF
No time limitation. The event is found if the pattern condition is fulfilled.

TIMeout
Defines how long the result of the pattern condition stays high or low. The duration of the timeout is defined using SEARch:TRIGger:PATTern:TIMeout[:TIME] The result state is defined using SEARch:TRIGger:PATTern:TIMeout:MODE.

WIDTh
Defines a time range for keeping up the true result of the pattern condition. The range is defined using SEARch:TRIGger:PATTern:WIDTh:RANGe.

*RST: OFF

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:TIMeout:MODE <SearchName>,<TimeoutMode>
SEARch:TRIGger:PATTern:TIMeout:MODE? <SearchName>

Defines the condition for the timeout.

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

EITHer
High or low, the pattern remains unchanged for the given time.

*RST: HIGH

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:TIMeout[:TIME] <SearchName>, <Time>
SEARch:TRIGger:PATTern:TIMeout[:TIME]? <SearchName>

Defines how long the result of the pattern condition must keep the given state.

Parameters:

<Time> Range: 100E-12 to 864
Increment: 100E-9
*RST: 100E-9
Default unit: s

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:WIDTh:RANGe <SearchName>, <WidthRangeMode>
SEARch:TRIGger:PATTern:WIDTh:RANGe? <SearchName>

Defines the time range of a pulse width for keeping up the true result of the pattern condition. The width and delta are specified using `SEARch:TRIGger:PATTern:WIDTh[:WIDTh]` and `SEARch:TRIGger:PATTern:WIDTh:DELTa`.

Parameters:

<WidthRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin | OUTSide
Triggers on pulses inside or outside a given range. The range is defined by the width ±delta.

SHORter | LONGer
Triggers on pulses shorter or longer than the given width.

*RST: WITHin

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:WIDTh[:WIDTh] <SearchName>, <Width>
SEARch:TRIGger:PATTern:WIDTh[:WIDTh]? <SearchName>

For the ranges WITHin and OUTSide, the width defines the center of a range that is defined by the limits ±delta.

For the ranges SHORter and LONGer, the width defines the maximum and minimum pulse width, respectively.

To set the range mode, use `SEARch:TRIGger:PATTern:WIDTh:RANGe`. To set the delta value, use `SEARch:TRIGger:PATTern:WIDTh:DELTa`.

Parameters:

<Width>
Range: 100E-12 to 864
Increment: 100E-9
*RST: 5E-9
Default unit: s

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:WIDTh:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:PATTern:WIDTh:DELTa? <SearchName>

Defines a range around the width value specified using `SEARch:TRIGger:PATTern:WIDTh[:WIDTh]`.

Parameters:

<WidthDelta> Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

16.15.13 State Search Conditions

SEARch:TRIGger:STATe:CSOurce <SearchName>,<ClockSource>
SEARch:TRIGger:STATe:CSOurce? <SearchName>

Sets the source of the clock signal.

Parameters:

<ClockSource> C1W1 | C2W1 | C3W1 | C4W1
*RST: NONE

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:CEDGe <SearchName>,<ClockEdge>
SEARch:TRIGger:STATe:CEDGe? <SearchName>

Sets the trigger edge of the clock signal.

Parameters:

<ClockEdge> POSitive | NEGative | EITHer
*RST: POSitive

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:CLEVel <SearchName>,<ClockLevel>
SEARch:TRIGger:STATe:CLEVel? <SearchName>

Sets the trigger level of the clock signal.

The command has the same effect as with `SEARch:TRIGger:LEVel[:VALue]`.

Parameters:

<ClockLevel> Range: -10 to 10
Increment: 1E-3
*RST: 0
Default unit: V

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:A[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:A[:ENABle]? <Searchname>
SEARch:TRIGger:STATe:B[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:B[:ENABle]? <Searchname>
SEARch:TRIGger:STATe:C[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:C[:ENABle]? <Searchname>
SEARch:TRIGger:STATe:D[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:D[:ENABle]? <Searchname>

Enables the channel to be considered in the state search. You can enable all channel signals except for the trigger source.

- A[:ENABle]: CH1
- B[:ENABle]: CH2
- C[:ENABle]: CH3
- D[:ENABle]: CH4

Digital channels are not available.

Parameters:

<State> ON | OFF

Parameters for setting and query:

<Searchname> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:A:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:A:LOGic? <Searchname>
SEARch:TRIGger:STATe:B:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:B:LOGic? <Searchname>
SEARch:TRIGger:STATe:C:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:C:LOGic? <Searchname>
SEARch:TRIGger:STATe:D:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:D:LOGic? <Searchname>

Defines the logic for the indicated channel:

- A: CH1
- B: CH2
- C: CH3
- D: CH4

Parameters:

<Operator> DIRect | NOT

DIRect
Input value remains unchanged

NOT
Input value is inverted

Parameters for setting and query:

<Searchname> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:AB:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:AB:LOGic? <Searchname>
SEARch:TRIGger:STATe:CD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:CD:LOGic? <Searchname>
SEARch:TRIGger:STATe:ABCD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:ABCD:LOGic? <Searchname>

Defines the logical combination of the indicated channels after evaluating the previous logical operations:

- AB: CH1 and CH2
- CD: CH3 and CH4
- ABCD: result of AB and CD

Parameters:

<Operator> AND | NAND | OR | NOR

AND: logical AND, conjunctive combination
NAND:logical NOT AND
OR:logical OR, disjunctive combination
NOR: logical NOT OR

Parameters for setting and query:

<Searchname> String with the name of the search

Firmware/Software: FW 1.40

16.15.14 Search on Spectrum

CURSor<m>:PEXCursion <Value>

Defines the minimum level by which the waveform must rise or fall so that it will be identified as a maximum or a minimum by the search functions.

Suffix:

<m>	1..* The suffix is irrelevant

Parameters:

<Value>	Range: 0 to 100 Increment: 1 *RST: 5 Default unit: dB

CURSor<m>:THReshold <Value>

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

Suffix:

<m>	1..* The suffix is irrelevant.

Parameters:

<Value>	Threshold in dBm

Firmware/Software: Version 2.70

16.15.15 Search Scope Settings

SEARch:GATE[:STATe] <SearchName>,<State>
SEARch:GATE[:STATe]? <SearchName>

Performs the search only on the defined gate area of the source waveform.

Parameters:

<State> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName> Search definition

SEARch:GATE:MODE <SearchName>,<Mode>
SEARch:GATE:MODE? <SearchName>

Defines whether the gate settings are configured using absolute or relative values.

Parameters:

<Mode> ABS | REL
*RST: ABS

Parameters for setting and query:

<SearchName> Search definition

SEARch:GATE:ABSolute:STARt <SearchName>,<Start>
SEARch:GATE:ABSolute:STARt? <SearchName>

Defines the starting value for the gate.

Parameters:

<Start> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<SearchName> Search definition

SEARch:GATE:ABSolute:STOP <SearchName>,<Stop>
SEARch:GATE:ABSolute:STOP? <SearchName>

Defines the end value for the gate.

Parameters:

<Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<SearchName> Search definition

SEARch:GATE:RELative:STARt <SearchName>,<RelativeStart>
SEARch:GATE:RELative:STARt? <SearchName>

Defines the starting value for the gate.

Parameters:

<RelativeStart> Range: 0 to 100
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:

<SearchName> Search definition

SEARch:GATE:RELative:STOP <SearchName>,<RelativeStop>
SEARch:GATE:RELative:STOP? <SearchName>

Defines the end value for the gate.

Parameters:

<RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<SearchName> Search definition

SEARch:GATE:ZCOupling <SearchName>,<ZoomCoupling>
SEARch:GATE:ZCOupling? <SearchName>

If enabled, the gate area is set to the limits of a zoom area.

The zoom diagramm is selected using `SEARch:GATE:ZDIagram`.

Parameters:

<ZoomCoupling> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName> String with the name of the search

SEARch:GATE:ZDIagram <SearchName>,<DiagramName>, <ZoomName>
SEARch:GATE:ZDIagram? <SearchName>

Selects the zoom to which the gate area is set if `SEARch:GATE:ZCOupling` is set to "ON".

Parameters:

<DiagramName> String with the name of the diagram on which the zoom area is based.

<ZoomName> String with the name of the zoom.

Parameters for setting and query:

<SearchName> String with the name of the search

Example:

```
SEARch:GATE:ZCOupling 'Search1',ON
SEARch:GATE:ZDIagram 'Search1','Diagram1',
'Zoom2'
SEARch:GATE:ZDIagram? 'Search1'
<-- Diagram1;Zoom2
```

Enables the zoom coupling to define the gate,and selects Zoom2 as gate area. Zoom2 is based on Diagram1.

16.15.16 Noise Rejection

SEARch:TRIGger:LEVel:NOISe:ABSolute <SearchName>, <SignalSource>, <Value>

Defines the trigger hysteresis, a range in absolute values around the trigger level. If the signal jitters inside this range and crosses the trigger level, no trigger event is detected.

Parameters:

<Value> Hysteresis value

Setting parameters:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Source of the search, see Chapter 16.4.2, "Waveform Parameter", on page 879

SEARch:TRIGger:LEVel:NOISe:MODE <SearchName>, <SignalSource>, <Mode>
SEARch:TRIGger:LEVel:NOISe:MODE? <SearchName>, <SignalSource>

Defines whether absolute values or relative values to the vertical scaling are used as a hysteresis for noise rejection.

Parameters:

<Mode> ABS | REL

Parameters for setting and query:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Source of the trigger waveform, see Chapter 16.4.2, "Waveform Parameter", on page 879

SEARch:TRIGger:LEVel:NOISe:RELative <SearchName>, <SignalSource>, <Value>

Defines a range around the trigger level in relative values. If the signal jitters inside this range and crosses the trigger level, no trigger event is detected.

Parameters:

<Value> Hysteresis value in %

Setting parameters:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Source of the search, see Chapter 16.4.2, "Waveform Parameter", on page 879

SEARch:TRIGger:LEVel:NOISe[:STATe] <SearchName>, <SignalSource>, <State>
SEARch:TRIGger:LEVel:NOISe[:STATe]? <SearchName>, <SignalSource>

If enabled, the noise reject settings for the waveform are considered for the search.

Parameters:

<State> ON | OFF

Parameters for setting and query:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Source of the search, see Chapter 16.4.2, "Waveform Parameter", on page 879

16.15.17 Search Results

SEARch:RESDiagram:HORZ:ABSolute:POSition <SearchName>,<Position>
SEARch:RESDiagram:HORZ:ABSolute:POSition? <SearchName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<Position> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESDiagram:HORZ:ABSolute:SPAN <SearchName>,<Span>
SEARch:RESDiagram:HORZ:ABSolute:SPAN? <SearchName>

Defines the width of the zoom area.

Parameters:

<Span> Range: 0 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESDiagram:HORZ:MODE <SearchName>,<Mode>
SEARch:RESDiagram:HORZ:MODE? <SearchName>

Defines whether absolute or relative values are used to specify the x-axis values.

Parameters:

<Mode> ABS | REL
*RST: ABS

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESDiagram:HORZ:RELative:POSition <SearchName>,<RelPosi>
SEARch:RESDiagram:HORZ:RELative:POSition? <SearchName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<RelPosi>	Range:	0 to 100
	Increment:	0.1
	*RST:	100
	Default unit:	%

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:HORZ:RELative:SPAN <SearchName>,<RelativeSpan>
SEARch:RESDiagram:HORZ:RELative:SPAN? <SearchName>

Defines the width of the zoom area.

Parameters:

<RelativeSpan>	Range:	1E-15 to 100
	Increment:	0.1
	*RST:	1
	Default unit:	%

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:SHOW <SearchName>,<ShowSearchWind>
SEARch:RESDiagram:SHOW? <SearchName>

If enabled, a zoom window is displayed for the currently selected search result. The zoom area is indicated in the diagram that displays the source waveform of the search.

Parameters:

<ShowSearchWind>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:VERT:ABSolute:POSition <SearchName>,<Position>
SEARch:RESDiagram:VERT:ABSolute:POSition? <SearchName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<Position>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:VERT:ABSolute:SPAN <SearchName>,<Span>
SEARch:RESDiagram:VERT:ABSolute:SPAN? <SearchName>

Defines the height of the zoom area.

Parameters:

<Span>	Range:	0 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:VERT:MODE <SearchName>,<Mode>
SEARch:RESDiagram:VERT:MODE? <SearchName>

Defines whether absolute or relative values are used to specify the y-axis values.

Parameters:

<Mode>	ABS | REL	
	*RST:	ABS

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:VERT:RELative:POSition <SearchName>,<RelPosi>
SEARch:RESDiagram:VERT:RELative:POSition? <SearchName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<RelPosi>	Range:	0 to 100
	Increment:	0.1
	*RST:	100
	Default unit:	%

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:VERT:RELative:SPAN <SearchName>,<RelativeSpan>
SEARch:RESDiagram:VERT:RELative:SPAN? <SearchName>

Defines the height of the zoom area.

Parameters:

<RelativeSpan>	Range:	1E-15 to 100
	Increment:	0.1
	*RST:	1
	Default unit:	%

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESult:LIMit <SearchName>,<ResultListLimit>
SEARch:RESult:LIMit? <SearchName>

Defines the maximum number of entries in the search result table.

Parameters:

<ResultListLimit>	Range:	1 to 1000
	Increment:	1
	*RST:	100

Parameters for setting and query:

<SearchName> Search definition

Example: See Chapter 16.3.4.1, "Searching for a pulse of specified width", on page 869

SEARch:RESult:SHOW <SearchName>,<ShowResultTable>
SEARch:RESult:SHOW? <SearchName>

Displays or hides the search result table.

Parameters:

<ShowResultTable> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESult:SORT:ASCending <SearchName>,<SortAscending>
SEARch:RESult:SORT:ASCending? <SearchName>

If enabled, the results are listed in asscending order, i.e. the smallest value at the top.

Parameters:

<SortAscending> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESult:SORT[:MODE] <SearchName>,<SortMode>
SEARch:RESult:SORT[:MODE]? <SearchName>

Sorts the search result table by x-value position or value of the result.

Parameters:

<SortMode> POSition | VALue

POSition
Sorts the search result table by the x-value position.

VALue
Sorts the search result table by the value of the result.

*RST: POSition

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESult[:ALL]? <SearchName>

Returns all search results.

Query parameters:

<SearchName> Search definition

Return values:

<Data> List of search results, separated by commas. For each result, six values are returned:
1. Acquisition index, currently always 0.
2. X-position of the search result
3. Y-position of the search result, currently not relevant
4. Type of the search result (Edge, Glitch, ...)
5. Slope or polarity of the search result
6. For runt, glitch, width, and window searches, the value contains the width. For timeout and interval searches, it contains the timeout. For transition searches, it contains the slew rate. For all other searches, the value is not relevant.
If a value is not relevant, 9.91E+37 is returned.

Example:

```
SEAR:RES? 'Search1'
0,1.5375e-007,-84,Edge,Positive,9.91E+37,
0,5.3e-008,-84,Edge,Positive,9.91E+37
```

The query returns two search results for edge search on rising edges at X-position 153,75 ns and 53 ns.

Usage: Query only

16.16 Data Management

16.16.1 Instrument Settings

The Mass MEMory subsystem provides commands to access the storage media and to save and reload instrument settings.

File and directory names

The <file_name> and <directory_name> parameters are strings. Some commands use a fixed directory; for others the <file_name> can contain the complete path including the drive name and all subdirectories, e.g. '`C:\TEMP\TRASH\test.txt`' for the file named test.txt in the TEMP\TRASH subdirectory of the internal hard disk drive C:\. If no complete path is specified, the file location is relative to the current directory, queried with `MMEMory:CDIRectory?`. The file name itself may contain the period as a separator for extensions.

File and directory names can be chosen according to Windows™ conventions; the restrictions placed on file names known from DOS systems do not apply. All letters and numbers are allowed, as well as the special characters "_", "^", "$", "~", "!", "#", "%", "&", "-", "{", "}", "(", ")", "@" and "`". Reserved file names are CON, AUX, COM1, ..., COM4, LPT1, ..., LPT3, NUL and PRN.

The use of wildcards ? and * is not allowed.

MMEMory:DRIVes?

Returns a list of the logical drives of the instrument as configured in the operating system.

Return values:

<Drive> List of strings, for example, `"C:\","F:\","H:\"`

Usage: Query only

MMEMory:MSIS [<msus>]

Changes the default storage device to the indicated drive or network server.

Parameters:

<msus> String parameter. Drives are indicated with their drive letter, network servers require the UNC format.

Example: `MMEM:MSIS 'C:'`

Example: `MMEM:MSIS '\\server1\share1'`

MMEMory:DCATalog? [<PathName>]

Returns the subdirectories of the current or of a specified directory.

Query parameters:

<PathName> String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be set and queried with `MMEMory:CDIRectory`.

Return values:

<FileEntry> Names of the subdirectories separated by colons. The first two strings are related to the parent directory.

Example:

```
MMEM:DCAT?
".","..","Documents and Settings","Program
Files","temp"
```

Usage: Query only

MMEMory:DCATalog:LENGth? [<PathName>]

Returns the number of subdirectories of the current or of a specified directory. The number includes the parent directory strings "." and ".." and corresponds to the number of strings returned by the `MMEMory:DCATalog?` command.

Query parameters:

<PathName> String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be set and queried with `MMEMory:CDIRectory`.

Return values:

<FileEntryCount> Number of parent and subdirectories.

Example: `MMEM:DCAT:LENG?`
`5`

Usage: Query only

MMEMory:CDIRectory [<DirectoryName>]

Changes the default directory for file access.

Parameters:

<DirectoryName> String parameter to specify the directory. If the string also contains a drive letter or network server name, the command `MMEMory:MSIS` is executed implicitely.

*RST: "\"

Example: `MMEM:CDIR 'C:\USER\DATA'`

Usage: SCPI confirmed

MMEMory:MDIRectory <DirectoryName>

Creates a new directory with the specified name.

Setting parameters:

<DirectoryName> String parameter to specify the new directory. If the path consists of several subdirectories, the complete tree will be created if necessary. If no drive letter or server name is indicated, the directory is created on the default soreage device specified with `MMEMory:MSIS`.

Example: `MMEM:MDIR 'C:\USER\DATA'`

Usage: Setting only

MMEMory:RDIRectory <DirectoryName>

Deletes the specified directory.

Setting parameters:

<DirectoryName> String parameter to specify the directory to be deleted.

Example: `MMEM:RDIR 'C:\USER\TEST'`

Usage: Setting only

MMEMory:CATalog? [<PathName>][, <Format>]

Returns the a list of files contained in the specified directory. The result corresponds to the number of files returned by the MMEMory:CATalog:LENgth command.

Query parameters:

<PathName> String parameter to specify the directory. If the directory is omitted, the command queries directory specified with `MMEMory:CDIRectory`.

<Format> ALL | WTIMe

ALL: Extended result including file, date, time and attributes
WTIMe: Extended result including file, date, time

Return values:

<UsedMemory> Total amount of storage currently used in the directory, in bytes.

<FreeMemory> Total amount of storage available in the directory, in bytes.

<FileEntry> All files and subdirectories of the directory are listed with their file name, format and size in bytes. The first two strings are related to the parent directory.

Example:

```
MMEM:CAT 'C:\USER\DATA'?
529479,1831777894400,".,DIR,0","..,DIR,0",
"Backup,DIR,0","CSS,DIR,0","DATEN,DIR,0",
"Commands.jar,BIN,529479","FAVORITES,DIR,0",
"LOG,DIR,0","DATA,DIR,0","test,DIR,0",
"TotalCMD,DIR,0"
```

Usage: Query only
SCPI confirmed

MMEMory:CATalog:LENGth? [<PathName>]

Returns the number of files and subdirectories of the current or specified directory. The number includes the parent directory strings "." and ".." and it corresponds to the number of <FileEntry> strings returned by the `MMEMory:CATalog?` command.

Query parameters:

<PathName> String parameter, directory to be queried. If the directory is omitted, the current directory is queried, specified with `MMEMory:CDIRectory`.

Return values:

<Count> Number of files and subdirectories including parent directory entries.

Example:

```
MMEM:CAT:LENG?
11
```

Usage: Query only

MMEMory:COPY <FileSource>[, <FileDestination>]

Copies an existing file to a new file.

Setting parameters:

<FileSource> String parameter, contains name and path of the file to be copied. Wildcards (* and ?) are allowed.

<FileDestination> String parameter, contains name and path of the new file. If the file already exists, it is overwritten without notice. If no file destination is specified, the source file is written to the current directory specified with `MMEMory:CDIRectory`.

Example: `MMEM:COPY 'C:\Users\Public\Documents\Rohde-Schwarz\RTx\RefWaveforms\RefCurve_2011-03-16*.bin','E:'`
Copies all reference waveforms saved on March 16, 2011 to an external storage medium, mapped to drive `E:\`.

Usage: Setting only
SCPI confirmed

MMEMory:MOVE <FileSource>, <FileDestination>

Moves the specified file to a new location on the same drive and renames it.

Setting parameters:

<FileSource> String parameter, contains name and path of the file to be copied.
Wildcards (* and ?) are allowed. Therefore, specify a directory for <FileDestination>. Renaming is not possible.

<FileDestination> String parameter, contains name and path of the new file. If no path is specified, the <FileSource> directory is used - the file is renamed.

Example: `MMEM:MOVE 'C:\USER\DATA\SETUP.CFG','C:\STORE'`
Moves the file "Setup.cfg" from the directory `C:\USER\DATA` to `C:\STORE`.

Usage: Setting only
SCPI confirmed

MMEMory:DELete <FileName>

Removes the specified file(s). To delete directories, use `MMEMory:RDIRectory`.

Setting parameters:

<FileName> String parameter to specify the name and directory of the file to be removed. Wildcards (* and ?) are allowed.
If no path is defined, the current directory is used, specified with `MMEMory:CDIRectory`.

Example: `MMEM:DEL '*.CFG’`
Deletes all cfg files from the current directory.

Usage: Setting only
SCPI confirmed

MMEMory:DATA <FileName>, <Data>
MMEMory:DATA? <FileName>

Stores data in the specified file to the storage location specified using `MMEMory:CDIRectory`.

Parameters:

<Data> <block>

488.2 block data format. The delimiter EOI must be selected to achieve correct data transfer.
The block begins with character '#'. The next digit is the length of the length information, followed by this given number of digits providing the number of bytes in the following binary data.

Parameters for setting and query:

<FileName> String parameter, the name of the file the data is stored to.

Example: `MMEM:DATA 'abc.txt' #216This is the file`
#2: the length infomation has two digits
16: the binary data has 16 bytes

MMEMory:ATTRibute <FileName>, <Attributes>
MMEMory:ATTRibute? <FileName>

Sets file attributes for the specified file(s). The command can be used for files only.

Setting parameters:

<Attributes> String with attributes and setting information.
'+' before the attribute: sets the attribute
'-' before the attribute: deletes the attribute
'R': read only
'A': archive file
'S': system file
'H': hidden file

Parameters for setting and query:

<FileName> String parameter, contains name and path of the file. Wildcards (* and ?) are allowed.

Return values:

<FileEntry> String containing: "<file_name>,<file_attributes>"

Example: `MMEM:ATTR 'C:\USER\DATA\*.LOG', '-R -A'`
Deletes the read-only and archive attributes from all LOG files in the directory`C:\USER\DATA\*.LOG`.

Example:
```
MMEM:ATTR? 'C:\USER\DATA\*.*'
"Datei1.LOG,A", "Datei2.LOG,A",
"Datei3.LOG,ASH", "Datei4.DLL,RSH",
"Datei5.INI,SH"
```

MMEMory:SAV <FileDestination>

Stores the current instrument settings to the specified file.

This command has the same effect as the combination of `*SAV` and `MMEMory:STORe:STATe`.

Parameters:

<FileDestination> String parameter specifying path and filename of the target file. Wildcards are not allowed.

Example: `MMEM:SAV 'C:\mysavefile.dfl'`
Saves the current instrument settings to the file `mysavefile.dfl` located in the directory C:\.

Usage: Event

MMEMory:RCL <FileSource>

Restores the instrument settings from the specified file.

This command has the same effect as the combination of `MMEMory:LOAD:STATe` and `*RCL`.

Parameters:

'<FileSource>' String parameter specifying the path and filename of the source file. Wildcards are not allowed.

Example: `MMEM:RCL 'C:\mysavefile.dfl'`
Loads and activates the instrument settings from the file `mysavefile.dfl` located in the directory C:\.

Usage: Event

MMEMory:STORe:STATe <MemoryNumber>, <FileName>

Stores the instrument settings from the specified internal memory to the specified file. To store the current instrument settings to the internal memory, use `*SAV` first.

Setting parameters:

<MemoryNumber> Number of the internal memory
Range: 1 to 99

<FileName> String parameter specifying the complete path and filename of the source file.

Example:
```
*SAV 4
MMEM:STORe:STATe 4,'C:
\Settings\Settings_1051.dfl'
```
Saves current instrument settings to the internal memory number 4. Then stores the settings from the internal memory number 4 to the file `C:\Settings\Settings_1051.dfl`.

Usage: Setting only

MMEMory:LOAD:STATe <MemoryNumber>, <FileName>

Loads the instrument settings from the specified file to the specified internal memory. After the file has been loaded, the settings must be activated using a `*RCL` command.

Setting parameters:

<MemoryNumber>	Number of the internal memory Range: 1 to 99
<FileName>	String parameter specifying the complete path and filename of the source file.

Example:
`MMEM:LOAD:STATe 4,'C:\Settings\Settings_1051.dfl'`
`*RCL 4`
Loads instrument settings from the file `C:\Settings\Settings_1051.dfl` to the internal memory number 4, and then activates the settings in internal memory number 4.

Usage: Setting only

SAVeset:CONFig:PREView <Include>

If set to OFF, the saveset is stored without the preview image to reduce the file size.

Use the command each time before you save a saveset.

Parameters:

<Include>	ON | OFF *RST: ON

16.16.2 Autonaming

MMEMory:AUTonaming:PREFix <State>
MMEMory:AUTonaming:USERtext <State>
MMEMory:AUTonaming:DATE <State>

MMEMory:AUTonaming:INDex <State>
MMEMory:AUTonaming:TIME <State>

Includes or excludes the name part in the file name pattern for automatic file name generation. This name is used as the default file name.

The prefix indicates the type of data that is saved, for example, Histogram, RefCurve, Settings.

To define a user text, use `MMEMory:AUTonaming:TEXT`.

Parameters:

<State>	ON | OFF	
	*RST:	ON

MMEMory:AUTonaming:TEXT <NameString>

Defines a text, that can be included in the autonaming pattern.

Parameters:

<NameString>	String parameter

MMEMory:AUTonaming:DEFaultpath <Path>

Sets the path where data and settings files will be stored. The default path is `C:\Users\Public\Documents\Rohde-Schwarz\RTx`.

Parameters:

<Path>	String parameter

MMEMory:AUTonaming:RESPath

Resets the path for file operations to the default path.

Usage: Event

MMEMory:AUTonaming:RESall

Resets all autonaming settings to the default value, including the path.

Usage: Event

16.16.3 Waveform Data Transmission

The R&S RTE provides specific data export commands for the various waveform types. The commands transmit the data of the waveform points from the instrument to the controlling computer. The data can be used in MATLAB, for example.

The commands are described in the relevant chapters:

- Analog waveforms: Chapter 16.8.6, "Waveform Data", on page 923
- Reference waveforms: Chapter 16.10.2.3, "Waveform Data Export", on page 997

- Math waveforms: Chapter 16.10.3, "Mathematics", on page 1000
- Spectrum waveforms: Chapter 16.13.2, "Waveform Data", on page 1082
- Logic channels: Chapter 16.18.5, "MSO Data ", on page 1552

16.16.4 Waveform Data Export to File

The resulting files of waveforms exports are described in Chapter 11.2.1, "Waveform Export Files", on page 410.

The export settings for manual operation are explained in Chapter 11.2.2, "Waveforms - Export Settings", on page 416.

EXPort:WAVeform:SOURce <Source>

Selects the waveform to be exported to file.

The commands takes effect if `EXPort:WAVeform:MULTichannel` is `OFF`.

Parameters:

<Source> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8

Example: See Chapter 16.3.5.2, "Exporting Waveform Data to File", on page 869

Firmware/Software: V 1.25

EXPort:WAVeform:MULTichannel <MultiChExport>

Enables or disables the multichannel export.

If you enable the multichannel export, all active channels are included to the export data. You can change the export state using the CHANnel<m>:EXPortstate command.

If multichannel export is disabled, select the waveform to be exported using the EXPort:WAVeform:SOURce command.

Note that CHANnel<m>[:WAVeform<n>]:DATA[:VALues]? returns the data of all channels that are selected for export, no matter of the channel suffix.

Parameters:

<MultiChExport> ON | OFF

*RST: OFF

CHANnel<m>:EXPortstate <ExportState>

Includes or excludes the indicated channel in waveform export. The data of channel waveform 1 is exported.

The commands takes effect if EXPort:WAVeform:MULTichannel is ON.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<ExportState> ON | OFF

If you enable the multichannel export, the export state of all active channels is automatically set ON.

*RST: OFF

EXPort:WAVeform:NAME <FileName>

Sets the file name, file format and path to save the waveform to.

See also: Chapter 11.2.1, "Waveform Export Files", on page 410

Parameters:

<FileName> String with path and file name with extension .xml, .bin, or .csv

Example:

```
EXPort:WAVeform:NAME 'C:\temp\Export_Ch11.xml'
EXPort:WAVeform:SAVE
```

Saves the waveform data in XML format to C:\temp\Export_Ch1.xml.

Example:

```
EXPort:WAVeform:NAME 'C:\temp\Export_Ch2.bin'
EXPort:WAVeform:SAVE
```

Saves the waveform data in binary format to C:\temp\Export_Ch2.bin.

Firmware/Software: V 1.25

EXPort:WAVeform:SAVE

Saves the waveform(s) to the file specified with `EXPort:WAVeform:NAME`. The file format is also set using the `...NAME` command.

Example: See Chapter 16.3.5.2, "Exporting Waveform Data to File", on page 869

Usage: Event

Firmware/Software: V 1.25

EXPort:WAVeform:SCOPe <Scope>

Defines the part of the waveform record that has to be stored.

Parameters:

<Scope> WFM | ZOOM | CURSor | GATE | MANual

WFM
Complete waveform

ZOOM
Data included in the zoom area if a zoom is defined for the source waveform.

CURSor
Data between the cursor lines if a cursor measurement is defined for the source waveform.

GATE
data included in the measurement gate if a gated measurement is defined for the source waveform.

MANual
Saves the data between user-defined start and stop values to be set with `EXPort:WAVeform:STARt` and `EXPort:WAVeform:STOP`.

*RST: WFM

Example: See Chapter 16.3.5.2, "Exporting Waveform Data to File", on page 869

Firmware/Software: V 1.25

EXPort:WAVeform:STARt <Start>

Sets the start value of the waveform section for export, if `EXPort:WAVeform:SCOPe` is set to `Manual`.

Parameters:

<Start> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01
Default unit: s

Firmware/Software: V 1.25

EXPort:WAVeform:STOP <Stop>

Sets the end value of the waveform section for export, if `EXPort:WAVeform:SCOPe` is set to `Manual`.

Parameters:

<Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01
Default unit: s

Firmware/Software: V 1.25

EXPort:WAVeform:ZOOM <DiagramName>, <ZoomName>
EXPort:WAVeform:ZOOM? <DiagramName>

Sets the zoom area to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `ZOOM`.

Parameters:

<ZoomName> Name of the zoom diagram

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

Example: See "Exporting Interleaved x/y Data of a Zoom to CSV File" on page 872

Firmware/Software: V 1.25

EXPort:WAVeform:CURSorset <Cursorset>

Sets the cursor set to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `CURSor`.

Parameters:

<Cursorset> CURSOR1 | CURSor1 | CURSOR2 | CURSor2 | CURSOR3 | CURSor3 | CURSOR4 | CURSor4

CURSOR1 = CURSor1, CURSOR2 = CURSor2, CURSOR3 = CURSor3, CURSOR4 = CURSor4

*RST: CURSOR1

Firmware/Software: V 1.25

EXPort:WAVeform:MEAS <MeasGate>

Sets the gate to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `GATE`.

Parameters:

<MeasGate> MEAS1 | MEAS2 | MEAS3 | MEAS4 | MEAS5 | MEAS6 | MEAS7 | MEAS8

Measurement for which the gate is defined.

*RST: MEAS1

Example: See "Exporting Raw Data of a Measurement Gate to BIN File" on page 871

Firmware/Software: V 1.25

EXPort:WAVeform:DLOGging <DataLogging>

The command enables the export of subsequent acquisitions of the selected waveforms. The waveforms are taken from a running Nx Single acquisition (data logging, history is disabled), or from the history (multiple waveforms, history is enabled).

If the history is disabled (`CHANnel<m>[:WAVeform<n>]:HISTory[:STATe]`) and data logging is enabled, a specified number of waveforms is transferred to file directly during RUN Nx SINGLE acquisition. Enabling data logging stops a running acquisition. Set the number of acquisitions to be acquired and stored with `ACQuire:COUNt` and start export using `RUNSingle`.

If the history is enabled, the subsequent waveforms are taken from the history. Specify the range with `CHANnel<m>[:WAVeform<n>]:HISTory:STARt` and `CHANnel<m>[:WAVeform<n>]:HISTory:STOP`. Then play the history with `CHANnel<m>[:WAVeform<n>]:HISTory:PLAY`.

The commands `EXPort:WAVeform:SAVE`, `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?` and `CHANnel<m>[:WAVeform<n>]:DATA:HEADer?` are not available if data logging is enabled. The `RUNContinous` command disables data logging.

If data logging is off, and the history is enabled, one waveform out of the history is written to file. Specify the waveform using `CHANnel<m>[:WAVeform<n>]:HISTory:CURRent` and save it using `EXPort:WAVeform:SAVE`.

Parameters:

<DataLogging> ON | OFF

*RST: OFF

Example: See:
"Exporting Multiple Running Acquisitions of a Single Waveform to XML File" on page 872
"Exporting Multiple Acquisition of the History to XML File" on page 873
"Exporting a Single Acquisition of the History to BIN File" on page 872

Firmware/Software: V 1.25

EXPort:WAVeform:TIMestamps <UseTimestamps>

Exports the relative timestamps of all history waveforms to the waveform data file. The time is written at the beginning of each waveform record.

Parameters:

<UseTimestamps>	ON | OFF *RST: OFF

EXPort:WAVeform:INCXvalues <IncHorValues>

Includes horizontal values in the retrieved data (time or frequency values, depending on the waveform). X and Y-values are written alternately to the file. If disabled, only Y-values - mostly voltage values - are written. The X-values are always returned in 64 bit real format, regardless of the defined data format.

The setting is not available for the export of raw data.

The command affects the content of export files as well as data retrieved with:

- `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?`
- `CALCulate:MATH<m>:DATA[:VALues]?`
- `REFCurve<m>:DATA[:VALues]?`

Parameters:

<IncHorValues>	ON | OFF *RST: OFF

Example: See:
"Exporting Interleaved x/y Data of a Single Waveform to CSV File" on page 871
"Exporting Interleaved x/y Data of a Zoom to CSV File" on page 872

Firmware/Software: FW 1.40

EXPort:WAVeform:RAW <RawValues>

Enables the export of raw sample data, and sets the data format to integer 8 bit. In high definition acquisition mode, the data format is integer 16 bit (requires option R&S RTE-K17). Fot INT16, you can set the byte order using the `FORMat:BORDer` command.

The raw format reduces the file size but changes also the precision of the values.

The setting is not available for the export of digital channel data and for the export of interleaved X/Y values.

Parameters:

<RawValues>	ON | OFF *RST: OFF

Example: See:
"Exporting Raw Data of a Single Waveform to BIN File" on page 870
"Exporting Raw Data of a Measurement Gate to BIN File" on page 871

Firmware/Software: FW 1.40

EXPort:WAVeform:FASTexport <Enable>

To improve the performance of data export to file, the measurements are performed slower while the data export speeds up.

Setting parameters:

<Enable> ON | OFF

Example: See Chapter 16.3.5.2, "Exporting Waveform Data to File", on page 869

Usage: Setting only

Firmware/Software: V 1.47

16.16.5 Waveform Histogram Export to File

EXPort:HISTogram:SELect <Name>

Selects the histogram to be exported.

Parameters:

<Name> String with the histogram name.

Example: See "Exporting Histogram Data to File" on page 867

Firmware/Software: V 1.47

EXPort:HISTogram:INCidence <Incidence>

Sets the mode of exported data: relative or absolute frequency of amplitude values.

Parameters:

<Incidence> ABS | REL

*RST: REL

Example: See "Exporting Histogram Data to File" on page 867

Firmware/Software: V 1.47

EXPort:HISTogram:NAME <Path>

Sets the file name and path to save the histogram to.

Parameters:

<Path> String with path and file name. The file extension defines the file format: XML, CSV, or BIN.

Example: See "Exporting Histogram Data to File" on page 867

Firmware/Software: V 1.47

EXPort:HISTogram:SAVE

Saves the histogram to the file specified with `EXPort:HISTogram:NAME`.

Example: See "Exporting Histogram Data to File" on page 867

Usage: Event

Firmware/Software: V 1.47

EXPort:HISTogram:DATA?

Transfers the histogram data to the controlling computer. The data can be used in MATLAB, for example.

To set the export data format, use `FORMat[:DATA]`.

Return values:

<Data> List of values according to the format settings and `EXPort:HISTogram:INCidence`.
See also: Chapter 11.2.3, "Waveform Histograms", on page 421

Example: See "Transferring Histogram Data" on page 867

Usage: Query only

Firmware/Software: V 1.47

16.16.6 Long Term Measurement Results and Measurement Histogram Export to File

EXPort:MEASurement:SELect <SelectedMeas>

Selects the measurement for export of long term or measurement histogram data.

Parameters:

<SelectedMeas> MEAS1 | MEAS2 | MEAS3 | MEAS4 | MEAS5 | MEAS6 | MEAS7 | MEAS8

*RST: MEAS1

Example: See "Exporting Long Term Measurement Data to File" on page 867

Firmware/Software: V 1.47

EXPort:MEASurement:TYPE <ExportType>

You can export the result data of the long term measurement, or the measurement histogram.

To export the measurement histogram, it must be enabled using `MEASurement<m>:STATistics:HISTogram`.

To export the long term results, the long term measurement must be enabled using `MEASurement<m>:LTMeas[:STATe]`.

Parameters:

<ExportType> LONGTERM | LONGterm | HISTOGRAM | HISTogram

LONGTERM = LONGterm, HISTOGRAM = HISTogram

*RST: HISTOGRAM

Example: See "Exporting Long Term Measurement Data to File" on page 867

Firmware/Software: V 1.47

EXPort:MEASurement:NAME <Path>

Sets the file name and path to save the long term or measurement histogram data to.

Parameters:

<Path> String with path and file name. The file extension defines the file format: XML, CSV, or BIN.

Example: See "Exporting Long Term Measurement Data to File" on page 867

Firmware/Software: V 1.47

EXPort:MEASurement:SAVE

Saves the long term or measurement histogram results to the file specified using `EXPort:MEASurement:NAME`.

The measurement data can be exported as absolute or relative values, which is defined using `EXPort:HISTogram:INCidence`.

Example: See "Exporting Long Term Measurement Data to File" on page 867

Usage: Event

Firmware/Software: V 1.47

EXPort:MEASurement:DATA?

Transfers the long term measurement data to the controlling computer. The data can be used in MATLAB, for example.

To set the export data format, use `FORMat[:DATA]`.

Return values:

<Data> List of values according to the format settings
Long term data:
If statistics are enabled (`MEASurement<m>:STATistics[:ENABle]`), six values for each long term point are returned: maximum, minimum, average, standard deviation, number of measured results per long term point, number of waveforms per long term point.
If statistics are disabled, the current value of each long term point is returned.
For measurement histograms, absolute values are returned.
See also: Chapter 11.2.5, "Long Term / Meas Histograms", on page 425

Example: See "Transferring Long Term Measurement Data" on page 868

Usage: Query only

Firmware/Software: V 1.47

16.16.7 Screenshots

The HCOPy subsystem and some other commands control the output of display information for documentation purposes on output devices (printer and clipboard) or files (also for report files). The instrument allows two independent output configurations which can be set separately with the suffix.

HCOPy:DESTination<1..2> <Medium>

Selects the output medium: file, printer or clipboard.

Suffix:

<1..2> Selects the output configuration.

Parameters:

<Medium> MMEM | SYST:COMM:PRIN | SYST:COMM:CLIP

String parameter

MMEM
Directs the display image to a file. The `MMEMory:NAME` command defines the file name. The file format is defined with `HCOPy:DEVice<m>:LANGuage`.

SYST:COMM:PRIN
Directs the display image to the printer. The printer is selected with the `SYSTem:COMMunicate:PRINter:SELect<1..2>` command. The `HCOPy:DESTination` command should always be sent after setting the printer.

SYST:COMM:CLIP
Directs the hardcopy to the clipboard.

*RST: SYST:COMM:CLIP

Example: `HCOP:DEST 'SYST:COMM:PRIN'`
See also Chapter 16.3.5.1, "Saving a Screenshot to File", on page 869

MMEMory:NAME <FileName>

Defines the file name when an image of the display is stored to a file rather than printed to a printer using the `HCOPy:IMMediate<m>[:DUM]` command.

Setting parameters:

<FileName> String parameter specifiying path and file name of the screenshot

Example: See Chapter 16.3.5.1, "Saving a Screenshot to File", on page 869

Usage: Setting only
SCPI confirmed

HCOPy:DEVice<m>:LANGuage <FileFormat>

Defines the file format for output of the display image to file.

To set the output to file, use `HCOPy:DESTination<1..2>` with parameter `'MMEM'`.

Suffix:

<m>	1..2 Selects the output configuration.

Parameters:

<FileFormat>	PNG | JPG | BMP | TIFF | PDF *RST: PNG

Example: See Chapter 16.3.5.1, "Saving a Screenshot to File", on page 869

HCOPy:PAGE:ORIentation<1..2> <Orientation>

Defines the page orientation for output of the display image to a printer.

To set the output to printer, use `HCOPy:DESTination<1..2>` with parameter `'SYST:COMM:PRIN'`.

Suffix:

1..2	Selects the output configuration.

Parameters:

<Orientation>	PORTrait | LANDscape *RST: LANDscape

HCOPy:DEVice<m>:COLor <Color>

Selects between color and monochrome printing of the display image.

To set the output to printer, use `HCOPy:DESTination<1..2>` with parameter `'SYST:COMM:PRIN'`.

Suffix:

<m>	1..2 Selects the output configuration.

Parameters:

<Color>	ON | OFF ON: Color output OFF: Black and white output *RST: ON

HCOPy:DEVice<m>:INVerse <InverseColor>

Inverts the colors of the output, i.e. a dark waveform is printed on a white background.

Suffix:

<m>	1..2 Selects the output configuration.

Parameters:

<InverseColor> ON | OFF

*RST: ON

Firmware/Software: V 1.27

HCOPy:WBKG <WhiteBackground>

Inverts the background color. So you can print waveforms with normal waveform colors on white background.

Parameters:

<WhiteBackground> ON | OFF

*RST: OFF

HCOPy:CMAP<m>:DEFault <PrintColorSet>

Defines the default color set for printing of the display image.

To set the output to printer, use `HCOPy:DESTination<1..2>` with parameter `'SYST:COMM:PRIN'`.

Suffix:

<m> 1..2

Selects the output configuration.

Parameters:

<PrintColorSet> DEF1 | DEF4

DEF1

Current screen colors with white background and black grid.

DEF4

Current screen colors without any changes (black background).

*RST: DEF1

HCOPy:SSD <ShowSetupDialog>

Enables or disables the display of open dialog boxes in screenshots. Use this command if you want to document settings in screenshots.

Parameters:

<ShowSetupDialog> ON | OFF

*RST: OFF

Firmware/Software: FW 3.20

HCOPy:IMMediate<m>[:DUM]

Starts the immediate output of the display image to printer, file, or clipboard, depending on the `HCOPy:DESTination<1..2>` setting.

Suffix:

<m> 1..2
Selects the output configuration.

Example: See Chapter 16.3.5.1, "Saving a Screenshot to File", on page 869

Usage: Event
Asynchronous command

HCOPy:IMMediate<m>:NEXT

Starts the output of the next display image to printer, file, or clipboard, depending on the `HCOPy:DESTination<1..2>` setting.

If the output is printed to a file, the file name used in the last saving process is automatically counted up to the next unused name.

Suffix:

<m> 1..2
Selects the output configuration.

Example: See Chapter 16.3.5.1, "Saving a Screenshot to File", on page 869

Usage: Event
Asynchronous command

SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?

Queries the name of the first printer in the list of printers that is configured in the Windows operating system.

To query the names of other installed printers, use the `SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]?` command.

Return values:

<PrinterName> If no printer is configured an empty string is returned.

Usage: Query only

SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]?

Queries the name of the next printer that is configured in the Windows operating system.

Before you send the ...NEXT command, send `SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?` to return to the beginning of the printer list and query the name of the first printer.

Return values:

<PrinterName> After all available printer names have been returned, an empty string enclosed by quotation marks (") is returned for the next query. Further queries are answered by a query error.

Usage: Query only

SYSTem:COMMunicate:PRINter:SELect<1..2> <PrinterName>

Selects a configured printer.

Parameters:

<PrinterName> Enter the string as it is returned with `SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?` or `SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]?`.

16.16.8 Reports

The following commands configure and save report files. To configure the screenshot that is included in the report, use the commands explained in Chapter 16.16.7, "Screenshots", on page 1155.

REPort:LANGuage <Language>

Sets the language to be used in the report. Available languages are listed in the data sheet.

Parameters:

<Language> String with the english language name, upper case.

Example: `REPort:LANGuage 'Spanish'`

REPort:PAPersize <PaperSize>

Selects the paper size: A4 or US Letter.

Parameters:

<PaperSize> A4 | USL

*RST: A4

REPort:LOGType <Logo>

By default, the Rohde & Schwarz logo is shown in the header of the report pages. You can switch the logo off, or select your logo to be shown.

Parameters:

<Logo> RS | CUST | NONE

CUST
Select the logo file using REPort:LOGO.

*RST: RS

REPort:LOGO <LogoFile>

Defines the logo file that is used on the report if REPort:LOGType is set to CUSTom.

Parameters:

<LogoFile> String with the path and filename of the logo image.

Example: `REPort:LOGO 'C:\Company files\logo.jpg'`

REPort:USER <User>

Enter the user name that appears in the general information section at the beginning of the report.

Parameters:

<User> String parameter

REPort:COMMent <Comment>

Enter a comment that appears in the general information section at the beginning of the report.

Parameters:

<Comment> String parameter

REPort:FILE:NAME <ReportFile>

Sets the file name and path to save the report to.

Parameters:

<ReportFile> String with path and file name. The file extension defines the file format: PDF, HTML, or DOC.

REPort:FILE:SAVE

Saves the report to the specified file.

Usage: Event
Asynchronous command

16.17 Protocols

16.17.1 Configuration Settings for all Serial Protocols

BUS<m>:TYPE <Type>

Defines the bus or protocol type for analysis.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Type> I2C | SPI | UART | CAN | CANFd | LIN | FLXRay | I2S | MILS1553 | MILStd1553 | ARIN429 | ARINc429 | MDIO | USB | ETHernet | CMSB | SENT

MILS1553 = MILStd1553: specification MIL-STD-1553 (option R&S RTE-K6)
ARIN429 = ARINc429: specification ARINC 429 (option R&S RTE-K7)
CMSB: custom decode serial bus (option R&S RTE-K50)

*RST: I2C

Usage: Asynchronous command

BUS<m>[:STATe] <State>

Enables the decoding of the specified bus.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<State> ON | OFF

*RST: OFF

Usage: Asynchronous command

BUS<m>:SETReflevels

Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Suffix:

<m> 1..4
Selects the serial bus.

Usage: Event
Asynchronous command

Firmware/Software: FW 1.45

BUS<m>:LABel <Label>

Defines a label to be displayed with the bus.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Label> String containing the label text.

Usage: Asynchronous command

BUS<m>:RESult <ShowResultTable>

Opens a table with decoded data of the serial signal. The function requires the option for the analyzed protocol.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<ShowResultTable> ON | OFF
*RST: OFF

Usage: Asynchronous command

BUS<m>:FORMat <DataFormat>

Sets the number format for decoded data values of the indicated bus. It defines the format in the "Decode table" and in the combs of the decoded signal.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<DataFormat> HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG
ASCII = ASCii
SYMB = Symbolic, only available for CAN and CAN FD if a DBC label list is applied.
*RST: HEX

BUSFormat <DataFormat>

Sets the number format for decoded data values in the "Decode table" and on the display for all parallel and serial buses.

For serial buses, the command overwrites the the bus-specific format setting `BUS<m>:FORMat`.

For parallel buses, the command sets also the number representation for data export. In case of export to BIN file or remote data transfer, SIGN returns signed values, and all other formats return unsigned values.

Parameters:
<DataFormat> HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG
ASCII = ASCii
*RST: HEX

Usage: Asynchronous command

Firmware/Software: FW 1.45

BUS<m>:NEWList <FileName>

Loads a label list file.

Suffix:

<m> 1..4
Selects the serial bus.

Setting parameters:

<FileName> String parameter with path and file name.

Example:
```
BUS1:NEWList 'C:\Protocols\CAN.csv'
BUS1:SYMBols ON
```

Usage: Setting only

BUS<m>:SYMBols <UseTranslation>

Activates the lable list to be used for decoding.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<UseTranslation> ON | OFF
*RST: OFF

Usage: Asynchronous command

Firmware/Software: FW 1.36

16.17.2 Trigger Settings for all Serial Protocols

TRIGger<m>:SOURce <SourceDetailed>

Selects the source of the trigger signal.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = not available
Available values depend on the selected trigger source. For input channels CHAN1...4, a trigger sequence can be configured.
For all other trigger sources, only suffix 1 is allowed.
See also: `TRIGger<m>:SEQuence:MODE`

Parameters:

<SourceDetailed> CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 | EXTernanalog | LINE | SBUS | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | LOGIC | MSOB1 | MSOB2 | MSOB3 | MSOB4

CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4
Input channels

EXTernanalog
External analog signal connected to the External Trigger Input. For this source, only the analog edge trigger is available.

LINE
The instrument generates the trigger from the AC power input and synchronizes the signal to the AC power frequency.

SBUS
Serial bus

D0...D15
Digital channels (option R&S RTE-B1)
See also: Chapter 16.18.4, "Trigger Settings for Digital Signals and Parallel Buses", on page 1543

LOGIc
Logic combination of digital channels, used as trigger source (option R&S RTE-B1)

MSOB1 | MSOB2 | MSOB3 | MSOB4
Parallel bus (option R&S RTE-B1)

*RST: CHAN1

TRIGger<m>:SOURce:SBSelect <SerialBus>

Selects the serial bus to be triggered on.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event only

Parameters:

<SerialBus> SBUS1 | SBUS2 | SBUS3 | SBUS4

*RST: SBUS1

Firmware/Software: Version 2.70

BUS<m>:TYPE <Type>

Defines the bus or protocol type for analysis.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Type> I2C | SPI | UART | CAN | CANFd | LIN | FLXRay | I2S | MILS1553 | MILStd1553 | ARIN429 | ARINc429 | MDIO | USB | ETHernet | CMSB | SENT

MILS1553 = MILStd1553: specification MIL-STD-1553 (option R&S RTE-K6)
ARIN429 = ARINc429: specification ARINC 429 (option R&S RTE-K7)
CMSB: custom decode serial bus (option R&S RTE-K50)

*RST: I2C

Usage: Asynchronous command

16.17.3 I²C (Option R&S RTE-K1)

16.17.3.1 Configuration

BUS<m>:I2C:SCL:SOURce <SCLSource>

Sets the waveform of the clock line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SCLSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data and clock lines.
See Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: C1W1

Usage: Asynchronous command

BUS<m>:I2C:SDA:SOURce <SDASource>

Sets the waveform of the data line.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<SDASource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data and clock lines.
See Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: C1W1

Usage: Asynchronous command

BUS<m>:I2C:SCL:THReshold <SCLThreshold>

Sets a user-defined threshold value for the clock line.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:I2C:TECHnology`.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<SCLThreshold> User-defined clock threshold

Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:I2C:SDA:THReshold <SDAThreshold>

Sets a user-defined threshold value for the data line.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:I2C:TECHnology`.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:

<SDAThreshold> User-defined data threshold

Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:I2C:TECHnology <Technology>

Sets the threshold voltage clock and data lines as defined for various signal technologies.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN

V15 | V25 | V165 | V125 | V09 | V38 | V20 | V0
1.5 V, 2.5 V, 1.65 V ... respectively

VM13
-1.3 V (negative value)

MAN
Manual setting of user-defined values with `BUS<m>:I2C:SCL:THReshold` and `BUS<m>:I2C:SDA:THReshold`.

*RST: V165

Usage: SCPI confirmed

BUS<m>:I2C:RWBit <BusConfig>

Defines if the R/W bit of a 7-bit address is considered separately or as part of the address. The setting defines which address lengths are available with `TRIGger<m>:I2C:AMODe`.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<BusConfig> SEParate | INADdress

SEParate
Address types BIT7 and BIT10 are available.

INADdress
Address types BIT7_RW and BIT10 are available.

*RST: SEParate

Firmware/Software: FW 1.35

16.17.3.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:I2C:MODE <Type>

Selects the trigger type for I²C analysis.

See: "Trigger type" on page 451

Parameters:

<Type> STARt | REPStart | STOP | NACK | ADDRess | ADOR | ADAT

STARt
Start condition

REPStart
Repeated start - the start condition occurs without previous stop condition.

STOP
Stop condition, end of frame

NACK
Missing acknowledge bit. To localize specific missing acknowledge bits, use `TRIGger<m>:I2C:ADNack`, `TRIGger<m>:I2C:DWNack`, and `TRIGger<m>:I2C:DRNack`.

ADDRess
Triggers on one specific address

ADOR
Triggers on an OR combination with up to four four address conditions.

ADAT
Triggers on a combination of address and data condition.

*RST: STARt

Usage: Asynchronous command

TRIGger<m>:I2C:ACCess <RWBitAddress>

Sets the trigger condition for the R/W bit - the transfer direction of the data.

Parameters:

<RWBitAddress> READ | WRITe | EITHer

EITHer
Transfer direction is not relevant.

*RST: EITHer

Usage: Asynchronous command

TRIGger<m>:I2C:ADNack <AddressNack>

Triggers if the address acknowledge bit is missing - no slave recognizes the address.

Parameters:

<AddressNack> ON | OFF

*RST: ON

Usage: Asynchronous command

TRIGger<m>:I2C:DWNack <DataWriteNack>

Triggers if a date acknowledge bit is missing - the addressed slave does not accept the data.

Parameters:
<DataWriteNack> ON | OFF
*RST: ON

Usage: Asynchronous command

TRIGger<m>:I2C:DRNack <DataReadNack>

Triggers on the end of the read process when the master reads data from the slave. This Nack is sent according to the protocol definition, it is not an error.

Parameters:
<DataReadNack> ON | OFF
*RST: ON

Usage: Asynchronous command

TRIGger<m>:I2C:AMODe <AddressType>

Sets the address length. The setting affects the address input with TRIGger<m>:I2C:ADDRess and TRIGger<m>:I2C:ADDTo.

Parameters:
<AddressType> BIT7 | BIT7_RW | BIT10 | ANY

Available address types depend on BUS<m>:I2C:RWBit SEParate | INADdress.

BIT7 | BIT10
Only address bits have to be entered for address.

BIT7_RW
Seven address bits and also the R/W bit have to be entered for address.

ANY
Only available for trigger type "Address + data" (TRIGger<m>:I2C:MODE ADAT). Used to trigger on data only, regardless of the address.

*RST: BIT7

Usage: Asynchronous command

TRIGger<m>:I2C:ACONdition <AddressOperator>

Sets the operator to set a specific address or an address range. The address values are set with TRIGger<m>:I2C:ADDRess and TRIGger<m>:I2C:ADDTo.

Parameters:

<AddressOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Firmware/Software: V 1.25

TRIGger<m>:I2C:ADDRess <Address>

Triggers on the specified slave address, or sets the the start value of an address range depending on the condition set with `TRIGger<m>:I2C:ACONdition`.

Parameters:

<Address> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

TRIGger<m>:I2C:ADDTo <AddressTo>

Sets the the end value of an address range if the condition is set to an address range with `TRIGger<m>:I2C:ACONdition`.

Parameters:

<AddressTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Usage: Asynchronous command

TRIGger<m>:I2C:ADOR<n>:ENABle <UseAddress>

Includes the indicated ADOR address in the "address OR" trigger condition.

Suffix:

<n> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:

<UseAddress> ON | OFF

*RST: OFF

TRIGger<m>:I2C:ADOR<n>:ADRType <AddressType>

Sets the address type for the indicated ADOR address in the "address OR" trigger condition.

Suffix:

<n> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:

<AddressType> BIT7 | BIT7_RW | BIT10

*RST: BIT7

TRIGger<m>:I2C:ADOR<n>[:VALue] <Address>

Defines the address pattern of the indicated ADOR address in the "address OR" trigger condition.

Suffix:

<n>	1..4 Index of the address in an "address OR" condition (OR slot)

Parameters:

<Address>	Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

TRIGger<m>:I2C:ADOR<n>:RWBit <RWBit>

Defines the R/W bit of the indicated ADOR address in the "address OR" trigger condition.

Suffix:

<n>	1..4 Index of the address in an "address OR" condition (OR slot)

Parameters:

<RWBit> UNDefined | READ | WRITe | EITHer

UNDefined
Return value only

*RST: EITHer

TRIGger<m>:I2C:DPOPerator <DataPosiOperator>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DataPosiOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The position of the required pattern is not relevant.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:I2C:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `TRIGger<m>:I2C:DPOSition` and `TRIGger<m>:I2C:DPTO`.

*RST: ANY

TRIGger<m>:I2C:DPOSition <DataPosition>

Sets the number of data bytes before the first byte of interest. These bytes are ignored.

Parameters:

<DataPosition> The index 0 is associated with the first data byte.

Range: 0 to 4095
Increment: 1
*RST: 0

TRIGger<m>:I2C:DPTO <DataPositionTo>

Defines the last byte of interest, if `TRIGger<m>:I2C:DPOPerator` is set to `RANGe`.

Parameters:

<DataPositionTo> Range: 0 to 4095
Increment: 1
*RST: 0

TRIGger<m>:I2C:DCONdition <DataOperator>

Sets the operator to set a specific data value or a data range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

TRIGger<m>:I2C:DMIN <Data>

Specifies the data bit pattern, or sets the the start value of a data pattern range.. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Parameters:

<Data> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Usage: Asynchronous command

Firmware/Software: V 1.30

TRIGger<m>:I2C:DMAX <DataTo>

Sets the the end value of an data range if `TRIGger<m>:I2C:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Usage: Asynchronous command

Firmware/Software: V 1.30

16.17.3.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1165
- `BUS<m>:SYMBols` on page 1165

BUS<m>:I2C:FRAMe<n>:DATA?

Returns the data words of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<Data> Comma-separated list of integer values (N, D1, D2,…, DN). N is the number of bytes in the frame, and D1…DN are the values of the bytes.

Example:

```
BUS:I2C:FRAMe4:DATA?
<-- 3,74,164,18
```

Usage: Query only

BUS<m>:I2C:FCOunt?

Returns the number of decoded frames.

Suffix:

<m>	1..4 Selects the serial bus.

Return values:

<Count>	Total number of decoded frames.

Usage: Query only

BUS<m>:I2C:FRAMe<n>:AACCess?

Returns the address acknowledge bit value for the indicated frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<AddressAckBit>	INComplete | ACK | NACK | EITHer *RST: INComplete

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ACCess?

Returns the value of the R/W bit of the indicated frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<RWBit>	UNDefined | READ | WRITe | EITHer *RST: UNDefined

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ACOMplete?

Returns if the address is completely contained in the acquisition.

Suffix:

<m>	1..4 Selects the serial bus.

<n> *
Selects the frame.

Return values:
<AddressComplete> ON | OFF
*RST: OFF

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ADBStart?

Returns the start time of the address acknowledge bit.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<AddressAckBitStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ADDRess?

Returns the address value of the indicated frame *including* the R/W bit.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<AddressValue> To set the value format, use FORMat:BPATtern.
The values below – range, increment and default – are decimal values.
Range: 0 to 2047
*RST: 0

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ADEVice?

Returns the pure device address of the indicated frame *without* the R/W bit.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<DevAddressValue> To set the value format, use FORMat:BPATtern.
The values below – range, increment and default – are decimal values.
Range: 0 to 1023
*RST: 0

Usage: Query only

BUS<m>:I2C:FRAMe<n>:AMODe?

Returns the address length.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<AddressType> BIT7 | BIT7_RW | BIT10 | AUTO | ANY
*RST: BIT7

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ASTart?

Returns the start time of the address for the indicated frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<AddressStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:RWBStart?

Returns the start time of the R/W bit

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<RWBitStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:STATus?

Returns the overall state of the frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameState> INComplete | OK | UNEXpstop | INSufficient | ADDifferent

INComplete
The stop bit is missing.

OK
The frame is valid.

UNEXpstop
A stop bit was detected but clock and data are continued.

INSufficient
The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

ADDifferent
Error in 10 bit address. In case of a read access on a 10 bit address, the first address byte is sent twice, first as write, the second as read. The first seven bits of the byte must be identical. If they are not identical, the ADDiffernt error is indicated.

*RST: OK

Usage: Query only

BUS<m>:I2C:FRAMe<n>:STARt?

Returns the start time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameStart>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:STOP?

Returns the end time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameStop>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the number of the frame in the current acquisition, 1...n.

Return values:

<Label>	String with symbolic name of the address

Usage: Query only

Firmware/Software: FW 1.36

BUS<m>:I2C:FRAMe<n>:BCOunt?

Returns the number of bytes in the specified frame

Suffix:

<m>	1..4 Selects the input channel.
<n>	* Selects the frame.

Return values:

<Count>	Byte count

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:ACCess?

Returns the acknowledge bit value of the specified data byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte number.

Return values:

<ByteAckBit>	INComplete | ACK | NACK | EITHer *RST: INComplete

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:ACKStart?

Returns the start time of the acknowledge bit of the specified byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte number.

Return values:

<ByteAckBitStart> To set the value format, use FORMat:BPATtern.
The values below – range, increment and reset – are decimal values.

Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:COMPlete?

Returns if the indicated byte is completely contained in the acquisition.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:

<ByteComplete> ON | OFF

*RST: OFF

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:STARt?

Returns the start time of the specified data byte.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:

<ByteStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:VALue?

Returns the data value of the specified byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte number.

Return values:

<ByteData> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and default – are decimal values.

Range: 0 to 255
*RST: 0

Usage: Query only

16.17.3.4 I²C Search Settings

In search setup commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name. The commands are similar to I²C trigger commands.

SEARch:TRIGger:I2C:SCONdition <SearchName>,<Start>
SEARch:TRIGger:I2C:SCONdition? <SearchName>

Enables the search for the start of the message.

Parameters:
<Start> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:RCONdition <SearchName>,<RepeatedStart>
SEARch:TRIGger:I2C:RCONdition? <SearchName>

Enables the search for a start condition without previous stop condition.

Parameters:
<RepeatedStart> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:STCNdition <SearchName>,<Stop>
SEARch:TRIGger:I2C:STCNdition? <SearchName>

Enables the search for the start of the message.

Parameters:
<Stop> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:NACKnowledge <SearchName>,<NoAcknowledge>
SEARch:TRIGger:I2C:NACKnowledge? <SearchName>

Searches for missing address acknowledge bits.

Parameters:
<NoAcknowledge> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:SADDress <SearchName>,<Address>
SEARch:TRIGger:I2C:SADDress? <SearchName>

Enables the search for one specific address condition or for a combination of address conditions.

To define the address condition, use the following commands:

- SEARch:TRIGger:I2C:ACONdition on page 1187
- SEARch:TRIGger:I2C:ADDRess on page 1188
- SEARch:TRIGger:I2C:ADDTo on page 1188
- SEARch:TRIGger:I2C:AMODe on page 1187
- SEARch:TRIGger:I2C:ACCess on page 1188

Parameters:

<Address> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:ADOR <SearchName>,<AddressOr>
SEARch:TRIGger:I2C:ADOR? <SearchName>

Enables the search for one to four address conditions.

- SEARch:TRIGger:I2C:ADDO<m>:ENABle on page 1188
- SEARch:TRIGger:I2C:ADDO<m>:ADRType on page 1189
- SEARch:TRIGger:I2C:ADDO<m>[:VALue] on page 1189
- SEARch:TRIGger:I2C:ADDO<m>:RWBit on page 1190

Parameters:

<AddressOr> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:ADDData <SearchName>,<AddressData>
SEARch:TRIGger:I2C:ADDData? <SearchName>

Enables the search for a combination of address and data conditions.

Parameters:

<AddressData> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:ACONdition <SearchName>,<AddressOperator>
SEARch:TRIGger:I2C:ACONdition? <SearchName>

Sets the operator to set a specific address or an address range.

Parameters:

<AddressOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with `SEARch:TRIGger:I2C:ADDRess` on page 1188.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:I2C:ADDRess` on page 1188 and `SEARch:TRIGger:I2C:ADDTo` on page 1188.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:AMODe <SearchName>,<AddressType>
SEARch:TRIGger:I2C:AMODe? <SearchName>

Sets the address length.

Parameters:

<AddressType> BIT7 | BIT7_RW | BIT10 | ANY

BIT7 | BIT10
Enter only address bits in the address pattern.

BIT7_RW
Enter seven address bits and also the R/W bit in the address pattern.

ANY
Only available for search criteria "Address and data" (`SEARch:TRIGger:I2C:ADData` is set `ON`). Used to search for data only, regardless of the address.

*RST: BIT7

Parameters for setting and query:

<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ADDRess <SearchName>,<Address>
SEARch:TRIGger:I2C:ADDRess? <SearchName>

Specifies an address pattern, or sets the the start value of an address range.

Parameters:

<Address> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.
The pattern length is defined with `SEARch:TRIGger:I2C:AMODe`.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:ADDTo <SearchName>,<AddressTo>
SEARch:TRIGger:I2C:ADDTo? <SearchName>

Sets the the end value of an address range if `SEARch:TRIGger:I2C:ACONdition` is set to `INRange` or `OORange`.

Parameters:

<AddressTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.
The pattern length is defined with `SEARch:TRIGger:I2C:AMODe`.

Parameters for setting and query:

<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ACCess <SearchName>,<RWBitAddress>
SEARch:TRIGger:I2C:ACCess? <SearchName>

Sets the transfer direction of the data.

Parameters:

<RWBitAddress> READ | WRITe | EITHer
*RST: EITHer

Parameters for setting and query:

<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ADDO<m>:ENABle <SearchName>,<UseAddress>
SEARch:TRIGger:I2C:ADDO<m>:ENABle? <SearchName>

Includes the indicated ADOR address in the "address OR" search condition.

Suffix:
<m> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:
<UseAddress> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADDO<m>:ADRType <SearchName>,<AddressType>
SEARch:TRIGger:I2C:ADDO<m>:ADRType? <SearchName>

Sets the address type for the indicated ADOR address in the "address OR" search condition.

Suffix:
<m> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:
<AddressType> BIT7 | BIT7_RW | BIT10

BIT7 | BIT10
Enter only address bits in the address pattern.

BIT7_RW
Enter seven address bits and also the R/W bit in the address pattern.

*RST: BIT7

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADDO<m>[:VALue] <SearchName>,<Address>
SEARch:TRIGger:I2C:ADDO<m>[:VALue]? <SearchName>

Defines the address pattern of the indicated ADOR address in the "address OR" search condition.

Suffix:
<m> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:
<Address> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.
The pattern length is defined with `SEARch:TRIGger:I2C:ADDO<m>:ADRType`.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADDO<m>:RWBit <SearchName>,<RWBit>
SEARch:TRIGger:I2C:ADDO<m>:RWBit? <SearchName>

Defines the R/W bit of the indicated ADOR address in the "address OR" search condition.

Suffix:

<m> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:

<RWBit> UNDefined | READ | WRITe | EITHer

UNDefined
Only return value

*RST: EITHer

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:DPOPerator <SearchName>,<DataPosiOperator>
SEARch:TRIGger:I2C:DPOPerator? <SearchName>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DataPosiOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The position of the required pattern is not relevant.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `SEARch:TRIGger:I2C:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `SEARch:TRIGger:I2C:DPOSition` and `SEARch:TRIGger:I2C:DPTO`.

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:I2C:DPOSition? <SearchName>

Defines the first byte of interest. All bytes before that byte are ignored.

Parameters:

<DataPosition> The index 0 is associated with the first data byte.

Range: 0 to 4095
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:DPTO <SearchName>,<DataPositionTo>
SEARch:TRIGger:I2C:DPTO? <SearchName>

Defines the last byte of interest, if `SEARch:TRIGger:I2C:DPOPerator` defines a range.

Parameters:

<DataPositionTo> Range: 0 to 4095
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:I2C:DCONdition? <SearchName>

Sets the operator to set a specific data value or a data range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:DMIN <SearchName>,<Data>
SEARch:TRIGger:I2C:DMIN? <SearchName>

Specifies the data bit pattern, or sets the the start value of a data pattern range.. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Parameters:

<Data> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:DMAX <SearchName>,<DataTo>
SEARch:TRIGger:I2C:DMAX? <SearchName>

Sets the the end value of an address range if `SEARch:TRIGger:I2C:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:

<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ADNack <SearchName>,<AddressNack>
SEARch:TRIGger:I2C:ADNack? <SearchName>

Parameters:

<AddressNack> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:DRNack <SearchName>,<DataReadNack>
SEARch:TRIGger:I2C:DRNack? <SearchName>

Searches for the end of the read process when the master reads data from the slave. This Nack is sent according to the protocol definition, it is not an error.

Parameters:

<DataReadNack> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:DWNack <SearchName>,<DataWriteNack>
SEARch:TRIGger:I2C:DWNack? <SearchName>

Searches for missing data write acknowledge bits.

Parameters:

<DataWriteNack> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

Usage: Asynchronous command

16.17.3.5 I²C Search Results

The search on decoded CAN data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 16.17.3.3, "Decode Results ", on page 1176.

SEARch:RESult:I2C:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:STATus? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameState> INComplete | OK | UNEXpstop | INSufficient | ADDifferent
*RST: OK

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:STARt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:STOP? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameStop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:AACCess? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<AddressAckBit> INComplete | ACK | NACK | EITHer
*RST: INComplete

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ACCess? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<RWBit> UNDefined | READ | WRITe | EITHer
*RST: UNDefined

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ACOMplete? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<AddressComplete> ON | OFF
*RST: OFF

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ADBStart? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<AddressAckBitStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ADDRess? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<AddressValue> Range: 0 to 2047
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ADEVice? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<DeviceAddressValue> Range: 0 to 1023
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:AMODe? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<AddressType> BIT7 | BIT7_RW | BIT10 | AUTO | ANY
*RST: BIT7

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ASTart? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<AddressStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:DATA? <FrameData>

Suffix:

<m> *

Query parameters:

<FrameData>

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:RWBStart? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<RWBitStart>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:SYMBol? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Translation>

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BCOunt?

Suffix:

<m> *

Return values:

<Count>

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACCess? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<FrameByteAckBit> INComplete | ACK | NACK | EITHer

*RST: INComplete

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACKStart? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<FrameByteAckBitStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:COMPlete? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<FrameByteComplete> ON | OFF

*RST: OFF

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:STARt? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:

<FrameByteStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:VALue? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<FrameByteData> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

16.17.4 SPI (Option R&S RTE-K1)

16.17.4.1 SPI Bus Configuration

BUS<m>:SPI:BORDer <BitOrder>

Defines if the data of the messages starts with msb (most significant bit) or lsb (least significant bit).

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<BitOrder> LSBF | MSBF
*RST: MSBF

Usage: Asynchronous command

BUS<m>:SPI:WSIZe <WordLength>

Sets the number of bits in a message.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<WordLength> Number of bits
Range: 4 to 32
Increment: 1
*RST: 8

Usage: Asynchronous command

BUS<m>:SPI:SCLK:SOURce <SCLKsource>

Sets the input channel of the clock line.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<SCLKsource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15
Digital and analog channels cannot be used at the same time for data, clock and slave select lines.
See Chapter 16.4.2, "Waveform Parameter", on page 879
*RST: C1W1

Usage: Asynchronous command

BUS<m>:SPI:SSELect:SOURce <SSsource>

Sets the input channel of the Slave Select line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SSsource> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data, clock and slave select lines.
See Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: NONE

Usage: Asynchronous command

BUS<m>:SPI:SSELect:POLarity <SSPolarity>

Selects whether transmitted slave select signal is high active (high = 1) or low active (low = 1).

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SSPolarity> ACTLow | ACTHigh

*RST: ACTLow

Usage: Asynchronous command

BUS<m>:SPI:MISO:SOURce <MISOsource>

Sets the input channel of the MISO line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<MISOsource> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data, clock and slave select lines.
See Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: NONE

Usage: Asynchronous command

BUS<m>:SPI:MISO:POLarity <MISOPolarity>

Selects whether transmitted data is high active (high = 1) or low active (low = 1).

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<MISOPolarity> ACTLow | ACTHigh

*RST: ACTHigh

Usage: Asynchronous command

BUS<m>:SPI:MOSI:SOURce <MOSIsource>

Sets the input channel of the MOSI line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<MOSIsource> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data, clock and slave select lines.
See Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: NONE

Usage: Asynchronous command

BUS<m>:SPI:MOSI:POLarity <MOSIPolarity>

Selects whether transmitted data is high active (high = 1) or low active (low = 1).

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<MOSIPolarity> ACTLow | ACTHigh

*RST: ACTHigh

Usage: Asynchronous command

BUS<m>:SPI:TECHnology <Technology>

Sets the threshold voltage clock, slave select and data lines as defined for various signal technologies.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN

V15 | V25 | V165 | V125 | V09 | V38 | V20 | V0
1.5 V, 2.5 V, 1.65 V ... respectively

VM13
-1.3 V (negative value)

MAN
Manual setting of user-defined values with
`BUS<m>:SPI:SCLK|SSEL|MISO|MOSI:THReshold`.

*RST: V165

Usage: SCPI confirmed

BUS<m>:SPI:SCLK:THReshold <SCLKThreshold>
BUS<m>:SPI:MISO:THReshold <MISOThreshold>
BUS<m>:SPI:MOSI:THReshold <MOSIThreshold>
BUS<m>:SPI:SSELect:THReshold <SSThreshold>

Set user-defined threshold values for the clock, MISO, MOSI and slave select lines.

Alternatively, you can set the thresholds according to the signal technology with `BUS<m>:SPI:TECHnology`.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SSThreshold> User-defined value

Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:SPI:FRCondition <FrameCondition>

Defines the start of a frame. A frame contains a number of successive words, at least one word.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<FrameCondition> SS | CLKTimeout

SS
Start and end of the frame is defined by the active state of the slave select signal, see BUS<m>:SPI:SSELect:POLarity.

CLKTimeout
Defines a timeout on the clock line SCLK as limiter between two frames. The timeout condition is used for SPI connections without an SS line.

*RST: SS

BUS<m>:SPI:TIMeout <ClockTimeout>

Defines a timeout on the clock line SCLK as limiter between two frames. The timeout condition is used for SPI connections without an SS line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ClockTimeout> Range: 50E-9 to 10
Increment: 1E-6
*RST: 1E-3
Default unit: s

16.17.4.2 SPI Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- TRIGger<m>:SOURce is set to SBUS.
- The source(s) of the serial bus are channel signals: use BUS<m>:...:SOURce commands.
- Decoding is enabled: BUS<m>[:STATe] is set to ON.

TRIGger<m>:SPI:MODE <Type>

Selects the trigger type for SPI analysis.

Parameters:

<Type> SSACtive | TIMeout | MOSI | MISO | MOMI

SSACtive
Start of the message: slave select signal SS changes to the active state.

TIMeout
Triggers on the next message start after the "Timeout" time.

MOSI
Triggers on a specified data pattern in that is expected on the MOSI line. Define the pattern with `TRIGger<m>:SPI:MOSipattern`.

MISO
Triggers on a specified data pattern in that is expected on the MISO line. Define the pattern with `TRIGger<m>:SPI:MISopattern`

MOMI
Triggers on a specified data patterns on the MISO and MISO lines.

*RST: SSACtive

Usage: Asynchronous command

TRIGger<m>:SPI:PALignment <DataAlignment>

Defines how the specified data pattern is searched.

Parameters:

<DataAlignment> WORD | BIT

WORD
The pattern is matched only at word boundaries.

BIT
Bit-by bit: the pattern can be at any position in the data word.

*RST: WORD

Usage: Asynchronous command

TRIGger<m>:SPI:DPOPerator <DataPosiOperator>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DataPosiOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The position of the required pattern is not relevant.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:SPI:DPOSition`.

INRange = RANGe
Set the minimum and maximum value of the range with `TRIGger<m>:SPI:DPOSition` and `TRIGger<m>:SPI:DPTO`.

*RST: ANY

TRIGger<m>:SPI:DPOSition <DataPosition>

Sets the number of bits or words to be ignored before the first bit or word od interest. The effect is defined by `TRIGger<m>:SPI:PALignment`.

Parameters:

<DataPosition> The index 0 is associated with the first data byte.

Range: 0 to 4095 for triggering on one line (MISO or MOSI), 2047 for triggering on both lines.
Increment: 1
*RST: 0

TRIGger<m>:SPI:DPTO <DataPositionTo>

Defines the last bit or word of interest, if `TRIGger<m>:SPI:DPOPerator` is set to `INRange`.

Parameters:

<DataPositionTo> Range: 1 to 4095 for triggering on one line (MISO or MOSI), 2047 for triggering on both lines.
Increment: 1
*RST: 1

TRIGger<m>:SPI:FCONdition <DataOperator>

Selects the operator for the MISO and MOSI pattern.

Parameters:

<DataOperator> EQUal | NEQual

*RST: EQUal

Firmware/Software: V 1.25

TRIGger<m>:SPI:MISopattern <MISOPattern>

Specifies the pattern to be triggered on the MOSI line.

Parameters:

<MISOPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Usage: Asynchronous command

TRIGger<m>:SPI:MOSipattern <MOSIPattern>

Specifies the pattern to be triggered on the MOSI line.

Parameters:

<MOSIPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Usage: Asynchronous command

16.17.4.3 SPI Decode Results

BUS<m>:SPI:FRAMe<n>:DATA?

Returns the data words of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Parameters:

<Data> Comma-separated sequence of integer values (N, L1, R1,…, LN, RN). N is the number of word pairs in the frame, and {L1,R1}…{LN,RN} are the value pairs. The values Lx and Rx are associated with the MOSI and the MISO channel, respectively. If a channel is disabled, an empty value is returned.

Example: `BUS:SPI:FRAMe3:DATA?`
`<-- 2,10,108,35,70` (MOSI+MISO)
`2,10,,35,` (MOSI only)
`2,,108,,70` (MISO only)

Usage: Query only
Asynchronous command

BUS<m>:SPI:FCOunt?

Returns the number of decoded frames.

Suffix:

<m> 1..4
Selects the serial bus.

Return values:

<Count> Total number of decoded frames.

Usage: Query only

Firmware/Software: V 1.27

BUS<m>:SPI:FRAMe<n>:STATus?

Returns the overall state of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameState> OK | VOID | INCFirst | INCLast | INSufficient

OK: the frame is valid.
VOID: the frame is empty.
INCFirst: INComplete First word. The first word does not have the expected word length.
INCLast: INComplete Last word. The last word does not have the expected word length.
INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:SPI:FRAMe<n>:STARt?

Returns the start time of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:STOP?

Returns the end time of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameStop> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WCOunt?

Returns the number of words in the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<WordCount> Range: 0 to 4096
*RST: 0

Usage: Query only

Firmware/Software: V 1.27

BUS<m>:SPI:FRAMe<n>:WORD<o>:STARt?

Returns the start time of the specified data word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the word number.

Return values:

<WordStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WORD<o>:STOP?

Returns the end time of the specified data word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the word number.

Return values:

<WordStop> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WORD<o>:MISO?

Returns the data value of the specified word on the MISO line.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the word number.

Return values:

<MISOValue> To set the value format, use FORMat:BPATtern.

The values below – range, increment and reset – are decimal values.

Range: 0 to 4294967295

*RST: 0

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WORD<o>:MOSI?

Returns the data value of the specified word on the MOSI line.

Suffix:

<m> 1..4

Selects the serial bus.

<n> *

Selects the frame.

<o> *

Selects the word number.

Return values:

<MOSIValue> To set the value format, use FORMat:BPATtern.

The values below – range, increment and reset – are decimal values.

Range: 0 to 4294967295

*RST: 0

Usage: Query only

16.17.4.4 SPI Search Settings

In search setup commands, you must specify the <SearchName> parameter. It is a string parameter that contains the search definition name. All commands are similar to SPI trigger commands.

SEARch:TRIGger:SPI:MODE <SearchName>,<Type>
SEARch:TRIGger:SPI:MODE? <SearchName>

Sets the event to be searched for.

Parameters:

<Type> SSACtive | TIMeout | MOSI | MISO | MOMI

SSACtive
Searches for the start of the frame when slave select signal SS changes to the active state. This type is available if the slave select line is configured in the bus setup, and `BUS<m>:SPI:FRCondition` is `SS`.

TIMeout
Searches for the start of the frame when the clock idle time exceeds the timeout. This type is available if the slave select line is configured in the bus setup, and `BUS<m>:SPI:FRCondition` is `CLKTimeout`.

MOSI | MISO
Searches for a specified data pattern expected on the MOSI line or on the MISO line, respectively.

MOMI
Searches in parallel for specified data patterns expected on the MOSI and MISO lines.

*RST: SSACtive

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:FCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:SPI:FCONdition? <SearchName>

Selects the operator for the data pattern: equal or not equal.

Parameters:
<DataOperator> EQUal | NEQual

*RST: EQUal

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:MISopattern <SearchName>,<PATTern>
SEARch:TRIGger:SPI:MISopattern? <SearchName>
SEARch:TRIGger:SPI:MOSipattern <SearchName>,<PATTern>
SEARch:TRIGger:SPI:MOSipattern? <SearchName>

Specifies a data pattern for the MISO or MOSI line, respectively.

Parameters:
<PATTern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:DPOPerator <SearchName>,<DataPosiOperator>
SEARch:TRIGger:SPI:DPOPerator? <SearchName>

Operator for the data position. You can define an exact position, a position range, or let the position undefined (ANY).

Parameters:
<DataPosiOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF, INRange = RANGe

*RST: ANY

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:SPI:DPOSition? <SearchName>

Sets the number of bits or words before the first word of interest, see also `SEARch:TRIGger:SPI:PALignment`. These offset bits/words are skipped. The index 0 is associated with the first data bit or word.

If the position operator defines a range, also define the last bit/word of interest using `SEARch:TRIGger:SPI:DPTO`

Parameters:
<DataPosition> Range: 0 to 32767
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:DPTO <SearchName>,<DataPositionTo>
SEARch:TRIGger:SPI:DPTO? <SearchName>

Sets the the end value of a data postion range.

Parameters:
<DataPositionTo> Range: 1 to 32767
Increment: 1
*RST: 1

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:PALignment <SearchName>,<DataAlignment>
SEARch:TRIGger:SPI:PALignment? <SearchName>

Defines how the specified data pattern is searched.

Parameters:
<DataAlignment> WORD | BIT

WORD
The pattern is matched only at word boundaries.

BIT
Bit-by-bit: the pattern can start at any position in the message.

*RST: WORD

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

Firmware/Software: FW 3.30

16.17.4.5 SPI Search Results

The search on decoded SPI data returns the same results as the queries for decode results.

In search result commands, you must specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

The suffix FRAMe<m> indicates the frame index. The suffix WORD<n> indicates the word index inside a frame-

For a description of the returned values, see the corresponding commands in Chapter 16.17.4.3, "SPI Decode Results ", on page 1207. All SPI search commands are first implemented in firmware version 3.30.

SEARch:RESult:SPI:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:
<Count> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:COUNt?

Returns the number of frames that have matched the search criteria. In the search result table on the display, the number of rows is the number of frames that match the search criteria.

Suffix:
<m> *

Return values:
<Count>

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:DATA?

Suffix:
<m> *

Usage: Query only
Asynchronous command

SEARch:RESult:SPI:FRAMe<m>:STARt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:STATus? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameState> OK | VOID | INCFirst | INCLast | INSufficient
*RST: OK

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:STOP? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameStop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WCOunt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameWordCount> Range: 0 to 4096
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:MISO? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:

<WordMISOValue>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:MOSI? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<WordMOSIValue>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:STARt? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<FrameWordStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:STOP? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<FrameWordStop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

16.17.5 UART (Option R&S RTE-K2)

16.17.5.1 Configuration

BUS<m>:UART:RX:SOURce <RxSource>

Selects the input channel for the receiver signal.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<RxSource>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital and analog channels cannot be used at the same time for RX and TX lines. See Chapter 16.4.2, "Waveform Parameter", on page 879 *RST: NONE

Usage: Asynchronous command

BUS<m>:UART:TX:SOURce <TxSource>

Selects the input channel for the transmitter signal.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<TxSource> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for RX and TX lines.
See Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: NONE

Usage: Asynchronous command

BUS<m>:UART:RX:THReshold <RxThreshold>

Sets a user-defined threshold value for the Rx line.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:UART:TECHnology`.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<RxThreshold> User-defined clock threshold

Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:UART:TX:THReshold <TxThreshold>

Sets a user-defined threshold value for the Tx line.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:UART:TECHnology`.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<TxThreshold> User-defined clock threshold

Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:UART:TECHnology <Technology>

Sets the threshold voltage Tx and Rx lines as defined for various signal technologies.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN

V15 | V25 | V165 | V125 | V09 | V38 | V20 | V0
1.5 V, 2.5 V, 1.65 V ... respectively

VM13
-1.3 V (negative value)

MAN
Manual setting of user-defined values with `BUS<m>:UART:RX:THReshold` and `BUS<m>:UART:TX:THReshold`.

*RST: V165

Usage: SCPI confirmed

BUS<m>:UART:BITRate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:

<m> 1..4

Parameters:

<Bitrate> Range: 300 to 20000000
Increment: 1
*RST: 9600
Default unit: bps

Usage: Asynchronous command

BUS<m>:UART:BAUDrate <Bitrate>

Same as `BUS<m>:UART:BITRate`.

Suffix:

<m> 1..4

Parameters:

<Bitrate> Range: 300 to 20000000
Increment: 1
*RST: 9600
Default unit: bps

Usage: Asynchronous command

BUS<m>:UART:PARity <Parity>

Defines the optional parity bit that is used for error detection.

See also: "Parity" on page 479.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Parity> NONE | ODD | EVEN | MARK | SPC | DC

MARK
The parity bit is always a logic 1.

SPC
SPaCe: The parity bit is always a logic 0.

DC
Don't Care: the parity is ignored.

*RST: NONE

Usage: Asynchronous command

BUS<m>:UART:POLarity <Polarity>

Defines the idle state of the bus. The idle state corresponds to a logic 1. The transmitted data on the bus is high (high = 1) or low (low = 1) active.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Polarity> IDLLow | IDLHigh

*RST: IDLHigh

Usage: Asynchronous command

BUS<m>:UART:SBIT <StopBits>

Sets the number of stop bits: 1; 1.5 or 2 stop bits are possible.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<StopBits>	B1 | B15 | B2
	*RST: B1
Usage:	Asynchronous command

BUS<m>:UART:SSIZe <DataBits>

Sets the number of data bits in a message.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<DataBits> Number of data bits

Range: 5 to 8
Increment: 1
*RST: 8

Usage: Asynchronous command

BUS<m>:UART:PACKets <Packets>

Defines the method of packet separation. A packet is a number of subsequent words in a date stream.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Packets> NONE | EWORd | TOUT

NONE
Packets are not considered.

EWORd
End word, the end condition of a packet is a pattern. To define the end word, use `BUS<m>:UART:EWORd`

TOUT
Defines a timeout between the packets. To set the timeout, use `BUS<m>:UART:TOUT`

*RST: NONE

Firmware/Software: FW 2.25

BUS<m>:UART:TOUT <InterframeTime>

Sets the timeout between packets in a UART data stream. A new packet starts with the first start bit after the timeout.

The command is relevant if `BUS<m>:UART:PACKets` is set to `TOUT`.

Suffix:

<m> 1..4

Selects the serial bus.

Parameters:

<InterframeTime> Range: 1E-6 to 1

Increment: 1

*RST: 1E-3

Default unit: s

Usage: Asynchronous command

Firmware/Software: FW 2.25

BUS<m>:UART:EWORd <EndOfFrame>

Sets the end pattern of the packets. A new packet starts with the first start bit after the defined end pattern.

The command is relevant if `BUS<m>:UART:PACKets` is set to `EWORd`.

Suffix:

<m> 1..4

Selects the serial bus.

Parameters:

<EndOfFrame> End word value in decimal format (range 0 to 255) or hexadecimal format (prefix #H). The query always returns hexadecimal values.

Example:

```
:BUS:UART:PACK EWOR
:BUS:UART:EWOR 10 // Decimal value
:BUS:UART:EWOR?
#H0A // Query returns hex
```

Example:

```
:BUS:UART:PACK EWOR
:BUS:UART:EWOR #Hff // Hexadecimal, prefix #H
:BUS:UART:EWOR?
#HFF
```

Usage: Asynchronous command

Firmware/Software: FW 2.25

16.17.5.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.

- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:UART:TYPE <Type>

Selects the trigger type for UART analysis.

See also: "Type" on page 481

Parameters:

<Type> STBT | PCKS | DATA | PRER | BRKC | STPerror

STBT: Start bit
PCKS: Packet start
DATA: Serial pattern
PRER: Parity error
BRKC: Break condition
STPerror: Stop error

*RST: STBT

Usage: Asynchronous command

TRIGger<m>:UART:SOURce <Source>

Selects the transmitter or receiver line as trigger source.

Parameters:

<Source> TX | RX

*RST: TX

Usage: Asynchronous command

TRIGger<m>:UART:DPOPerator <DataPosiOperator>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DataPosiOperator> EQUal | GETHan | INRange | RANGe

INRange = RANGe

*RST: GETHan

Usage: Asynchronous command

TRIGger<m>:UART:DPOSition <DataPosition>

Sets the number of words before the first word of interest. These offset words are ignored.

Parameters:

<DataPosition> Number of words

Range: 0 to 32767
Increment: 1
*RST: 0

Usage: Asynchronous command

TRIGger<m>:UART:DPTO <DataPositionTo>

Defines the last word of interest, if `TRIGger<m>:UART:DPOPerator` defines a position range.

Parameters:

<DataPositionTo> Range: 0 to 32767
Increment: 1
*RST: 0

Usage: Asynchronous command

TRIGger<m>:UART:FCONdition <DataOperator>

Selects the operator for the data pattern (`TRIGger<m>:UART:DATA`).

Parameters:

<DataOperator> EQUal | NEQual

*RST: EQUal

TRIGger<m>:UART:DATA <Data>

Specifies the data pattern to be found on the specified trigger source, in binary or hex format. Enter the words in msb first bit order.

Parameters:

<Data> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Usage: Asynchronous command

16.17.5.3 Decode Results

BUS<m>:UART:WORD<n>:RXValue?
BUS<m>:UART:WORD<n>:TXValue?

Returns the value of the specified word on the Rx line or Tx line, respectively.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<RxValue>
<TxValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.
Range: 0 to 255
*RST: 0

Usage: Query only

BUS<m>:UART:WORD<n>:COUNt?

Returns the number of words in the acquisition.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
The suffix is irrelevant.

Return values:

<Count> Number of words

Usage: Query only

BUS<m>:UART:WORD<n>:SOURce?

Returns the line on which the specified word was transferred.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<WordSource> TX | RX

*RST: TX

Usage: Query only

BUS<m>:UART:WORD<n>:STARt?

Returns the start time of the specified word.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<WordStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:UART:WORD<n>:STATe?

Returns the status of the specified word.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<WordState> OK | FRSTart | FRENd | FRME | BREak | STERror | SPERror | PRERror | INSufficient

OK: the frame is valid.
BREak:stop bit error with 0x00 word
STERror: StarT ERror, incorrect start bit
SPERror: StoP ERror, incorrect stop bit
PRERror:PaRity ERror, incorrect parity bit.
INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

*RST: OK

Usage: Query only

16.17.6 CAN (Option R&S RTE-K3)

16.17.6.1 Configuration

BUS<m>:CAN:DATA:SOURce <DataSource>

Sets the source of the data line that is selected with `BUS<m>:CAN:TYPE`.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<DataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: C1W1

Usage: Asynchronous command

BUS<m>:CAN:TYPE <SignalType>

Selects the CAN-High or CAN-Low line. Both lines are required for differential signal transmission used by CAN.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<SignalType> CANH | CANL
*RST: CANL

BUS<m>:CAN:FDATa:PSTandard <ProtocolStandard>

Only available for CAN FD buses. Selects whether the tested signal is an ISO CAN FD signal or not.

Suffix:
<m> 1..4

Parameters:
<ProtocolStandard> ISO | NISO

ISO
Signals are decoded according to the the ISO CAN FD protocol. This protocol has an additional stuff count field before the CRC sequence.

NISO
Non-ISO. Signals are decoded according to the the Bosch CAN FD protocol.

*RST: ISO

Firmware/Software: FW 3.35

BUS<m>:CAN:DATA:THReshold <Threshold>

Sets a user-defined threshold value.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:CAN:TECHnology`.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<Threshold> Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:CAN:TECHnology <Technology>

Sets the threshold voltage as defined for various signal technologies.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Technology> V25 | V3 | V2 | V0 | MAN

V25
2.5 Volt (CMOS 5.0 V)

V3
3.0 Volt (CAN_H HS / CAN_L LS)

V2
2.0 Volt (CAN_L HS / CAN_H LS)

V0
Ground

MAN
Manual setting of user-defined values with `BUS<m>:CAN:DATA:THReshold`.

*RST: V25

BUS<m>:CAN:BITRate <Bitrate>

For CAN buses, the "Bit rate" sets the number of transmitted bits per second.

For CAN FD buses, this parameter is called "Arbitration rate" and sets the bit rate of the arbitration phase.

The maximum bit rate for High Speed CAN is 1 Mbit/s. The bit rate is uniform and fixed for a given CAN or CAN FD bus.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Bitrate>
Range: 100 to 5E+6
Increment: 1
*RST: 100E+3
Default unit: bps

BUS<m>:CAN:FDATa:ENABle <CANFDEnabled>

Enables the CAN FD protocol configuration.

The setting is available in CAN FD option R&S RTE-K9.

Suffix:

<m> 1..4

Parameters:

<CANFDEnabled> ON | OFF

*RST: ON

BUS<m>:CAN:FDATa:DBITrate <DataBitrate>

Sets the bit rate of the data phase. The data rate can be higher than the arbitration rate, but it is uniform and fixed for a given CAN FD bus.

The setting is available in CAN FD option R&S RTE-K9.

Suffix:

<m>	1..4

Parameters:

<DataBitrate>	Range:	100 to 15E+6
	Increment:	1
	*RST:	1E+6
	Default unit:	bps

BUS<m>:CAN:SAMPlepoint <SamplePoint>

Sets the position of the sample point within the bit in percent of the nominal bit time.

Alternatively, you can set the sample point with `BUS<m>:CAN:T1Segment` and `BUS<m>:CAN:T2Segment`.

For CAN FD signals, this setting defines the synchronization of the arbitration phase.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SamplePoint>	Range:	12 to 96 if number of segments is 25. The range reduces if the signal has fewer segments.
	Increment:	5
	*RST:	50
	Default unit:	%

BUS<m>:CAN:T1Segment <TimeSeg1>

Sets the number of time quanta before the sample point (T1Segment). T1Segment comprises the segments Synch_seg, Prop_seg, and Phase_seg1 which are specified in the CAN standard.

Make sure to set also `BUS<m>:CAN:T2Segment` for correct definition of the sample point. Alternatively, you can use `BUS<m>:CAN:SAMPlepoint`.

See also: "Synchronization: Sample point, Time segments, Jump width" on page 488

For CAN FD signals, this setting defines the synchronization of the arbitration phase.

Suffix:

<m>	1..4

Parameters:

<TimeSeg1> Time quanta

Range: 3 to 24
Increment: 1
*RST: 5

BUS<m>:CAN:T2Segment <TimeSeg2>

Sets the number of time quanta after the sample point (T2Segment). T2Segment matches Phase_seg2 specified in the CAN standard.

Make sure to set also `BUS<m>:CAN:T1Segment` on page 1231 for correct definition of the sample point. Alternatively, you can use `BUS<m>:CAN:SAMPlepoint`.

See also: "Synchronization: Sample point, Time segments, Jump width" on page 488

For CAN FD signals, this setting defines the synchronization of the arbitration phase.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<TimeSeg2> Time quanta

Range: 1 to 22
Increment: 1
*RST: 5

BUS<m>:CAN:JWIDth <JumpWidth>

Defines the maximum number of time quanta for phase correction. Time segment1 may be lengthened or Time segment2 may be shortened due to resynchronization. Resynchronization corrects the phase error of an edge caused by the drift of the oscillators.

For CAN FD signals, this setting defines the synchronization of the arbitration phase.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<JumpWidth> Time quanta

Range: 1 to 4, available maximum depends on the number of segments and the sample point
Increment: 1
*RST: 1

BUS<m>:CAN:FDATa:SAMPlepoint <FlexibleDataSmpPoint>
BUS<m>:CAN:FDATa:T1Segment <FlexibleDataTimeSeg1>

BUS<m>:CAN:FDATa:T2Segment <FlexibleDataTimeSeg2>
BUS<m>:CAN:FDATa:JWIDth <FlexibleDataJumpWidth>

These commands define the synchronization of the data phase.

For a command description, see:

- `BUS<m>:CAN:T1Segment` on page 1231
- `BUS<m>:CAN:T2Segment` on page 1232
- `BUS<m>:CAN:SAMPlepoint` on page 1231
- `BUS<m>:CAN:JWIDth` on page 1232

Suffix:
<m> 1..4

Parameters:
<FlexibleDataJumpWidth> Range: 1 to 4
Increment: 1
*RST: 1

Firmware/Software: FW 3.35

16.17.6.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:CAN:TYPE <Type>

Selects the trigger type for CAN analysis.

See: "Trigger type" on page 490.

Parameters:

<Type> STOF | FTYP | ID | IDDT | ERRC

STOF
STart Of Frame: triggers on the first edge of the dominant SOF bit (synchronization bit).

FTYP
Frame TYPe: triggers on a specified frame type (data, remote, error, or overload) and on the identifier format.
To set the frame type, use TRIGger<m>:CAN:FTYPe. ´Set the identifier format with TRIGger<m>:CAN:ITYPe

ID
IDentifier: Sets the trigger to one specific identifier or an identifier range. To set the identifier, use TRIGger<m>:CAN:ICONdition, TRIGger<m>:CAN:IMIN, and TRIGger<m>:CAN:IMAX.

IDDT
IDentifier and DaTa: Combination of identifier and data conditions To set the identifier condition, use TRIGger<m>:CAN:ICONdition, TRIGger<m>:CAN:IMIN, and TRIGger<m>:CAN:IMAX.
To set the data condition, use TRIGger<m>:CAN:DCONdition, TRIGger<m>:CAN:DMIN, and TRIGger<m>:CAN:DMAX.

ERRC
ERRor Condition: Define the error types with
TRIGger<m>:CAN:ACKerror,
TRIGger<m>:CAN:BITSterror,
TRIGger<m>:CAN:CRCerror,
TRIGger<m>:CAN:FORMerror,
TRIGger<m>:CAN:FDATa:SCERror on page 1241.

*RST: STOF

TRIGger<m>:CAN:FDATa:STANdard <StandardSelection>

Selects the CAN standard. Use `ANY` if the standard of the signal is unknown.

The setting is available in CAN FD option R&S RTE-K9.

Parameters:
<StandardSelection> ANY | CAN | CANFd
*RST: CAN

TRIGger<m>:CAN:FTYPe <FrameType>

Selects the CAN frame type if TRIGger<m>:CAN:TYPE is set to FTYP (frame type) or ID (identifier).

For data and remote frames, the identifier format has to be set with TRIGger<m>:CAN:ITYPe.

See also: "Frame type" on page 491

Parameters:
<FrameType> ANY | DATA | REMote | ERRor | OVERload

Available values depend on the CAN standard and on the TRIGger<m>:CAN:TYPE setting:
Remote frames are not available in the CAN FD protocol.
If the trigger type is set to FTYP (frame type), you can set the values DATA | REMote | ERRor | OVERload.
If the trigger type is set to ID (identifier), you can set the values ANY | DATA | REMote.

*RST: ANY

TRIGger<m>:CAN:ITYPe <IdentifierType>

Selects the format of data and remote frames.

Remote frames are not available in the CAN FD protocol.

Parameters:
<IdentifierType> ANY | B11 | B29

B11
11 bit identifier (standard format). The instrument triggers on the sample point of the IDE bit.

B29
29 bit identifier (extended format). The instrument triggers on the sample point of the RTR bit.

ANY
The ID type and ID pattern are not relevant for the trigger condition.

*RST: ANY

TRIGger<m>:CAN:ICONdition <IdentifierOperator>

Sets the operator to set a specific identifier or an identifier range.

Parameters:

<IdentifierOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with `TRIGger<m>:CAN:IMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:CAN:IMIN` and `TRIGger<m>:CAN:IMAX` on page 1236.

*RST: EQUal

TRIGger<m>:CAN:IMIN <IdentifierPattern>

Specifies a message identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdentifierPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

TRIGger<m>:CAN:IMAX <IdentifierPatternTo>

Sets the the end value of an identifier range if `TRIGger<m>:CAN:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<IdentifierPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

TRIGger<m>:CAN:FDATa:FDF <Bit>

Specifies the CAN FD frame format. It corresponds to the EDL bit (extended data length), which only exists in CAN FD format.

Parameters:

<Bit> ONE | ZERO | DC

ONE: CAN FD.
ZERO: CAN.
DC: don't care, the format is not relevant.

*RST: DC

TRIGger<m>:CAN:FDATa:BRS <Bit>

Sets the bit rate switch bit.

Parameters:

<Bit> ONE | ZERO | DC

ONE: the bit rate switches from the bit rate of the arbitration phase to the faster data rate.

*RST: ONE

TRIGger<m>:CAN:FDATa:ESI <Bit>

Sets the error state indicator bit.

Parameters:

<Bit> ONE | ZERO | DC

DC: don't care, bit is nor relevant

*RST: DC

TRIGger<m>:CAN:DCONdition <DataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `TRIGger<m>:CAN:DMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:CAN:DMIN` and `TRIGger<m>:CAN:DMAX`.

*RST: EQUal

TRIGger<m>:CAN:DMIN <DataPattern>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:CAN:DMAX <DataPatternTo>

Sets the the end value of an data range if `TRIGger<m>:CAN:DCONdition` is set to `INRange` or `OORange`.

Parameters:
<DataPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:CAN:BORDer <Endianness>

Sets the byte order (endianness) of the data transfer. Only for CAN protocol.

Parameters:
<Endianness> BENDian | LENDian

BENDian
Big endian, data is analyzed and evaluated in the order of reception.

LENDian
Little endian, the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

*RST: BENDian

TRIGger<m>:CAN:DLCCondition <DLCOperator>

Operator to set the data length code for triggering on CAN and CAN FD data.

For details, see "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 494.

The number of data bytes to be found is set with `TRIGger<m>:CAN:DLC`.

See also: `TRIGger<m>:CAN:BORDer`.

Parameters:
<DLCOperator> EQUal | GETHan

For little endian transfer direction, EQUal must be set.

*RST: GETHan

TRIGger<m>:CAN:DLC <WordCount>

Sets the Data Length Code, the number of data bytes to be found. For complete definition, set also the operator with `TRIGger<m>:CAN:DLCCondition` on page 1238.

Parameters:
<WordCount> Range: CAN: 1 to 8, CAN FD: 1 to 15 (64 bytes)
Increment: 1
*RST: 1

TRIGger<m>:CAN:NDBYtes?

Returns the number of data bytes defined by DLC. DLC and NDB are different in CAN FD for DLCs > 8.

See also: "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 494.

Return values:

<NDBytes>	Range:	1 to 64
	Increment:	1
	*RST:	1

Usage: Query only

TRIGger<m>:CAN:FDATa:DPOPerator <DataPosiOperator>

Sets the operator to define an exact position or a data range where the instrument looks for the specified data pattern.

The setting is available in CAN FD option R&S RTE-K9.

The position can be defined if the data field of the frame is longer than 8 bytes - if `TRIGger<m>:CAN:DLC`≥9.

Parameters:

<DataPosiOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The data position is not relevant for the trigger condition.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:CAN:FDATa:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `TRIGger<m>:CAN:FDATa:DPOSition` and `TRIGger<m>:CAN:FDATa:DPTO`.

*RST: ANY

TRIGger<m>:CAN:FDATa:DPOSition <DataPosition>

Defines the number of the first data byte at which the data pattern may start.

The setting is available in CAN FD option R&S RTE-K9.

Parameters:

<DataPosition>	Range:	1 to 57
	Increment:	1
	*RST:	1

TRIGger<m>:CAN:FDATa:DPTO <DataPositionTo>

Sets the number of the last byte at which the required data pattern may start.

Parameters:

<DataPositionTo>	Range:	8 to 64
	Increment:	1
	*RST:	8

TRIGger<m>:CAN:ACKerror <AckError>

Triggers when the transmitter does not receive an acknowledgment - a dominant bit during the Ack Slot.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<AckError> ON | OFF

*RST: ON

TRIGger<m>:CAN:BITSterror <BitStuffingError>

Triggers if astuff error occurs - when the 6th consecutive equal bit level in the mentioned fields is detected.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<BitStuffingError> ON | OFF

*RST: ON

TRIGger<m>:CAN:CRCerror <ChecksumError>

Triggers on CRC errors. A CRC error occurs when the CRC calculated by the receiver differs from the received value in the CRC sequence.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<ChecksumError> ON | OFF

*RST: ON

TRIGger<m>:CAN:FORMerror <FormError>

Triggers when a fixed-form bit field contains one or more illegal bits.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<FormError> ON | OFF

*RST: ON

TRIGger<m>:CAN:FDATa:SCERror <StuffCountError>

Triggers on stuff count errors. A stuff count error occurs if th received stuff count value does not match the value calculated from the own stuff bit count.

The trigger type `TRIGger<m>:CAN:TYPE` must be set to `ERRC`.

Only relevant for CAN FD signals in ISO standard.

Parameters:

<StuffCountError> ON | OFF
*RST: ON

16.17.6.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1165
- `BUS<m>:SYMBols` on page 1165

BUS<m>:CAN:FCOunt?

Returns the number of decoded frames of the acquisition.

Suffix:

<m> 1..4
Selects the serial bus.

Return values:

<Count> Total number of decoded frames.

Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:CAN:FDATa:FRAMe<n>:STANdard?

Returns the CAN standard.

The setting is available in CAN FD option R&S RTE-K9.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
The frame suffix is irrelevant.

Return values:

<Standard> CAN | CANFd

*RST: CAN

Usage: Query only

BUS<m>:CAN:FRAMe<n>:STATus?

Returns the overall state of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameState> OK | FORM | BTST | CRC | CRCD | NOACk | ACKD | EOFD | CAERror | FCERor | INSufficient | SERRror | SFERror | SCERror | SAERror | SCAE | SCFE

OK: the frame is valid.
FORM: Fixed-bit form error
BTST: Bit stuffing error occured.
CRC: Cyclic redundancy check failed.
CRCD: Wrong CRC delimiter occured.
NOACK: Acknowlegde is missing.
ACKD: Wrong ACK delimiter occured.
EOFD: Wrong end of frame.
CAERror: CRC error followed by an acknowledgement error (missing acknowledge)
FCERor: CRC error followed by a form error (wrong CRC delimiter or wrong ACK delimiter)
INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.
SERRror: Stuff count error (CAN-FD ISO only)
SFER: Stuff count error and FORM error (CAN-FD ISO only)
SCER: Stuff count error and CRC error (CAN-FD ISO only)
SAER: Stuff count error and ACK error (CAN-FD ISO only)
SCAE: Stuff count error and CRC error and ACK error (CAN-FD ISO only)
SCFE: Stuff count error and CRC error and FORM error (CAN-FD ISO only)

*RST: OK

Usage: Query only

BUS<m>:CAN:FRAMe<n>:NDBYtes?

REturns the number of data bytes.

Suffix:

<m> 1..4

<n> *

Return values:

<NDBytes> Range: 1 to 64
Increment: 1
*RST: 1

Usage: Query only

Firmware/Software: FW 3.35

BUS<m>:CAN:FRAMe<n>:STARt?
BUS<m>:CAN:FRAMe<n>:STOP?

Return the start time and stop time of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameStart> <FrameStop>	Time Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:CAN:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the number of the frame in the current acquisition, 1...n.

Return values:

<Label>	String with symbolic label of the identifier

Example: `BUS:CAN:FRAMe:SYMBol?`
Response: `Temperature`

Usage: Query only

Firmware/Software: FW 1.36

BUS<m>:CAN:FRAMe<n>:TYPE?

Returns the frame type of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameType>	DATA | REMote | ERR | OVLD Data, remote, error or overload frame. *RST: DATA

Usage: Query only

BUS<m>:CAN:FRAMe<n>:DATA?

Returns the data of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<Data> Comma-separated list of integer values. The first value is the number of bytes, followed by the values of the data bytes.

Example:
```
BUS1:CAN:FRAMe2:DATA?
--> 3,208,231,32
```
Returns the data of the second frame: the number of bytes is 3 data (first value).

Usage: Query only

BUS<m>:CAN:FRAMe<n>:ACKState?
BUS<m>:CAN:FRAMe<n>:CSSTate?
BUS<m>:CAN:FRAMe<n>:DLCState?
BUS<m>:CAN:FRAMe<n>:IDSTate?

Return the states of following parts of a message

- ACKState: state of acknowledgement field
- CSSTate: state of checksum field (CRC)
- DLCState: state of data length code
- IDSTate: identifier state

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<State> OK | ERRor | UNDF
UNDF: Undefined
*RST: OK

Usage: Query only

BUS<m>:CAN:FRAMe<n>:ACKValue?

Returns the value of the acknowledge slot for the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<AckValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 1
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:CSValue?

Returns the CRC sequence value of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<ChecksumValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 2097151
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:DLCValue?

Returns the data length code of the selected frame - the number of data bytes in the frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<DataLengthCode> Number of data bytes in decimal values.

Range: 0 to 15
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:IDTYpe?

Returns the identifier type of the selected frame, the identifier format of data and remote frames.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<IdentifierType> ANY | B11 | B29

B11: standard format, 11 bit
B29: extended format, 29 bit

*RST: B11

Usage: Query only

BUS<m>:CAN:FRAMe<n>:IDValue?

Returns the identifier value of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<IdentifierValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 536870911
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:BSEPosition?

Returns the location of a bit stuffing error.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<BitStuffErrorPos> Time when the error occured

Range: 0 to 5000
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:FERCause?

Returns information on a form error, if the frame status query returned a FORM error.

See also: `BUS<m>:CAN:FRAMe<n>:STATus?` on page 1242

Suffix:

<m> 1..4

<n> *

Return values:

<FormErrorCause> NONE | CRCDerror | ACKDerror | FSBE | RESerror

CRCD = CRC delimiter error
ACKD = ACK delimiter error
FSBE = Fixed stuff bit error (CAN-FD ISO only)
RESE = Reserved bit error

*RST: NONE

Usage: Query only

BUS<m>:CAN:FDATa:FRAMe<n>:SCValue?

Returns the stuff bit count modulo 8 value.

Suffix:

<m> 1..4

<n> *

Return values:

<StuffCount> Range: 0 to 7
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:BYTE<o>:STATe?

Returns the state of the specified byte.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:
<ByteState> OK | ERRor | UNDF
UNDF: Undefined
*RST: OK

Usage: Query only

BUS<m>:CAN:FRAMe<n>:BYTE<o>:VALue?

Returns the value of the specified byte.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:
<ByteValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.
Range: 0 to 255
*RST: 0

Usage: Query only

16.17.6.4 Search Settings

SEARch:TRIGger:CAN[:STATe] <SearchName>,<State>
SEARch:TRIGger:CAN[:STATe]? <SearchName>

Includes the search conditions for the CAN trigger event type in the next search.

Parameters:

<State>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN[:SSOFrame] <SearchName>,<CheckStartOfFrame>
SEARch:TRIGger:CAN[:SSOFrame]? <SearchName>

Enables the search for a start of frame.

Parameters:

<CheckStartOfFrame>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:SFTYpe <SearchName>,<CheckFrameType>
SEARch:TRIGger:CAN:SFTYpe? <SearchName>

Enables the search for a specified frame type.

Parameters:

<CheckFrameType>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:SFIDentifier <SearchName>,<CheckIdentifier>
SEARch:TRIGger:CAN:SFIDentifier? <SearchName>

Enables the search for frame indentifier.

Parameters:
<CheckIdentifier> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:SIDData <SearchName>,<CheckIdentifierData>
SEARch:TRIGger:CAN:SIDData? <SearchName>

Enables the search for identifier and data.

Parameters:
<CheckIdentifierData>ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:SERRor <SearchName>,<CheckErrorCondition>
SEARch:TRIGger:CAN:SERRor? <SearchName>

Enables the search for a specified error.

Parameters:
<CheckErrorCondition>ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:FDATa:STANdard <SearchName>,<StandardSelection>
SEARch:TRIGger:CAN:FDATa:STANdard? <SearchName>

Selects the CAN standard: CAN, CAN FD, or Any.

Use "Any" to search on either CAN or CAN-FD frame. In this case, the search configuration provides all possible settings, for CAN as well as for CAN FD.

The setting is available in CAN FD option R&S RTE-K9.

Parameters:
<StandardSelection> ANY | CAN | CANFd
*RST: CAN

Parameters for setting and query:
<SearchName> String with the search name

SEARch:TRIGger:CAN:FTYPe <SearchName>,<RemoteFrameType>
SEARch:TRIGger:CAN:FTYPe? <SearchName>

Selects the CAN frame type to be searched for.

For data and remote frames, the identifier format has to be set with `SEARch:TRIGger:CAN:ITYPe` on page 1252.

Parameters:

<RemoteFrameType> ANY | DATA | REMote | ERRor | OVERload

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:ITYPe <SearchName>,<IdentifierType>
SEARch:TRIGger:CAN:ITYPe? <SearchName>

Selects the format of data and remote frames: 11 bit for CAN base frames, or 29 bits for CAN extended frames.

Parameters:

<IdentifierType> ANY | B11 | B29

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:ICONdition <SearchName>,<IdentifierOperator>
SEARch:TRIGger:CAN:ICONdition? <SearchName>

Sets the operator to set a specific identifier or an identifier range.

Parameters:

<IdentifierOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with `SEARch:TRIGger:CAN:IMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:CAN:IMIN` and `SEARch:TRIGger:CAN:IMAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:IMAX <SearchName>,<IdentifierPatternTo>
SEARch:TRIGger:CAN:IMAX? <SearchName>

Sets the the end value of an identifier range if `SEARch:TRIGger:CAN:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<IdentifierPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:IMIN <SearchName>,<IdentifierPattern>
SEARch:TRIGger:CAN:IMIN? <SearchName>

Specifies a message identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdentifierPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:CAN:DCONdition? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:CAN:DMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:CAN:DMIN` and `SEARch:TRIGger:CAN:DMAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:DMIN <SearchName>,<DataPattern>
SEARch:TRIGger:CAN:DMIN? <SearchName>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:DMAX <SearchName>,<DataPatternTo>
SEARch:TRIGger:CAN:DMAX? <SearchName>

Sets the the end value of an data range if `SEARch:TRIGger:CAN:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:DLCCondition <SearchName>,<DLCOperator>
SEARch:TRIGger:CAN:DLCCondition? <SearchName>

Operator to set the data length code for search.

Parameters:

<DLCOperator> EQUal | GETHan

*RST: GETHan

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:DLC <SearchName>,<WordCount>
SEARch:TRIGger:CAN:DLC? <SearchName>

Sets the Data Length Code, the number of data bytes to be found. For complete definition, set also the operator with `SEARch:TRIGger:CAN:DLCCondition`.

Parameters:

<WordCount> Range: 1 to 8
Increment: 1
*RST: 1

Parameters for setting and query:

<SearchName>

SEARch:RESult:CAN:FRAMe<m>:NDBYtes? <SearchName>

Returns the number of data bytes defined by DLC. DLC and NDB are different in CAN FD for DLCs > 8.

See also: "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 494.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<NDBytes>	Range:	1 to 64
	Increment:	1
	*RST:	1

Usage: Query only

SEARch:TRIGger:CAN:FDATa:DPOPerator <SearchName>,<DataPosiOperator>
SEARch:TRIGger:CAN:FDATa:DPOPerator? <SearchName>

Sets the operator for the data position if DLC ≥ 9. You can define an exact position, or a position range.

The setting is available in CAN FD option R&S RTE-K9.

Parameters:
<DataPosiOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The data position is not relevant for the search.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `SEARch:TRIGger:CAN:FDATa:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `SEARch:TRIGger:CAN:FDATa:DPOSition` and `SEARch:TRIGger:CAN:FDATa:DPTO`.

*RST: ANY

Parameters for setting and query:
<SearchName> String with the search name

SEARch:TRIGger:CAN:FDATa:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:CAN:FDATa:DPOSition? <SearchName>

Defines the first possible start position of the data pattern.

The setting is available in CAN FD option R&S RTE-K9.

Parameters:

<DataPosition> Range: 1 to 57
Increment: 1
*RST: 1

Parameters for setting and query:

<SearchName> String with the search name

SEARch:TRIGger:CAN:FDATa:DPTO <SearchName>,<DataPositionTo>
SEARch:TRIGger:CAN:FDATa:DPTO? <SearchName>

Defines the last possible start position of the data pattern if the position operator `SEARch:TRIGger:CAN:FDATa:DPOPerator` defines a range.

The setting is available in CAN FD option R&S RTE-K9.

Parameters:

<DataPositionTo> Range: 8 to 64
Increment: 1
*RST: 8

Parameters for setting and query:

<SearchName> String with the search name

SEARch:TRIGger:CAN:ACKerror <SearchName>,<AckError>
SEARch:TRIGger:CAN:ACKerror? <SearchName>

Searches for acknowledgement errors. An acknowledgement error occurs when the transmitter does not receive an acknowledgment - a dominant bit during the Ack Slot.

Parameters:

<AckError> ON | OFF
*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:BITSterror <SearchName>,<BitStuffingError>
SEARch:TRIGger:CAN:BITSterror? <SearchName>

Searches for bit stuffing errors.

Parameters:

<BitStuffingError> ON | OFF
*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:CRCerror <SearchName>,<ChecksumError>
SEARch:TRIGger:CAN:CRCerror? <SearchName>

Searches for errors in the Cyclic Redundancy Check.

Parameters:

<ChecksumError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:FORMerror <SearchName>,<FormError>
SEARch:TRIGger:CAN:FORMerror? <SearchName>

Searches for form errors. A form error occurs when a fixed-form bit field contains one or more illegal bits.

Parameters:

<FormError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:FDATa:SCERror <SearchName>,<StuffCountError>
SEARch:TRIGger:CAN:FDATa:SCERror? <SearchName>

Triggers on stuff count errors. A stuff count error occurs if th received stuff count value does not match the value calculated from the own stuff bit count.

Only relevant for CAN FD signals in ISO standard.

Parameters:

<StuffCountError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:FDATa[:FDF] <SearchName>,<Bit>
SEARch:TRIGger:CAN:FDATa[:FDF]? <SearchName>

Sets the EDL bit (extended data length), which determines whether a frame is CAN or CAN-FD.

The setting is available in CAN FD option R&S RTE-K9.

Parameters:
<Bit> ONE | ZERO | DC

ONE: CAN FD.
ZERO: CAN.
DC: don't care, the format is not relevant.

*RST: DC

Parameters for setting and query:
<SearchName> String with the search name

SEARch:TRIGger:CAN:FDATa:BRS <SearchName>,<Bit>
SEARch:TRIGger:CAN:FDATa:BRS? <SearchName>

Sets the bit rate switching bit for identifier and identifier + data searches.

The setting is available in CAN FD option R&S RTE-K9.

Parameters:
<Bit> ONE | ZERO | DC

DC: Don't care

*RST: ONE

Parameters for setting and query:
<SearchName> String with the search name

SEARch:TRIGger:CAN:FDATa:ESI <SearchName>,<Bit>
SEARch:TRIGger:CAN:FDATa:ESI? <SearchName>

Sets the error state indicator bit for identifier and identifier + data searches.

The setting is available in CAN FD option R&S RTE-K9.

Parameters:
<Bit> ONE | ZERO | DC

*RST: DC

Parameters for setting and query:
<SearchName> String with the search name

16.17.6.5 Search Results

The search on decoded CAN data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 16.17.6.3, "Decode Results", on page 1241.

SEARch:RESult:CAN:FCOunt? <SearchName>

Query parameters:

<SearchName>

Return values:

<Count>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:ACKState? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameAckState> OK | ERRor | UNDF

*RST: OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:ACKValue? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameAckValue> Range: 0 to 1
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:BSEPosition? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameBitStuffingErrorPosition> Range: 0 to 5000
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:STATe? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<FrameByteState> OK | ERRor | UNDF
*RST: OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:VALue? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:

<FrameByteValue>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:CSSTate? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameChecksumState> OK | ERRor | UNDF
*RST: OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:CSValue? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameChecksumValue>	Range:	0 to 2097151
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:DATA? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:DLCState? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameDLCState> OK | ERRor | UNDF

*RST: OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:DLCValue? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameDLCValue> Range: 0 to 15
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:FERCause? <SearchName>

Returns information on a form error, if the frame status query returned a FORM error.

See also: `SEARch:RESult:CAN:FRAMe<m>:STATus?` on page 1264.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FormErrorCause> NONE | CRCDerror | ACKDerror | FSBE | RESerror

See `BUS<m>:CAN:FRAMe<n>:FERCause?` on page 1248.

*RST: NONE

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:IDSTate? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameIdentifierState> OK | ERRor | UNDF
*RST: OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:IDTYpe? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameIdentifierType> ANY | B11 | B29
*RST: B11

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:IDValue? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameIdentifierValue> Range: 0 to 536870911
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:CAN:FDATa:FRAMe<m>:SCValue? <SearchName>

Returns the stuff bit count modulo 8.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<StuffCount> Range: 0 to 7
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:CAN:FDATa:FRAMe<m>:STANdard? <SearchName>

Returns the CAN protocol standard: CAN or CAN FD.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Standard> CAN | CANFd

*RST: CAN

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:STARt? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStart> Range: -100E+24 to 100E+24

Increment: 100E-12

*RST: 0

Default unit: s

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:STATus? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameState> OK | FORM | BTST | CRC | CRCD | NOACk | ACKD | EOFD | CAERror | FCERor | INSufficient | SERRror | SFERror | SCERror | SAERror | SCAE | SCFE

See `BUS<m>:CAN:FRAMe<n>:STATus?` on page 1242.

*RST: OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:
<SearchName>

Return values:

<FrameStop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:SYMBol? <SearchName>

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m>	* Selects the number of the frame in the current acquisition, 1...n.

Query parameters:

<SearchName>	String parameter that contains the search definition name

Return values:

<Label>	Symbolic label (string)

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:TYPE? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<FrameType>	DATA | REMote | ERR | OVLD *RST: DATA

Usage: Query only

16.17.6.6 Symbolic Trigger, Decode and Search

Symbolic Trigger

TRIGger<m>:CAN:SYMBolic:MSGValue <MessageName>

Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

See also: `SEARch:TRIGger:CAN:SYMBolic:MSGValue` on page 1268

Parameters:

<MessageName>	String with the symbolic message name

TRIGger<m>:CAN:SYMBolic:TSIGnals <TriggerOnSignal>

Enables the trigger on a specific signal value that is part of the selected message.

Parameters:

<TriggerOnSignal>	ON | OFF	
	*RST:	OFF

TRIGger<m>:CAN:SYMBolic:SIGValue <SignalName>

Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

See also: `SEARch:TRIGger:CAN:SYMBolic:SIGValue` on page 1269

Parameters:

<SignalName>	String with the signal name as defined in the DBC file.

TRIGger<m>:CAN:SYMBolic:DMAX <MaxSignalValue>

Defines the maximum data value of the signal.

This value is required to specify a range if condition `INRange | OORange` is set with `TRIGger<m>:CAN:DCONdition`.

Parameters:

<MaxSignalValue>	Decimal representation of the data pattern	
	Range:	-100E+24 to 100E+24
	Increment:	0.5
	*RST:	1

TRIGger<m>:CAN:SYMBolic:DMIN <MinSignalValue>

Defines the minimum data value of the signal.

To set the condition, use `TRIGger<m>:CAN:DCONdition`.

Parameters:

<MinSignalValue>	Decimal representation of the data pattern Range: -100E+24 to 100E+24 Increment: 0.5 *RST: 0

TRIGger<m>:CAN:SYMBolic:SGEValue <SignalEnumValue>

Sets a symbolic data value for signals with enumerated values.

Parameters:

<SignalEnumValue> Numeric value according to the value definition in the DBC file

Example: Definition line in DBC file:

```
VAL_ 2175091489 Gear 0 "Idle" 1 "Gear_1" 2 "Gear_2" 3 "Gear_3" 4 "Gear_4"
```

Search for "Gear_4"

```
TRIGger:CAN:SYMBolic:SGEValue "Search1",4
```

Symbolic Decode Results

BUS<m>:CAN:FRAMe<n>:SDATa?

Returns the complete symbolic data of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<SymbolicData> String with comma-separated list of symbolic data

Example:

```
BUS:CAN:FRAMe9:SDATa?
<-- [sym] 325 kW, 0x0A, 423 N, 174 l, Running, 90 degC, 0x06, 437 rpm
```

Returns the symbolic results of the 9th frame.

Usage: Query only

Symbolic Search

SEARch:RESult:CAN:FRAMe<m>:SDATa? <SearchName>

Returns the symbolic data of the selected result frame.

Suffix:

<m> *
Sets the index of the search result frame.

Query parameters:

<SearchName> String that contains the search definition name

Return values:

<SymbolicData> String with comma-separated list of symbolic data

Example:

```
SEARch:RESult:CAN:FRAMe:SDATa? 'Search1'
<-- [sym] 325 kW, 0x0A, 423 N, 174 l, Running, 90 degC, 0x06, 437 rpm
```

Returns the symbolic results of the first search result.

Usage: Query only

SEARch:TRIGger:CAN:SSYMbolic <SearchName>,<CheckSymbolic>
SEARch:TRIGger:CAN:SSYMbolic? <SearchName>

Enables the symbolic search and disables all other search criteria.

Parameters:

<CheckSymbolic> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName> String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:MSGValue <SearchName>, <MessageName>
SEARch:TRIGger:CAN:SYMBolic:MSGValue? <SearchName>

Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

See also: `TRIGger<m>:CAN:SYMBolic:MSGValue` on page 1266

Parameters:

<MessageName> String that contains the symbolic message name

Parameters for setting and query:

<SearchName> String that contains the search definition name

Example: `SEARch:TRIGger:CAN:SYMBolic:MSGValue "Search1", "EngineData"`

SEARch:TRIGger:CAN:SYMBolic:SSIGnals <SearchName>,<SearchForSignal>
SEARch:TRIGger:CAN:SYMBolic:SSIGnals? <SearchName>

Enables the search for a specific signal value that is part of the selected message.

Parameters:
<SearchForSignal> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName> String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:SIGValue <SearchName>, <SignalName>
SEARch:TRIGger:CAN:SYMBolic:SIGValue? <SearchName>

Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

See also: `TRIGger<m>:CAN:SYMBolic:SIGValue` on page 1266

Parameters:
<SignalName> String that contains the symbolic signal name

Parameters for setting and query:
<SearchName> String that contains the search definition name

Example: `SEARch:TRIGger:CAN:SYMBolic:SIGValue "Search1", "EngForce"`

SEARch:TRIGger:CAN:SYMBolic:DMIN <SearchName>,<MinSignalValue>
SEARch:TRIGger:CAN:SYMBolic:DMIN? <SearchName>

Defines the minimum data value of the signal.

To set the condition, use `SEARch:TRIGger:CAN:DCONdition`.

Parameters:
<MinSignalValue> Range: -100E+24 to 100E+24
Increment: 0.5
*RST: 0

Parameters for setting and query:
<SearchName> String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:DMAX <SearchName>,<MaxSignalValue>
SEARch:TRIGger:CAN:SYMBolic:DMAX? <SearchName>

Defines the maximum data value of the signal.

This value is required to specify a range if condition `INRange | OORange` is set with `SEARch:TRIGger:CAN:DCONdition` on page 1253.

Parameters:

<MaxSignalValue> Range: -100E+24 to 100E+24
Increment: 0.5
*RST: 1

Parameters for setting and query:

<SearchName> String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:SGEValue <SearchName>, <SignalEnumValue>
SEARch:TRIGger:CAN:SYMBolic:SGEValue? <SearchName>

Sets a symbolic data value for signals with enumerated values.

Parameters:

<SignalEnumValue> Numeric value according to the value definition in the DBC file

Parameters for setting and query:

<SearchName> String that contains the search definition name

Example: Definition line in DBC file:

```
VAL_ 2175091489 Gear 0 "Idle" 1 "Gear_1" 2 "Gear_2" 3 "Gear_3" 4 "Gear_4"
```

Search for "Gear_3"

```
SEARch:TRIGger:CAN:SYMBolic:SGEValue "Search1",3
```

16.17.7 LIN (Option R&S RTE-K3)

16.17.7.1 Configuration

BUS<m>:LIN:DATA:SOURce <DataSource>

Sets the waveform of the data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 See Chapter 16.4.2, "Waveform Parameter", on page 879 *RST: C1W1
Usage:	Asynchronous command

BUS<m>:LIN:DATA:THReshold <Threshold>

Sets a user-defined threshold value.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:LIN:TECHnology`.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Threshold>	Range: -12 to 12 Increment: 0.1 *RST: 0 Default unit: V

BUS<m>:LIN:TECHnology <Technology>

Sets the threshold voltage as defined for various signal technologies.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Technology> V15 | V25 | V35 | V6 | V9 | MAN

V15
1.5 Volt (TTL)

V25
2.5 Volt (CMOS 5.0 V)

V35 | V6 | V9
3.5 V (7 V supply), 6.0 V (12 V supply), 9.0 V (18 V supply) respectively

MAN
Manual setting of user-defined values with `BUS<m>:LIN:DATA:THReshold`.

*RST: V35

Usage: SCPI confirmed

BUS<m>:LIN:BITRate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Bitrate> Range: 1000 to 20000
Increment: 1
*RST: 9600
Default unit: bps

BUS<m>:LIN:POLarity <Polarity>

Defines the idle state of the bus. The idle state is the rezessive state and corresponds to a logic 1.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Polarity> IDLLow | IDLHigh

*RST: IDLHigh

BUS<m>:LIN:STANdard <Standard>

Selects the version of the LIN standard.

See also: "LIN standard" on page 525

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Standard> V1X | V2X | J2602 | AUTO
*RST: AUTO

16.17.7.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:LIN:TYPE <Type>

Selects the trigger type for LIN analysis.

See: "Trigger type" on page 526.

Parameters:

<Type> SYNC | ID | IDOR | IDDT | WKFR | ERRC

SYNC
Start of the frame, triggers on the stop bit of the sync field.

ID
Sets the trigger to one specific identifier or an identifier range.
To set the identifier, use TRIGger<m>:LIN:ICONdition, TRIGger<m>:LIN:IMIN on page 1275, and TRIGger<m>:LIN:IMAX on page 1275.

IDOR
Triggers on an OR combination with up to four four identifier conditions. For each identifier condition, enable it with TRIGger<m>:LIN:IDOR<n>:ENABle and set the value with TRIGger<m>:LIN:IDOR<n>[:VALue]

IDDT
Combination of identifier and data conditions
To set the identifier condition, use TRIGger<m>:LIN:ICONdition, TRIGger<m>:LIN:IMIN, and TRIGger<m>:LIN:IMAX.
To set the data condition, use TRIGger<m>:LIN:DCONdition , TRIGger<m>:LIN:DMIN, and TRIGger<m>:LIN:DMAX.

WKFR
Wakeup frame

ERRC
Error condition. Define the error types with TRIGger<m>:LIN:CHKSerror on page 1278, TRIGger<m>:LIN:IPERror, and TRIGger<m>:LIN:SYERror

*RST: SYNC

TRIGger<m>:LIN:ICONdition <IdentifierOperator>

Sets the operator to set a specific identifier or an identifier range.

Parameters:

<IdentifierOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with TRIGger<m>:LIN:IMIN

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with TRIGger<m>:LIN:IMIN and TRIGger<m>:LIN:IMAX

*RST: EQUal

TRIGger<m>:LIN:IMIN <IdPattern>

Specifies a slave identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

TRIGger<m>:LIN:IMAX <IdPatternTo>

Sets the the end value of an identifier range if `TRIGger<m>:LIN:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<IdPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

TRIGger<m>:LIN:DCONdition <DataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `TRIGger<m>:LIN:DMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:LIN:DMIN` and `TRIGger<m>:LIN:DMAX`

*RST: EQUal

TRIGger<m>:LIN:DMIN <DataPattern>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:LIN:DMAX <DataPatternTo>

Sets the the end value of an data range if `TRIGger<m>:LIN:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:LIN:BORDer <Endianness>

Sets the byte order (endianness) of the data transfer.

According to the standard, LIN data is transmitted in little endian transfer order.

Parameters:

<Endianness> BENDian | LENDian

BENDian
Big endian, data is analyzed and evaluated in the order of reception.

LENDian
Little endian, the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

*RST: BENDian

TRIGger<m>:LIN:DLECondition <DLCOperator>

Operator to set the data length for triggering on LIN data.

For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set.

Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*. With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*.

The number of data bytes to be found is set with `TRIGger<m>:LIN:DLENgth` on page 1276.

See also:`TRIGger<m>:LIN:BORDer` on page 1276 .

Parameters:

<DLCOperator> EQUal | GETHan

For little endian transfer direction, EQUal must be set.

*RST: GETHan

TRIGger<m>:LIN:DLENgth <WordCount>

Sets the length of the bit pattern to be found, in bytes. For "Big Endian" transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the beginning of the data pattern. For "Little Endian" transfer direction, the exact number of data bytes in the frame must be set.

For complete definition, set also the operator with `TRIGger<m>:LIN:DLECondition` on page 1276.

Parameters:

<WordCount>	Range: 1 to 8 Increment: 1 *RST: 1

TRIGger<m>:LIN:IDOR<n>:ENABle <UseIdentifier>

Includes the indicated IDOR address in the "identifier OR" trigger condition.

Suffix:

<n>	1..4 Index of the identifier in an "identifier OR" condition

Parameters:

<UseIdentifier>	ON | OFF *RST: OFF

Firmware/Software: V 1.25

TRIGger<m>:LIN:IDOR<n>[:VALue] <IdentifierPattern>

Defines the pattern of the indicated IDOR identifier in the "identifier OR" trigger condition.

Suffix:

<n>	1..4 Index of the identifier in an "identifier OR" condition

Parameters:

<IdentifierPattern>	Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The parameter accepts the bit value X (don't care).

Firmware/Software: V 1.25

TRIGger<m>:LIN:SYERror <SyncError>

Triggers if a synchronization error occurs.

The trigger type has to be set before: `TRIGger<m>:LIN:TYPE` to `ERRC`.

Parameters:

<SyncError>	ON | OFF *RST: ON

TRIGger<m>:LIN:IPERror <IdParityError>

Triggers if an error occurs in the identifier parity bits. These are the bits 6 and 7 of the identifier.

The trigger type has to be set before: TRIGger<m>:LIN:TYPE to ERRC.

Parameters:

<IdParityError> ON | OFF
*RST: ON

TRIGger<m>:LIN:CHKSerror <ChecksumError>

Triggers on checksum errors according to the LIN standard set with BUS<m>:LIN:STANdard.

The trigger type has to be set before: TRIGger<m>:LIN:TYPE to ERRC.

The frame identifier must be set with TRIGger<m>:LIN:ERRPattern on page 1278 and the data length with TRIGger<m>:LIN:CRCDatalen on page 1279.

Parameters:

<ChecksumError> ON | OFF
*RST: ON

TRIGger<m>:LIN:ERRPattern <ErrorPattern>

Sets the frame identifier to trigger on a checksum error with TRIGger<m>:LIN:CHKSerror on page 1278.

Parameters:

<ErrorPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.
Possible values depend on TRIGger<m>:LIN:CRCDatalen.
Defining don't care bits 'X' in the ERRP bit string resets CRCDatalen to 0. When CRCDatalen is different than 0, then all the bits in ERRP must be 1 or 0, and X bits are set to 0.

Example:

```
FORM:BPAT STRG
TRIG1:LIN:ERRP '1X0'
TRIG1:LIN:ERRP?
<-- 1X0XXX
TRIGger:LIN:CRCDatalen?
<-- 0
TRIGger:LIN:CRCDatalen 4
TRIG1:LIN:ERRP?
<-- 100000
TRIG1:LIN:ERRP '00x11'
TRIG1:LIN:ERRP?
<-- 00X11X
TRIGger:LIN:CRCDatalen?
<-- 0
```

Firmware/Software: V 1.25

TRIGger<m>:LIN:CRCDatalen <CRCDataLength>

Sets the number of data bytes to trigger on CRC errors (TRIGger<m>:LIN:TYPE is set to ERRC and TRIGger<m>:LIN:CHKSerror is set ON.)

Parameters:

<CRCDataLength> Values ≠0 restrict allowed bit values in TRIGger<m>:LIN:ERRPattern to 0 and 1.

Range: 0 to 8
Increment: 1
*RST: 0

TRIGger<m>:LIN:STANdard <ChecksumStandard>

Sets the LIN standard to trigger on CRC errors (TRIGger<m>:LIN:TYPE is set to ERRC and TRIGger<m>:LIN:CHKSerror is set ON.)

See also: "LIN standard" on page 525.

Parameters:

<ChecksumStandard>V1X | V2X | J2602 | AUTO

*RST: AUTO

16.17.7.3 Decode Results

To load and acivate a label list, use:

- BUS<m>:NEWList on page 1165
- BUS<m>:SYMBols on page 1165

BUS<m>:LIN:FCOunt?

Returns the number of decoded frames.

Suffix:

<m> 1..4
Selects the serial bus.

Return values:

<Count> Total number of decoded frames.

Usage: Query only

BUS<m>:LIN:FRAMe<n>:STATus?

Returns the overall state of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameState> OK | UART | CHCKsum | VERS | LENer | SPERror | PRERror | SYERror | WAKeup | CPERror | INSufficient

UART: at least one UART error occured. LIN uses UART words without parity bit.
CHCKsum: checksum error
VERS: the version of the LIN standard is not valid
LENer: unexpected length
SPERror: stop error
PRERror: parity error in identifier
SYERror: synchronization error
WAKeup: the frame is a wakeup frame
CPERror: parity error and checksum error
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:STARt?
BUS<m>:LIN:FRAMe<n>:STOP?

Returns the start time and stop time of the selected frame, respectively.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameStart> <FrameStop>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:LIN:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the number of the frame in the current acquisition, 1...n.

Return values:

<Label> String with symbolic name of the identifier

Example: `BUS:LIN:FRAMe2:SYMBol?`
Response: `Temperature`

Usage: Query only

Firmware/Software: FW 1.36

BUS<m>:LIN:FRAMe<n>:VERSion?

Returns the version of the LIN standard for the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameVersion> V1X | V2X | UNK
UNK: Unknown
*RST: UNK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:DATA?

Returns the data bytes of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<Data> Comma-separated list of integer values (N, D1, D2,..., DN). N is the number of bytes in the frame, and D1...DN are the values of the bytes.

Example:

```
BUS:LIN:FRAMe4:DATA?
<-- 4,118,39,71,123
```

Usage: Query only

BUS<m>:LIN:FRAMe<n>:IDSTate?

Returns the identifier state of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<IdentifierState> OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient

STERror: start error
SPERror: stop error
PRERror: parity error
UVAL: unexpected value
NOEXists: byte does not exist
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:IDValue?

Returns the identifier value of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<IdentifierValue> To set the value format, use FORMat:BPATtern.
The values below – range, increment and reset – are decimal values.

Range: 0 to 63
*RST: 0

Usage: Query only

BUS<m>:LIN:FRAMe<n>:IDPValue?

Returns the value of the identifier parity bits of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<IdentifierParity> To set the value format, use FORMat:BPATtern.
The values below – range, increment and reset – are decimal values.

Range: 0 to 3
*RST: 0

Usage: Query only

BUS<m>:LIN:FRAMe<n>:SYSTate?

Returns the state of the sync field for the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<SyncState> OK | STERror | SPERror | UVAL | NOEXists | INSufficient

STERror: start error
SPERror: stop error
UVAL: unexpected value
NOEXists: byte does not exist
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:CSSTate?

Returns the checksum state of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<ChecksumState> OK | STERror | SPERror | UVAL | NOEXists | INSufficient

STERror: start error
SPERror: stop error
UVAL: unexpected value
NOEXists: byte does not exist
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:CSValue?

Returns the checksum value of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<ChecksumValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 255
*RST: 0

Usage: Query only

BUS<m>:LIN:FRAMe<n>:BYTE<o>:STATe?

Returns the state of the specified byte.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:

<ByteState> OK | STERror | SPERror | UVAL | NOEXists | INSufficient

STERror: start error
SPERror: stop error
UVAL: unexpected value
NOEXists: byte does not exist
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:BYTE<o>:VALue?

Returns the value of the specified byte.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte.

Return values:

<ByteValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 255
*RST: 0

Usage: Query only

16.17.7.4 LIN Search Settings

In search setup commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name. The commands are similar to LIN trigger commands.

SEARch:TRIGger:LIN:SSOFrame <SearchName>,<FrameStart>
SEARch:TRIGger:LIN:SSOFrame? <SearchName>

Enables the search for the stop bit of the sync field, which marks the frame start.

Parameters:

<FrameStart> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:SFIDentifier <SearchName>,<SearchSymbol>
SEARch:TRIGger:LIN:SFIDentifier? <SearchName>

Enables the search for one specific identifier or an identifier range.

Parameters:

<SearchSymbol> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:IDENtifieror <SearchName>,<SearchSymbol>
SEARch:TRIGger:LIN:IDENtifieror? <SearchName>

Enables the search for one to four address conditions.

Parameters:

<SearchSymbol> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:SIDData <SearchName>,<IdentifierData>
SEARch:TRIGger:LIN:SIDData? <SearchName>

Enables the search for a combination of identifier and data conditions.

Parameters:
<IdentifierData> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:SERRor <SearchName>,<ErrorCondition>
SEARch:TRIGger:LIN:SERRor? <SearchName>

Enables the search for various errors in the frame.

Parameters:
<ErrorCondition> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:WUFRame <SearchName>,<WakeUpFrame>
SEARch:TRIGger:LIN:WUFRame? <SearchName>

Enables the search for wakeup frames.

Parameters:
<WakeUpFrame> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:ICONdition <SearchName>,<IdentifierOperator>
SEARch:TRIGger:LIN:ICONdition? <SearchName>

Sets the operator to define a specific identifier or an identifier range.

Parameters:

<IdentifierOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These operators require one identifier pattern to be set with `SEARch:TRIGger:LIN:IMIN`

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:LIN:IMIN` and `SEARch:TRIGger:LIN:IMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:IMIN <SearchName>,<IdentifierPattern>
SEARch:TRIGger:LIN:IMIN? <SearchName>

Specifies a slave identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdentifierPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:IMAX <SearchName>,<IdentifierPatternTo>
SEARch:TRIGger:LIN:IMAX? <SearchName>

Sets the the end value of an identifier range if `SEARch:TRIGger:LIN:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<IdentifierPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:IDOR<m>:ENABle <SearchName>,<UseIdentifier>
SEARch:TRIGger:LIN:IDOR<m>:ENABle? <SearchName>

Includes the indicated IDOR address in the "identifier OR" search.

Suffix:

<m> 1..4
Index of the identifier in an "identifier OR" condition

Parameters:
<UseIdentifier> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:IDOR<m>[:VALue] <SearchName>,<IdentifierPattern>
SEARch:TRIGger:LIN:IDOR<m>[:VALue]? <SearchName>

Defines the pattern of the indicated IDOR identifier in the "identifier OR" trigger condition.

Suffix:
<m> 1..4
Index of the identifier in an "identifier OR" condition

Parameters:
<IdentifierPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:LIN:DCONdition? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:
<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:LIN:DMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:LIN:DMIN` and `SEARch:TRIGger:LIN:DMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:DMIN <SearchName>,<DataPattern>
SEARch:TRIGger:LIN:DMIN? <SearchName>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:DMAX <SearchName>,<DataPatternTo>
SEARch:TRIGger:LIN:DMAX? <SearchName>

Sets the the end value of an identifier range if `SEARch:TRIGger:LIN:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:BORDer <SearchName>,<Endianness>
SEARch:TRIGger:LIN:BORDer? <SearchName>

Sets the byte order (endianness) of the data transfer.

Parameters:

<Endianness> BENDian | LENDian

BENDian
Big endian, data is analyzed and evaluated in the order of reception.

LENDian
Little endian, the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

*RST: BENDian

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:DLECondition <SearchName>,<DLCOperator>
SEARch:TRIGger:LIN:DLECondition? <SearchName>

Operator to set the data length for search on LIN data.

For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set.

Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*. With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*.

The number of data bytes to be found is set with `SEARch:TRIGger:LIN:DLENgth`.

See also: `SEARch:TRIGger:LIN:BORDer` on page 1290.

Parameters:

<DLCOperator> EQUal | GETHan

For little endian transfer direction, EQUal must be set.

*RST: GETHan

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:DLENgth <SearchName>,<WordCount>
SEARch:TRIGger:LIN:DLENgth? <SearchName>

Sets the length of the bit pattern to be found, in bytes.

For complete definition, set the operator using `SEARch:TRIGger:LIN:DLECondition`, and the transfer direction with `SEARch:TRIGger:LIN:BORDer`.

Parameters:

<WordCount> Range: 1 to 8
Increment: 1
*RST: 1

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:IPERror <SearchName>,<IdentifierParityError>
SEARch:TRIGger:LIN:IPERror? <SearchName>

Searches for errors in the identifier parity bits. These are the bits 6 and 7 of the identifier.

Parameters:

<IdentifierParityError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:SYERror <SearchName>,<SyncError>
SEARch:TRIGger:LIN:SYERror? <SearchName>

Searches for synchronization errors.

Parameters:

<SyncError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:CHKSerror <SearchName>,<ChecksumError>
SEARch:TRIGger:LIN:CHKSerror? <SearchName>

Searches for checksum errors according to the LIN standard.

Use the following commands to configure the checksum error search:

- `SEARch:TRIGger:LIN:ERRPattern` on page 1292
- `SEARch:TRIGger:LIN:CRCDatalen` on page 1292
- `SEARch:TRIGger:LIN:STANdard` on page 1293

Parameters:

<ChecksumError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:ERRPattern <SearchName>,<ErrorPattern>
SEARch:TRIGger:LIN:ERRPattern? <SearchName>

Sets the frame identifier to search for a checksum error.

Parameters:

<ErrorPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:CRCDatalen <SearchName>,<CRCDataLength>
SEARch:TRIGger:LIN:CRCDatalen? <SearchName>

Sets the number of data bytes search for CRC errors.

Parameters:

<CRCDataLength> Range: 0 to 8
Increment: 1
*RST: 0

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:STANdard <SearchName>,<ChecksumStandard>
SEARch:TRIGger:LIN:STANdard? <SearchName>

Sets the LIN standard to search for CRC errors.

Parameters:
<ChecksumStandard>V1X | V2X | J2602 | AUTO

*RST: AUTO

Parameters for setting and query:
<SearchName>

16.17.7.5 LIN Search Results

The search on decoded LIN data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 16.17.7.3, "Decode Results", on page 1279.

SEARch:RESult:LIN:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:
<Count>

Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:STATus? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameState> OK | UART | CHCKsum | VERS | LENer | SPERror | PRERror | SYERror | WAKeup | CPERror | INSufficient

*RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:STARt? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:DATA? <SearchName>

Suffix:

<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:CSSTate? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameChecksumState> OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient

*RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:CSValue? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameChecksumValue> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:IDSTate? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameIdentifierState> OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient

*RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:IDValue? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameIdentifierValue> Range: 0 to 63
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:IDPValue? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameIdentifierParityValue> Range: 0 to 3
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:SYMBol? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<SearchName>

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:SYSTate? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameSyncState> OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient

*RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:VERSion? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameVersion> V1X | V2X | UNK

*RST: UNK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:STATe? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<FrameByteState> OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient

*RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:VALue? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<FrameByteValue> Range: 0 to 255

Increment: 1

*RST: 0

Usage: Query only

16.17.8 FlexRay (Option R&S RTE-K4)

16.17.8.1 Configuration

BUS<m>:FLXRay:SRCType <SourceType>

Sets the type of measurement.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SourceType> SINGle | DIFFerential | LOGic

SINGle
Used for measurements with single-ended probes or single-ended voltage measurements with differential probes on the FlexRay bus. Two thresholds have to be defined as absolute voltage levels, see BUS<m>:FLXRay:THReshold<n> on page 1299.

DIFFerential
Used for differential measurements on the FlexRay bus. This is the most common measurement. Two thresholds have to be defined as differential voltages.

LOGic
Used for measurements of the logic signal inside the FlexRay node, between the communication controller and the bus driver. It is possible to measure simultaneously on a data line and on the "enable" line. Each line requires its own threshold.

*RST: SINGle

BUS<m>:FLXRay:SOURce<n> <Sources>

Sets the input channel of the bus signal, or of the data and enable lines in case of a LOGic source type.

Suffix:

<m> 1..4
Selects the serial bus.

<n> 1 | 2
Selects the source: 1 = bus signal or data line, 2 = enable line

Parameters:

<Sources> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

C1W1 | C2W1 | C3W1 | C4W1
Always available

NONE
Only available for SOURce2 (enable line)

M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
Only available if the trigger source is one of the input channels but not the serial bus.

D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15
Only available if `BUS<m>:FLXRay:SOURce<n>` is set to `LOGic`.

BUS<m>:FLXRay:THReshold<n> <THResholds>

Sets the thresholds for the bus signal if the source type is SINGle or DIFFerential.

For LOGic source type, use `BUS<m>:FLXRay:THData` on page 1300 and `BUS<m>:FLXRay:THENable` on page 1299.

Suffix:

<m> 1..4
Selects the serial bus.

<n> 1 | 2
1 = threshold high, 2 = threshold low

Parameters:

<THResholds> Differential or absolute voltage level, depending on the source type. See `BUS<m>:FLXRay:SRCType` on page 1298.

BUS<m>:FLXRay:THENable <ThresholdEnable>

Sets the threshold for the enable line if the source type is LOGic.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:
<ThresholdEnable> Range: -12 to 12
Increment: 0.1
*RST: 2.65
Default unit: V

BUS<m>:FLXRay:THData <ThresholdData>

Sets the threshold for the data line if the source type is LOGic.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<ThresholdData> Range: -12 to 12
Increment: 0.1
*RST: 2.35
Default unit: V

BUS<m>:FLXRay:PRSingle <PresetSingleEnded>

Selects a default threshold voltage if `BUS<m>:FLXRay:SRCType` is set to `SINGle`.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<PresetSingleEnded> MV150 | MV200 | MV250 | MV300 | MAN

MV150 | MV200 | MV250 | MV300
2.5 ± 0.15 V; 2.5 ± 0.2 V; 2.5 ± 0.25 V; 2.5 ± 0.3 V, respectively

MAN
Manual setting of user-defined values with `BUS<m>:FLXRay:THResold<n>` on page 1299.

*RST: MV150

BUS<m>:FLXRay:PRDiff <PresetDifferential>

Selects a default threshold voltage if `BUS<m>:FLXRay:SRCType` is set to `DIFFerential`.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:

<PresetDifferential> MV150 | MV200 | MV250 | MV300 | MAN

MV150 | MV200 | MV250 | MV300
±150 mV, ±200 mV, ±250 mV, ±300 mV respectively

MAN
Manual setting of user-defined values with BUS<m>:FLXRay:THResholdn<n> on page 1299.

*RST: MV150

BUS<m>:FLXRay:PRLogic <PresetLogic>

Selects a default threshold voltage if BUS<m>:FLXRay:SRCType is set to LOGic.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<PresetLogic> V25 | V165 | V125 | V09 | V0 | MAN

V25 | V165 | V125 | V09 | V0
2.5 V (CMOS 5.0 V); 1.65 V (CMOS 3.5V), 1.25 V (CMOS 2.5V), 0.9 V (CMOS 1.8V), 0 V (ground)

MAN
Manual setting of user-defined values with BUS<m>:FLXRay:THResholdn<n> on page 1299.

*RST: V25

BUS<m>:FLXRay:POLarity <Polarity>

Selects the wire on which the bus signal is measured in case of SINGle source type. The setting affects the digitization of the signal.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Polarity> BPLus | BMINus

*RST: BPLus

BUS<m>:FLXRay:BITRate <Bitrate>

Selects the number of transmitted bits per second.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Bitrate> M10 | M5 | M2_5

10, 5, or 2.5 Mbit/s.
The return value of 2.5 Mbit/s is M25.

*RST: M10

Example:

```
BUS:FLXRay:BITRate M2_5
BUS:FLXRay:BITRate?
M25
```

BUS<m>:FLXRay:CHTYpe <Channel>

Selects the channel on which the signal is measured. The setting is considered in the calculation of the frame CRC.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Channel> CHA | CHB

Channel A or channel B

*RST: CHA

BUS<m>:FLXRay:SEHB <SeparateHeaderBits>

The command affects the decoding and its display. If ON, the leading five indicator bits of the header are decoded as five single bits. Otherwise, the indicator bits are shown as one word with word length five bit.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SeparateHeaderBits> ON | OFF

*RST: OFF

16.17.8.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:FLXRay:TYPE <Type>

Selects the trigger type for FlexRay analysis.

Parameters:

<Type> STOF | IDDT | SYMBol | ERRC

STOF
STart Of Frame: triggers on the first rising edge after the transmission start sequence (TSS).

IDDT
IDentifier and DaTa: triggers on the decoded frame content, on header and payload data.
For all settings that are not needed for the trigger condition, make sure to set its condition to `OFF`.
Indicator bits: see `TRIGger<m>:FLXRay:NUFRame`
Frame identifier: sets the trigger to one specific frame ID or an identifier range. To set the identifier, use `TRIGger<m>:FLXRay:FCONdition`, `TRIGger<m>:FLXRay:FMIN`, and `TRIGger<m>:FLXRay:FMAX`.
Payload length: trigger on the number of words in the payload segment. To set the payload length, use `TRIGger<m>:FLXRay:PCONdition`, `TRIGger<m>:FLXRay:PMIN`, and `TRIGger<m>:FLXRay:PMAX`.
Cycle count: trigger on the number of the current FlexRay cycle. To set the cycle count, use `TRIGger<m>:FLXRay:CENable`, `TRIGger<m>:FLXRay:CMIN`, `TRIGger<m>:FLXRay:CMAX`, and `TRIGger<m>:FLXRay:CSTep`.
Data position: sets the position of the data bit pattern within the payload segment. To set the data position, use `TRIGger<m>:FLXRay:DPOPerator`, `TRIGger<m>:FLXRay:DPOSition`, and `TRIGger<m>:FLXRay:DPTO`.
Data bit pattern: sets the data bit pattern to be found in the payload segment. The starting point of the pattern is defined by the data position. To set the bit pattern, use `TRIGger<m>:FLXRay:DCONdition`, `TRIGger<m>:FLXRay:DMIN`, and `TRIGger<m>:FLXRay:DMAX`.

SYMBol
Triggers on a symbol or wakeup pattern. Set the required symbol with `TRIGger<m>:FLXRay:SYMBol`

ERRC
ERRor Condition: triggers on one or more errors that are detected in the decoded data. Use `TRIGger<m>:FLXRay:BSSerror`, `TRIGger<m>:FLXRay:FESerror`, `TRIGger<m>:FLXRay:FSSerror`, and `TRIGger<m>:FLXRay:PCRCerror`.

*RST: STOF

TRIGger<m>:FLXRay:PLPReamble <PayloadPreamble>

Triggers on the payload preamble indicator bit that indicates a Network Management Vector in the payload segment.

Parameters:

<PayloadPreamble> ONE | ZERO | DC

Bit value: 1, 0, or X (don't care)

*RST: DC

TRIGger<m>:FLXRay:NUFRame <NullFrame>

Triggers on the null frame indicator bit, a frame without usable data.

Parameters:

<NullFrame> ONE | ZERO | DC

Bit value: 1, 0, or X (don't care)

*RST: DC

TRIGger<m>:FLXRay:SYFRame <SyncFrame>

Triggers on the sync frame used for synchronization of the FlexRay system. Only sync nodes can send this frame type.

Parameters:

<SyncFrame> ONE | ZERO | DC

Bit value: 1, 0, or X (don't care)

*RST: DC

TRIGger<m>:FLXRay:STFRame <StartupFrame>

Triggers on startup frames used for startup of the network. Only specific start nodes can send this frame type.

Parameters:

<StartupFrame> ONE | ZERO | DC

Bit value: 1, 0, or X (don't care)

*RST: DC

TRIGger<m>:FLXRay:FCONdition <IdentifierOperator>

Sets the operator to set a frame ID or a frame ID range.

Parameters:

<IdentifierOperator> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The frame ID is not relevant for the trigger condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one frame ID to be set with `TRIGger<m>:FLXRay:FMIN`.

INRange | OORange
In range, Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:FLXRay:FMIN` and `TRIGger<m>:FLXRay:FMAX`.

*RST: EQUal

TRIGger<m>:FLXRay:FMIN <IdPattern>

Specifies a frame identifier pattern - the number of the slot - or sets the the start value of an identifier range.

Parameters:

<IdPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

TRIGger<m>:FLXRay:FMAX <IdPatternTo>

Sets the the end value of an identifier range if the condition `TRIGger<m>:FLXRay:FCONdition` is set to `INRange` or `OORange`.

Parameters:

<IdPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.
FMAX must be greater or equal than FMIN, and the position of the X bits are common to FMIN and FMAX.

TRIGger<m>:FLXRay:PCONdition <PLOperator>

Sets the operator for the payload length trigger setting. You can defined an exact value, or a range.

Parameters:

<PLOperator> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The payload length is not relevant for the trigger condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one payload length to be set with `TRIGger<m>:FLXRay:PMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:FLXRay:PMIN` and `TRIGger<m>:FLXRay:PMAX`.

*RST: OFF

TRIGger<m>:FLXRay:PMIN <PayloadLengthMin>

Specifies a payload length - the number of words in the payload segment - or sets the the start value of an payload length range. Information is transmitted in 2-byte words, so the number of data bytes in the payload segment is twice the payload length.

Parameters:

<PayloadLengthMin>
Range: 0 to 127
Increment: 1
*RST: 0

TRIGger<m>:FLXRay:PMAX <PayloadLengthTo>

Sets the the end value of a payload length range if the condition `TRIGger<m>:FLXRay:PCONdition` is set to `INRange` or `OORange`.

Parameters:

<PayloadLengthTo>
Range: 0 to 127
Increment: 1
*RST: 0

TRIGger<m>:FLXRay:CENable <CycleCount>

Sets the operator to define a cycle count or a cycle count range.

Parameters:

<CycleCount> OFF | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF
The cycle count is not relevant for the trigger condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one cycle count number to be set with `TRIGger<m>:FLXRay:CMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:FLXRay:CMIN` and `TRIGger<m>:FLXRay:CMAX`.

*RST: OFF

TRIGger<m>:FLXRay:CMIN <CycleCount>

Specifies a cycle count - the number of the current FlexRay cycle - or sets the the start value of an cycle count range.

Parameters:

<CycleCount> Range: 0 to 63
Increment: 1
*RST: 0

TRIGger<m>:FLXRay:CMAX <CycleCountTo>

Sets the the end value of a cycle count range if the condition `TRIGger<m>:FLXRay:CENable` on page 1307 is set to `INRange` or `OORange`.

Parameters:

<CycleCountTo> Range: 0 to 63
Increment: 1
*RST: 0

TRIGger<m>:FLXRay:CSTep <CycleCountStep>

Specifies a step to trigger on each n-th cycle inside the given range. This allows for specific triggering if slot multiplexing is used.

The condition `TRIGger<m>:FLXRay:CENable` on page 1307 must be set to `INRange` or `OORange`.

Parameters:

<CycleCountStep> Range: 1 to 63
Increment: 1
*RST: 1

TRIGger<m>:FLXRay:DPOPerator <DataPosiOperator>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DataPosiOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

OFF = ANY
The data position is not relevant for the trigger condition.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:FLXRay:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `TRIGger<m>:FLXRay:DPOSition` and `TRIGger<m>:FLXRay:DPTO`.

*RST: EQUal

TRIGger<m>:FLXRay:DPOSition <DataPosition>

Sets the number of data bytes to be skipped after start of the payload segment

Parameters:

<DataPosition> Range: 0 to 255
Increment: 1
*RST: 0

TRIGger<m>:FLXRay:DPTO <DataPositionTo>

Defines the last byte of interest, if the position operator `TRIGger<m>:FLXRay:DPOPerator` defines a range.

Parameters:

<DataPositionTo> Range: 0 to 255
Increment: 1
*RST: 0

TRIGger<m>:FLXRay:DCONdition <DataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:
<DataOperator> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The data position is not relevant for the trigger condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:FLXRay:DMIN`.

INRange | OORange
In range, Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:FLXRay:DMIN` and `TRIGger<m>:FLXRay:DMAX`.

*RST: EQUal

TRIGger<m>:FLXRay:DMIN <DataPattern>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:
<DataPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:FLXRay:DMAX <DataPatternTo>

Sets the the end value of an data range if the operator `TRIGger<m>:FLXRay:DCONdition` is set to INRange or OORange.

Parameters:
<DataPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:FLXRay:SYMBol <Symbol>

Triggers on a symbol or on a wakeup pattern.

Parameters:
<Symbol> CASMts | WAKeup

CASMts
Collision Avoidance Symbol / Media access Test Symbol. These symbols are identical and can be sent in the optional symbol window at the end of a communication cycle. They are used to avoid collisions during the system start.

WAKeup
The wakeup pattern is sent to activate the nodes of the system.

*RST: CASMts

TRIGger<m>:FLXRay:BSSerror <BSSError>

Triggers on error in SyteStart Sequence. The BSS is transmitted before each byte.

Parameters:

<BSSError>	ON | OFF	
	*RST:	ON

TRIGger<m>:FLXRay:FESerror <FESError>

Triggers on error in Frame End Sequence. FES indicates the end of each frame.

Parameters:

<FESError>	ON | OFF	
	*RST:	ON

TRIGger<m>:FLXRay:FSSerror <FSSError>

Triggers on Error in a Frame Start Sequence. FSS follows the Transmission Start Sequence TSS at the beginning of each frame.

Parameters:

<FSSError>	ON | OFF	
	*RST:	ON

TRIGger<m>:FLXRay:HCRCerror <CRCHeaderError>

Triggers on error in the Cyclic Redundancy Check of the header data (mainly frame ID and payload length).

Parameters:

<CRCHeaderError>	ON | OFF	
	*RST:	ON

TRIGger<m>:FLXRay:PCRCerror <CRCPayloadError>

Triggers on error in the Cyclic Redundancy Check of the payload data.

Parameters:

<CRCPayloadError>	ON | OFF	
	*RST:	ON

16.17.8.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1165
- `BUS<m>:SYMBols` on page 1165

BUS<m>:FLXRay:FCOunt?

Returns the number of decoded frames.

Suffix:

<m> 1..4
Selects the serial bus.

Return values:

<Count> Returns the number of decoded frames.

Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:STATus?

Returns the overall state of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameState> OK | FSS | BSS | FES | INDicator | HCRCerror | CRCerr | LENER | LENer | HCFCerror | INSufficient

OK: the frame is valid.
FSS: Frame Start Sequence after TSS is missing.
BSS: Byte Start Sequence is missing.
FES: error in the Frame End Sequence.
INDicator: Error in indicator bits.
HCRCerror: Header CRC is not valid.
CRCerr: Payload CRC is not valid.
LENER = LENer: Unexpected length of the frame.
HCFCerror: Header CRC error and frame CRC error
INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:STARt?
BUS<m>:FLXRay:FRAMe<n>:STOP?

Return the start time and stop time of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameStop> Time

Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the number of the frame in the current acquisition, 1...n.

Return values:

<Label> String with symbolic name of the identifier

Example: `BUS:FLXRay:FRAMe2:SYMBol?`
Response: `Temperature`

Usage: Query only

Firmware/Software: FW 1.36

BUS<m>:FLXRay:FRAMe<n>:TYPE?

Returns the frame type of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameType> UNKNown | STATic | DYNamic | WAKE | SYMBol

STATic: frame of the static segment
DYNamic: frame of the dynamic segment
WAKE: frame contains wakeup pattern
SYMBol: frame contains a MTS or CAS symbol

*RST: STATic

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:DATA?

Returns the data of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<Data> Comma-separated list of integer values (N, D1, D2,…, DN). N is the number of bytes in the frame, and D1…DN are the values of the bytes.

Example: `BUS:FLXRay:FRAMe4:DATA?`
`<-- 4,17,85,170,85`

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:FLAGs?

Returns the value of the indicator bits at the beginning of the header segment. The five bits are read as one word.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<IndicatorBits> Range: 0 to 31
*RST: 0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:ADID?

Returns the frame identifier, the number of the slot in which the frame is transmitted.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameIDvalue> To set the value format, use `FORMat:BPATtern` on page 889.
The values below – range, increment and default – are decimal values.
Range: 0 to 2047
*RST: 0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:PAYLength?

Returns the payload length, the number of data words in the payload segment. Information is transmitted in 2-byte words, so the number of data bytes in the payload segment is twice the payload length.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<Value> Range: 0 to 127
*RST: 0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:CYCount?

Returns the number of the current FlexRay cycle.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<CycleCount>	Range: 0 to 63 *RST: 0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:CSSTate?

Returns the state of the cyclic redundancy check code of the header data.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<HeaderCRCstate>	OK | UVAL | INSufficient OK: the CRC is valid. UVAL: unexpected value INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid. *RST: OK

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:CSValue?

Returns the checksum value of the header CRC.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<HeaderCRCvalue> To set the value format, use FORMat:BPATtern on page 889.
The values below – range, increment and default – are decimal values.

Range: 0 to 2047
*RST: 0

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:FCSTate?

Returns the state of the cyclic redundancy check code of the frame data.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameCRCstate> OK | UVAL | INSufficient

OK: the CRC is valid.
UVAL: unexpected value
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:FLXRay:FRAMe<n>:FCValue?

Returns the cyclic redundancy check code of the frame CRC.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameCRCvalue> To set the value format, use FORMat:BPATtern on page 889.
The values below – range, increment and default – are decimal values.

Range: 0 to 16777215
*RST: 0

Usage: Query only

16.17.8.4 Search Settings

SEARch:TRIGger:FLXRay[:STATe] <SearchName>,<State>
SEARch:TRIGger:FLXRay[:STATe]? <SearchName>

Includes the search conditions for the FlexRay trigger event type in the next search.

Parameters:

<State> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:FLXRay:ACOPy <SearchName>

Copies the trigger event configuration from Trigger A for the selcted FlexRay bus to the search condition settings.

Setting parameters:
<SearchName>

Usage: Setting only

SEARch:TRIGger:FLXRay:SERRor <SearchName>,<CheckErrorCondition>
SEARch:TRIGger:FLXRay:SERRor? <SearchName>

Enables the search for specified error or error combination.

Parameters:
<CheckErrorCondition> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:SIDData <SearchName>,<CheckIdentifierData>
SEARch:TRIGger:FLXRay:SIDData? <SearchName>

Enables the search for indentifier and data.

Parameters:
<CheckIdentifierData> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay[:SSOFrame] <SearchName>,<CheckStartOfFrame>
SEARch:TRIGger:FLXRay[:SSOFrame]? <SearchName>

Enables the search for a start of frame.

Parameters:
<CheckStartOfFrame> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:SSYMbol <SearchName>,<CheckSymbol>
SEARch:TRIGger:FLXRay:SSYMbol? <SearchName>

Enables the search for specified symbol.

Parameters:
<CheckSymbol> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:CENable <SearchName>,<CycleCount>
SEARch:TRIGger:FLXRay:CENable? <SearchName>

Sets the operator to define a cycle count or a cycle count range.

Parameters:
<CycleCount> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The cycle count is not relevant for the search condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one cycle count number to be set with `SEARch:TRIGger:FLXRay:CMIN`.

INRange | OORange
In range, Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:FLXRay:CMIN` and `SEARch:TRIGger:FLXRay:CMAX`.

*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:CMAX <SearchName>,<CycleCountMax>
SEARch:TRIGger:FLXRay:CMAX? <SearchName>

Sets the the end value of a cycle count range if the condition `SEARch:TRIGger:FLXRay:CENable` is set to `INRange` or `OORange`.

Parameters:
<CycleCountMax> Range: 0 to 63
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:CMIN <SearchName>,<CycleCountMin>
SEARch:TRIGger:FLXRay:CMIN? <SearchName>

Specifies a cycle count - the number of the current FlexRay cycle - or sets the the start value of an cycle count range.

Parameters:

<CycleCountMin>	Range:	0 to 63
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:CSTep <SearchName>,<CycleCountStep>
SEARch:TRIGger:FLXRay:CSTep? <SearchName>

Specifies a step to search for each n-th cycle inside the given range. This allows for a specific search if slot multiplexing is used.

The condition `SEARch:TRIGger:FLXRay:CENable` must be set to `INRange` or `OORange`.

Parameters:

<CycleCountStep>	Range:	1 to 63
	Increment:	1
	*RST:	1

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:FLXRay:DCONdition? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The data pattern is not relevant for the search condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:FLXRay:DMIN`.

INRange | OORange
In range, Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:FLXRay:DMIN` and `SEARch:TRIGger:FLXRay:DMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:DMAX <SearchName>,<DataPatternTo>
SEARch:TRIGger:FLXRay:DMAX? <SearchName>

Sets the the end value of an data range if `SEARch:TRIGger:FLXRay:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:FLXRay:DMIN <SearchName>,<DataPattern>
SEARch:TRIGger:FLXRay:DMIN? <SearchName>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:FLXRay:DPOPerator <SearchName>,<DataPosiOperator>
SEARch:TRIGger:FLXRay:DPOPerator? <SearchName>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DataPosiOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

OFF = ANY
The data position is not relevant for the search condition.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `SEARch:TRIGger:FLXRay:DPOSition`

INRange = RANGe
In range: Set the minimum and maximum value of the range with `SEARch:TRIGger:FLXRay:DPOSition` and `SEARch:TRIGger:FLXRay:DPTO`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:FLXRay:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:FLXRay:DPOSition? <SearchName>

Sets the number of data bytes to be skipped after start of the payload segment.

Parameters:

<DataPosition> Range: 0 to 255
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:DPTO <SearchName>,<DataPositionTo>
SEARch:TRIGger:FLXRay:DPTO? <SearchName>

Defines the last byte of interest, if the position operator `SEARch:TRIGger:FLXRay:DPOPerator` defines a range.

Parameters:

<DataPositionTo> Range: 0 to 255
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:FCONdition <SearchName>,<IdentifierOperator>
SEARch:TRIGger:FLXRay:FCONdition? <SearchName>

Sets the operator to set a frame ID or a frame ID range.

Parameters:

<IdentifierOperator> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The frame ID is not relevant for the search condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one frame ID to be set with `SEARch:TRIGger:FLXRay:FMIN`.

INRange | OORange
In range, Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:FLXRay:FMIN` and `SEARch:TRIGger:FLXRay:FMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:FMAX <SearchName>,<IdentifierPatternTo>
SEARch:TRIGger:FLXRay:FMAX? <SearchName>

Sets the the end value of an identifier range if the condition `SEARch:TRIGger:FLXRay:FCONdition` is set to `INRange` or `OORange`.

Parameters:
<IdentifierPatternTo> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:FMIN <SearchName>,<IdentifierPattern>
SEARch:TRIGger:FLXRay:FMIN? <SearchName>

Specifies a frame identifier pattern - the number of the slot - or sets the the start value of an identifier range.

Parameters:
<IdentifierPattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:NUFRame <SearchName>,<NullFrame>
SEARch:TRIGger:FLXRay:NUFRame? <SearchName>

Searches for the null frame indicator bit, a frame without usable data.

Parameters:
<NullFrame> ONE | ZERO | DC

Bit value: 1, 0, or X (don't care)

*RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:PLPReamble <SearchName>,<PayloadPreamble>
SEARch:TRIGger:FLXRay:PLPReamble? <SearchName>

Searches for the payload preamble indicator bit that indicates a Network Management Vector in the payload segment.

Parameters:
<PayloadPreamble> ONE | ZERO | DC

Bit value: 1, 0, or X (don't care)

*RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:PCONdition <SearchName>,<PayloadOperator>
SEARch:TRIGger:FLXRay:PCONdition? <SearchName>

Sets the operator for the payload length search setting. You can defined an exact value, or a range.

Parameters:

<PayloadOperator> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The payload length is not relevant for the search condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one payload length to be set with `SEARch:TRIGger:FLXRay:PMIN`.

INRange | OORange
In range, Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:FLXRay:PMIN` and `SEARch:TRIGger:FLXRay:PMAX`.

*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:PMAX <SearchName>,<PayloadLengthMax>
SEARch:TRIGger:FLXRay:PMAX? <SearchName>

Sets the the end value of a payload length range if the condition `SEARch:TRIGger:FLXRay:PCONdition` is set to `INRange` or `OORange`.

Parameters:

<PayloadLengthMax> Range: 0 to 127
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:PMIN <SearchName>,<PayloadLengthMin>
SEARch:TRIGger:FLXRay:PMIN? <SearchName>

Specifies a payload length - the number of words in the payload segment - or sets the the start value of an payload length range. Information is transmitted in 2-byte words, so the number of data bytes in the payload segment is twice the payload length.

Parameters:

<PayloadLengthMin>	Range:	0 to 127
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:STFRame <SearchName>,<StartupFrame>
SEARch:TRIGger:FLXRay:STFRame? <SearchName>

Searches for startup frames used for startup of the network. Only specific start nodes can send this frame type.

Parameters:

<StartupFrame> ONE | ZERO | DC

Bit value: 1, 0, or X (don't care)

*RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:SYFRame <SearchName>,<SyncFrame>
SEARch:TRIGger:FLXRay:SYFRame? <SearchName>

Searches for the sync frame used for synchronization of the FlexRay system. Only sync nodes can send this frame type.

Parameters:

<SyncFrame> ONE | ZERO | DC

Bit value: 1, 0, or X (don't care)

*RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:SYMBol <SearchName>,<Symbol>
SEARch:TRIGger:FLXRay:SYMBol? <SearchName>

Searches for a symbol or for a wakeup pattern.

Parameters:
<Symbol> CASMts | WAKeup

CASMts
Collision Avoidance Symbol / Media access Test Symbol. These symbols are identical and can be sent in the optional symbol window at the end of a communication cycle. They are used to avoid collisions during the system start.

WAKeup
The wakeup pattern is sent to activate the nodes of the system.

*RST: CASMts

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:BSSerror <SearchName>,<BSSError>
SEARch:TRIGger:FLXRay:BSSerror? <SearchName>

Searches for error in SyteStart Sequence. The BSS is transmitted before each byte.

Parameters:
<BSSError> ON | OFF

*RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:FESerror <SearchName>,<FESError>
SEARch:TRIGger:FLXRay:FESerror? <SearchName>

Searches for error in Frame End Sequence. FES indicates the end of each frame.

Parameters:
<FESError> ON | OFF

*RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:FSSerror <SearchName>,<FSSError>
SEARch:TRIGger:FLXRay:FSSerror? <SearchName>

Searches for an error in a Frame Start Sequence(FSS). FSS follows the Transmission Start Sequence (TSS) at the beginning of each frame.

Parameters:
<FSSError> ON | OFF

*RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:HCRCerror <SearchName>,<CRCHeaderError>
SEARch:TRIGger:FLXRay:HCRCerror? <SearchName>

Searches for an error in the Cyclic Redundancy Check of the header data (mainly frame ID and payload length).

Parameters:

<CRCHeaderError>	ON | OFF
	*RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:FLXRay:PCRCerror <SearchName>,<CRCPayloadError>
SEARch:TRIGger:FLXRay:PCRCerror? <SearchName>

Searches for error in the Cyclic Redundancy Check of the payload data.

Parameters:

<CRCPayloadError>	ON | OFF
	*RST: ON

Parameters for setting and query:
<SearchName>

16.17.8.5 Search Results

The search on decoded FlexRay data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 16.17.8.3, "Decode Results", on page 1311.

SEARch:RESult:FLXRay:FCOunt? <SearchName>

Query parameters:

<SearchName>

Return values:

<Count>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:ADID? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<HeaderFlags>	Range:	0 to 2047
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:CSSTate? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<HeaderChecksumState> OK | STERror | SPERror | PRERror | UVAL | INSufficient

*RST: OK

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:CSValue? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<HeaderChecksumValue>	Range:	0 to 2047
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:CYCount? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<CycleCount> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:DATA? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:FCSTate? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameChecksumState> OK | STERror | SPERror | PRERror | UVAL | INSufficient
*RST: OK

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:FCValue? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameChecksumValue> Range: 0 to 16777215
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:FLAGs? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<HeaderFlags> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:PAYLength? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<HeaderFlags> Range: 0 to 127
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:STATus? <SearchName>

Returns the overall state of the selected frame.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameState> OK | FSS | BSS | FES | INDicator | HCRCerror | CRCerr | LENER | LENer | HCFCerror | INSufficient

OK: the frame is valid.
FSS: Frame Start Sequence after TSS is missing.
BSS: Byte Start Sequence is missing.
FES: error in the Frame End Sequence.
INDicator: Error in indicator bits.
HCRCerror: Header CRC is not valid.
CRCerr: Payload CRC is not valid.
LENER = LENer: Unexpected length of the frame.
HCFCerror: Header CRC error and frame CRC error
INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

*RST: OK

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:STARt? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:TYPE? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameType> UNKNown | STATic | DYNamic | WAKE | SYMBol
*RST: STATic

Usage: Query only

SEARch:RESult:FLXRay:FRAMe<m>:SYMBol? <SearchName>

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:
<m> *
Selects the number of the frame in the current acquisition, 1...n.

Query parameters:
<SearchName> String parameter that contains the search definition name

Return values:
<Translation> Symbolic label (string)

Usage: Query only

16.17.9 Audio Signals (Option R&S RTE-K5)

16.17.9.1 Configuration

BUS<m>:I2S:AVARiant <AudioVariant>

Selects the audio signal type.

For details, see "Audio Variant" on page 557.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<AudioVariant>	I2S | LJ | RJ | TDM I2S: Inter-IC Sound standard audio format. LJ: left-justified data format RJ: right-justified data format TDM: Time Division Multiplexed audio format *RST: I2S

BUS<m>:I2S:CLOCk:SOURce <SCLKsource>

Selects the source of the clock line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SCLKsource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Digital channels require installation of R&S RTE-B1. Digital and analog channels cannot be used at the same time. For triggering on a serial bus, analog or digital input channels are required. *RST: C1W1

BUS<m>:I2S:CLOCk:POLarity <BitClockEdge>

Sets the polarity of the clock signal, that is the edge at which the instrument samples the data on the data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<BitClockEdge> FALLing | RISing

*RST: RISing

BUS<m>:I2S:WSELect:SOURce <WSsource>

Selects the source of the word select line for I²S standard, left- und right-justified data formats, or the source of the frame synchronization pulse for TDM audio signals.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<WSsource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital channels require installation of R&S RTE-B1. Digital and analog channels cannot be used at the same time. For triggering on a serial bus, analog or digital input channels are required.

*RST: C1W1

BUS<m>:I2S:WSELect:POLarity <WSPolarity>

For a word select line, the polarity defines the signal values assigned to the left and right channels.

For an FSYNC line (TDM), the polarity defines the edge of the FSYNC pulse that identifies the beginning of a frame.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<WSPolarity> NORMal | INVert

NORMal: 0 = left, 1 = right channel; or rising edge for TDM
INVert: 1= left, 0 = right channel; or falling edge for TDM

*RST: NORMal

BUS<m>:I2S:DATA:SOURce <DataSource>

Selects the source of the audio data line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<DataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital channels require installation of R&S RTE-B1.Digital and analog channels cannot be used at the same time. For triggering on a serial bus, analog or digital input channels are required.

*RST: C1W1

BUS<m>:I2S:DATA:POLarity <SDataPolarity>

Defines the interpretation of high and low signal states on the data line.

Suffix:

<m> 1..4

Selects the serial bus.

Parameters:

<SDataPolarity> ACTLow | ACTHigh

ACTHigh: HIGH = 1 and LOW = 0
ACTLow: HIGH = 0 and LOW = 1

*RST: ACTHigh

BUS<m>:I2S:TCOupling <Coupling>

Sets all thresholds to the value of the clock threshold `BUS<m>:I2S:CLOCk:THReshold`.

Suffix:

<m> 1..4

Selects the serial bus.

Parameters:

<Coupling> ON | OFF

*RST: ON

BUS<m>:I2S:CLOCk:THReshold <SCLKThreshold>

Sets the threshold value for the clock line SCLK.

If `BUS<m>:I2S:TCOupling` is `ON`, the command sets the threshold for all lines.

Suffix:

<m> 1..4

Selects the serial bus.

Parameters:

<SCLKThreshold> Range: -10 to 10
Increment: 1E-3
*RST: 1.6
Default unit: V

BUS<m>:I2S:WSELect:THReshold <WSThreshold>

Sets the threshold value for the word select and FSYNC lines.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<WSThreshold> Range: -10 to 10
Increment: 1E-3
*RST: 1.6
Default unit: V

BUS<m>:I2S:DATA:THReshold <SDATAThreshold>

Sets the threshold value for the data line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SDATAThreshold> Range: -10 to 10
Increment: 1E-3
*RST: 1.6
Default unit: V

BUS<m>:I2S:CHANnel:ORDer <ChannelOrder>

Defines if the left or the right channel is the first channel in the frame.

The setting is not available for TDM audio signals.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ChannelOrder> LFIRst | RFIRst

Left channel first or right first

*RST: LFIRst

BUS<m>:I2S:WLENgth <WordLength>

Defines the number of bits in an audio data word.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<WordLength> Range: 4 to 32
Increment: 4
*RST: 8
Default unit: bit

BUS<m>:I2S:BORDer <BitOrder>

Sets the bit order of the audio data words.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<BitOrder> LSBF | MSBF

LSB first or MSB first

*RST: MSBF

BUS<m>:I2S:CHANnel:OFFSet <ChannelOffset>

Sets the number of bits between the channel start and the start of the audio word.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ChannelOffset> Range: 0 to 32 (left-justified). TDM: maximum delay is Channel length - Word length
Increment: 1
*RST: 0
Default unit: bit

BUS<m>:I2S:CHANnel:TDMCount <ChannelsTDM>

Sets the number of channels transmitted on the TDM audio line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ChannelsTDM> Range: 1 to 8
Increment: 1
*RST: 1

BUS<m>:I2S:FOFFset <FrameOffsetTDM>

Sets the number of bits between the frame start and the start of the first channel of a TDM audio line. Each FSYNC edge restarts the offset count.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<FrameOffsetTDM>	Range: 0 to 256 Increment: 1 *RST: 0 Default unit: bit

---

BUS<m>:I2S:CHANnel:LENGth <ChLengthTDM>

Sets the number of bits in a TDM channel block.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ChLengthTDM>	Range: 4 to 32 Increment: 4 *RST: 8 Default unit: bit

16.17.9.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:I2S:TYPE <Type>

Selects the trigger type for audio signal analysis.

Parameters:

<Type> DATA | WINDow | CONDition | WSELect | ECONdition

DATA
Triggers on a data word or data range on a specified channel or on any channel.
To set the channel, use `TRIGger<m>:I2S:TCONdition<n>:CHANnel`.
To set the data condition, use:
`TRIGger<m>:I2S:TCONdition<n>:CONDtion`,
`TRIGger<m>:I2S:TCONdition<n>:DMIN` and `TRIGger<m>:I2S:TCONdition<n>:DMAX`.

WINDow
Triggers if the decoded data values stay inside a "window" that is formed by a data range and a time specified by a number of subsequent words. It considers a selected channel or all channels.
To set up a window trigger, you define the channel and data condition in the same way as for DATA trigger type. Additionally, you set the time limit with `TRIGger<m>:I2S:SOWords`.

CONDition
The frame condition trigger sets the trigger on an AND combination of data conditions on different channels. The instrument triggers if all conditions are met inside one frame.
To set up a CONDition trigger, you define up to four channel and data conditions in the same way as for DATA trigger type.

WSELect
WordSELect: Triggers on the selected edge of the WS line (I²S standard, left- and right-justified). For TDM signals, it triggers on the selected edge of the FSYNC line. Set the edge with `TRIGger<m>:I2S:WSSLope`.

ECONdition
ErrorCONdition: Triggers on irregularities between the WS or FSYNC edges.

*RST: DATA

Usage: Asynchronous command

TRIGger<m>:I2S:TCONdition<n>:CHANnel <Channel>

Selects the audio channel on which the instrument looks for the specified data condition.

Suffix:

<n> 1..4
1 if trigger type is DATA or WINDow
Specifies the condition number if trigger type is CONDition:
– 1 | 2 for I²S standard, left- und right-justified data formats
– 1 | 2 | 3 | 4 for TDM signals

Parameters:

<Channel> ANY | TDMC1 | TDMCh1 | TDMC2 | TDMCh2 | TDMC3 | TDMCh3 | TDMC4 | TDMCh4 | TDMC5 | TDMCh5 | TDMC6 | TDMCh6 | TDMC7 | TDMCh7 | TDMC8 | TDMCh8 | LEFT | RIGHT | RIGHt

ANY
The instrument triggers on any channel on which the specified data is found.

LEFT | RIGHT = RIGHt
Available for I²S Standard, left- und right-justified data formats.

TDMCh1 | TDMCh2 | TDMCh3 | TDMCh4 | TDMCh5 | TDMCh6 | TDMCh7 | TDMCh8
Available for TDM audio signals
TDMC1 = TDMCh1, TDMC2 = TDMCh2, TDMC3 = TDMCh3, TDMC4 = TDMCh4, TDMC5 = TDMCh5, TDMC6 = TDMCh6, TDMC7 = TDMCh7, TDMC8 = TDMCh8. Query returns short form.
Note: Available audio channels depend on the configuration of the audio bus. The command BUS<m>:I2S:CHANnel:TDMCount specifies the number of channels in a TDM frame.

*RST: ANY

TRIGger<m>:I2S:TCONdition<n>:CONDtion <DataCondition>

Sets the operator to set a specific data pattern or a data pattern range.

Suffix:

<n> 1..4
1 if trigger type is DATA or WINDow
Specifies the condition number if trigger type is CONDition:
– 1 | 2 for I²S standard, left- und right-justified data formats
– 1 | 2 | 3 | 4 for TDM signals

Parameters:

<DataCondition> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
No range is defined.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with TRIGger<m>:I2S:TCONdition<n>:DMIN.

INRange | OORange
In range, Out of range: Set the minimum and maximum value of the range with TRIGger<m>:I2S:TCONdition<n>:DMIN and TRIGger<m>:I2S:TCONdition<n>:DMAX.

*RST: OFF

TRIGger<m>:I2S:TCONdition<n>:DMIN <DataMinPattern>

Specifies a data pattern, or sets the the start value of a data pattern range.

Suffix:

<n>	1..4 1 if trigger type is DATA or WINDow Specifies the condition number if trigger type is CONDition: – 1 | 2 for I²S standard, left- und right-justified data formats – 1 | 2 | 3 | 4 for TDM signals

Parameters:

<DataMinPattern>	Numeric pattern in 2's complement format. See also: Chapter 16.4.6, "Bit Pattern Parameter", on page 881 X bits are not allowed. If the bit string is shorter than the word length, the rightmost bit of the input bit string is aligned to the rightmost (LSB) bit of the word.

TRIGger<m>:I2S:TCONdition<n>:DMAX <DataMaxPattern>

Sets the the end value of an data range if the operator `TRIGger<m>:I2S:TCONdition<n>:CONDtion` is set to `INRange` or `OORange`.

Suffix:

<n>	1..4 1 if trigger type is DATA or WINDow Specifies the condition number if trigger type is CONDition: – 1 | 2 for I²S standard, left- und right-justified data formats – 1 | 2 | 3 | 4 for TDM signals

Parameters:

<DataMaxPattern>	Numeric pattern in 2's complement format. See also: Chapter 16.4.6, "Bit Pattern Parameter", on page 881 DMAX must be greater or equal than DMIN. X bits are not allowed. If the bit string is shorter than the word length, the rightmost bit of the input bit string is aligned to the rightmost (LSB) bit of the word.

TRIGger<m>:I2S:SOWords <SequenceOfWords>

Sets the number of words that is used as time limit for the "Window" trigger type. The instrument triggers if the data condition is fulfilled on the same channel for the given number of subsequent frames.

Parameters:

<SequenceOfWords>	Range: 1 to 1000000 Increment: 1 *RST: 1 Default unit: word

Usage: Asynchronous command

TRIGger<m>:I2S:WSSLope <WSSlope>

Sets the edge of the WS or FSYNC signal as trigger condition. The instrument triggers on the first clock edge after the specified edge.

Parameters:

<WSSlope> POSitive | NEGative

*RST: POSitive

Usage: Asynchronous command

16.17.9.3 Decode Results

BUS<m>:I2S:FCOunt?

Returns the number of decoded frames.

Suffix:

<m> 1..4
Selects the serial bus.

Return values:

<Count> Number of decoded audio frames

Usage: Query only

BUS<m>:I2S:FRAMe<n>:STATe?

Returns the overall state of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameState>	ERRor | OK | INSufficient OK: the frame is valid. ERRor: an error occured in the frame. INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

Usage: Query only

BUS<m>:I2S:FRAMe<n>:STARt?
BUS<m>:I2S:FRAMe<n>:STOP?

Return the start time and stop time of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Start>, <Stop>	Range: -100E+24 to 100E+24 *RST: 0

Usage: Query only

BUS<m>:I2S:FRAMe<n>:LEFT:VALue?
BUS<m>:I2S:FRAMe<n>:RIGHt:VALue?

Return the data values of the left and right channel, respectively.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Value>	Comma-separated list of values. To set the value format, use `FORMat:BPATtern`. Range: 0 to 4294967295 *RST: 0

Usage: Query only

BUS<m>:I2S:FRAMe<n>:LEFT:STATe?
BUS<m>:I2S:FRAMe<n>:RIGHt:STATe?

Return the status of the left and right channel of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<WordState> ERRor | OK | INSufficient
OK: the channel data is valid.
ERRor: an error occured in the channel.
INSufficient: the channel is not completely contained in the acquisition.

Usage: Query only

BUS<m>:I2S:FRAMe<n>:TDM<o>:STATe?

Returns the state of the indicated channel of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> 1..8
Selects the TDM channel.

Return values:

<State> ERRor | OK | INSufficient
OK: the channel data is valid.
ERRor: an error occured in the channel.
INSufficient: the channel is not completely contained in the acquisition.

Usage: Query only

BUS<m>:I2S:FRAMe<n>:TDM<o>:VALue?

Return the data value of the indicated TDM channel.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> 1..8
Selects the TDM channel.

Return values:

<Value> To set the value format, use FORMat:BPATtern on page 889.
The values below – range, increment and default – are decimal values.

Usage: Query only

16.17.9.4 Track and Trend

BUS<m>:I2S:TRACk:LEFT <Channel>
BUS<m>:I2S:TRACk:RIGHt <Channel>

Enables or disables the track of the indicated channel. The commands are relevant for I²S standard, left-justified and right-justified audio data formats.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Channel> ON | OFF
*RST: OFF

BUS<m>:I2S:TRACk:TD1Ch <TDMCh1>
BUS<m>:I2S:TRACk:TD2Ch <TDMCh2>
BUS<m>:I2S:TRACk:TD3Ch <TDMCh3>
BUS<m>:I2S:TRACk:TD4Ch <TDMCh4>
BUS<m>:I2S:TRACk:TD5Ch <TDMCh5>
BUS<m>:I2S:TRACk:TD6Ch <TDMCh6>
BUS<m>:I2S:TRACk:TD7Ch <TDMCh7>
BUS<m>:I2S:TRACk:TD8Ch <TDMCh8>

Enables or disables the track of the indicated channel. The commands are relevant for TDM audio data.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<TDMChX> ON | OFF

*RST: OFF

MEASurement<m>:TRACk[:STATe] <State>

Enables the track functionality and displays the track.

The track functionality requires at least one option, see "Enable (Track)" on page 321.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Parameters:

<State> ON | OFF

*RST: OFF

MEASurement<m>:TRACk:DATA:HEADer?

Returns the header of the track.

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Usage: Query only

MEASurement<m>:TRACk:DATA:STYPe?

Returns the data type: TRK (track)

Suffix:

<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Usage: Query only

MEASurement<m>:TRACk:DATA[:VALues]?

Returns the data of track points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

Suffix:
<m> 1..10
See "Measurement selection: MEASurement<m>" on page 1018.

Usage: Query only

16.17.10 MIL-1553 (Option R&S RTE-K6)

16.17.10.1 Configuration

BUS<m>:MILStd:SOURce <DataSource>

Sets the channel for the signal source.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<DataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
*RST: C1W1

BUS<m>:MILStd:MAXResponse:BITS <MaxResponseTime>

Sets the value for the maximum response time.

See also: `BUS<m>:MILStd:MAXResponse:SELect`.

Suffix:
<m> 1..4

Parameters:

<MaxResponseTime> Range: 2E-6 to 262E-6
Increment: 100E-9
*RST: 14E-6
Default unit: s

BUS<m>:MILStd:MAXResponse:SELect <MaxResponseSelect>

Enables the detection of the maximum response time between the last bit of a word and the following status word sync during decoding.

To specify the maximum response time, use `BUS<m>:MILStd:MAXResponse:BITS` on page 1348.

Suffix:

<m> 1..4

Parameters:

<MaxResponseSelect> ON | OFF
*RST: ON

BUS<m>:MILStd:MINGap:SELect <MinGapSelect>

Enables the detection of the minimum idle time between the last bit of a message and the following command word sync during decoding.

To specify the minimum gap, use `BUS<m>:MILStd:MINGap:BITS`.

Suffix:

<m> 1..4

Parameters:

<MinGapSelect> ON | OFF
*RST: ON

BUS<m>:MILStd:MINGap:BITS <MinGapTime>

Sets a value for the minimum gap.

See also: `BUS<m>:MILStd:MINGap:SELect`.

Suffix:

<m> 1..4

Parameters:

<MinGapTime> Range: 2E-6 to 262E-6
Increment: 100E-9
*RST: 4E-6
Default unit: s

BUS<m>:MILStd:POLarity <Polarity>

Selects the wire on which the bus signal is measured.

Suffix:

<m> 1..4

Parameters:

<Polarity> NORMal | INVerted

*RST: NORMal

BUS<m>:MILStd:PRESet <Preset>

Sets the default threshold voltage.

Suffix:

<m> 1..4

Parameters:

<Preset> V05 | V2 | V5 | V7 | MAN

*RST: V5

BUS<m>:MILStd:THReshold:HIGH <ThresholdHigh>

Sets the lower threshold level of the signal.

Suffix:

<m> 1..4

Parameters:

<ThresholdHigh> Range: 0 to 14
Increment: 0.1
*RST: 5
Default unit: V

BUS<m>:MILStd:THReshold:LOW <ThresholdLow>

Sets the lower threshold level of the signal.

Suffix:

<m> 1..4

Parameters:

<ThresholdLow> Range: -14 to 0
Increment: 0.1
*RST: -5
Default unit: V

16.17.10.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:MILStd:TYPE <Type>

Sets the trigger type for MIL-1553 analysis.

Parameters:

<Type> STYPe | WTYPe | DATA | CDST | CMD | STATword | ERR

STYPe
SyncTYPe: triggers on a sync impulse.

WTYPe
WordTYPe: triggers on the selected word type.

DATA
Triggers on a data word that can be specified.

CDST
CommanDSTatus word: triggers on a command word or on a status word that can be specified.

CMD
CoMmanD word: triggers on a command word or on a status word that can be specified.

STATword
STATus word: triggers on a status word that can be specified.

ERR
ERRor: triggers on any combination of protocol errors.

*RST: STYPe

TRIGger<m>:MILStd:DATA:RCONdition <Operator>
TRIGger<m>:MILStd:CMD:RCONdition <Operator>
TRIGger<m>:MILStd:CDST:RCONdition <Operator>

Sets the operator to define a remote terminal address:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `TRIGger<m>:MILStd:CDST:RMIN`.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MILStd:CDST:RMIN` and `TRIGger<m>:MILStd:CDST:RMAX`.

*RST: EQUal

TRIGger<m>:MILStd:DATA:RMIN <PatternMin>
TRIGger<m>:MILStd:CMD:RMIN <PatternMin>
TRIGger<m>:MILStd:CDST:RMIN <PatternMin>

Specify a remote terminal address or set the the start value of a remote terminal address range:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<PatternMin> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:DATA:RMAX <PatternMax>
TRIGger<m>:MILStd:CMD:RMAX <PatternMax>
TRIGger<m>:MILStd:CDST:RMAX <PatternMax>

Set the end value of a data range if `TRIGger<m>:MILStd:CDST:RCONdition` is set to `INRange` or `OORange`:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<PatternMax> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CMD:CCONdition <Operator>

Sets the operator to set a specific data word count or mode code pattern.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `TRIGger<m>:MILStd:CMD:CMIN`.

INRange | OORange
In range/Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:MILStd:CMD:CMIN` and `TRIGger<m>:MILStd:CMD:CMAX`.

*RST: EQUal

TRIGger<m>:MILStd:CMD:CMAX <PatternMax>

Sets the end value of a data word count/mode code pattern if `TRIGger<m>:MILStd:CMD:CCONdition` is set to `INRange` or `OORange`.

Parameters:

<PatternMax> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CMD:CMIN <PatternMin>

Specifies a data word count/mode code pattern or sets the the start value of a pattern range.

Parameters:

<PatternMin> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CMD:SCONdition <Operator>

Sets the operator to set a specific subaddress/mode pattern.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with`TRIGger<m>:MILStd:CMD:SMIN`.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MILStd:CMD:SMIN` and `TRIGger<m>:MILStd:CMD:SMAX`.

*RST: EQUal

TRIGger<m>:MILStd:CMD:SMAX <PatternMax>

Sets the end value of the subaddress range if `TRIGger<m>:MILStd:CMD:SCONdition` is set to `INRange` or `OORange`.

Parameters:

<PatternMax> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CMD:SMIN <PatternMin>

Specifies a subaddress or sets the the start value of a subaddress range.

Parameters:

<PatternMin> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CMD:TR <Flag>

Triggers on a transmission mode.

Parameters:

<Flag> ONE | ZERO | DC

ONE
Transmit direction.

ZERO
Receive direction.

DC
Either directions.

*RST: DC

TRIGger<m>:MILStd:CDST:ICONdition <Operator>

Sets the operator to set a specific info for the 9th to 19th bit of a command or status word.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `TRIGger<m>:MILStd:CDST:IMIN`.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MILStd:CDST:IMIN` and `TRIGger<m>:MILStd:CDST:IMAX`.

*RST: EQUal

TRIGger<m>:MILStd:CDST:IMAX <PatternMax>

Sets the end value of the info range if `TRIGger<m>:MILStd:CDST:ICONdition` is set to `INRange`.

Parameters:

<PatternMax> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:CDST:IMIN <PatternMin>

Specifies an info or sets the the start value of an info range.

Parameters:

<PatternMin> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:DATA:DCONdition <Operator>

Sets the operator to set a specific data pattern.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `TRIGger<m>:MILStd:DATA:DMIN`.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MILStd:DATA:DMIN` and `TRIGger<m>:MILStd:DATA:DMAX`.

*RST: EQUal

TRIGger<m>:MILStd:DATA:DMAX <PatternMax>

Sets the end value of a data pattern range if `TRIGger<m>:MILStd:DATA:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<PatternMax> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:DATA:DMIN <PatternMin>

Specifies a data pattern or sets the the start value of a data pattern range.

Parameters:

<PatternMin> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MILStd:DATA:ICONdition <Operator>

Sets the operator to set a specific range within this series of the data words that is considered for the analysis.

Parameters:

<Operator> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal| LTHan | LETHan | GTHan | GETHan
Equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with TRIGger<m>:MILStd:DATA:IMIN.

INRange = RANGe
In range: set the minimum and maximum value of the range with TRIGger<m>:MILStd:DATA:IMIN and TRIGger<m>:MILStd:DATA:IMAX.

*RST: INRange

TRIGger<m>:MILStd:DATA:IMAX <Max>

Sets the end value of a data word series index range if TRIGger<m>:MILStd:DATA:ICONdition is set to INRange.

Parameters:

<Max> Range: 1 to 32
Increment: 1
*RST: 32

TRIGger<m>:MILStd:DATA:IMIN <Min>

Specifies an index or sets the the start value of a data word series index range.

Parameters:

<Min> Range: 1 to 32
Increment: 1
*RST: 1

TRIGger<m>:MILStd:ERRor:MANChester <ManCodingError>

Triggers on an error of the manchester coding if TRIGger<m>:MILStd:TYPE is set to ERRor.

Parameters:

<ManCodingError> ON | OFF

*RST: ON

TRIGger<m>:MILStd:ERRor:PARity <ParityError>

Triggers on even parity if TRIGger<m>:MILStd:TYPE is set to ERRor.

Parameters:

<ParityError> ON | OFF

*RST: ON

TRIGger<m>:MILStd:ERRor:SYNC <SyncError>

Triggers on an error of the synchronization if TRIGger<m>:MILStd:TYPE is set to ERRor.

Parameters:

<SyncError>	ON | OFF	
	*RST:	ON

TRIGger<m>:MILStd:MAXResponse:BITS <MaxResponseTime>

Sets the value for the maximum response time to be triggered on if TRIGger<m>:MILStd:TYPE is set to ERRor

Enable the error trigger on maximum response time with TRIGger<m>:MILStd:MAXResponse:SELect.

Parameters:

<MaxResponseTime>	Range:	2E-6 to 262E-6
	Increment:	100E-9
	*RST:	14E-6
	Default unit:	s

TRIGger<m>:MILStd:MAXResponse:SELect <MaxResponseSelect>

Enables the trigger on exceeding the maximum response time if TRIGger<m>:MILStd:TYPE is set to ERRor. You can set the maximum time with: TRIGger<m>:MILStd:MAXResponse:BITS.

Parameters:

<MaxResponseSelect>	ON | OFF	
	*RST:	ON

TRIGger<m>:MILStd:MINGap:BITS <MinGapTime>

Sets the value for the minimum gap to be triggered on if TRIGger<m>:MILStd:TYPE is set to ERRor.

Parameters:

<MinGapTime>	Range:	2E-6 to 262E-6
	Increment:	100E-9
	*RST:	4E-6
	Default unit:	s

TRIGger<m>:MILStd:MINGap:SELect <MinGapSelect>

Enables triggering when the minimum gap is out of range if TRIGger<m>:MILStd:TYPE is set to ERRor. You can set the minimum gap with: TRIGger<m>:MILStd:MINGap:BITS.

Parameters:

<MinGapSelect>	ON | OFF	
	*RST:	ON

TRIGger<m>:MILStd:STATus:BCReceived <Flag>

Triggers on the state of the broadcast command received bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<Flag>	ONE | ZERO | DC	
	*RST:	DC

TRIGger<m>:MILStd:STATus:BUSY <Flag>

Triggers on the state of the busy bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<Flag>	ONE | ZERO | DC	
	*RST:	DC

TRIGger<m>:MILStd:STATus:DBCaccept <Flag>

Triggers on the state of the dynamic bus control accept bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<Flag>	ONE | ZERO | DC	
	*RST:	DC

TRIGger<m>:MILStd:STATus:INSTrument <Flag>

Triggers on the state of the instrumentation bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<Flag>	ONE | ZERO | DC	
	*RST:	ZERO

TRIGger<m>:MILStd:STATus:MERRor <Flag>

Triggers on the state of the message error bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<Flag>	ONE | ZERO | DC	
	*RST:	DC

TRIGger<m>:MILStd:STATus:SREQuest <Flag>

Triggers on the state of the the service request bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<Flag>	ONE | ZERO | DC
	*RST: DC

TRIGger<m>:MILStd:STATus:SUBSystem <Flag>

Triggers on the state of the subsystem flag bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<Flag>	ONE | ZERO | DC
	*RST: DC

TRIGger<m>:MILStd:STATus:TERMinal <Flag>

Triggers on the state of theterminal flag bit of the status word if `TRIGger<m>:MILStd:TYPE` is set to `STATword`.

Parameters:

<Flag>	ONE | ZERO | DC
	*RST: DC

TRIGger<m>:MILStd:TPSPecifier <TypeSpecifier>

Sets the sync impulse/ word type to be triggered on.

Parameters:

<TypeSpecifier>	CSTatus | DATA | ALL
	CSTatus: command/status word
	*RST: ALL

16.17.10.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1165
- `BUS<m>:SYMBols` on page 1165

BUS<m>:MILStd:WCOunt?

Returns the number of decoded words.

Suffix:

<m> 1..4

Return values:

<Count>

Usage: Query only

BUS<m>:MILStd:WORD<n>:DATA?

Return the data bytes of the specified word.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<FrameDataPattern> 16-bit data of the specified word as a 2-byte bit pattern (B1, B2).
The first byte B1 is the most significant byte.

Example:

```
BUS:MILStd:WORD4:DATA?
<-- #H08,#H49
```

Usage: Query only

BUS<m>:MILStd:WORD<n>:INFO?

Returns the info value for the specified word.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<FrameInfo> Range: 0 to 2047
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:MILStd:WORD<n>:RTADdress?

Returns the RT address for the selected word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<FrameRta>	Range:	0 to 31
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:MILStd:WORD<n>:STARt?

Return the start time of the selected word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<FrameStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

BUS<m>:MILStd:WORD<n>:STATus?

Returns the overall state of the selected word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:
<FrameState> OK | SYNC | MANC | PAR | GAP | RT

OK: the word is valid.
SYNC: synchronization error occured.
MANC: manchester coding error occured.
PAR: parity error occured.
GAP: timing gap error occured.
RT: remote terminal error occured.

*RST: OK

Usage: Query only

BUS<m>:MILStd:WORD<n>:STOP?

Return the stop time of the selected word.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:
<FrameStop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:MILStd:WORD<n>:SYMBol?

Returns the label name of the word ID.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:
<Translation>

Usage: Query only

BUS<m>:MILStd:WORD<n>:TYPE?

Returns the type of the specified word.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<FrameType> UNKNown | DATA | CMD | STAT | CMST | IM

CMD: command word
CMST: command/status word
IM: inter message. Shows if there are gap errors or response timeout.

*RST: DATA

Usage: Query only

16.17.10.4 Search Settings

The search remote commands are very similar to the trigger commands. Therefore, search coommands are described in short, for more details, see the corresponding trigger command in Chapter 16.17.10.2, "Trigger", on page 1351.

SEARch:TRIGger:MILStd:TYPE <SearchName>,<Type>
SEARch:TRIGger:MILStd:TYPE? <SearchName>

Sets the event to be searched for.

Parameters:

<Type> STYPe | WTYPe | DATA | CDST | CMD | STATword | ERR

See TRIGger<m>:MILStd:TYPE on page 1352

*RST: STYPe

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MILStd:DATA:RCONdition <SearchName>,<Operator>
SEARch:TRIGger:MILStd:DATA:RCONdition? <SearchName>
SEARch:TRIGger:MILStd:CMD:RCONdition <SearchName>,<Operator>
SEARch:TRIGger:MILStd:CMD:RCONdition? <SearchName>
SEARch:TRIGger:MILStd:CDST:RCONdition <SearchName>,<Operator>
SEARch:TRIGger:MILStd:CDST:RCONdition? <SearchName>

Set the operator to define a remote terminal address:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with SEARch:TRIGger:MILStd:CDST:RMIN.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with SEARch:TRIGger:MILStd:CDST:RMIN and SEARch:TRIGger:MILStd:CDST:RMAX on page 1367.

*RST: EQUal

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:MILStd:DATA:RMIN <SearchName>,<PatternMin>
SEARch:TRIGger:MILStd:DATA:RMIN? <SearchName>
SEARch:TRIGger:MILStd:CMD:RMIN <SearchName>,<PatternMin>
SEARch:TRIGger:MILStd:CMD:RMIN? <SearchName>
SEARch:TRIGger:MILStd:CDST:RMIN <SearchName>,<PatternMin>
SEARch:TRIGger:MILStd:CDST:RMIN? <SearchName>

Specify a remote terminal address or set the the start value of a remote terminal address range:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<PatternMin> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MILStd:DATA:RMAX <SearchName>,<PatternMax>
SEARch:TRIGger:MILStd:DATA:RMAX? <SearchName>
SEARch:TRIGger:MILStd:CMD:RMAX <SearchName>,<PatternMax>
SEARch:TRIGger:MILStd:CMD:RMAX? <SearchName>
SEARch:TRIGger:MILStd:CDST:RMAX <SearchName>,<PatternMax>
SEARch:TRIGger:MILStd:CDST:RMAX? <SearchName>

Set the end value of a data range if `SEARch:TRIGger:MILStd:CDST:RCONdition` is set to `INRange` or `OORange`:

- DATA: for data words
- CMD: for command words
- CDST: for status words

Parameters:

<PatternMax> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MILStd:CDST:ICONdition <SearchName>,<Operator>
SEARch:TRIGger:MILStd:CDST:ICONdition? <SearchName>
SEARch:TRIGger:MILStd:CMD:CCONdition <SearchName>,<Operator>
SEARch:TRIGger:MILStd:CMD:CCONdition? <SearchName>
SEARch:TRIGger:MILStd:CMD:SCONdition <SearchName>,<Operator>
SEARch:TRIGger:MILStd:CMD:SCONdition? <SearchName>
SEARch:TRIGger:MILStd:DATA:DCONdition <SearchName>,<Operator>
SEARch:TRIGger:MILStd:DATA:DCONdition? <SearchName>

Sets the operator for the corresponding search:

- CDST:ICON - specific info for the 9th to 19th bit of a command or status word.
- CMD:CCON - specific data word count or mode code pattern in a command word
- CMD:SCON - specific subaddress/mode pattern in a command word
- DATA:DCON - data pattern in a data word

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MILStd:CDST:IMIN <SearchName>,<PatternMin>
SEARch:TRIGger:MILStd:CDST:IMIN? <SearchName>
SEARch:TRIGger:MILStd:CMD:CMIN <SearchName>,<PatternMin>
SEARch:TRIGger:MILStd:CMD:CMIN? <SearchName>
SEARch:TRIGger:MILStd:CMD:SMIN <SearchName>,<PatternMin>
SEARch:TRIGger:MILStd:CMD:SMIN? <SearchName>
SEARch:TRIGger:MILStd:DATA:DMIN <SearchName>,<PatternMin>
SEARch:TRIGger:MILStd:DATA:DMIN? <SearchName>

Sets the pattern or the start value of a pattern range for the corresponding search:

- CDST:IMIN - specific info for the 9th to 19th bit of a command or status word.
- CMD:CMIN - specific data word count or mode code pattern in a command word
- CMD:SMIN - specific subaddress/mode pattern in a command word
- DATA:DMIN - data pattern in a data word

Parameters:

<PatternMin>

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MILStd:CDST:IMAX <SearchName>,<PatternMax>
SEARch:TRIGger:MILStd:CDST:IMAX? <SearchName>
SEARch:TRIGger:MILStd:CMD:CMAX <SearchName>,<PatternMax>
SEARch:TRIGger:MILStd:CMD:CMAX? <SearchName>

SEARch:TRIGger:MILStd:CMD:SMAX <SearchName>,<PatternMax>
SEARch:TRIGger:MILStd:CMD:SMAX? <SearchName>
SEARch:TRIGger:MILStd:DATA:DMAX <SearchName>,<PatternMax>
SEARch:TRIGger:MILStd:DATA:DMAX? <SearchName>

Sets the end value of a pattern range for the corresponding search:

- CDST:IMAX - specific info for the 9th to 19th bit of a command or status word.
- CMD:CMAX - specific data word count or mode code pattern in a command word
- CMD:SMAX - specific subaddress/mode pattern in a command word
- DATA:DMAX - data pattern in a data word

Parameters:
<PatternMax>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:DATA:ICONdition <SearchName>,<Operator>
SEARch:TRIGger:MILStd:DATA:ICONdition? <SearchName>

Sets the operator to set a range within a series of the data words that is considered for the search.

Parameters:

<Operator>	EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe INRange = RANGe *RST: INRange

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:DATA:IMIN <SearchName>,<Min>
SEARch:TRIGger:MILStd:DATA:IMIN? <SearchName>

Specifies an index or sets the the start value of a data word series index range.

Parameters:

<Min>	Range:	1 to 32
	Increment:	1
	*RST:	1

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:DATA:IMAX <SearchName>,<Max>
SEARch:TRIGger:MILStd:DATA:IMAX? <SearchName>

Sets the end value of a data word series index range if the operator is set to `INRange`.

Parameters:

<Max>	Range:	1 to 32
	Increment:	1
	*RST:	32

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:CMD:TR <SearchName>,<Flag>
SEARch:TRIGger:MILStd:CMD:TR? <SearchName>

Searches for a transmission mode.

Parameters:

<Flag>	ONE | ZERO | DC	
	*RST:	DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:ERRor:MANChester <SearchName>,<ManCodingError>
SEARch:TRIGger:MILStd:ERRor:MANChester? <SearchName>
SEARch:TRIGger:MILStd:ERRor:PARity <SearchName>,<ParityError>
SEARch:TRIGger:MILStd:ERRor:PARity? <SearchName>
SEARch:TRIGger:MILStd:ERRor:SYNC <SearchName>,<SyncError>
SEARch:TRIGger:MILStd:ERRor:SYNC? <SearchName>
SEARch:TRIGger:MILStd:ERRor:TIMing <SearchName>,<MinGapSelect>
SEARch:TRIGger:MILStd:ERRor:TIMing? <SearchName>

Enables search for errors if `SEARch:TRIGger:MILStd:TYPE` is set to `ERRor`.

- MANChester: error of the manchester coding
- PARity: even parity (parity error)
- SYNC: error of the synchronization
- TIMing: Minimum gap is out of range

Parameters:

<SyncError>, <ParityError>, <ManCodingError>, <MinGapSelect>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:STATus:BCReceived <SearchName>,<Flag>
SEARch:TRIGger:MILStd:STATus:BCReceived? <SearchName>
SEARch:TRIGger:MILStd:STATus:BUSY <SearchName>,<Flag>
SEARch:TRIGger:MILStd:STATus:BUSY? <SearchName>

SEARch:TRIGger:MILStd:STATus:DBCaccept <SearchName>,<Flag>
SEARch:TRIGger:MILStd:STATus:DBCaccept? <SearchName>
SEARch:TRIGger:MILStd:STATus:INSTrument <SearchName>,<Flag>
SEARch:TRIGger:MILStd:STATus:INSTrument? <SearchName>
SEARch:TRIGger:MILStd:STATus:MERRor <SearchName>,<Flag>
SEARch:TRIGger:MILStd:STATus:MERRor? <SearchName>
SEARch:TRIGger:MILStd:STATus:SREQuest <SearchName>,<Flag>
SEARch:TRIGger:MILStd:STATus:SREQuest? <SearchName>
SEARch:TRIGger:MILStd:STATus:SUBSystem <SearchName>,<Flag>
SEARch:TRIGger:MILStd:STATus:SUBSystem? <SearchName>
SEARch:TRIGger:MILStd:STATus:TERMinal <SearchName>,<Flag>
SEARch:TRIGger:MILStd:STATus:TERMinal? <SearchName>

Specifies the values (0, 1, X) of the status flags if `SEARch:TRIGger:MILStd:TYPE` is set to `STATword`.

Parameters:

<Flag>	ONE | ZERO | DC
	*RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MILStd:TPSPecifier <SearchName>,<TypeSpecifier>
SEARch:TRIGger:MILStd:TPSPecifier? <SearchName>

Sets the sync impulse/ word type to be searched for.

Parameters:

<TypeSpecifier>	CSTatus | DATA | ALL
	CSTatus: command/status word
	*RST: ALL

Parameters for setting and query:
<SearchName>

16.17.10.5 Search Results

The search on decoded MIL-1553 data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 16.17.10.3, "Decode Results", on page 1361.

SEARch:RESult:MILStd:WCOunt <SearchName>

Setting parameters:
<SearchName>

Return values:
<Count>

SEARch:RESult:MILStd:WORD<m>:TYPE? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameType> UNKNown | DATA | CMD | STAT | CMST | IM
*RST: DATA

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:STATus? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameState> OK | SYNC | MANC | PAR | GAP | RT
*RST: OK

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:STARt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:SYMBol? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Translation>

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:RTADdress? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameRta> Range: 0 to 31
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:DATA? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameDataPattern>

Usage: Query only

SEARch:RESult:MILStd:WORD<m>:INFO? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameInfo> Range: 0 to 2047
Increment: 1
*RST: 0

Usage: Query only

16.17.11 ARINC 429 (Option R&S RTE-K7)

16.17.11.1 Configuration

BUS<m>:ARINc:SOURce <DataSource>

Sets the channel for the signal source.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C1W1

BUS<m>:ARINc:BRValue <BitRateValue>

Sets the number of transmitted bits per second.

Suffix:

<m>	1..4

Parameters:

<BitRateValue>	Range: 10000 to 110000 Increment: 100 *RST: 100000 Default unit: bps

BUS<m>:ARINc:BRMode <BitRateMode>

Sets the bit rate mode to high or low speed.

Suffix:

<m>	1..4

Parameters:

<BitRateMode>	HIGH | LOW *RST: HIGH

BUS<m>:ARINc:MAXGap:SELect <MaxGapSelect>

Enables the detection of the maximum gap time during decoding.

To specify the minimum gap time `BUS<m>:ARINc:MINGap:BITS`.

Suffix:

<m>	1..4

Parameters:

<MaxGapSelect>	ON | OFF *RST: OFF

BUS<m>:ARINc:MAXGap:BITS <MaxGapBits>

Sets the value for the maximum gap between two words.

See also: `BUS<m>:ARINc:MAXGap:SELect`

Suffix:

<m>	1..4

Parameters:

<MaxGapBits>
Range: 0 to 1000
Increment: 1
*RST: 100
Default unit: bit

BUS<m>:ARINc:MINGap:SELect <MinGapSelect>

Enables the detection of the minimum idle time between two words during decoding.

To specify the minimum gap, use`BUS<m>:ARINc:MINGap:BITS`.

Suffix:

<m>	1..4

Parameters:

<MinGapSelect> ON | OFF
*RST: ON

BUS<m>:ARINc:MINGap:BITS <MinGapBits>

Sets a value for the minimum timing gap between two words.

See also: `BUS<m>:ARINc:MINGap:SELect` on page 1376.

Suffix:

<m>	1..4

Parameters:

<MinGapBits>
Range: 0 to 100
Increment: 1
*RST: 4
Default unit: bit

BUS<m>:ARINc:POLarity <Polarity>

Sets the wire on which the bus signal is measured.

Suffix:

<m>	1..4

Parameters:

<Polarity> ALEG | BLEG
*RST: ALEG

BUS<m>:ARINc:PRESet <Preset>

Sets the default threshold voltage.

Suffix:

<m>	1..4

Parameters:

<Preset>	V25 | V5 | MAN
	*RST: V5

BUS<m>:ARINc:THReshold:HIGH <ThresholdHigh>

Sets the high threshold level of the signal.

Suffix:

<m>	1..4

Parameters:

<ThresholdHigh>	Range:	0 to 12
	Increment:	0.1
	*RST:	5
	Default unit:	V

BUS<m>:ARINc:THReshold:LOW <ThresholdLow>

Sets the low threshold level of the signal.

Suffix:

<m>	1..4

Parameters:

<ThresholdLow>	Range:	-12 to 0
	Increment:	0.1
	*RST:	-5
	Default unit:	V

16.17.11.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:ARINc:TYPE <Type>

Sets the trigger type for ARINC 429 analysis.

Parameters:

<Type> STARt | STOP | LABel | ERRor

*RST: STARt

TRIGger<m>:ARINc:DATA:CONDition <Operator>

Sets the condition for the data. You can define an exact data patterm or a data range.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with `TRIGger<m>:ARINc:DATA:MIN`.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:ARINc:DATA:MIN` and `TRIGger<m>:ARINc:DATA:MAX`.

*RST: EQUal

TRIGger<m>:ARINc:DATA:MIN <Min>

Defines the minimum bit pattern for the data.

Parameters:

<Min> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:ARINc:DATA:MAX <Max>

Sets the end value of a data pattern if TRIGger<m>:ARINc:DATA:CONDition is set to INRange or OORange.

Parameters:
<Max>

TRIGger<m>:ARINc:ERRor:CODing <Error>

Enables triggering when a coding error occurs.

Parameters:

<Error>	ON | OFF
	*RST: ON

TRIGger<m>:ARINc:ERRor:PARity <Error>

Enables triggering when a parity error occurs.

Parameters:

<Error>	ON | OFF
	*RST: ON

TRIGger<m>:ARINc:LABel:CONDition <Operator>

Sets the condition for the label. You can define an exact label or a label range.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set withTRIGger<m>:ARINc:LABel:MIN.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range withTRIGger<m>:ARINc:LABel:MIN and TRIGger<m>:ARINc:LABel:MAX.

*RST: EQUal

TRIGger<m>:ARINc:LABel:MIN <Min>

Defines the minimum bit pattern for the label.

Parameters:

<Min> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:ARINc:LABel:MAX <Max>

Sets the end value of a label pattern if TRIGger<m>:ARINc:LABel:CONDition is set to INRange or OORange.

Parameters:

<Max>	Numeric or string pattern, see TRIGger<m>:ARINc:LABel:MIN

TRIGger<m>:ARINc:MINGap:SELect <MinGapSelect>

Enables triggering when the minimum gap is out of range. You can set the minimum gap with: TRIGger<m>:ARINc:MINGap:BITS.

Parameters:

<MinGapSelect>	ON | OFF *RST: ON

TRIGger<m>:ARINc:MINGap:BITS <MinGapBits>

Sets the value for the minimum gap to be triggered on.

Parameters:

<MinGapBits>	Range: 0 to 100 Increment: 1 *RST: 4 Default unit: bit

TRIGger<m>:ARINc:MAXGap:SELect <MaxGapSelect>

Enables triggering when the maximum gap is out of range. You can set the maximum gap with: TRIGger<m>:ARINc:MAXGap:BITS.

Parameters:

<MaxGapSelect>	ON | OFF *RST: OFF

TRIGger<m>:ARINc:MAXGap:BITS <MaxGapBits>

Sets the value for the maximum gap to be triggered on.

Parameters:

<MaxGapBits>	Range: 0 to 1000 Increment: 1 *RST: 100 Default unit: bit

TRIGger<m>:ARINc:SDI <SDI>

Sets the source/destination identifier (SDI) bits.

Parameters:
<SDI>

TRIGger<m>:ARINc:SSM <SSM>

Sets the sign/status matrix (SSM) bits.

Parameters:
<SSM>

16.17.11.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1165
- `BUS<m>:SYMBols` on page 1165

BUS<m>:ARINc:WCOunt?

Returns the number of decoded words.

Suffix:

<m>	1..4

Return values:
<Count>

Usage: Query only

BUS<m>:ARINc:WORD<n>:DATA?

Returns the data of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameData> 19-bit data field of the word as an integer

Range: 0 to 0
Increment: 1
*RST: 0

Example:
```
BUS:ARINc:WORD3:DATA?
<-- 148035
```

Usage: Query only

BUS<m>:ARINc:WORD<n>:LABel?

Returns the label of the specified word.

Suffix:

<m> 1..4

<n> *

Return values:

<FrameLabel> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:ARINc:WORD<n>:PATTern?

Returns all 32 bits of the specified word.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *

Return values:

<FrameData> Comma-separated list of 4 bytes in big endian order. The format of each byte is defined by FORMat:BPATtern.

Example:
```
BUS2:ARINc:WORD3:PATTern?
--> #H75,#H11,#H55,#H82
FORMat:BPATtern DEC
BUS2:ARINc:WORD3:PATTern?
--> 117,17,85,130
```

Usage: Query only

BUS<m>:ARINc:WORD<n>:SDI?

Returns the source/destination identifier (SDI) bits of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameType> Range: 0 to 3
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:ARINc:WORD<n>:SSM?

Returns the sign/status matrix(SSM) bits of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameInfo> Range: 0 to 3
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:ARINc:WORD<n>:STARt?

Returns the start time of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:ARINc:WORD<n>:STATe?

Returns the overall state of the specified word.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the word.

Return values:

<FrameState> OK | CODE | GAP | PAR

CODE: coding error occured.
GAP: timing gap error occured.
PAR: parity error occured.

*RST: OK

Usage: Query only

BUS<m>:ARINc:WORD<n>:STOP?

Returns the end time of the specified word.

Suffix:

<m> 1..4

<n> *

Return values:

<FrameStop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:ARINc:WORD<n>:SYMBol?

Returns the label name of the word ID.

Suffix:

<m> 1..4

<n> *

Return values:

<Translation>

Usage: Query only

16.17.11.4 Search Settings

SEARch:TRIGger:ARINc:TYPE <SearchName>,<Type>
SEARch:TRIGger:ARINc:TYPE? <SearchName>

Sets the search type.

Parameters:

<Type> STARt | STOP | LABel | ERRor

*RST: STARt

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:ARINc:LABel:CONDition <SearchName>,<Operator>
SEARch:TRIGger:ARINc:LABel:CONDition? <SearchName>
SEARch:TRIGger:ARINc:DATA:CONDition <SearchName>,<Operator>
SEARch:TRIGger:ARINc:DATA:CONDition? <SearchName>

Set the condition for the label or data, respectively. You can define an exact value or a value range

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding SEARch:TRIGger:ARINc:...:MIN command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range. with`TRIGger<m>:ARINc:LABel:MIN` and `TRIGger<m>:ARINc:LABel:MAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:ARINc:LABel:MIN <SearchName>,<Min>
SEARch:TRIGger:ARINc:LABel:MIN? <SearchName>
SEARch:TRIGger:ARINc:DATA:MIN <SearchName>,<Min>
SEARch:TRIGger:ARINc:DATA:MIN? <SearchName>

Specifies a label or data bit pattern, or sets the the start value of a pattern range.

Parameters:
<Min> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName> String parameter

SEARch:TRIGger:ARINc:LABel:MAX <SearchName>,<Max>
SEARch:TRIGger:ARINc:LABel:MAX? <SearchName>
SEARch:TRIGger:ARINc:DATA:MAX <SearchName>,<Max>
SEARch:TRIGger:ARINc:DATA:MAX? <SearchName>

Set the end value of a label or data pattern if the condition is set to `INRange` or `OORange`.

Parameters:
<Max> Numeric or string pattern, see `SEARch:TRIGger:ARINc:LABel:MIN`

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:ARINc:SDI <SearchName>,<SDI>
SEARch:TRIGger:ARINc:SDI? <SearchName>

Sets the source/destination identifier (SDI) bits.

Parameters:
<SDI>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:ARINc:SSM <SearchName>,<SSM>
SEARch:TRIGger:ARINc:SSM? <SearchName>

Sets the sign/status matrix (SSM) bits.

Parameters:
<SSM>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:ARINc:ERRor:CODing <SearchName>,<Error>
SEARch:TRIGger:ARINc:ERRor:CODing? <SearchName>

Enables the search for coding errors.

Parameters:

<Error> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:ARINc:ERRor:PARity <SearchName>,<Error>
SEARch:TRIGger:ARINc:ERRor:PARity? <SearchName>

Enables the search for parity errors.

Parameters:

<Error> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:ARINc:ERRor:TIMing <SearchName>,<MinGapSelect>
SEARch:TRIGger:ARINc:ERRor:TIMing? <SearchName>

Enables the search for timing errors, when the minimum gap is out of range.

Parameters:

<MinGapSelect> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

16.17.11.5 Search Results

The search on decoded ARINC 429 data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 16.17.11.3, "Decode Results", on page 1381.

SEARch:RESult:ARINc:WORD<m>:LABel? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameRta> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:PATTern? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameDataPattern>

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:DATA? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameData> Range: 0 to 0
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:SSM? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameInfo> Range: 0 to 3
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:SYMBol? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Translation>

Usage: Query only

SEARch:RESult:ARINc:WCOunt <Key>

Setting parameters:

<Key>

Return values:

<Count>

SEARch:RESult:ARINc:WORD<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:SDI? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameType>	Range:	0 to 3
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:STATe? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameState> OK | CODE | GAP | PAR

*RST: OK

Usage: Query only

SEARch:RESult:ARINc:WORD<m>:STARt? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

16.17.12 Ethernet (Option R&S RTE-K8)

16.17.12.1 Configuration

In all `BUS<m>:ETHernet` commands, the suffix <m> selects the serial bus.

BUS<m>:ETHernet:VARiant <Variant>

Selects the Ethernet protocol variant and transmission speed.

Suffix:

<m> 1..4

Parameters:

<Variant> B10T | B100TX | B100tx

B10T
Ethernet protocol variant 10BASE-T (10 Mbit/s)

B100TX = B100tx
Ethernet protocol variant 100BASE-TX (100 Mbit/s)

*RST: B10T

BUS<m>:ETHernet:SOURce <DataSource>

Selects the source channel for the data signal. For triggering on a serial bus, analog channels "C1"–"C4" are required. Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:

<m> 1..4

Parameters:

<DataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

See Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: NONE

BUS<m>:ETHernet:POLarity <Polarity>

Defines the polarity of the data signal. This setting is only available in 10BASE-T.

Suffix:

<m> 1..4

Parameters:

<Polarity> NORMal | INVert

NORMal
Normal (non-inverted) data signal polarity

INVert
Inverted data signal polarity

*RST: NORMal

BUS<m>:ETHernet:THReshold:HIGH <ThresholdUpper>

Sets the upper threshold value for the signal digitization. If the signal value is higher than the this threshold, the signal state is considered high.

Suffix:

<m>	1..4

Parameters:

<ThresholdUpper>	Range: 0 to 10 Increment: 0.1 *RST: 1.25 Default unit: V

BUS<m>:ETHernet:THReshold:LOW <ThresholdLower>

Sets the lower threshold value for the signal digitization. If the signal value is below this threshold, the signal state is considered low.

Suffix:

<m>	1..4

Parameters:

<ThresholdLower>	Range: -10 to 0 Increment: 0.1 *RST: -1.25 Default unit: V

BUS<m>:ETHernet:PRESet <ThresholdPreset>

Sets the thresholds to predefined or individually definable voltage levels.

Suffix:

<m>	1..4

Parameters:

<ThresholdPreset> T0 | T100 | TX0 | TX100 | MAN

T0
Sets the thresholds to the default values for 10BASE-T (0 meters): upper threshold to 1.25 V, lower threshold to -1.25 V

T100
Sets the thresholds to the default values for 10BASE-T (100 meters): upper threshold to 0.75 V, lower threshold to -0.75 V

TX0
Sets the thresholds to the default values for 100BASE-TX (0 meters): upper threshold to 0.5 V, lower threshold to -0.5 V

TX100
Sets the thresholds to the default values for 100BASE-TX (100 meters): upper threshold to 0.35 V, lower threshold to -0.35 V

MAN
Allows to set individual threshold voltage levels

*RST: T0

BUS<m>:ETHernet:BITRate <BitRateValue>

Sets the bit rate value that defines the transmission speed in bits per second.

Suffix:

<m> 1..4

Parameters:

<BitRateValue> Range: 10000 to 150000000
Increment: 1000
*RST: 10000000
Default unit: bps

16.17.12.2 Decode Results

In all `BUS<m>:ETHernet:WORD<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the word number in the decode table.

As an example, with reference to Table 12-11, a set of query commands for bus #1 and word #1 is shown in the following, together with examples for results of these queries:

- `BUS1:ETH:WCOunt?` !2
- `BUS1:ETH:WORD1:STATe?` !OK
- `BUS1:ETH:WORD1:STARt?` !-0.000135
- `BUS1:ETH:WORD1:STOP?` !-6.62e-5
- `BUS1:ETH:WORD1:DEST?` !FF:FF:FF:FF:FF:FF
- `BUS1:ETH:WORD1:SRC?` !0F:0E:0D:0C:0B:0A

- `BUS1:ETH:WORD1:DATA?` ![60]45003c3e6210...
- `BUS1:ETH:WORD1:TYPE?` !2048
- `BUS1:ETH:WORD1:CRC?` !-1821935433
- `BUS1:ETH:WORD1:SSYM?` !
- `BUS1:ETH:WORD1:DSYM?` !BroadCast
- `BUS1:ETH:WORD1:BYTE1:VAL?` !69
- `BUS1:ETH:WORD1:BYTE2:VAL?` !0

BUS<m>:ETHernet:WCOunt?

Returns the word count for the selected serial bus, i.e. the number of words in the current acquisition.

Suffix:

<m> 1..4

Return values:

<Count>

Usage: Query only

BUS<m>:ETHernet:WORD<n>:STATe?

Returns the frame state of the selected word in the current acquisition.

Suffix:

<m> 1..4

<n> *

Return values:

<State> OK | ERR_PREAMBLE | ERR_LENGTH

OK
No error detected

ERR_PREAMBLE
Error in the preamble of the selected word

ERR_LENGTH
Error in the number of bits in the selected word

*RST: OK

Usage: Query only

BUS<m>:ETHernet:WORD<n>:STARt?

Returns the frame start time of the selected word in the current acquisition

Suffix:

<m> 1..4

<n> *

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

BUS<m>:ETHernet:WORD<n>:STOP?

Returns the frame stop time of the selected word in the current acquisition

Suffix:

<m> 1..4

<n> *

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

BUS<m>:ETHernet:WORD<n>:DESTaddress?

Returns the destination address of the specified word.

Suffix:

<m> 1..4

<n> *

Return values:
<str> String parameter

Usage: Query only

BUS<m>:ETHernet:WORD<n>:SRCaddress?

Returns the source address of the specified word.

Suffix:
<m> 1..4

<n> *

Return values:
<str> String parameter

Usage: Query only

BUS<m>:ETHernet:WORD<n>:TYPE?

The sub-protocol (e.g. HTML, video, etc.) determines what meaning this field has. Since the content of this data area is not decoded, the interpretation of the TYPE field is ambivalent. The query either returns the word type (specific for the sub-protocol), or the length of the selected word.

Suffix:
<m> 1..4

<n> *

Return values:
<Type>

Usage: Query only

BUS<m>:ETHernet:WORD<n>:DATA?

Returns the number of word bytes in brackets [.] followed by the first six word bytes of data in hexadecimal format.

Use `BUS<m>:ETHernet:WORD<n>:BYTE<o>:VALue?` to access the word bytes.

Suffix:
<m> 1..4

<n> *

Return values:
<Data> String parameter

Example:
```
BUS:ETHernet:WORD3:DATA?
<-- '[60]FF00FFFF1234'
```

Usage: Query only

BUS<m>:ETHernet:WORD<n>:CRC?

Returns the Cyclic Redundancy Code (CRC, or frame check) checksum of the selected word.

Suffix:

<m>	1..4
<n>	*

Return values:
<CRC>

Usage: Query only

BUS<m>:ETHernet:WORD<n>:DSYMbol?

Returns the symbolic label (or translation) of the destination address of the specified word, if the label list is enabled.

Suffix:

<m>	1..4
<n>	*

Return values:

<DestTranslation>	String parameter

Usage: Query only

BUS<m>:ETHernet:WORD<n>:SSYMbol?

Returns the symbolic label (or translation) of the source address of the specified word, if the label list is enabled.

Suffix:

<m>	1..4
<n>	*

Return values:

<SrcTranslation>	String parameter

Usage: Query only

BUS<m>:ETHernet:WORD<n>:BYTE<o>:VALue?

BYTE returns all data of up to 1982 bytes (not just the first 5 or 6 bytes). This is also visible in the data table under "Show details". The format of the byte value is hexadecimal.

Suffix:

<m>	1..4
<n>	*

<o> *

Selects the byte number.

Return values:
<FrameByteValue>

Usage: Query only

16.17.12.3 Search Settings

SEARch:TRIGger:ETHernet:FRAMe:SELect <SearchName>,<CheckFrame>
SEARch:TRIGger:ETHernet:FRAMe:SELect? <SearchName>

Defines, whether a search within a frame shall be activated or not.

Parameters:
<CheckFrame> ON | OFF

*RST: OFF

Parameters for setting and query:
<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:DCONdition <SearchName>,<Operator>
SEARch:TRIGger:ETHernet:FRAMe:DCONdition? <SearchName>

Defines the operator to search a specific destination address within a frame.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a destination address to be set with SEARch:TRIGger:ETHernet:FRAMe:DMIN.

INRange | OORange
In range, Out of range. Set the minimum and maximum value of the range with SEARch:TRIGger:ETHernet:FRAMe:DMIN and SEARch:TRIGger:ETHernet:FRAMe:DMAX.

*RST: EQUal

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:DMIN <SearchName>,<PatternMin>
SEARch:TRIGger:ETHernet:FRAMe:DMIN? <SearchName>

Defines a destination address, or sets the start value of a destination address range.

Parameters:

<PatternMin> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:DMAX <SearchName>,<PatternMax>
SEARch:TRIGger:ETHernet:FRAMe:DMAX? <SearchName>

Sets the end value of a destination address range, if SEARch:TRIGger:ETHernet:FRAMe:DCONdition is set to INRange or OORange.

Parameters:

<PatternMax> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:SCONdition <SearchName>,<Operator>
SEARch:TRIGger:ETHernet:FRAMe:SCONdition? <SearchName>

Defines the operator to search a specific source address within a frame.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a destination address to be set with `SEARch:TRIGger:ETHernet:FRAMe:SMIN`.

INRange | OORange
In range, Out of range. Set the minimum and maximum value of the range with `SEARch:TRIGger:ETHernet:FRAMe:SMIN` and `SEARch:TRIGger:ETHernet:FRAMe:SMAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:SMIN <SearchName>,<PatternMin>
SEARch:TRIGger:ETHernet:FRAMe:SMIN? <SearchName>

Defines a source address, or sets the start value of a source address range.

Parameters:

<PatternMin> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:SMAX <SearchName>,<PatternMax>
SEARch:TRIGger:ETHernet:FRAMe:SMAX? <SearchName>

Sets the end value of a source address range, if `SEARch:TRIGger:ETHernet:FRAMe:SCONdition` is set to `INRange` or `OORange`.

Parameters:

<PatternMax> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:TCONdition <SearchName>,<Operator>
SEARch:TRIGger:ETHernet:FRAMe:TCONdition? <SearchName>

Defines the operator to search for a specific frame length or type.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a pattern to be set with SEARch:TRIGger:ETHernet:FRAMe:TMIN.

INRange | OORange
In range, Out of range. Set the minimum and maximum value of the range with SEARch:TRIGger:ETHernet:FRAMe:TMIN and SEARch:TRIGger:ETHernet:FRAMe:TMAX.

*RST: EQUal

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:TMIN <SearchName>,<PatternMin>
SEARch:TRIGger:ETHernet:FRAMe:TMIN? <SearchName>

Defines a frame length/type, or sets the start value for a range of frame lengths/types.

Parameters:

<PatternMin> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:TMAX <SearchName>,<PatternMax>
SEARch:TRIGger:ETHernet:FRAMe:TMAX? <SearchName>

Sets the end value of a range of frame lengths/types, if SEARch:TRIGger:ETHernet:FRAMe:TCONdition is set to INRange or OORange.

Parameters:

<PatternMax> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:CCONdition <SearchName>,<Operator>
SEARch:TRIGger:ETHernet:FRAMe:CCONdition? <SearchName>

Defines the operator to search for a Cyclic Redundancy Code (CRC, or frame check) error condition within a frame.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a CRC pattern to be set with SEARch:TRIGger:ETHernet:FRAMe:CMIN.

INRange | OORange
In range, Out of range. Set the minimum and maximum value of the range with SEARch:TRIGger:ETHernet:FRAMe:CMIN and SEARch:TRIGger:ETHernet:FRAMe:CMAX.

*RST: EQUal

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:CMIN <SearchName>,<PatternMin>
SEARch:TRIGger:ETHernet:FRAMe:CMIN? <SearchName>

Defines a CRC error condition pattern, or sets the start value of such a pattern.

Parameters:

<PatternMin> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:CMAX <SearchName>,<PatternMax>
SEARch:TRIGger:ETHernet:FRAMe:CMAX? <SearchName>

Sets the end value of a CRC error condition pattern, if SEARch:TRIGger:ETHernet:FRAMe:CCONdition is set to INRange or OORange.

Parameters:

<PatternMax> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:ERRor:SELect <SearchName>,<CheckErrorCondition>
SEARch:TRIGger:ETHernet:ERRor:SELect? <SearchName>

Defines, whether a search for an error condition shall be activated or not.

Parameters:
<CheckErrorCondition> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName> String parameter

SEARch:TRIGger:ETHernet:ERRor:PREamble <SearchName>,<Preamble>
SEARch:TRIGger:ETHernet:ERRor:PREamble? <SearchName>

Defines, whether a search for any preamble error shall be activated or not.

Parameters:
<Preamble> ON | OFF
*RST: ON

Parameters for setting and query:
<SearchName> String parameter

SEARch:TRIGger:ETHernet:ERRor:LENGth <SearchName>,<Length>
SEARch:TRIGger:ETHernet:ERRor:LENGth? <SearchName>

Defines, whether a search for any word length error (too few or too many bits per word) shall be activated or not.

Parameters:
<Length> ON | OFF
*RST: ON

Parameters for setting and query:
<SearchName> String parameter

16.17.12.4 Search Results

In all `SEARch:RESult:ETHernet:WORD<m>` commands, the suffix <m> selects the word number in the list of search results.

SEARch:RESult:ETHernet:WCOunt <Key>

Returns the number of decoded words within the search result.

Setting parameters:

<Key> String parameter

Return values:

<Count>

SEARch:RESult:ETHernet:WORD<m>:STATe? <SearchName>

Returns the frame state of the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<State> OK | ERR_PREAMBLE | ERR_LENGTH

OK
No error detected

ERR_PREAMBLE
Error in the preamble of the selected word

ERR_LENGTH
Error in the number of bits in the selected word

*RST: OK

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:STARt? <SearchName>

Returns the frame start time of the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:STOP? <SearchName>

Returns the frame stop time of the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName> String parameter

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:DESTaddress? <SearchName>

Returns the destination address of the specified word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName> String parameter

Return values:
<str> String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:SRCaddress? <SearchName>

Returns the source address of the specified word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName> String parameter

Return values:
<str> String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:TYPE? <SearchName>

The sub-protocol (e.g. HTML, video, etc.) determines what meaning this field has. Since the content of this data area is not decoded, the interpretation of the TYPE field is ambivalent. The query either returns the word type (specific for the sub-protocol), or the length of the selected word within the search result.

Suffix:
<m> *

Query parameters:

<SearchName> String parameter

Return values:

<Type> Range: 0 to 0
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:DATA? <SearchName>

Returns the data bytes of the specified word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<Data> String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:CRC? <SearchName>

Returns the Cyclic Redundancy Code (CRC, or frame check) checksum of the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<CRC> Range: 0 to 0
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:DSYMbol? <SearchName>

Returns the symbolic label (or translation) of the destination address of the specified word within the search result, if the label list is enabled.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<DestTranslation> String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:SSYMbol? <SearchName>

Returns the symbolic label (or translation) of the source address of the specified word within the search result, if the label list is enabled.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<SrcTranslation> String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:BYTE<n>:VALue? <SearchName>

BYTE returns all data of up to 1982 bytes (not just the first 5 or 6 bytes). This is also visible in the data table under "Show details". The format of the byte value is hexadecimal.

Suffix:

<m> *

<n> *
Selects the byte number.

Query parameters:

<SearchName> String parameter

Return values:

<FrameByteValue> Range: 0 to 0
Increment: 1
*RST: 0

Usage: Query only

16.17.13 SENT (Option R&S RTE-K10)

16.17.13.1 Configuration

BUS<m>:SENT:DATA:SOURce <DataSource>

Selects the source of the data line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<DataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

*RST: C1W1

Usage: Asynchronous command

BUS<m>:SENT:DATA:THReshold <Threshold>

Sets a user-defined threshold value. Alternatively, you can set the threshold according to the signal technology `BUS<m>:SENT:TECHnology`.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Threshold> Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:SENT:TECHnology <Technology>

Selects the threshold voltage.

Suffix:

<m> 1..4
Selects the serial data bus.

Parameters:

<Technology> V25 | MAN

V25
The threshold value is 2.5 V, according to CMOS technology.

MAN
Sets the threshold to the value set with BUS<m>:SENT:DATA:THReshold.

*RST: V25

BUS<m>:SENT:CLKPeriod <ClockPeriod>

Sets the nominal clock period (clock tick).

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ClockPeriod> Range: 1E-6 to 100E-6
Increment: 1E-6
*RST: 3E-6
Default unit: s

BUS<m>:SENT:CLKTolerance <ClockTolerance>

Sets a tolerated deviation of the clock signal.

Suffix:

<m> 1..4
Sets a deviation tolerated for the clock signal.

Parameters:

<ClockTolerance> Range: 0 to 25
Increment: 1
*RST: 20
Default unit: %

BUS<m>:SENT:DNIBbles <DataNibbles>

Sets the number of data nibbles for a transmission sequence.

Suffix:

<m> 1..4
Selects the serial data bus.

Parameters:

<DataNibbles> Range: 1 to 6
Increment: 1
*RST: 3

BUS<m>:SENT:SFORmat <SerialMsgFormat>

Selects the serial message format.

Suffix:

<m> 1..4

Parameters:

<SerialMsgFormat> SHORt | ENHanced | NONE

Short serial message, Enhanced serial message, none = single transmission sequence.

*RST: NONE

BUS<m>:SENT:CRCVersion <CRCVersion>

Selects the calculaction method for the cyclic redundancy check (CRC).

Suffix:

<m> 1..4

Selects the serial data bus.

Parameters:

<CRCVersion> LEGA | V2010

Legacy: method used up to 2010

V2010: current method

*RST: V2010

BUS<m>:SENT:CRCMethod <CRCCalculation>

Selects the calculation method for the CRC checksum.

Suffix:

<m> 1..4

Selects the serial bus.

Parameters:

<CRCCalculation> SAEJ | TLE

SAEJ: according to the standard

TLE: according to the computing method for TLE_4998X sensors.

*RST: SAEJ

BUS<m>:SENT:PPULse <PausePulse>

Determines wether a pause pulse is part of the SENT transmission sequence.

Suffix:

<m> 1..4

Selects the serial data bus.

Parameters:

<PausePulse> NPP | PP | PPFL

NPP
Transmits the SENT message without pause pulse.

PP
Transmits the message with a fixed pulse length, automatically calculated.

PPFL
Transmits the pause pulse with a user-defined frame length to obtain a transmission sequence with constant length.

*RST: NPP

BUS<m>:SENT:PPFLength <FrameLength>

Defines a constant transmission sequence length. To select the fixed sequence length, set BUS:SENT:PPUL PPFL.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<FrameLength> Range: 104 to 922
Increment: 1
*RST: 128

16.17.13.2 Trigger

Event in a trigger sequence: 1 = A-event only

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:SENT:TYPE <Type>

Selects the trigger event for the SENT transmission type.

Parameters:

<Type> CALI | TSEQ | SMSG | ERRC

CALI
CALIbration: triggers on the falling edge of the calibration/synchronization pulse.

TSEQ
Transmission SEQuence: triggers either on the falling edge of the status nibble, or on the last data nibble.
To set the transmission sequence conditions, use `TRIGger<m>:SENT:TTYPe` and `TRIGger<m>:SENT:STATus`.
To set the data condition, use `TRIGger<m>:SENT:TDCN`, `BUS<m>:SENT:DNIBbles`, `TRIGger<m>:SENT:TDMN` and `TRIGger<m>:SENT:TDMX`.

SMSG
Serial Message: combination of identifier and data conditions.
To select the sequence condition, use `TRIGger<m>:SENT:STYPe`.
To select the message ID format for an enhanced serial message, use `TRIGger<m>:SENT:SIDType`.
To set the identifier condition, use `TRIGger<m>:SENT:SICN`, `TRIGger<m>:SENT:SIMN` and `TRIGger<m>:SENT:SIMX`.
To set the data condition, use `TRIGger<m>:SENT:SCONdition`, `TRIGger<m>:SENT:SDMN` and `TRIGger<m>:SENT:SDMX`.

ERRC
ERRor Condition: triggers on an error event.
Define the error types with `TRIGger<m>:SENT:PULSeerror`, `TRIGger<m>:SENT:PPERioderror` or `TRIGger<m>:SENT:CRCerror`.

*RST: CALI

TRIGger<m>:SENT:TTYPe <TSFieldType>

Selects the trigger sequence type for TRIGger<m>:SENT:TYPE TSEQ (transmission sequence).

Parameters:

<TSFieldType> STAT | STDA

STAT
Triggers on the status nibble.

STDA
Triggers at the end of the combination of status and data nibble(s).
Define the data conditions with TRIGger<m>:SENT:STATus, TRIGger<m>:SENT:TDCN, BUS<m>:SENT:DNIBbles, TRIGger<m>:SENT:TDMN and TRIGger<m>:SENT:TDMX

*RST: STAT

TRIGger<m>:SENT:STATus <StatusBits>

Sets the status nibble data.

Parameters:

<StatusBits> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:TDCN <TSDataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<TSDataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with TRIGger<m>:SENT:TDMN.

INRange | OORange
In range / Out of range. To define the range set the minimum and maximum values with TRIGger<m>:SENT:TDMN and TRIGger<m>:SENT:TDMX.

*RST: EQUal

TRIGger<m>:SENT:TDMN <TSDataPattern>

Specifies a data pattern, or sets the start value of a data pattern range.

Parameters:

<TSDataPattern> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:TDMX <TSDataPatternTo>

Sets the end value of an identifier range for TRIGger:SENT:TDCN INRange or OORange.

Parameters:

<TSDataPatternTo> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:STYPe <SMFieldType>

Selects the trigger sequence type for TRIGger:SENT:TYPE SSMSg or ESMSg (serial message).

Parameters:

<SMFieldType> ID | IDDT

ID
Triggers on the identifier.
To set the identifier condition for a serial message, use `TRIGger<m>:SENT:SICN`, `TRIGger<m>:SENT:SIMN` and `TRIGger<m>:SENT:SIMX`.

IDDT
Triggers at the end of the combination of identifier and data.
To set the identifier condition, use the commands shown above.
To set the data condition, use `TRIGger<m>:SENT:SCONdition`, `TRIGger<m>:SENT:SDMN` and `TRIGger<m>:SENT:SDMX`.

*RST: ID

TRIGger<m>:SENT:SIDType <SMIDType>

Sets the message ID format (4 bit or 8 bit) of the enhanced serial message.

Parameters:

<SMIDType> B4 | B8

*RST: B4

TRIGger<m>:SENT:SICN <SMIDOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<SMIDOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with TRIGger<m>:SENT:SIMN.

INRange | OORange
In range / Out of range. To define the range set the minimum and maximum values with TRIGger<m>:SENT:SIMN and TRIGger<m>:SENT:SIMX.

*RST: EQUal

TRIGger<m>:SENT:SIMN <SMIDPattern>

Specifies a message identifier pattern, or sets the start value of an identifier range.

Parameters:

<SMIDPattern> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:SIMX <SMIDPatternTo>

Sets the end value of an identifier range for TRIGger<m>:SENT:SICN INRange or OORange.

Parameters:

<SMIDPatternTo> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:SCONdition <SSMDataOperator>

Sets the operator to define a specific data pattern or a data pattern range.

Parameters:

<SSMDataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with TRIGger<m>:SENT:SIMN.

INRange | OORange
In range / Out of range. To define the range set the minimum and maximum values with TRIGger<m>:SENT:SIMN and TRIGger<m>:SENT:SIMX.

*RST: EQUal

TRIGger<m>:SENT:SDMN <SMDataPattern>

Specifies a data pattern, or sets the start value of a data pattern range.

Parameters:

<SMDataPattern> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:SDMX <SMDataPatternTo>

Sets the end value of an identifier range for TRIGger<m>:SENT:SCONdition INRange or OORange.

Parameters:

<SMDataPatternTo> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

TRIGger<m>:SENT:FORMerror <FormError>

Triggers on format errors in serial messages.

A form error occurs when at least one of the transmission sequences that form a serial message has an error.

To trigger on an error event, select the corresponding trigger type with TRIGger<m>:SENT:TYPE ERRC.

Parameters:

<FormError> ON | OFF

*RST: OFF

TRIGger<m>:SENT:PULSeerror <CalibPulseError>

Trigger son calibration pulse erors in transmission sequences.

An error occurs when

- the duration of the "Calibration/Sync" pulse (in ticks) is less than 56*(1-clock tolerance) or more than 56*(1+clock tolerance)
- the "Calibration/Sync" pulse duration of frame (n-1) varies by more than 1.5625% from the "Calibration/Sync" pulse duration of frame (n)

To trigger on an error event, select the correspondig trigger type with TRIGger<m>:SENT:TYPE ERRC.

Parameters:

<CalibPulseError> ON | OFF

*RST: OFF

TRIGger<m>:SENT:PPERioderror <PulsePeriodError>

Triggers on pulse period errors.

An error occurs when a nibble has any of the following:

- number of ticks at low is less than 4 ticks.
- nibble value < 0 (less than 12 ticks) or > 15 (more than 27 ticks).

To trigger on an error event, select the correspondig trigger type with TRIGger<m>:SENT:TYPE ERRC.

Parameters:

<PulsePeriodError>	ON | OFF	
	*RST:	OFF

TRIGger<m>:SENT:CRCerror <CRCError>

Triggers on CRC errors in both, the transmission sequences and serial messages.

A CRC error occurs when the CRC calculated by the receiver differs from the received value in the CRC sequence. The CRC length is 4 bits for transmission sequences and short serial messages, and 6 bit of enhanced serial messages.

To trigger on an error event, select the correspondig trigger type with TRIGger<m>:SENT:TYPE ERRC.

Parameters:

<CRCError>	ON | OFF	
	*RST:	ON

TRIGger<m>:SENT:IRFLength <IrregularFrameLen>

Triggers on frame length errors in transmission sequences when pause pulse for constant frame length is set, see BUS<m>:SENT:PPULse PPFL.

An error occurs when the total length of the transmission sequence (including pause pulse) does not match the frame length setting, see `BUS<m>:SENT:PPFLength` on page 1411.

To trigger on an error event, select the correspondig trigger type with TRIGger<m>:SENT:TYPE ERRC.

Parameters:

<IrregularFrameLen>	ON | OFF	
	*RST:	OFF

16.17.13.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1165
- `BUS<m>:SYMBols` on page 1165

BUS<m>:SENT:FCOunt?

Returns the number of decoded frames of the acquisition.

Suffix:

<m> 1..4
Selects the serial data bus.

Return values:

<Count> Total number of decoded frames.

Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:SENT:FRAMe<n>:STATus?

Returns the overall state of the selected frame.

Suffix:

<m> 1..4
Selects the serial data bus.

<n> *
Selects the frame.

Return values:

<FrameState> OK | SYNC | PULSe | CRC | IRFL | FORM | INSufficient

OK: the frame is valid.
SYNC: Synchronization error occured.
PULse: Pulse error occured.
CRC: Cyclic redundancy check failed.
IRFL: Irregular frame length error occured.
FORM: Format error occurred.
INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:SENT:FRAMe<n>:STARt?
BUS<m>:SENT:FRAMe<n>:STOP?

Returns the start time and stop time of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameStart>
<FrameStop>

Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SENT:FRAMe<n>:CSValue?

Returns the CRC sequence value of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameCSValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 63
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:SENT:FRAMe<n>:DATA?

Returns the data of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Parameters:

<Data> Comma-separated sequence of integer values (N, D1, D2,…, DN). N is the number of nibbles in the frame, and D1…DN are the values of the nibbles.

Example:

```
BUS:SENT:FRAMe4:DATA?
<-- 4,3,15,11,9
```

Usage: Query only

BUS<m>:SENT:FRAMe<n>:IDTYpe?

Returns the identifier type of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameIDType> B4 | B8

B4: standard format, 4 bit
B8: extended format, 8 bit

*RST: B4

Usage: Query only

BUS<m>:SENT:FRAMe<n>:IDValue?

Returns the identifier value of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameIdValue> To set the value format, use FORMat:BPATtern.

The values below – range, increment and reset – are decimal values.

Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:SENT:FRAMe<n>:NIBBle<o>:STATe?

Returns the state of the specified nibble.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the nibble number.

Return values:

<FrameNibbleState> OK | UNDF

UNDF: Undefined

*RST: OK

Usage: Query only

BUS<m>:SENT:FRAMe<n>:NIBBle<o>:VALue?

Returns the value of the specified nibble.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the nibble number.

Return values:

<FrameNibbleValue> To set the value format, use FORMat:BPATtern.

The values below – range, increment and reset – are decimal values.

Range: 0 to 15
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:SENT:FRAMe<n>:PAPTicks?

Returns the number of the pulse pause clock ticks.

Suffix:

<m> — 1..4
Selects the serial bus.

<n> — *
Selects the frame.

Return values:

<PausePulseTicks> — Range: 12 to 768
Increment: 1
*RST: 12

Usage: Query only

BUS<m>:SENT:FRAMe<n>:SCOM?

Returns the value of the status/communication pulse.

Suffix:

<m> — 1..4
Selects the serial bus.

<n> — *
Selects the frame.

Return values:

<StatusCom> — Range: 0 to 15
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:SENT:FRAMe<n>:SDATa?

Returns the symbolic data of the frame.

Suffix:

<m> — 1..4
Selects the serial bus.

<n> — *
Selects the frame.

Return values:

<SymbolicData> — Comma-separated list of values. The first value is the number of bytes, followed by the decoded data bytes.
To set the value format, use `FORMat:BPATtern`.

Usage: Query only

BUS<m>:SENT:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the number of the frame in the current acquisition, 1...n.

Return values:

<Translation> String with symbolic label of the identifier.

Example: `BUS:SENT:FRAMe:SYMBol?`
Response: `Air Temperature`

Usage: Query only

BUS<m>:SENT:FRAMe<n>:SYNCduration?

Returns the time of the synchronization pulse.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<SyncDuration> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SENT:FRAMe<n>:TYPE?

Returns the type of SENT message.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameType> TRSQ | SMSG | EMSG

Transmission sequence, short serial message or enhanced serial message.

*RST: TRSQ

Usage: Query only

BUS<m>:SENT:RDSL <ResultDispSelect>

Selects the results to be displayed.

Suffix:

<m> 1..4

Selects the serial bus.

Parameters:

<ResultDispSelect> TRSQ | SMSG | ALL

Transmission sequence, serial messages or all.

*RST: ALL

16.17.13.4 SENT Search Settings

In search setup commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name. The commands are similar to SENT trigger commands.

SEARch:TRIGger:SENT:TYPE <SearchName>,<Type>
SEARch:TRIGger:SENT:TYPE? <SearchName>

Selects the SENT transmission type to be searched for.

Parameters:

<Type> CALI | TSEQ | SMSG | ERRC

CALI
CALIbration: searches for the calibration/synchronization pulse.

TSEQ
Transmission sequence: combination of status and data conditions.
To set the transmission sequence conditions, use SEARch:TRIGger:SENT:TTYPe and SEARch:TRIGger:SENT:STATus.
To set the data condition, use SEARch:TRIGger:SENT:TDCN, TRIGger<m>:SENT:TDCN, SEARch:TRIGger:SENT:TDMN and SEARch:TRIGger:SENT:TDMX.

SMSG
Short serial message: combination of identifier and data conditions.
To select the sequence condition, use SEARch:TRIGger:SENT:STYPe.
To set the identifier condition for the serial message, use SEARch:TRIGger:SENT:SICN, SEARch:TRIGger:SENT:SIMN and SEARch:TRIGger:SENT:SIMX.
To set the data condition, use SEARch:TRIGger:SENT:SDCN, SEARch:TRIGger:SENT:SDMN and SEARch:TRIGger:SENT:SDMX.

ERRC
Error condition: searches for error events.
Define the error types with SEARch:TRIGger:SENT:PULSeerror, SEARch:TRIGger:SENT:PPERioderror, SEARch:TRIGger:SENT:FORMerror on page 1432 and SEARch:TRIGger:SENT:CRCerror.

*RST: CALI

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:CALibration <SearchName>,<CheckCalibSync>
SEARch:TRIGger:SENT:CALibration? <SearchName>

Enables the search for the Calibration/Synchronization pulse.

Parameters:

<CheckCalibSync> ON | OFF

*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:TRANsmission <SearchName>,<CheckTransSeq>
SEARch:TRIGger:SENT:TRANsmission? <SearchName>

Enables the search for a transmission sequence.

Parameters:
<CheckTransSeq> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SMSG <SearchName>,<CheckSerialMsg>
SEARch:TRIGger:SENT:SMSG? <SearchName>

Enables the search in a serial message.

Parameters:
<CheckSerialMsg> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:ERRor <SearchName>,<CheckErrorCond>
SEARch:TRIGger:SENT:ERRor? <SearchName>

Enables the search for a specified error.

Parameters:
<CheckErrorCond> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:TTYPe <SearchName>,<TSFieldType>
SEARch:TRIGger:SENT:TTYPe? <SearchName>

Selects the SENT transmission sequence to be searched for.

To enable the search for the transmission sequence, use `SEARch:TRIGger:SENT:TRANsmission`.

Parameters:
<TSFieldType> STAT | STDA

STAT
Searches on the status nibble.

STDA
Searches for the end of the combination of status and data nibble(s).
Define the data conditions with SEARch:TRIGger:SENT:STATus, SEARch:TRIGger:SENT:TDCN, BUS<m>:SENT:DNIBbles, SEARch:TRIGger:SENT:TDMN and SEARch:TRIGger:SENT:TDMX.

*RST: STAT

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:STATus <SearchName>,<StatusBits>
SEARch:TRIGger:SENT:STATus? <SearchName>

Sets the status nibble data.

Parameters:
<StatusBits> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:TDCN <SearchName>,<TSDataOperator>
SEARch:TRIGger:SENT:TDCN? <SearchName>

Sets the operator for a specific data pattern or a data pattern range.

Parameters:
<TSDataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with SEARch:TRIGger:SENT:TDMN.

INRange | OORange
In range / Out of range. To define the range set the minimum and maximum values with SEARch:TRIGger:SENT:TDMN and SEARch:TRIGger:SENT:TDMX.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:TDMN <SearchName>,<TSDataPattern>
SEARch:TRIGger:SENT:TDMN? <SearchName>

Specifies a data pattern, or sets the start value of a data pattern range.

Parameters:

<TSDataPattern> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:SENT:TDMX <SearchName>,<TSDataPatternTo>
SEARch:TRIGger:SENT:TDMX? <SearchName>

Sets the end value of an identifier range for SEARch:TRIGger:SENT:DCONdition INRange or OORange.

Parameters:

<TSDataPatternTo> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:SENT:STYPe <SearchName>,<SMFieldType>
SEARch:TRIGger:SENT:STYPe? <SearchName>

Selects the serial message sequence to be searched for.

To enable the search for one of the serial message types, use `BUS<m>:SENT:SFORmat` and enable with `SEARch:TRIGger:SENT:SMSG`.

Parameters:

<SMFieldType> ID | IDDT

ID
Searches for the identifier.
To set the identifier condition for the serial message, use `SEARch:TRIGger:SENT:SICN`, `SEARch:TRIGger:SENT:SIMN` and `SEARch:TRIGger:SENT:SIMX`.

IDDT
Searches for the combination of identifier and data.
To set the identifier condition, use the commands shown above.
To set the data condition, use `SEARch:TRIGger:SENT:SDCN`, `SEARch:TRIGger:SENT:SDMN` and `SEARch:TRIGger:SENT:SDMX`.

*RST: ID

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SIDType <SearchName>,<SMIDType>
SEARch:TRIGger:SENT:SIDType? <SearchName>

Sets the message ID format (4 bit or 8 bit) of the enhanced serial message.

Parameters:

<SMIDType> B4 | B8

*RST: B4

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SICN <SearchName>,<SMIDOperator>
SEARch:TRIGger:SENT:SICN? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<SMIDOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with SEARch:TRIGger:SENT:SIMN.

INRange | OORange
In range / Out of range. To define the range set the minimum and maximum values with SEARch:TRIGger:SENT:SIMN and SEARch:TRIGger:SENT:SIMX.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SIMN <SearchName>,<SMIDPattern>
SEARch:TRIGger:SENT:SIMN? <SearchName>

Specifies a message identifier pattern, or sets the start value of an identifier range.

Parameters:

<SMIDPattern> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:SIMX <SearchName>,<SMIDPatternTo>
SEARch:TRIGger:SENT:SIMX? <SearchName>

Sets the end value of an identifier range for SEARch:TRIGger:SENT:SICN INRange or OORange.

Parameters:

<SMIDPatternTo> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:SENT:SDCN <SearchName>,<SMDataOperator>
SEARch:TRIGger:SENT:SDCN? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<SMDataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:SENT:SDMN`.

INRange | OORange
In range / Out of range. To define the range set the minimum and maximum values with `SEARch:TRIGger:SENT:SDMN` and `SEARch:TRIGger:SENT:SDMX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:SENT:SDMN <SearchName>,<SMDataPattern>
SEARch:TRIGger:SENT:SDMN? <SearchName>

Specifies a data pattern, or sets the start value of a data pattern range.

Parameters:

<SMDataPattern> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:SENT:SDMX <SearchName>,<SMDataPatternTo>
SEARch:TRIGger:SENT:SDMX? <SearchName>

Sets the end value of an identifier range for SEARch:TRIGger:SENT:SDCN INRange or OORange.

Parameters:

<SMDataPatternTo> Numeric or string pattern, Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:SENT:PULSeerror <SearchName>,<CalibPulseError>
SEARch:TRIGger:SENT:PULSeerror? <SearchName>

Enables the search for pulse errors.

To initially enable the search for an error event, set SEARch:TRIGger:SENT:TYPE ERRC

Parameters:

<CalibPulseError> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:SENT:PPERioderror <SearchName>,<PulsePeriodError>
SEARch:TRIGger:SENT:PPERioderror? <SearchName>

Enables the search for pulse period errors.

To initially enable the search for an error event, set SEARch:TRIGger:SENT:TYPE ERRC

Parameters:

<PulsePeriodError> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:SENT:IRFLength <SearchName>,<IrregularFrameLen>
SEARch:TRIGger:SENT:IRFLength? <SearchName>

Enables the search for irregular frame length errors.

To initially enable the search for an error event, set SEARch:TRIGger:SENT:TYPE ERRC

Parameters:
<IrregularFrameLen> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:FORMerror <SearchName>,<FormError>
SEARch:TRIGger:SENT:FORMerror? <SearchName>

Enables the search for format errors in serial messages.

To initially enable the search for an error event, set SEARch:TRIGger:SENT:TYPE ERRC.

Parameters:
<FormError> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SENT:CRCerror <SearchName>,<CRCError>
SEARch:TRIGger:SENT:CRCerror? <SearchName>

Enables the search for errors in the Cyclic Redundancy Check.

To initially enable the search for an error event, set SEARch:TRIGger:SENT:TYPE ERRC

Parameters:
<CRCError> ON | OFF
*RST: ON

Parameters for setting and query:
<SearchName>

16.17.13.5 SENT Search Results

The search on decoded SENT data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 16.17.13.3, "Decode Results", on page 1417.

SEARch:RESult:SENT:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:CSValue? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameCSValue>	Range:	0 to 63
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:DATA? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:IDTYpe? <SearchName>

Returns the identifier type of the selected frame.

Suffix:

<m> *

Selects the frame.

Query parameters:

<SearchName>

Return values:

<FrameIdType> B4 | B8

B4: standard format, 4 bit
B8: extended format, 8 bit

*RST: B4

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:IDValue? <SearchName>

Returns the identifier value of the selected frame.

Suffix:

<m> *

Selects the serial bus.

Query parameters:

<SearchName>

Return values:

<FrameIdValue> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:NIBBle<n>:STATe? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<FrameNibbleState> OK | UNDF

*RST: OK

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:NIBBle<n>:VALue? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<FrameNibbleValue> Range: 0 to 15
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:PAPTicks? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<PausePulseTicks> Range: 12 to 768
Increment: 1
*RST: 12

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:SCOM? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<StatusCom> Range: 0 to 15
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:SDATa? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<SymbolicData>

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:STARt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:STATus? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameState> OK | SYNC | PULSe | CRC | IRFL | FORM | INSufficient
*RST: OK

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:STOP? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameStop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:SYMBol? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Translation>

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:SYNCduration? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<SyncDuration> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:SENT:FRAMe<m>:TYPE? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameType> TRSQ | SMSG | EMSG
*RST: TRSQ

Usage: Query only

16.17.14 Custom: Manchester / NRZ (Option R&S RTE-K50)

16.17.14.1 Configuration

In all `BUS<m>:CMSB` commands, the suffix <m> selects the serial bus.

In all `BUS<m>:CMSB:FRAMe<n>` commands, the suffix <n> selects a frame number, and the suffix <o> selects a cell number.

BUS<m>:CMSB:CODing <CodingStandard>

Selects the custom serial bus coding standard.

Suffix:

<m> 1..4

Parameters:

<CodingStandard> MANC | MANT | NRZ | NRZU

MANC
Manchester (normal polarity)

MANT
Manchester II (inverted polarity).
Note that some additional subtle differences between MANC and MANT require separate protocols.

NRZ
NRZ (non-return-to-zero), clocked

NRZU
NRZ (non-return-to-zero), unclocked

*RST: MANC

BUS<m>:CMSB:MANChester:DATA <ManchDataSource>

Selects the source channel for the data signal. For triggering on a serial bus, analog channels "C1"–"C4" are required. Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:

<m> 1..4

Parameters:

<ManchDataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

*RST: C1W1

BUS<m>:CMSB:MANChester:POLarity <PolarityData>

Selects the polarity of the custom serial bus data signal in Manchester coding standards.

Suffix:

<m> 1..4

Parameters:

<PolarityData> NORMal | INVert

NORMal
Manchester or Manchester II polarity remains unchanged

INVert
Manchester polarity is inverted and becomes Manchester II polarity, Manchester II polarity is inverted and becomes Manchester polarity

*RST: NORMal

BUS<m>:CMSB:MANChester:THReshold:HIGH <ThresholdUpper>

Sets the upper threshold for data signal digitization in Manchester coding standards.

Suffix:

<m> 1..4

Parameters:

<ThresholdUpper>
Range: -25 to 25
Increment: 0.1
*RST: 5
Default unit: V

BUS<m>:CMSB:MANChester:THReshold:LOW <ThresholdLower>

Sets the lower threshold for data signal digitization in Manchester coding standards.

Suffix:

<m> 1..4

Parameters:

<ThresholdLower>
Range: -25 to 25
Increment: 0.1
*RST: -5
Default unit: V

BUS<m>:CMSB:MANChester:THReshold:PRESet <ThresholdPreset>

Sets the Manchester thresholds to predefined or individually definable voltage levels.

Suffix:

<m> 1..4

Parameters:

<ThresholdPreset> V05 | V2 | V5 | V7 | MAN

V05
Sets the upper threshold to +0.5 V and the lower threshold to -0.5 V

V2
Sets the upper threshold to +2.0 V and the lower threshold to -2.0 V

V5
Sets the upper threshold to +5.0 V and the lower threshold to -5.0 V

V7
Sets the upper threshold to +7.0 V and the lower threshold to -7.0 V

MAN
Allows to set individual threshold voltage levels

*RST: V5

BUS<m>:CMSB:MANChester:THReshold:COUPling <ThresCoup>

Couples the upper and lower threshold values for the Manchester and Manchester II coding standards. The values are coupled to voltages with the same magnitude but opposite sign (positive for the upper threshold and negative for the lower threshold). However, if the upper threshold is set to a negative voltage or the lower threshold is set to a positive voltage, coupling is disabled, and the other voltage (the one that was not actively set) is automatically adjusted, to avoid an upper threshold below the lower one, or a lower threshold above the upper one.

Suffix:

<m> 1..4

Parameters:

<ThresCoup> ON | OFF

ON
Activates coupling of the upper and lower threshold values.

OFF
Disables coupling of the upper and lower threshold values.

*RST: ON

BUS<m>:CMSB:MANChester:CPHase <ClockPhaseMode>

Selects the phase of the custom serial bus clock signal for the "Manchester" coding standards. For details, see "Clock Phase (Manchester)" on page 663.

Suffix:

<m> 1..4

Parameters:

<ClockPhaseMode> FEDGe | SEDGe | AUTO

FEDGe
Sets the sampling edge to be on the first edge.

SEDGe
Sets the sampling edge to be on the second edge.

AUTO
Lets the decoder automatically select the method ("First Edge" or "Second Edge") for detecting the sampling edge.

*RST: AUTO

BUS<m>:CMSB:NRZ:CLCK <NRZClockSource>

Selects the source channel for the clock signal in the NRZ Clocked coding standard.

For triggering on the serial bus when the NRZ clocked coding standard is selected, analog or digital channel sources are required.

Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:
<m> 1..4

Parameters:
<NRZClockSource> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: C2W1

BUS<m>:CMSB:NRZ:DATA <NRZDataSource>

Selects the source channel for the data signal in NRZ coding standards.

For triggering on the serial bus when the NRZ clocked coding standard is selected, analog or digital channel sources are required.

For triggering on the serial bus when the NRZ unclocked coding standard is selected, analog channel sources are required.

Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:
<m> 1..4

Parameters:
<NRZDataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: C1W1

BUS<m>:CMSB:NRZ:IDLPolarity <PolarityIdle>

Selects the idle polarity of the custom serial bus data signal (only available for the coding standard "NRZ Unclocked").

Suffix:
<m> 1..4

Parameters:
<PolarityIdle> IDLLow | IDLHigh

IDLLow
Sets the base value of the data bus to be "0". After an idle period, the data signal starts with a low-to-high transition

IDLHigh
Sets the base value of the data bus to be "1". After an idle period, the data signal starts with a high-to-low transition

*RST: IDLLow

BUS<m>:CMSB:NRZ:CPOLarity <CPOLMode>

Selects the custom serial bus clock signal polarity for the coding standard NRZ Clocked.

Suffix:

<m>	1..4

Parameters:

<CPOLMode> IDLLow | IDLHigh

IDLLow
Sets the base value of the clock to be "0", the clock signal starts with a low-to-high transition

IDLHigh
Sets the base value of the clock to be "1", the clock signal starts with a high-to-low transition.

*RST: IDLLow

BUS<m>:CMSB:NRZ:CPHase <CPHAMode>

Selects the phase of the custom serial bus clock signal for the coding standard "NRZ Clocked", depending on `BUS<m>:CMSB:NRZ:IDLPolarity` on page 1442.

Suffix:

<m>	1..4

Parameters:

<CPHAMode> FEDGe | SEDGe

FEDGe
Sets the clocking transaction to be on the first edge:
If Clock Polarity = "IDLLow", data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge
If Clock Polarity = "IDLHigh", data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge

SEDGe
Sets the clocking transaction to be on the second edge:
If Clock Polarity = "IDLLow", data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge
If Clock Polarity = "IDLHigh", data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge

*RST: FEDGe

BUS<m>:CMSB:NRZ:ENBLe <NRZEnableSource>

Selects the input source for the custom serial bus enable signal.

If an input is chosen, signals will be only decoded while this channel is in the enabled state. This allows you to mark a time when the signal on the selected source is active and when not.

For triggering on a serial bus, analog channels "C1"–"C4" are required. Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:

<m> 1..4

Parameters:

<NRZEnableSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | IMResult | QUICK | QUICk | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | MSOB5 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | CDRSW1 | CDRSw1 | CDRSW2 | CDRSw2 | CDRHW | CDRHw | AEYE1 | AEYE2 | AEYE3 | AEYE4 | SG1 | SG2 | SG3 | SG4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2

*RST: NONE

BUS<m>:CMSB:NRZ:ENAPolarity <PolarityEnable>

Sets whether the transmitted enable signal is active when the voltage is below the threshold (`ENALow`) or higher than it (`ENAHIgh`).

Suffix:

<m> 1..4

Parameters:

<PolarityEnable> ENALow | ENAHigh

*RST: ENAHigh

BUS<m>:CMSB:NRZ:POLarity <PolarityData>

Selects the polarity of the custom serial bus data signal in NRZ coding standards.

Suffix:

<m> 1..4

Parameters:

<PolarityData> ACTLow | ACTHigh

ACTLow
Active low: the value "1" is represented by a voltage below the threshold

ACTHigh
Active high: the value "1" is represented by a voltage above the threshold

*RST: ACTHigh

BUS<m>:CMSB:NRZ:THReshold:CLCK <ThresholdClock>

Sets the threshold for the clock signal digitization in the NRZ Clocked coding standard.

Suffix:

<m> 1..4

Parameters:

<ThresholdClock> Range: -25 to 25
Increment: 0.1
*RST: 2
Default unit: V

BUS<m>:CMSB:NRZ:THReshold:DATA <ThresholdData>

Sets the threshold for the data signal digitization in NRZ coding standards.

Suffix:

<m> 1..4

Parameters:

<ThresholdData> Range: -25 to 25
Increment: 0.1
*RST: 2
Default unit: V

BUS<m>:CMSB:NRZ:THReshold:ENBLe <ThresholdEnable>

Sets the threshold for the enable signal digitization in NRZ coding standards.

Suffix:

<m> 1..4

Parameters:

<ThresholdEnable> Range: -25 to 25
Increment: 0.1
*RST: 2
Default unit: V

BUS<m>:CMSB:NRZ:THReshold:PRESet <ThresholdPreset>

Sets the NRZ thresholds to predefined or individually definable voltage levels.

Suffix:

<m> 1..4

Parameters:

<ThresholdPreset> V05 | V2 | V5 | V7 | MAN

V05
Sets the clock and data threshold to +0.5 V (in case of NRZ Unclocked: data threshold, only)

V2
Sets the clock and data threshold to +2.0 V (in case of NRZ Unclocked: data threshold, only)

V5
Sets the clock and data threshold to +5.0 V (in case of NRZ Unclocked: data threshold, only)

V7
Sets the clock and data threshold to +7.0 V (in case of NRZ Unclocked: data threshold, only)

MAN
Allows to set individual threshold voltage levels

*RST: V5

BUS<m>:CMSB:NRZ:THReshold:COUPling <ThresCoup>

Couples the clock and data threshold values for the NRZ Clocked coding standard. The values are coupled to the same number.

Suffix:

<m> 1..4

Parameters:

<ThresCoup> ON | OFF

ON
Activates coupling of the NRZ clock and data threshold values.

OFF
Disables coupling of the NRZ clock and data threshold values.

*RST: ON

BUS<m>:CMSB:BITRate:ENABle <BitrateEnable>

Enables the bit rate settings (must always be enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard).

Suffix:

<m> 1..4

Parameters:

<BitrateEnable> ON | OFF

ON
Bit rate settings enabled

OFF
Bit rate settings disabled

*RST: OFF

BUS<m>:CMSB:BITRate:VALue <Bitrate>

Sets the transmission speed setting for the custom serial bus data signal.

Suffix:

<m> 1..4

Parameters:

<Bitrate> Range: 300 to 100000000
Increment: 100000
*RST: 10000000
Default unit: bps

BUS<m>:CMSB:GAPTime:ENABle <GapTimeEnable>

Enables the gap time settings (must always be enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard).

Suffix:

<m> 1..4

Parameters:

<GapTimeEnable> ON | OFF

ON
Gap time settings enabled

OFF
Gap time settings disabled

*RST: OFF

BUS<m>:CMSB:GAPTime:VALue <MinGapTime>

Sets a minimum gap time for synchronization.

Suffix:

<m> 1..4

Parameters:

<MinGapTime> Range: 1E-9 to 1
Increment: 1E-9
*RST: 10E-6
Default unit: s

BUS<m>:CMSB:ADDFrame

Creates an empty frame format description and adds it to the end of the frame description list.

Suffix:
<m> 1..4

Usage: Event

BUS<m>:CMSB:FCOunt?

Returns the frame count.

Suffix:
<m> 1..4

Return values:
<Count>

Usage: Query only

BUS<m>:CMSB:CLR

Erases all cells and frames that have been created for a specific custom protocol.

Suffix:
<m> 1..4

Usage: Event

BUS<m>:CMSB:FRAMe<n>:TYPE <FrameType>

Enables the user to set a string to describe the frame type, typically according to the applicable protocol standard specifications. (For example, MDIO (Option R&S RTE-K55) defines the frames READ, WRITE, ADDRESS, etc.)

Suffix:
<m> 1..4

<n> *

Parameters:
<FrameType>

BUS<m>:CMSB:FRAMe<n>:APPend

Creates an empty cell description and adds it to the end of the active frame description.

Suffix:
<m> 1..4

<n> *

Usage: Event

BUS<m>:CMSB:FRAMe<n>:CCOunt?

Returns the cell count.

Suffix:

<m>	1..4
<n>	*

Return values:

<Count>

Usage: Query only

BUS<m>:CMSB:FRAMe<n>:CELL<o>:NAME <CellName>

Enables the user to set a cell name within a frame. Names do not have to be unique, they are just for user support.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<CellName>

BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITCount <BitCount>

Sets the bit count of a cell, hence its length. Based upon the lengths of the previous cells, this also defines the position of the cell start and end within a frame.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<BitCount> Range: 1 to 65535
Increment: 1
*RST: 1

BUS<m>:CMSB:FRAMe<n>:CELL<o>:CONDition <Condition>

Sets various operators for a cell, to identify, e.g., mandatory values such as a CRC checksum or an ID, that help to identify a frame.

The implemented conditions and functionalities are the "equal" and "array" operators. For details, see "Condition" on page 671.

The numeric format of the condition needs to be set according to `BUS<m>:CMSB:FRAMe<n>:CELL<o>:FORMat` on page 1450.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<Condition>

BUS<m>:CMSB:FRAMe<n>:CELL<o>:FORMat <CellFormat>

Selects the numeric data format for the command `BUS<m>:CMSB:FRAMe<n>:CELL<o>:CONDition` on page 1449, as well as for the result and honeycomb display.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<CellFormat> DEC | HEX | OCT | BIN

DEC
Decimal

HEX
Hexadecimal

OCT
Octal

BIN
Binary

*RST: BIN

BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITorder <BitOrder>

Selects in which order the bits of a cell are evaluated, as well as presented in the results table and honeycomb display.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<BitOrder> LSBF | MSBF

LSBF
Least significant bit first, evaluation starts at the LSB

MSBF
Most significant bit first, evaluation starts at the MSB

*RST: MSBF

BUS<m>:CMSB:FRAMe<n>:CELL<o>:CRGB <Color>

Selects a cell's color representation in the honeycomb display.

Suffix:

<m> 1..4

<n> *

<o> *

Parameters:

<Color> ARGB value of the color to be used for the table entry.
ARGB=<Opacity(alpha) value><red value><green value><blue value>, in hexadecimal or decimal format.

Range: 0 to 4294967295
Increment: 1
*RST: 0

BUS<m>:CMSB:FRAMe<n>:CELL<o>:CLMN <Column>

Selects which cell shall be displayed in which result column of the decode table.

The decode table supports three result columns, which have to be unique for each frame type. For different frame types, though, different result columns can be defined to display unrelated information.

Suffix:

<m> 1..4

<n> *

<o> *

Parameters:
<Column> NONE | COL1 | COL2 | COL3

NONE
The result is not displayed in the decode table.

COL1
The result is displayed in column 1 of the decode table.

COL2
The result is displayed in column 2 of the decode table.

COL3
The result is displayed in column 3 of the decode table.

*RST: NONE

BUS<m>:CMSB:LOAD <FileName>

Opens an existing frame description file in xml format. The default path is `\\Public\Documents\Rohde-Schwarz\RTx\SaveXML`

Suffix:
<m> 1..4

Setting parameters:
<FileName>

Usage: Setting only

BUS<m>:CMSB:SAVE <FileName>

Saves a created frame description into an xml file ("Save As..."). The default path is `\\Public\Documents\Rohde-Schwarz\RTx\SaveXML`

Suffix:
<m> 1..4

Setting parameters:
<FileName>

Usage: Setting only

16.17.14.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:CMSB:TYPE <Type>

Selects the trigger type for custom serial bus analysis.

Parameters:

<Type> STARt | PATTern

STARt
Triggers on the frame start, which is the end of the gap time as specified in `BUS<m>:CMSB:GAPTime:VALue` on page 1447

PATTern
Triggers on a data pattern to be specified in `TRIGger<m>:CMSB:PATTern` on page 1453

*RST: STARt

TRIGger<m>:CMSB:PATTern <DataPattern>

Sets the pattern match conditions for a payload data check. The trigger is set to the first occurrence of a matching data bit pattern (which can be freely specified), starting after the minimum gap time (`BUS<m>:CMSB:GAPTime:VALue` on page 1447), and after the detected start of the data frame.

Parameters:

<DataPattern>

TRIGger<m>:CMSB:ICONdition <DataIdxOperator>

Sets the operator to set a specific bit index (data position).

Parameters:

<DataIdxOperator> EQUal | GETHan | INRange

EQUal
Equal

GETHan
Greater than or equal

INRange
In range

*RST: INRange

TRIGger<m>:CMSB:IMIN <DataPosition>

Sets the bit index (data position). If `TRIGger<m>:CMSB:ICONdition` on page 1453 is set to "INRange", "IMIN" sets the start value of the bit index range.

Parameters:

<DataPosition>	Range:	0 to 65535
	Increment:	1
	*RST:	0

TRIGger<m>:CMSB:IMAX <DataPositionTo>

Sets the end value of the bit index range (data position range), if `TRIGger<m>:CMSB:ICONdition` on page 1453 is set to "INRange".

Parameters:

<DataPositionTo>	Range:	0 to 65535
	Increment:	1
	*RST:	65535

TRIGger<m>:CMSB:NRZ:WRDLength <WordLength>

Sets the number of bits in an NRZ Unclocked word.

Suffix:

<m>	1..3

Parameters:

<WordLength>	Range:	0 to 31
	Increment:	1
	*RST:	8

16.17.14.3 Decode Results

In all `BUS<m>:CSMB:RESult<n>` commands, the suffix <m> selects the serial bus, the suffix <n> selects the result number in the decode table, and the suffix <o> selects the cell number.

As an example, with reference to Figure 12-85, Table 12-13 and Table 12-14, a set of query commands for bus #1 and result #1 is shown in the following, together with examples for outcomes of these queries:

- `:BUS1:CMSB:RCOunt?` !5

- `:BUS1:CMSB:RESult1:STATe?` !OK
- `:BUS1:CMSB:RESult1:STARt?` ! -0.0024964177
- `:BUS1:CMSB:RESult1:STOP?` ! -0.0024030384
- `:BUS1:CMSB:RESult1:TYPE?` !ff
- `:BUS1:CMSB:RESult1:CONE?` !0b11111111
- `:BUS1:CMSB:RESult1:CTWO?` !0xAA

- `:BUS1:CMSB:RESult1:CTHR?` !0xF590
- `:BUS1:CMSB:RESult1:CCOunt?` !5
- `:BUS1:CMSB:RESult1:CELL1:STAT?` !OK
- `:BUS1:CMSB:RESult1:CELL1:NAME?` !Start Delim
- `:BUS1:CMSB:RESult1:CELL1:VALue?` !101010101HL10HL0
- `:BUS1:CMSB:RESult1:CELL2:STAT?` !OK
- `:BUS1:CMSB:RESult1:CELL2:NAME?` !OP-FF
- `:BUS1:CMSB:RESult1:CELL2:VALue?` !0b11111111
- `:BUS1:CMSB:RESult1:CELL3:STAT?` !OK
- `:BUS1:CMSB:RESult1:CELL3:NAME?` !data
- `:BUS1:CMSB:RESult1:CELL3:VALue?` !0xAA
- `:BUS1:CMSB:RESult1:CELL4:STAT?` !OK
- `:BUS1:CMSB:RESult1:CELL4:NAME?` !CRC
- `:BUS1:CMSB:RESult1:CELL4:VALue?` !0xF590
- `:BUS1:CMSB:RESult1:CELL5:STAT?` !OK
- `:BUS1:CMSB:RESult1:CELL5:NAME?` !End Delim
- `:BUS1:CMSB:RESult1:CELL5:VALue?` !1HLHL101

BUS<m>:CMSB:RCOunt?

Returns the count number of decoded result frames in a custom serial bus waveform. Basically, this is the maximum result index <n> when querying results by using `BUS<m>:CMSB:RESult<n>:XXX`.

Suffix:

<m> 1..4

Return values:
<Count>

Usage: Query only

BUS<m>:CMSB:RESult<n>:STATe?

Returns the overall state of the frame: either OK or the relevant error condition.
R&S RTE-K50 marks each frame with a status that indicates whether the decode succeeded or not.

Suffix:

<m> 1..4

<n> *

Return values:

<State> OK | LENGth | UNKNown | INComplete

OK
The frame was decoded normally and conforms to the frame description.

LENGth
The length error indicates that the frame ended prematurely, or an array in the frame had too few elements. The amount of bits that the software expected (based upon the user's frame description) was not found before the frame was terminated. This might occur because a new frame synchronized, or a gap appeared between the bits.

UNKNown
Unknown error

INComplete
The frame ended prematurely because it extends past the end of the record.

*RST: OK

Usage: Query only

BUS<m>:CMSB:RESult<n>:STARt?

Returns the start time of the frame.

Suffix:

<m> 1..4

<n> *

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:CMSB:RESult<n>:STOP?

Returns the stop time of the frame.

Suffix:

<m> 1..4

<n> *

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:CMSB:RESult<n>:TYPE?

Returns the name of the selected frame (n) from the user defined frame format description, labeled according to `BUS<m>:CMSB:FRAMe<n>:TYPE` on page 1448.

Suffix:

<m> 1..4

<n> *

Return values:

<Type>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CONE?

Returns the 1^{st} cell content as specified in the Result Column of the "Frame Format" specification table.

Suffix:

<m> 1..4

<n> *

Return values:

<Custom1>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CTWO?

Returns the 2^{nd} cell content as specified in the Result Column of the "Frame Format" specification table.

Suffix:
<m> 1..4

<n> *

Return values:
<Custom2>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CTHRee?

Returns the 3rd cell content as specified in the Result Column of the "Frame Format" specification table.

Suffix:
<m> 1..4

<n> *

Return values:
<Custom3>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CCOunt?

Returns the number of decoded cells.

Suffix:
<m> 1..4

<n> *

Return values:
<Count>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CELL<o>:NAME?

Returns the name of the specified cell. Cell names are not necessarily unique.

Suffix:
<m> 1..4

<n> *

<o> *

Return values:
<Name>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CELL<o>:STATe?

Returns the state of the cell.

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:

<State> OK | LENGth | UNKNown | INComplete

OK
No error detected

LENGth
The length error indicates that the cell ended prematurely. The amount of bits that the software expected (based upon the user's frame description) was not found before the cell was terminated. This might occur because a new frame synchronized, or a gap appeared between the bits.

UNKNown
Unknown error

INComplete
The cell ended prematurely because it extends past the end of the record.

Usage: Query only

BUS<m>:CMSB:RESult<n>:CELL<o>:VALue?

Data content of the specified cell.

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:

<Value>

Usage: Query only

16.17.15 MDIO (Option R&S RTE-K55)

16.17.15.1 Configuration

In all `BUS<m>:MDIO` commands, the suffix <m> selects the serial bus.

BUS<m>:MDIO:CLOCk:SOURce <ClockSource>

Selects the source for the clock line (management data clock, MDC). Permitted selections are the analog channels "C1"–"C4" and the digital channels "D0"–"D15".

Suffix:

<m> 1..4

Parameters:

<ClockSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data and clock lines. For triggering on a serial bus, analog or digital input channels are required.
See Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: NONE

BUS<m>:MDIO:DATA:SOURce <DataSource>

Selects the source for the data signal. Permitted selections are the analog channels "C1"–"C4" and the digital channels "D0"–"D15", but not the same as for "Clock".

Suffix:

<m> 1..4

Parameters:

<DataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data and clock lines. For triggering on a serial bus, analog or digital input channels are required.
See Chapter 16.4.2, "Waveform Parameter", on page 879

*RST: NONE

BUS<m>:MDIO:MAXGap <MaxGapTime>

Sets the maximum idle time between two frames.

Suffix:

<m>	1..4

Parameters:

<MaxGapTime>	Range: 100E-9 to 100E-6 Increment: 500E-9 *RST: 1E-6 Default unit: s

BUS<m>:MDIO:CLOCk:THReshold:HIGH <ThresClockHigh>

Defines the upper threshold level for the clock signal.

Suffix:

<m>	1..4

Parameters:

<ThresClockHigh>	Range: -5 to 5 Increment: 0.1 *RST: 2 Default unit: V

BUS<m>:MDIO:CLOCk:THReshold:LOW <ThresClockLow>

Defines the lower threshold level for the clock signal.

Suffix:

<m>	1..4

Parameters:

<ThresClockLow>	Range: -5 to 5 Increment: 0.1 *RST: 0.8 Default unit: V

BUS<m>:MDIO:DATA:THReshold:HIGH <ThresDataHigh>

Defines the upper threshold level for the data signal.

Suffix:

<m>	1..4

Parameters:

<ThresDataHigh>	Range: -5 to 5 Increment: 0.1 *RST: 2 Default unit: V

BUS<m>:MDIO:DATA:THReshold:LOW <ThresDataLow>

Defines the lower threshold level for the data signal.

Suffix:

<m>	1..4

Parameters:

<ThresDataLow>	Range: -5 to 5 Increment: 0.1 *RST: 0.8 Default unit: V

BUS<m>:MDIO:PRESet <Preset>

Selects the default threshold settings according to the Ethernet standard: 2.0 V and 0.8 V.

Suffix:

<m>	1..4

Parameters:

<Preset>	DEFault | MANual *RST: DEFault

BUS<m>:MDIO:COUPling <ThresCoup>

Overwrites the data thresholds with the clock thresholds.

Suffix:

<m>	1..4

Parameters:

<ThresCoup>	ON | OFF *RST: ON

16.17.15.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:MDIO:TYPE <Type>

Selects the trigger type for MDIO analysis.

Parameters:

<Type> STARt | STOP | DATA

STARt
Sets the trigger to the start of frame (SOF) field. The start of frame condition and the trigger instant is the end of the preamble. Trigger pattern: preamble (32 bits "1")

STOP
Sets the trigger to the end of frame (EOF) field. The trigger instant is after the last data bit. Trigger pattern: preamble (32 bits "1") + 32 bits "X"

DATA
Sets the trigger to the data field. For more information on the data condition, see MDIO in the Ethernet standard. The trigger instant is at the end of the frame after the last data bit, as indicated in the GUI. Trigger pattern: preamble (32 bits "1") + 2 bits "ST" (Start of Frame Code) + 2 bits "OP" (Frame Type Code, or "OpCode") + 5 bits "PHYAD/PRTAD" (Physical Layer Entity Address / Port Address) + 5 bits "REGAD/DEVAD" (Register Address / Device Address) + 2 bits "TA" (turnaround time, X bits) + 16 bits "DATA/ADDRESS"

*RST: STARt

TRIGger<m>:MDIO:ST <StartCode>

Selects the start of frame code of the frame pattern; available only in trigger type "Data".

Note that Clause 22 is coded by "01", while Clause 45 is coded by "00", thus the lower Clause number is represented by the higher parameter value.

Parameters:

<StartCode> ST00 | ST01 | ST0X

ST00
Clause 45

ST01
Clause 22

ST0X
Any permissible start pattern

*RST: ST0X

TRIGger<m>:MDIO:FRAMetype <FrameType>

Selects the Type of Frame code (or OP code, OpCode, operation code); available only in trigger type "Data".

Note that the same OpCode may have different meanings in Clause 22 and Clause 45.

Parameters:

<FrameType> OP00 | OP01 | OP10 | OP11 | OPXX

OP00
Address frame (in Clause 45, only)

OP01
Write frame (in Clause 22 or Clause 45)

OP10
Read frame (in Clause 22) or Post-Read increment address frame (in Clause 45)

OP11
Read frame (in Clause 45)

OPXX
Any frame type

*RST: OPXX

Note that the user interface shows interpretations of the numerical OpCode values corresponding to Clause 45. Clause 22 is not represented by this interpretation.

TRIGger<m>:MDIO:PHYS <PhyAddr>

Sets the physical address (in Clause 22) or port address (in Clause 45) of the frame pattern (5 bits); available only in trigger type "Data".

Parameters:

<PhyAddr>

TRIGger<m>:MDIO:REGI <RegAddr>

Sets the register address (in Clause 22) or device address (in Clause 45) of the frame pattern (5 bits); available only in trigger type "Data".

Parameters:

<RegAddr>

TRIGger<m>:MDIO:DATA <Data>

Defines the 16-bit payload data pattern (both in Clause 22 or Clause 45) or the address pattern (in Clause 45, only) to trigger for; available only in trigger type "Data".

Parameters:

<Data>

16.17.15.3 Decode Results

In all `BUS<m>:MDIO:WORD<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the word number in the decode table.

BUS<m>:MDIO:WCOunt?

Returns the word count for the selected serial bus, i.e. the number of words in the present acquisition.

Suffix:
<m> 1..4

Return values:
<Count>

Usage: Query only

BUS<m>:MDIO:WORD<n>:DATA?

Returns the 16-bit payload data field content (in Clause 22 or Clause 45), or the 16-bit address field content (in Clause 45, only) in the present acquisition of the selected word and the selected serial bus. The most significant bit (MSB) is transmitted first.

Suffix:
<m> 1..4

<n> *

Return values:
<Data>

Usage: Query only

BUS<m>:MDIO:WORD<n>:PHYS?

Returns the 5-bit address field content (PHYAD/PRTAD) in the present acquisition of the selected word and the selected serial bus.

Suffix:
<m> 1..4

<n> *

Return values:

<PhyAd>	Range:	0 to 32
	Increment:	1

Usage: Query only

BUS<m>:MDIO:WORD<n>:REGI?

Returns the 5-bit register or device address field content (REGAD/DEVAD) in the present acquisition of the selected word and the selected serial bus.

Suffix:

<m> 1..4

<n> *

Return values:

<RegAd>	Range:	0 to 32
	Increment:	1

Usage: Query only

BUS<m>:MDIO:WORD<n>:ST?

Returns the Start Code (= start of frame code) in the present acquisition of the selected word and the selected serial bus.

Suffix:

<m> 1..4

<n> *

Return values:

<StartCode>

Range: [bin]00 to [bin]11
Increment: 1
The parameter value "[bin]00" represents Clause 45, while "[bin]01" stands for Clause 22.
Note that the values "[bin]10" and "[bin]11" do not correspond with any legal parameters according to the standard, but they can still be searched for.

Usage: Query only

BUS<m>:MDIO:WORD<n>:STARt?

Returns the start time of the frame in the selected word of the selected serial bus.

Suffix:

<m> 1..4

<n> *

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:MDIO:WORD<n>:STATe?

Returns the state of the frame in the present acquisition of the selected serial bus.

Suffix:

<m> 1..4

<n> *

Return values:

<State> OK | UNSYN | UNSYncronized | OPCO | TA_ERROR | INComplete | SHORT | SHORt

OK
No error detected

UNSYN = UNSYncronized
UNSYncronized happens when bits are found, but they are not correlated with any synchronization sequence. We don't know what these bits are, but they are there. These bits receive a flag, but they are not decoded.

OPCO
OPcode Error

TA_ERROR
Tirnaround time error

INComplete
Incomplete Frame

SHORT = SHORt
Length Error

*RST: OK

Usage: Query only

BUS<m>:MDIO:WORD<n>:STOP?

Returns the stop time of the frame from the selected word within the search result.

Suffix:

<m> 1..4

<n> *

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:MDIO:WORD<n>:SYMBol?

Returns a textual translation (called Register Name) of the PHY or port address label in the present acquisition of the selected word and the selected serial bus.

The translation is defined in the label list.

Suffix:

<m> 1..4

<n> *

Return values:

<Translation>

Usage: Query only

BUS<m>:MDIO:WORD<n>:TYPE?

Returns the OpCode (= operation code or frame type) in the present acquisition of the selected word and the selected serial bus.

Suffix:

<m> 1..4

<n> *

Return values:

<FrameType> Range: [bin]00 to [bin]11
Increment: 1

Usage: Query only

16.17.15.4 Search Settings

SEARch:TRIGger:MDIO:DATA <SearchName>,<Data>
SEARch:TRIGger:MDIO:DATA? <SearchName>

Allows to define the 16-bit payload data pattern (both in Clause 22 or Clause 45) or the address pattern (in Clause 45, only) to search for; available only in search criteria type "Data".

Parameters:
<Data>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:FRAMetype <SearchName>,<FrameType>
SEARch:TRIGger:MDIO:FRAMetype? <SearchName>

Allows to select the Type of Frame code (or OP code, OpCode, operation code); available only in search criteria type "Data".

Note that the same OpCode may have different meanings in Clause 22 and Clause 45.

Parameters:
<FrameType> OP00 | OP01 | OP10 | OP11 | OPXX

OP00
Address frame (in Clause 45, only)

OP01
Write frame (in Clause 22 or Clause 45)

OP10
Read frame (in Clause 22) or Post-Read increment address frame (in Clause 45)

OP11
Read frame (in Clause 45)

OPXX
Any frame type

*RST: OPXX

Note that the user interface shows interpretations of the numerical OpCode values corresponding to Clause 45. Clause 22 is not represented by this interpretation.
Also, note that OPXX will never be a result of decoding, but it is still an option for triggering.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:PHYS <SearchName>,<PhyAddr>
SEARch:TRIGger:MDIO:PHYS? <SearchName>

Allows to set the physical address (in Clause 22) or port address (in Clause 45) of the frame pattern (5 bits); available only in search criteria type "Data".

Parameters:
<PhyAddr>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:REGI <SearchName>,<RegAddr>
SEARch:TRIGger:MDIO:REGI? <SearchName>

Allows to set the register address (in Clause 22) or device address (in Clause 45) of the frame pattern (5 bits); available only in search criteria type "Data".

Parameters:
<RegAddr>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:ST <SearchName>,<StartCode>
SEARch:TRIGger:MDIO:ST? <SearchName>

Allows to select the start of frame code of the frame pattern; available only in search criteria type "Data".

Parameters:

<StartCode> ST00 | ST01 | ST0X

ST00
Clause 45

ST01
Clause 22

ST0X
Any permissible start pattern

*RST: ST0X

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:TYPE <SearchName>,<Type>
SEARch:TRIGger:MDIO:TYPE? <SearchName>

Selects the event type to search for.

Parameters:
<Type> STARt | STOP | DATA

STARt
Searches for the start of frame (SOF).

STARt
Searches for the end of frame (EOF).

DATA
Allows to specify a payload data pattern (both in Clause 22 or Clause 45) or an address pattern (in Clause 45, only) to search for.

*RST: STARt

Parameters for setting and query:
<SearchName>

16.17.15.5 Search Results

In all `SEARch:RESult:MDIO:WORD<m>` commands, the suffix <m> selects the packet number in the list of search results.

SEARch:RESult:MDIO:WORD<m>:DATA? <SearchName>

Returns the 16-bit payload data field content (in Clause 22 or Clause 45), or the 16-bit address field content (in Clause 45, only) from the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:PHYS? <SearchName>

Returns the 5-bit address field content (PHYAD/PRTAD) from the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<PhyAd> Range: 0 to 32
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:REGI? <SearchName>

Returns the 5-bit register or device address field content (REGAD/DEVAD) from the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<RegAd> Range: 0 to 32
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:ST? <SearchName>

Returns the start of frame code from the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<StartCode> Range: 0 to 3
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:STARt? <SearchName>

Returns the start time of the frame from the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:STATe? <SearchName>

Returns the state of the frame from the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<State> OK | UNSYN | UNSYncronized | OPCO | TA_ERROR | INComplete | SHORT | SHORt

OK
No error detected

UNSYN = UNSYncronized
UNSYncronized happens when bits are found, but they are not correlated with any synchronization sequence. We don't know what these bits are, but they are there. These bits receive a flag, but they are not decoded.

OPCO
OPcode error

TA_ERROR
turnaround time error

INComplete
Incomplete Frame

SHORT = SHORt
Length Error

*RST: OK

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:STOP? <SearchName>

Returns the stop time of the frame from the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:SYMBol? <SearchName>

Returns a textual translation (called Register Name) of the PHY or port address label from the selected word within the search result.

This translation can be user-configured through the translation table. For details on how the configuration is done, see Chapter 12.1.3, "Label Lists", on page 441.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Translation>

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:TYPE? <SearchName>

Returns the frame type (= operation code or OpCode) for the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameType> Range: 0 to 3
Increment: 1
*RST: 0
Note that the user interface shows interpretations of the numerical OpCode values corresponding to Clause 45: "0" (= [bin]00) represents Address, "1" (= [bin]01" represents Write, "2" (= [bin]10) represents Post Read, "3" (= [bin]11) represents Read. Clause 22 is not represented by this interpretation.

Usage: Query only

SEARch:RESult:MDIO:WCOunt <SearchName>

Returns the word count within the search result.

Setting parameters:
<SearchName>

Return values:
<Count>

16.17.16 USB (Option R&S RTE-K60)

16.17.16.1 Configuration

In all `BUS<m>:USB` commands, the suffix <m> selects the serial bus.

BUS<m>:USB:TECHnology <ProtocolType>

Defines the USB protocol technology and transmission speed.

Suffix:

<m> 1..4

Parameters:

<ProtocolType> LOW | FULL | HIGH | HSIC

LOW
USB low speed protocol (1.5 Mbit/s)

FULL
USB full speed protocol (12 Mbit/s)

HIGH
USB high speed protocol (480 Mbit/s)

HSIC
USB high speed inter-chip (HSIC) protocol (480 Mbit/s)

*RST: LOW

Usage: SCPI confirmed

BUS<m>:USB:DPLus:SOURce <SourceDplus>

Selects the source for the D+ data signal (in USB low speed and USB full speed protocol, only). Permitted selections are the analog channels "C1"–"C4".

Suffix:

<m> 1..4

Parameters:

<SourceDplus> C1W1 | C2W1 | C3W1 | C4W1

*RST: C1W1

Usage: Asynchronous command

BUS<m>:USB:DMINus:SOURce <SourceDminus>

Selects the source for the D- data signal (in USB low speed and USB full speed protocol, only). Permitted selections are the analog channels "C1"–"C4".

Suffix:

<m> 1..4

Parameters:

<SourceDminus> C1W1 | C2W1 | C3W1 | C4W1

*RST: C2W1

Usage: Asynchronous command

BUS<m>:USB:DIFFerential:SOURce <SourceDifferential>

Selects the source for the differential signal in the USB high speed protocol. Permitted selections are the analog channels "C1"–"C4".

Suffix:
<m> 1..4

Parameters:
<SourceDifferential> C1W1 | C2W1 | C3W1 | C4W1
*RST: C1W1

Usage: Asynchronous command

BUS<m>:USB:DATA:SOURce <DataSource>

Selects the source for the data signal in the USB HSIC protocol. Permitted selections are the analog channels "C1"–"C4".

Suffix:
<m> 1..4

Parameters:
<DataSource> C1W1 | C2W1 | C3W1 | C4W1
*RST: NONE

Usage: Asynchronous command

BUS<m>:USB:STRobe:SOURce <SourceStrobe>

Selects the source for the strobe signal in the USB HSIC protocol. Permitted selections are the analog channels "C1"–"C4".

Suffix:
<m> 1..4

Parameters:
<SourceStrobe> C1W1 | C2W1 | C3W1 | C4W1
*RST: C2W1

Usage: Asynchronous command

BUS<m>:USB:DPLus:THReshold <ThresholdDplus>

Defines the threshold level for the D+ data signal (in USB low speed and USB full speed protocol, only).

Suffix:
<m> 1..4

Parameters:
<ThresholdDplus> Range: -5 to 5
Increment: 0.01
*RST: 1.55
Default unit: V

BUS<m>:USB:DMINus:THReshold <ThresholdDminus>

Defines the threshold level for the D- data signal (in USB low speed and USB full speed protocol, only).

Suffix:

<m> 1..4

Parameters:

<ThresholdDminus> Range: -5 to 5
Increment: 0.01
*RST: 1.55
Default unit: V

BUS<m>:USB:DIFFerential:THReshold <ThresDifferential>

Defines the threshold level for the differential signal in the USB high speed protocol.

Suffix:

<m> 1..4

Parameters:

<ThresDifferential> Range: -2 to 2
Increment: 0.01
*RST: 0
Default unit: V

BUS<m>:USB:DATA:THReshold <ThresholdData>

Defines the threshold level for the data signal in the USB HSIC protocol.

Suffix:

<m> 1..4

Parameters:

<ThresholdData> Range: -2 to 2
Increment: 0.01
*RST: 0.65
Default unit: V

BUS<m>:USB:STRobe:THReshold <ThresholdStrobe>

Defines the threshold level for the strobe signal in the USB HSIC protocol.

Suffix:

<m> 1..4

Parameters:

<ThresholdStrobe> Range: -2 to 2
Increment: 0.01
*RST: 0.65
Default unit: V

16.17.16.2 Trigger

In all TRIGger<m>:USB commands, the suffix <m> selects the trigger event: Only 1 (= A-trigger) is available; the suffix can be omitted.

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- TRIGger<m>:SOURce is set to SBUS.
- The source(s) of the serial bus are channel signals: use BUS<m>:...:SOURce commands.
- Decoding is enabled: BUS<m>[:STATe] is set to ON.

TRIGger<m>:USB:TYPE <Type>

Selects the trigger type for USB analysis. The available trigger types depend on the activated USB protocol type.

Parameters:

<Type> SOP | EOP | RST | SUSPend | RESume | TOKen | DATA | HANDshake | SPECial | ERRCond

SOP
Sets the trigger to the SOP (start of packet) field. The start of packet condition is the end of the SYNC field. The trigger instant is the end of the SOP field.

EOP
Sets the trigger to the EOP (end of packet) field. Not available for USB High Speed and USB HSIC protocol types. The trigger instant is the beginning of the EOP field.

RST
Sets the trigger to the Reset field. Not available for USB High Speed and USB HSIC protocol types. For more information on the reset condition, see the USB standard. The trigger instant is the end of the 10 ms period after the SE0 field.

SUSPend
Sets the trigger to the Suspend field. Not available for USB High Speed and USB HSIC protocol types. For more information on the suspend condition, see the USB standard. The trigger instant will be declared after the defined 3 ms timeout.

RESume
Sets the trigger to the Resume field. Not available for USB High Speed and USB HSIC protocol types. For more information on the resume condition, see the USB standard. The trigger instant will be declared after the defined 20 ms timeout.

TOKen
Sets the trigger to one out of four different token trigger types: OUT, IN, SOF, or SETUP.

DATA
Sets the trigger to one out of four different data trigger types: DATA0, DATA1, DATA2, or MDATA.

HANDshake
Sets the trigger to one out of four different handshake trigger types: ACK, NAK, STALL, or NYET.

SPECial
Sets the trigger to one out of four different Special PID trigger types: PREamble, ERR, SPLIT, or PING.

ERRCond
Sets the trigger to one out of seven different error condition trigger types: PID error, CRC5 error, CRC16 error, Bitstuffing error, Unexpected PID error, SE1 error, or Glitching error.

*RST: SOP

TRIGger<m>:USB:ACONdition <OperatorAddress>

Sets the operator to set a specific address or an address range. The address values are set with TRIGger<m>:USB:AMIN and TRIGger<m>:USB:AMAX.

Parameters:
<OperatorAddress> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one address value to be set using TRIGger<m>:USB:AMIN.

INRange | OORange
In range, out of range. These conditions require an address range to be set using TRIGger<m>:USB:AMIN and TRIGger<m>:USB:AMAX.

*RST: EQUal

TRIGger<m>:USB:AMIN <Address>

Specifies the address, or sets the the start value of an address range. The string parameter does not accept the bit value X (don't care).

Parameters:
<Address>

TRIGger<m>:USB:AMAX <AddressTo>

Sets the the end value of an address range if TRIGger<m>:USB:ACONdition is set to INRange or OORange. The string parameter does not accept the bit value X (don't care).

Parameters:
<AddressTo>

TRIGger<m>:USB:DATA <USBDataType>

Sets the trigger to one out of four different payload data types: DATA0, DATA1, DATA2, or MDATA.

Parameters:

<USBDataType> D0 | D1 | D2 | MD

D0
Sets the trigger to the DATA0 field (even PID).

D1
Sets the trigger to the DATA1 field (odd PID).

D2
Sets the trigger to the DATA2 field (data packet PID for high-speed, high bandwidth isochronous transaction in a microframe).

MD
Sets the trigger to the MDATA field (high-speed data packet PID for split and high bandwidth isochronous transactions).

*RST: D0

TRIGger<m>:USB:DCONdition <OperatorData>

Sets the operator (equal or unequal) to set a specific payload data pattern.

Parameters:

<OperatorData> EQUal | NEQual

*RST: EQUal

TRIGger<m>:USB:DPOPerator <OperatorPosi>

Sets the operator (any or equal) for the payload data index position.

Parameters:

<OperatorPosi> ANY | OFF | EQUal

ANY = OFF
The position of the bit pattern within the payload data is not relevant.

EQUal
Sets the operator for specifying a special start position for the bit pattern within the payload data.

*RST: ANY

TRIGger<m>:USB:DPOSition <DataPosition>

Specifies the position within a payload data packet, in which a special data pattern is to be searched.

Parameters:

<DataPosition> Range: 0 to 1024
Increment: 1
*RST: 0

TRIGger<m>:USB:ECONdition <OperatorEndpoint>

Sets the operator to set a specific endpoint or an endpoint range. The endpoint values are set with `TRIGger<m>:USB:EMIN` and `TRIGger<m>:USB:EMAX`.

Parameters:

<OperatorEndpoint> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `TRIGger<m>:USB:EMIN`.

INRange | OORange
In range, out of range. These conditions require a range of endpoint values to be set using `TRIGger<m>:USB:EMIN` and `TRIGger<m>:USB:EMAX`.

*RST: EQUal

TRIGger<m>:USB:EMIN <Endp>

Specifies the endpoint, or sets the the start value of an endpoint range.

Parameters:

<Endp>

TRIGger<m>:USB:EMAX <EndpTo>

Sets the the end value of an endpoint range if `TRIGger<m>:USB:ECONdition` is set to `INRange` or `OORange`.

Parameters:

<EndpTo>

TRIGger<m>:USB:ERRC <ErrorConditionType>

Sets the trigger to one of the following eight error condition types: PID error, CRC5 error, CRC16 error, Bitstuffing error, unexpected PID error, SE1 error, or Glitching error, as well as Any of these errors.

Parameters:
<ErrorConditionType> ANY | PIDerror | CRC5error | CRC16error | BTST | UNEXpid | SE1error | GLITcherr

ANY
Triggers on any of the errors listed below.

PIDerror
Triggers on any packet identifier error.

CRC5error
Triggers on any CRC5 error event.

CRC16error
Triggers on any CRC16 error event.

BTST
Triggers on any Bitstuffing error event (erroneous or missing bit stuffing sequence, see USB standard).

UNEXpid
Triggers on any unexpected PID error (illegal PID, that is not allowed in USB low speed and USB full speed protocols, especially PID's announcing packets such as SPLIT, DATA2, MDATA, or other noncompliant packets).

SE1error
Triggers on the illegal bus state Single Ended 1 (SE1 = both lines high).

GLITcherr
Triggers on any Glitching error (illegal bit period, see USB standard for the definition of glitching).

*RST: ANY

TRIGger<m>:USB:FCONdition <OperatorFrameNo>

Sets the operator to set a specific frame number or a frame number range. The frame number values are set with `TRIGger<m>:USB:FMIN` and `TRIGger<m>:USB:FMAX`.

Parameters:
<OperatorFrameNo> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one frame number value to be set using `TRIGger<m>:USB:FMIN`.

INRange | OORange
In range, out of range. These conditions require a range of frame number values to be set using `TRIGger<m>:USB:FMIN` and `TRIGger<m>:USB:FMAX`.

*RST: EQUal

TRIGger<m>:USB:FMIN <FrameNumber>

Specifies the frame number, or sets the the start value of a frame number range.

Parameters:
<FrameNumber>

TRIGger<m>:USB:FMAX <FrameNumberTo>

Sets the the end value of a frame number range if `TRIGger<m>:USB:FCONdition` is set to `INRange` or `OORange`.

Parameters:
<FrameNumberTo>

TRIGger<m>:USB:HAND <HandshakeType>

Sets the trigger to one out of four different handshake types: ACK, NAK, STALl, or NYET.

Parameters:

<HandshakeType> ACK | NAK | STALl | NYET

ACK
Sets the trigger to the ACK field (acknowledgment of error-free data packet).

NAK
Sets the trigger to the NAK field (non-acknowledgment, no successful data transmission).

STALl
Sets the trigger to the STALL field (endpoint is halted or a control pipe request is not supported).

NYET
Sets the trigger to the NYET field (no response yet from receiver).

*RST: ACK

TRIGger<m>:USB:PATT <PayloadMuster>

Specifies the payload data pattern that is to be searched.

Parameters:
<PayloadMuster>

TRIGger<m>:USB:PCONdition <OperatorPort>

Sets the operator to set a specific port number or a port number range. The port number values are set with `TRIGger<m>:USB:PMIN` and `TRIGger<m>:USB:PMAX`.

Parameters:

<OperatorPort> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one port number to be set using TRIGger<m>:USB:PMIN.

INRange | OORange
In range, out of range. These conditions require a port number range to be set using TRIGger<m>:USB:PMIN and TRIGger<m>:USB:PMAX.

*RST: EQUal

TRIGger<m>:USB:PMIN <Port>

Specifies the port number, or sets the the start value of a port number range.

Parameters:
<Port>

TRIGger<m>:USB:PMAX <PortTo>

Sets the the end value of a port number range if TRIGger<m>:USB:PCONdition is set to INRange or OORange.

Parameters:
<PortTo>

TRIGger<m>:USB:SCONdition <OperatorSEU>

Sets the operator to set a specific SEU or an SEU range. The SEU values are set with TRIGger<m>:USB:SMIN and TRIGger<m>:USB:SMAX.

For SEU, see "SEU check" on page 721.

Parameters:

<OperatorSEU> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The position of the SEU is not relevant.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one SEU value to be set using `TRIGger<m>:USB:SMIN`.

INRange | OORange
In range, out of range. These conditions require a range of SEU values to be set using `TRIGger<m>:USB:SMIN` and `TRIGger<m>:USB:SMAX`.

*RST: EQUal

TRIGger<m>:USB:SMIN <SEU>

Specifies the SEU, or sets the the start value of an SEU range.

Parameters:
<SEU>

TRIGger<m>:USB:SMAX <SEUTo>

Sets the the end value of an SEU range if `TRIGger<m>:USB:SCONdition` is set to `INRange` or `OORange`.

Parameters:
<SEUTo>

TRIGger<m>:USB:SPEC <USBSpecialType>

Sets the trigger to one out of four different Special PID types: PREamble, ERR, SPLit, or PING.

Parameters:

<USBSpecialType> PREamble | ERR | SPLit | PING

PREamble
Sets the trigger to the PREamble PID

ERR
Sets the trigger to the ERRor PID

SPLit
Sets the trigger to the SPLIT PID (in USB high speed transactions)

PING
Sets the trigger to the PING PID (in USB high speed transactions, flow control probe for a bulk/control endpoint)

*RST: PREamble

TRIGger<m>:USB:STCO <SC>

Sets the trigger to a specific start-split or complete-split transaction endpoint.

Parameters:

<SC> ONE | ZERO | DC

ONE
SC = 1 represents a complete-split (CSPLIT) transaction.

ZERO
SC = 0 represents a start-split (SSPLIT) transaction.

DC
SC = X represents "don't care" (DC)

*RST: DC

TRIGger<m>:USB:TCONdition <OperatorET>

Sets the operator to set a specific endpoint type (ET) or an ET range. The ET values are set with `TRIGger<m>:USB:TMIN` and `TRIGger<m>:USB:TMAX`.

Parameters:
<OperatorET> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The position of the endpoint type is not relevant.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one ET value to be set using `TRIGger<m>:USB:TMIN`.

INRange | OORange
In range, out of range. These conditions require a range of ET values to be set using `TRIGger<m>:USB:SMIN` and `TRIGger<m>:USB:SMAX`.

*RST: EQUal

TRIGger<m>:USB:TMIN <ET>

Specifies the endpoint type, or sets the the start value of an endpoint type range.

Parameters:
<ET>

TRIGger<m>:USB:TMAX <ETTo>

Sets the the end value of an endpoint type range if `TRIGger<m>:USB:TCONdition` is set to `INRange` or `OORange`.

Parameters:
<ETTo>

TRIGger<m>:USB:TOKen <USBTokenType>

Sets the trigger to one out of four different token types: OUT, IN, SOF, or SETup.

Parameters:
<USBTokenType> OUT | IN | SOF | SETup

OUT
Sets the trigger to the OUT token (OUT packet from host to device).

IN
Sets the trigger to the IN token (IN packet from device to host).

SOF
Sets the trigger to the SOF token (start of frame marker and frame number).

SETup
Sets the trigger to the SETUP token (address and endpoint number in OUT transaction for setup to a control pipe).

*RST: OUT

TRIGger<m>:USB:WADD <WithAddressCheck>

Defines, whether the address check shall be activated or not.

Parameters:
<WithAddressCheck> ON | OFF

*RST: OFF

TRIGger<m>:USB:WEND <WithEndpCheck>

Defines, whether the endpoint check shall be activated or not.

Parameters:
<WithEndpCheck> ON | OFF

*RST: OFF

TRIGger<m>:USB:WETCheck <WithETCheck>

Defines, whether the Endpoint Type (ET) check shall be activated or not.

Parameters:
<WithETCheck> ON | OFF

*RST: OFF

TRIGger<m>:USB:WFRN <WithFrameNoChk>

Defines, whether the frame number check shall be activated or not.

Parameters:
<WithFrameNoChk> ON | OFF

*RST: OFF

TRIGger<m>:USB:WPAY <WithPayloadCheck>

Defines, whether the payload data check shall be activated or not.

Parameters:

<WithPayloadCheck>	ON | OFF	
	*RST:	OFF

TRIGger<m>:USB:WPID <WithPIDCheck>

Defines, whether the packet ID error check shall be activated or not.

Parameters:

<WithPIDCheck>	ON | OFF	
	*RST:	OFF

TRIGger<m>:USB:WPOR <WithPortCheck>

Defines, whether the port check shall be activated or not.

Parameters:

<WithPortCheck>	ON | OFF	
	*RST:	OFF

TRIGger<m>:USB:WSEU <WithSEUCheck>

Defines, whether the SEU check shall be activated or not.

For SEU, see "SEU check" on page 721.

Parameters:

<WithSEUCheck>	ON | OFF	
	*RST:	OFF

TRIGger<m>:USB:WSTC <WithSCCheck>

Defines, whether the Start / Complete (SC) check shall be activated or not.

Parameters:

<WithSCCheck>	ON | OFF	
	*RST:	OFF

16.17.16.3 Decode Results

In all `BUS<m>:USB:PACKet<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the packet number in the decode table.

As an example, with reference to Figure 12-103 (packet #19) in Chapter 12.15.4, "USB Decode Results", on page 722, the status of the Token IN packet can be queried in the following way:

► `BUS:USB:PACKet19:STAT?`

The result of this remote command query should be "OK".

BUS<m>:USB:PACKet<n>:PID?

Returns the packet PID for the selected serial bus and packet number.

Suffix:

<m>	1..4
<n>	*

Return values:

<PID>

RES | OUT | ACK | DATA0 | DATa0 | PING | SOF | NYET | DATA2 | DATa2 | SPLIT | SPLit | IN | NAK | DATA1 | DATa1 | PRE | SETUP | SETup | STALL | STALl | MDATA | MDATa | UNK

RES
RES = Reserved

OUT
OUT Token PID

IN
IN Token PID

SOF
Start Of Frame PID

SETUP = SETup
SETUP PID

DATA0 = DATa0
DATA0 PID, even PID

DATA1 = DATa1
DATA1 PID, odd PID

DATA2 = DATa2
DATA2 PID (only valid in USB high speed and USB HSIC protocols)

MDATA = MDATa
MDATA PID (only valid in USB high speed and USB HSIC protocols)

ACK
ACKnowledgment PID

NAK
Non-AcKnowledgment PID

STALL = STALl
STALL PID

NYET
Not ready YET (only valid in USB high speed and USB HSIC protocols)

PRE
PREamble PID (only valid in USB high speed and USB HSIC protocols)

SPLIT = SPLit
SPLIT PID (only valid in USB high speed and USB HSIC protocols)

PING
PING PID (only valid in USB high speed and USB HSIC protocols)

UNK

UNK = Unknown PID

*RST: RES

Usage: Query only

BUS<m>:USB:PACKet<n>:ADDRess?

Returns the packet address for the selected serial bus and packet number.

Suffix:

<m> 1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:CRC?

Returns the packet CRC (Cyclic Redundancy Code) for the selected serial bus and packet number.

Suffix:

<m> 1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:DATA?

Returns the payload data from the packet with the selected packet number (for the selected serial bus).

Suffix:

<m> 1..4

<n> *

Parameters:

<Data> Comma-separated sequence of integer values (N, D1, D2,…, DN). N is the number of bytes in the packet. and D1…DN are the values of the bytes.

Example:

```
BUS:USB:PACKet4:DATA?
<-- 6,18,52,86,120,154,188
```

Usage: Query only

BUS<m>:USB:PACKet<n>:ENDPoint?

Returns the endpoint for the selected serial bus and packet number.

Suffix:

<m> 1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:ET?

Returns the endpoint type (ET) for the selected serial bus and packet number.

Suffix:
<m> 1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:FRAMe?

Returns the frame number for the selected serial bus and packet number.

Suffix:
<m> 1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:PORT?

Returns the port number for the selected serial bus and packet number.

Suffix:
<m> 1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:SC?

Returns the Start- / Complete-split transaction (SSPLIT / CSPLIT) flag bits for the selected serial bus and packet number.

Suffix:
<m> 1..4

<n> *

Usage: Query only

BUS<m>:USB:PACKet<n>:SEU?

Returns the SEU values for the selected serial bus and packet number.

For SEU, see "SEU check" on page 721.

Suffix:

<m>	1..4
<n>	*

Usage: Query only

BUS<m>:USB:PACKet<n>:STARt?

Returns the start position of the packet with the selected packet number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Usage: Query only

BUS<m>:USB:PACKet<n>:STATus?

Returns the status of the packet with the selected packet number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<State> OK | PID | CRC | BTST | GLITCH | GLITch | BYTE

*RST: OK

Usage: Query only

BUS<m>:USB:PACKet<n>:STOP?

Returns the stop time of the packet with the selected packet number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

BUS<m>:USB:PCOunt?

Returns the packet count for the selected serial bus, i.e. the number of packets in the present acquisition.

Suffix:

<m> 1..4

Return values:

<Count> Range: 0 to 4294967295
Increment: 1

Usage: Query only

16.17.16.4 Search Settings

SEARch:TRIGger:USB:ACONdition <SearchName>,<OperatorAddress>
SEARch:TRIGger:USB:ACONdition? <SearchName>

Sets the operator to set a specific address or an address range.

Parameters:

<OperatorAddress> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one address value to be set using `SEARch:TRIGger:USB:AMIN`.

INRange | OORange
In range, out of range. These conditions require an address range to be set using `SEARch:TRIGger:USB:AMIN` and `SEARch:TRIGger:USB:AMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:AMIN <SearchName>,<Address>
SEARch:TRIGger:USB:AMIN? <SearchName>

Specifies an address, or sets the start value of an address range. The string parameter does not accept the bit value X (don't care).

Parameters:
<Address>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:AMAX <SearchName>,<AddressTo>
SEARch:TRIGger:USB:AMAX? <SearchName>

Sets the the end value of an address range if `TRIGger<m>:USB:ACONdition` is set to `INRange` or `OORange`. The string parameter does not accept the bit value X (don't care).

Parameters:
<AddressTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:BITSterror <SearchName>,<Search bitstuff error>
SEARch:TRIGger:USB:BITSterror? <SearchName>

Defines, whether a search for any bitstuffing error shall be activated or not.

Parameters:

<Search bitstuff error>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:CRC16error <SearchName>,<Search CRC16 error>
SEARch:TRIGger:USB:CRC16error? <SearchName>

Defines, whether a search for any CRC16 error shall be activated or not.

Parameters:

<Search CRC16 error>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:CRC5error <SearchName>,<Search CRC5 error>
SEARch:TRIGger:USB:CRC5error? <SearchName>

Defines, whether a search for any CRC5 error shall be activated or not.

Parameters:

<Search CRC5 error>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:DATA <SearchName>,<USBDataType>
SEARch:TRIGger:USB:DATA? <SearchName>

Defines, which data packet type is searched for: "DATA0", "DATA1", "DATA2", or "MDATA", as well as "Any" data packet.

Parameters:
<USBDataType> ANY | D0 | D1 | D2 | MD

ANY
Searches for any of the data packet types listed below

D0
Searches for a DATA0 packet (even PID)

D1
Searches for a DATA1 packet (odd PID)

D2
Searches for a DATA2 packet (high-speed data packet for high bandwidth isochronous transaction in a microframe)

MD
Searches for an MDATA packet (high-speed data packet for split and high bandwidth isochronous transactions)

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:DCONdition <SearchName>,<OperatorData>
SEARch:TRIGger:USB:DCONdition? <SearchName>

Sets the operator (equal or unequal) to set a specific payload data pattern.

Parameters:
<OperatorData> EQUal | NEQual

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:DPOPerator <SearchName>,<OperatorPosi>
SEARch:TRIGger:USB:DPOPerator? <SearchName>

Sets the operator (any or equal) for the payload data index position.

Parameters:
<OperatorPosi> ANY | OFF | EQUal

ANY = OFF
The position of payload data is not relevant for the search condition.

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:USB:DPOSition? <SearchName>

Specifies the position within a payload data packet, in which a special data pattern is to be searched.

Parameters:

<DataPosition>	Range:	0 to 1024
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:ECONdition <SearchName>,<OperatorEndpoint>
SEARch:TRIGger:USB:ECONdition? <SearchName>

Sets the operator to set a specific endpoint or an endpoint range. The endpoint values are set with `SEARch:TRIGger:USB:EMIN` and `SEARch:TRIGger:USB:EMAX`.

Parameters:
<OperatorEndpoint> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `SEARch:TRIGger:USB:EMIN`.

INRange | OORange
In range, out of range. These conditions require a range of endpoint values to be set using `SEARch:TRIGger:USB:EMIN` and `SEARch:TRIGger:USB:EMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:EMIN <SearchName>,<Endp>
SEARch:TRIGger:USB:EMIN? <SearchName>

Specifies an endpoint, or sets the start value of an endpoint range.

Parameters:
<Endp>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:EMAX <SearchName>,<EndpTo>
SEARch:TRIGger:USB:EMAX? <SearchName>

Sets the the end value of an endpoint range if `TRIGger<m>:USB:ECONdition` is set to `INRange` or `OORange`.

Parameters:
<EndpTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:FCONdition <SearchName>,<OperatorFrameNo>
SEARch:TRIGger:USB:FCONdition? <SearchName>

Sets the operator to set a specific frame number or a frame number range. The frame number values are set with `SEARch:TRIGger:USB:FMIN` and `SEARch:TRIGger:USB:FMAX`.

Parameters:
<OperatorFrameNo> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one frame number value to be set using `SEARch:TRIGger:USB:FMIN`.

INRange | OORange
In range, out of range. These conditions require a range of frame number values to be set using `SEARch:TRIGger:USB:FMIN` and `SEARch:TRIGger:USB:FMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:FMIN <SearchName>,<FrameNumber>
SEARch:TRIGger:USB:FMIN? <SearchName>

Specifies a frame number, or sets the start value of a frame number range.

Parameters:
<FrameNumber>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:FMAX <SearchName>,<FrameNumberTo>
SEARch:TRIGger:USB:FMAX? <SearchName>

Sets the the end value of a frame number range if `TRIGger<m>:USB:FCONdition` is set to `INRange` or `OORange`.

Parameters:
<FrameNumberTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:GLITcherror <SearchName>,<Search glitch error>
SEARch:TRIGger:USB:GLITcherror? <SearchName>

Defines, whether a search for any glitch error shall be activated or not.

Parameters:

<Search glitch error>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:HAND <SearchName>,<HandshakeType>
SEARch:TRIGger:USB:HAND? <SearchName>

Defines, which handshake type is searched for.

Parameters:

<HandshakeType>	ANY | ACK | NAK | STALl | NYET *RST: ACK

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:PATT <SearchName>,<PayloadMuster>
SEARch:TRIGger:USB:PATT? <SearchName>

Defines the payload data pattern to search for.

Parameters:
<PayloadMuster>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:PCONdition <SearchName>,<OperatorPort>
SEARch:TRIGger:USB:PCONdition? <SearchName>

Sets the operator to set a specific port number or a port number range. The port number values are set with `SEARch:TRIGger:USB:PMIN` and `SEARch:TRIGger:USB:PMAX`.

Parameters:
<OperatorPort> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one port number to be set using `SEARch:TRIGger:USB:PMIN`.

INRange | OORange
In range, out of range. These conditions require a port number range to be set using `SEARch:TRIGger:USB:PMIN` and `SEARch:TRIGger:USB:PMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:PMIN <SearchName>,<Port>
SEARch:TRIGger:USB:PMIN? <SearchName>

Specifies a port number, or sets the start value of a port number range.

Parameters:
<Port>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:PMAX <SearchName>,<PortTo>
SEARch:TRIGger:USB:PMAX? <SearchName>

Sets the the end value of a port number range if `TRIGger<m>:USB:PCONdition` is set to `INRange` or `OORange`.

Parameters:
<PortTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:PIDerror <SearchName>,<Search PID error>
SEARch:TRIGger:USB:PIDerror? <SearchName>

Defines, whether a search for any PID error shall be activated or not.

Parameters:
<Search PID error> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SCONdition <SearchName>,<OperatorSEU>
SEARch:TRIGger:USB:SCONdition? <SearchName>

Sets the operator to set a specific SEU or an SEU range. The SEU values are set with `SEARch:TRIGger:USB:SMIN` and `SEARch:TRIGger:USB:SMAX`.

For SEU, see "SEU check" on page 721.

Parameters:
<OperatorSEU> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The SEU is not relevant for the search condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one SEU value to be set using `SEARch:TRIGger:USB:SMIN`.

INRange | OORange
In range, out of range. These conditions require a range of SEU values to be set using `SEARch:TRIGger:USB:SMIN` and `SEARch:TRIGger:USB:SMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SMIN <SearchName>,<SEU>
SEARch:TRIGger:USB:SMIN? <SearchName>

Specifies an SEU, or sets the start value of an SEU range.

Parameters:
<SEU>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SMAX <SearchName>,<SEUTo>
SEARch:TRIGger:USB:SMAX? <SearchName>

Sets the the end value of an SEU range if `TRIGger<m>:USB:SCONdition` is set to `INRange` or `OORange`.

Parameters:
<SEUTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SDATa <SearchName>,<Search Data Packet>
SEARch:TRIGger:USB:SDATa? <SearchName>

Defines, whether the search for any data packet shall be activated or not.

Parameters:

<Search Data Packet>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SERRor <SearchName>,<Search Error Condition>
SEARch:TRIGger:USB:SERRor? <SearchName>

Defines, whether the search for any error condition shall be activated or not.

Parameters:

<Search Error Condition>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SHANdshake <SearchName>,<Search Handshake Packet>
SEARch:TRIGger:USB:SHANdshake? <SearchName>

Defines, whether the search for any handshake packet shall be activated or not.

Parameters:

<Search Handshake Packet>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SSOP <SearchName>,<Search Start of Packet>
SEARch:TRIGger:USB:SSOP? <SearchName>

Defines, whether a start of packet (SOP) search shall be activated or not.

Parameters:

<Search Start of Packet>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SSPE <SearchName>,<Search Special Packet>
SEARch:TRIGger:USB:SSPE? <SearchName>

Defines, whether the search for any special PID packet shall be activated or not.

Parameters:

<Search Special Packet>	ON | OFF *RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:SPEC <SearchName>,<USBSpecialType>
SEARch:TRIGger:USB:SPEC? <SearchName>

Defines, which special PID packet type is searched for: "PREamble", "ERR", "SPLit", "PING", or "Any" special PID packet.

Parameters:

<USBSpecialType> ANY | PREamble | ERR | SPLit | PING

ANY
Searches for any of the special PID packet types listed below

PREamble
Searches for any host-issued preamble token (enables downstream bus traffic to low speed USB devices)

ERR
Searches for any SPLIT transaction error handshake token (reuses PRE value)

SPLit
Searches for any high speed SPLIT transaction token

PING
Searches for any high speed flow control probe for a bulk/control endpoint

*RST: PREamble

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:STCO <SearchName>,<SC>
SEARch:TRIGger:USB:STCO? <SearchName>

Defines, which Start- / Complete- (SC) split transaction type is searched for: SSPLIT or CSPLIT.

Parameters:
<SC> ONE | ZERO | DC

ONE
SC = 1 represents a complete-split (CSPLIT) transaction

ZERO
SC = 0 represents a start-split (SSPLIT) transaction

DC
SC = X represents "don't care" (DC)

*RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:STOKen <SearchName>,<Search Token Packet>
SEARch:TRIGger:USB:STOKen? <SearchName>

Defines, whether a search for any token packet shall be activated or not.

Parameters:
<Search Token Packet> ON | OFF

*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:TCONdition <SearchName>,<OperatorET>
SEARch:TRIGger:USB:TCONdition? <SearchName>

Sets the operator to set a specific endpoint type (ET) or an ET range. The ET values are set with `SEARch:TRIGger:USB:TMIN` and `SEARch:TRIGger:USB:TMAX`.

Parameters:
<OperatorET> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

OFF = ANY
The endpoint type is not relevant for the search condition.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one ET value to be set using `SEARch:TRIGger:USB:TMIN`.

INRange | OORange
In range, out of range. These conditions require a range of ET values to be set using `SEARch:TRIGger:USB:TMIN` and `SEARch:TRIGger:USB:TMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:TMIN <SearchName>,<ET>
SEARch:TRIGger:USB:TMIN? <SearchName>

Specifies an endpoint type (ET), or sets the start value of an ET range.

Parameters:
<ET>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:TMAX <SearchName>,<ETTo>
SEARch:TRIGger:USB:TMAX? <SearchName>

Sets the the end value of an endpoint type (ET) range if `TRIGger<m>:USB:TCONdition` is set to `INRange` or `OORange`.

Parameters:
<ETTo>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:TOKen <SearchName>,<USBTokenType>
SEARch:TRIGger:USB:TOKen? <SearchName>

Defines, which token packet type is searched for: "OUT", "IN", "SOF", "SETUP", or "Any" token packet.

Parameters:
<USBTokenType> ANY | OUT | IN | SOF | SETup

ANY
Searches for any of the token packet types listed below.

OUT
Searches for an OUT token.

IN
Searches for an IN token.

SOF
Searches for a start of frame (SOF) token.

SETup
Searches for a SETup token.

*RST: OUT

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WADD <SearchName>,<WithAddressCheck>
SEARch:TRIGger:USB:WADD? <SearchName>

Defines, whether a search for any address field shall be activated or not.

Parameters:
<WithAddressCheck> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WEND <SearchName>,<WithEndpCheck>
SEARch:TRIGger:USB:WEND? <SearchName>

Defines, whether a search for any endpoint shall be activated or not.

Parameters:
<WithEndpCheck> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WETCheck <SearchName>,<WithETCheck>
SEARch:TRIGger:USB:WETCheck? <SearchName>

Defines, whether a search for any Endpoint Type (ET) shall be activated or not.

Parameters:
<WithETCheck> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WFRN <SearchName>,<WithFrameNoChk>
SEARch:TRIGger:USB:WFRN? <SearchName>

Defines, whether a search for any frame number shall be activated or not.

Parameters:
<WithFrameNoChk> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WPAY <SearchName>,<WithPayloadCheck>
SEARch:TRIGger:USB:WPAY? <SearchName>

Defines, whether a search for any payload data shall be activated or not.

Parameters:
<WithPayloadCheck> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WPID <SearchName>,<WithPIDCheck>
SEARch:TRIGger:USB:WPID? <SearchName>

Defines, whether a search for any packet ID error shall be activated or not.

Parameters:

<WithPIDCheck>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WPOR <SearchName>,<WithPortCheck>
SEARch:TRIGger:USB:WPOR? <SearchName>

Defines, whether a search for any port shall be activated or not.

Parameters:

<WithPortCheck>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WSEU <SearchName>,<WithSEUCheck>
SEARch:TRIGger:USB:WSEU? <SearchName>

Defines, whether a search for any SEU shall be activated or not.

For SEU, see "SEU check" on page 721.

Parameters:

<WithSEUCheck>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:USB:WSTC <SearchName>,<WithSCCheck>
SEARch:TRIGger:USB:WSTC? <SearchName>

Defines, whether a search for any Start / Complete (SC) shall be activated or not.

Parameters:

<WithSCCheck>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

16.17.16.5 Search Results

In all `SEARch:RESult:USB:PACKet<m>` commands, the suffix <m> selects the packet number in the list of search results.

SEARch:RESult:USB:PACKet<m>:ADDRess? <SearchName>

Returns the packet address for the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:CRC? <SearchName>

Returns the packet CRC (Cyclic Redundancy Code) for the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:DATA? <SearchName>

Returns the payload data from the packet with the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:ENDPoint? <SearchName>

Returns the endpoint for the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:ET? <SearchName>

Returns the endpoint type (ET) for the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:FRAMe? <SearchName>

Returns the frame number for the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:PID? <SearchName>

Returns the packet PID for the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<PID> RES | OUT | ACK | DATA0 | DATa0 | PING | SOF | NYET | DATA2 | DATa2 | SPLIT | SPLit | IN | NAK | DATA1 | DATa1 | PRE | SETUP | SETup | STALL | STALl | MDATA | MDATa | UNK

For a description of the return values, see `BUS<m>:USB:PACKet<n>:PID?` on page 1493.

*RST: RES

Usage: Query only

SEARch:RESult:USB:PACKet<m>:PORT? <SearchName>

Returns the port number for the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:SC? <SearchName>

Returns the Start- / Complete-split transaction (SSPLIT / CSPLIT) flag bits for the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:SEU? <SearchName>

Returns the SEU values for the selected packet number within the search result.

For SEU, see "SEU check" on page 721.

Suffix:
<m> *

Query parameters:
<SearchName>

Usage: Query only

SEARch:RESult:USB:PACKet<m>:STARt? <SearchName>

Returns the start time of the packet with the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

SEARch:RESult:USB:PACKet<m>:STATus? <SearchName>

Returns the status of the packet with the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<State> OK | PID | CRC | BTST | GLITCH | GLITch | BYTE
*RST: OK

Usage: Query only

SEARch:RESult:USB:PACKet<m>:STOP? <SearchName>

Returns the stop time of the packet with the selected packet number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

SEARch:RESult:USB:PCOunt? <SearchName>

Returns the search result's packet count, i.e. the number of packets found in the search result.

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 4294967295
	Increment:	1

Usage: Query only

16.17.17 Space Wire (Option R&S RTE-K65)

16.17.17.1 Configuration

BUS<m>:SWIRe:BPOSition <SyncBitPos>

Sets the bit position, the align position for the manual synchronisation mode. This can be useful when parity errors exist in the signal, and parity check is the main indicator for the decoder to do packet alignment.

Suffix:
<m> 1..4

Parameters:

<SyncBitPos>	Range:	0 to 10
	Increment:	1
	*RST:	0

BUS<m>:SWIRe:DATA:HYSTeresis <HysteresisData>

Sets a value for the hysteresis of the data signal.

Suffix:

<m>	1..4

Parameters:

<HysteresisData>	Range: 0 to 0.8 Increment: 0.01 *RST: 0.2 Default unit: V

BUS<m>:SWIRe:DATA:SOURce <DataSource>

Selects the source of the data signal.

Suffix:

<m>	1..4

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 *RST: C1W1

BUS<m>:SWIRe:DATA:THReshold <ThresholdData>

Sets the threshold value for the digitization of the data signal.

Suffix:

<m>	1..4

Parameters:

<ThresholdData>	Range: -10 to 10 Increment: 0.1 *RST: 1.25 Default unit: V

BUS<m>:SWIRe:MGAP <MinGapTime>

Sets the minimum duration of a gap. Any inactivity greater than this time will be interpreted as a gap and lead to a resynchronization to the signal.

Suffix:

<m>	1..4

Parameters:

<MinGapTime>	Range: 1E-9 to 10E-6 Increment: 100E-9 *RST: 200E-9 Default unit: s

Firmware/Software: FW 3.30. Replaces `BUS<m>:SWIRe:MINGap`.

BUS<m>:SWIRe:STRBe:HYSTeresis <HystStrobe>

Sets a value for the hysteresis of the strobe signal.

Suffix:

<m> 1..4

Parameters:

<HystStrobe> Range: 0 to 0.8
Increment: 0.01
*RST: 0.2
Default unit: V

BUS<m>:SWIRe:STRBe:SOURce <StrobeSource>

Selects the source of the strobe signal.

Suffix:

<m> 1..4

Parameters:

<StrobeSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: C1W1

BUS<m>:SWIRe:STRBe:THReshold <ThresholdStrobe>

Sets the threshold value for the digitization of the strobe signal.

Suffix:

<m> 1..4

Parameters:

<ThresholdStrobe> Range: -10 to 10
Increment: 0.1
*RST: 1.25
Default unit: V

BUS<m>:SWIRe:SYSLect <SyncSelector>

Selects the mode for the synchronisation settings, i.e i.e. packet align.

Suffix:

<m> 1..4

Parameters:

<SyncSelector> AUTO | MANual

*RST: AUTO

BUS<m>:SWIRe:COUPling <ThresCoup>

Enables coupling, i.e. the same threshold and hysteresis value is used for the strob and the data signal.

Suffix:
<m> 1..4

Parameters:
<ThresCoup> ON | OFF
*RST: ON

Firmware/Software: FW 3.30. Replaces `BUS<m>:SWIRe:THRCoupling`.

BUS<m>:SWIRe:PRESet <ThresholdPreset>

Prests the threshold and hysteresis value of the strobe and data signal.

Suffix:
<m> 1..4

Parameters:
<ThresholdPreset> V25 | V165 | V125 | V09 | V12 | V0 | MAN
V25: 2.5 V (CMOS 5.0 V)
V165: 1.65 V (CMOS 3.5 V)
V125: 1.25 V (CMOS 1.5 V)
V09: 2.5 V (CMOS 1.8V)
V12: 1.2 V (LVDS single ended)
V0: 0 V (LVDS differential)
MAN: user-defined value
*RST: V12

Firmware/Software: FW 3.30. Replaces `BUS<m>:SWIRe:THRPreset`.

16.17.17.2 Trigger

TRIGger<m>:SWIRe:CTYPe <ControlType>

Triggers on a specific control type character.

Suffix:
<m> 1..3

Parameters:
<ControlType> ANY | FCT | EOP | EEP

FCT
Flow Control Token

EOP
Normal End of Packet

EEP
Error End of Packet

*RST: ANY

TRIGger<m>:SWIRe:DATA:CONDition <Operator>

Set the condition for the data value. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:SWIRe:DATA:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:SWIRe:DATA:MIN` and `TRIGger<m>:SWIRe:DATA:MAX`.

*RST: EQUal

TRIGger<m>:SWIRe:DATA:MAX <PatternMax>

Sets the the end value of a data for the data pattern range if `TRIGger<m>:SWIRe:DATA:CONDition` is set to `INRange` or `OORange`.

Suffix:
<m> 1..3

Parameters:
<PatternMax>

TRIGger<m>:SWIRe:DATA:MIN <PatternMin>

Specifies a data for the data pattern, or sets the the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<PatternMin>

TRIGger<m>:SWIRe:ERRor:ESC <ESC>

Enables searching for an escape error.

Suffix:
<m> 1..3

Parameters:
<ESC> ON | OFF
*RST: ON

TRIGger<m>:SWIRe:ERRor:PARity <Parity>

Enables triggering on a parity error (even parity).

Suffix:
<m> 1..3

Parameters:
<Parity> ON | OFF
*RST: ON

TRIGger<m>:SWIRe:TIME:CONDition <Operator>

Set the condition for the data value for the time code. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:SWIRe:TIME:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:SWIRe:TIME:MIN` and `TRIGger<m>:SWIRe:TIME:MAX`.

*RST: EQUal

TRIGger<m>:SWIRe:TIME:MAX <PatternMax>

Sets the the end value of a data value for the time code range if `TRIGger<m>:SWIRe:TIME:CONDition` is set to `INRange` or `OORange`.

Suffix:
<m> 1..3

Parameters:
<PatternMax>

TRIGger<m>:SWIRe:TIME:MIN <PatternMin>

Specifies a pattern for the data value for the time code, or sets the the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<PatternMin>

TRIGger<m>:SWIRe:TYPE <Type>

Sets the trigger type for the SpaceWire analysis.

Suffix:
<m> 1..3

Parameters:
<Type> CTRL | DATA | NULL | TIME | ERRor
*RST: CTRL

16.17.17.3 Decode Results

BUS<m>:SWIRe:RESults:FCOunt <Key>

Returns the number of decoded frames for the selected serial bus.

Suffix:
<m> 1..4

Setting parameters:
<Key>

Return values:
<Count>

BUS<m>:SWIRe:RESults:FRAMe<n>:DATA?

Returns the data value.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<Data> 8-bit data value

Example:
```
BUS:SWIRe:RESults:FRAMe2:DATA?
<-- #H12
```

Usage: Query only

BUS<m>:SWIRe:RESults:FRAMe<n>:STARt?

Returns the start time of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<Start>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SWIRe:RESults:FRAMe<n>:STATe?

Returns the overall state of the frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the serial bus.

Return values:

<State> OK | PAR | ESC | AMB | INComplete

OK
The frame is valid.

PARity
Parity error

ESC
Escape error

AMB
Ambiguous

INComplete
The frame is incomplete

*RST: OK

Usage: Query only

BUS<m>:SWIRe:RESults:FRAMe<n>:STOP?

Returns the end time of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SWIRe:RESults:FRAMe<n>:TYPE?

Returns the type of frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<Type> DATA | FCT | EOP | EEP | ESC | NULL | TCOD

DATA
Data frame

FCT
Flow control token

EOP
End of packet

EEP
Error end of packet

ESC
Escape

NULL
Null symbol

TCOD
Time code

*RST: DATA

Usage: Query only

16.17.17.4 Search Settings

SEARch:TRIGger:SWIRe:CTYPe <SearchName>,<ControlType>
SEARch:TRIGger:SWIRe:CTYPe? <SearchName>

Searches for a specific control type character.

Parameters:

<ControlType> ANY | FCT | EOP | EEP

FCT
Flow Control Token

EOP
Normal End of Packet

EEP
Error End of Packet

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:DATA:CONDition <SearchName>,<Operator>
SEARch:TRIGger:SWIRe:DATA:CONDition? <SearchName>

Set the condition for the data pattern data value. You can define an exact value or a value range.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:SWIRe:DATA:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:SWIRe:DATA:MIN` and `SEARch:TRIGger:SWIRe:DATA:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:DATA:MAX <SearchName>,<PatternMax>
SEARch:TRIGger:SWIRe:DATA:MAX? <SearchName>

Sets the the end value of a data type range if `SEARch:TRIGger:SWIRe:DATA:CONDition` is set to `INRange` or `OORange`.

Parameters:

<PatternMax> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:DATA:MIN <SearchName>,<PatternMin>
SEARch:TRIGger:SWIRe:DATA:MIN? <SearchName>

Specifies a data bit pattern, or sets the the start value of a pattern range.

Parameters:
<PatternMin>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:ERRor:ESC <SearchName>,<ESC>
SEARch:TRIGger:SWIRe:ERRor:ESC? <SearchName>

Enables triggering on an escape error.

Parameters:

<ESC> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:SWIRe:ERRor:PARity <SearchName>,<Parity>
SEARch:TRIGger:SWIRe:ERRor:PARity? <SearchName>

Enables searching for a parity error (even parity).

Parameters:

<Parity> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:SWIRe:TIME:CONDition <SearchName>,<Operator>
SEARch:TRIGger:SWIRe:TIME:CONDition? <SearchName>

Set the condition for the data value of the time code. You can define an exact value or a value range.

Parameters:

<Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:SWIRe:TIME:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:SWIRe:TIME:MIN` and `SEARch:TRIGger:SWIRe:TIME:MAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:SWIRe:TIME:MAX <SearchName>,<PatternMax>
SEARch:TRIGger:SWIRe:TIME:MAX? <SearchName>

Sets the the end value of a data type range for the time code if `SEARch:TRIGger:SWIRe:TIME:CONDition` is set to `INRange` or `OORange`.

Parameters:
<PatternMax>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:TIME:MIN <SearchName>,<PatternMin>
SEARch:TRIGger:SWIRe:TIME:MIN? <SearchName>

Specifies a data bit pattern for the time code, or sets the the start value of a pattern range.

Parameters:
<PatternMin>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:SWIRe:TYPE <SearchName>,<Type>
SEARch:TRIGger:SWIRe:TYPE? <SearchName>

Sets the search type for the SpaceWire analysis.

Parameters:

<Type>	CTRL | DATA | NULL | TIME | ERRor
	*RST: CTRL

Parameters for setting and query:
<SearchName>

16.17.17.5 Search Results

In all `SEARch:RESult:DPHY:FRAMe<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:SWIRe:FCOunt <Key>

Returns the number of frames within the search result for the selected serial bus.

Setting parameters:
<Key>

Return values:
<Count>

SEARch:RESult:SWIRe:FRAMe<m>:DATA? <SearchName>

Returns the data value for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:SWIRe:FRAMe<m>:STARt? <SearchName>

Returns the start time of the specified frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:SWIRe:FRAMe<m>:STATe? <SearchName>

Returns the overall state of the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<State> OK | PAR | ESC | AMB | INComplete

OK
The frame is valid

PARity
Parity error

ESC
Escape Error

AMB
Ambiguous

INComplete
The frame is incomplete

*RST: OK

Usage: Query only

SEARch:RESult:SWIRe:FRAMe<m>:STOP? <SearchName>

Returns the end time for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:SWIRe:FRAMe<m>:TYPE? <SearchName>

Returns the type of frame for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<Type> DATA | FCT | EOP | EEP | ESC | NULL | TCOD

DATA
Data frame

FCT
Flow control token

EOP
End of packet

EEP
Error end of packet

ESC
Escape

NULL
Null symbol

TCOD
Time code

*RST: DATA

Usage: Query only

16.18 Mixed Signal Option (MSO, R&S RTE-B1)

This chaptes decribes the remote commands of MSO option R&S RTE-B1.

16.18.1 Digital Channels

All `DIGital:` commands affect only the settings of the first MSO bus (Bus1). The settings of all other parallel buses (Bus 2, 3,4) remain unchanged.

DIGital<m>:DISPlay <Display>

Enables or disables the indicated digital channel, displays it, and enables the parallel Bus1 if the bus was disabled. That is, `BUS<m>:PARallel:DISPlay:SHDI` and `BUS<m>:PARallel:STATe` are set to ON automatically.

If another active bus already uses the selected digital channel, the instrument disables the other bus to avoid conflicts.

For Bus1, the `DIG:DISP` command has the same effect as `BUS<m>:PARallel:BIT<n>[:STATe]`. To enable digital channels for buses 2, 3 and 4, use the `BUS:PAR:BIT[:STAT]` command.

Suffix:

<m> 0..15
Number of the digital channel

Parameters:

<Display> ON | OFF

Firmware/Software: V 1.30

DIGital<m>:TECHnology <Technology>

Selects the threshold voltage for various types of integrated circuits and applies it to all digital channels.

The setting affects only the settings of the first MSO bus (Bus1). You can set the technology value for all buses with `BUS<m>:PARallel:TECHnology`.

Suffix:

<m> 0..15
The suffix is irrelevant.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN
See `BUS<m>:PARallel:TECHnology`

Firmware/Software: V 1.40

DIGital<m>:THReshold <Value>

Sets the logical threshold for the channel group to which the indicated digital channel belongs. The setting affects only the settings of the first MSO bus (Bus1).

The setting affects only the settings of the first MSO bus (Bus1). You can set the threshold for all buses with `BUS<m>:PARallel:TECHnology` or `BUS<m>:PARallel:THReshold<n>`.

See also: `DIGital<m>:THCoupling`

Suffix:

<m> 0..15

Number of the digital channel.

Channel groups: 0..3; 4..7; 8..11; 12..15

Parameters:

<Value> Range: -8.0 to 8.0

Increment: 200.0e-12

*RST: 0

Default unit: V

Firmware/Software: V 1.30

DIGital<m>:THCoupling <State>

Sets the threshold and the hysteresis for all digital channels of parallel bus 1 to the same value.

The command `BUS<m>:PARallel:THCoupling` is used to set all buses.

Suffix:

<m> 0..15

The suffix is irrelevant.

Parameters:

<State> ON | OFF

Firmware/Software: V 1.30

DIGital<m>:HYSTeresis <Hysteresis>

Defines the size of the hysteresis to avoid the change of signal states due to noise for the channel group to which the indicated digital channel belongs.

The setting affects only the settings of the first MSO bus (Bus1). You can set the hysteresis for all buses with `BUS<m>:PARallel:HYSTeresis<n>`.

See also: `DIGital<m>:THCoupling`

Suffix:

<m> 0..15

Number of the digital channel

Channel groups: 0..3; 4..7; 8..11; 12..15

Parameters:

<Hysteresis>	MAXIMUM | MAXimum | ROBUST | ROBust | NORMAL | NORMal **MAXIMUM = MAXimum** Maximum value that is possible and useful for the signal and its settings **ROBUST = ROBust** Different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system. **NORMAL = NORMal** The instrument sets a value suitable for the signal and its settings.

Firmware/Software: V 1.30

DIGital<m>:LABel <Label>

Sets a name for the indicated digital channel. The name is displayed in the diagram.

The setting affects only the settings of the first MSO bus (Bus1). You can set the label for all buses with `BUS<m>:PARallel:BIT<n>:LABel`.

Suffix:

<m>	0..15 Number of the digital channel

Parameters:

<Label>	String containing the channel name

Firmware/Software: V 1.30

DIGital<m>:DESKew <Deskew>

Sets an individual delay for each digital channel to time-align it with other digital channels. The deskew value compensates delays that are known from the circuit specifics or caused by the different length of cables.

The setting affects only the settings of the first MSO bus (Bus1). You can set the deskew for all buses with `BUS<m>:PARallel:BIT<n>:DESKew`.

Suffix:

<m>	0..15 Number of the digital channel

Parameters:

<Deskew>	Range: -200.0E-09 to 200.0E-09 Increment: 200.0E-12 *RST: 0 Default unit: s

16.18.2 Parallel Bus Configuration

The following commands configure the four parallel buses of R&S RTE-B1.

BUS<m>:PARallel:STATe <Enable>

Enables or disables the indicated parallel bus. The threshold settings of the bus take effect for all *active* parallel buses.

Dependencies: At least one digital channel must be enabled for the selected bus, otherwise the command does not work. The bus is enabled automatically if the first digital channel is enabled with `BUS<m>:PARallel:BIT<n>[:STATe]` or `DIGital<m>:DISPlay`.

Suffix:

<m> 1..4
Selects the parallel bus.

Parameters:

<Enable> ON | OFF
*RST: OFF

Firmware/Software: V 1.30

BUS<m>:PARallel:BIT<n>[:STATe] <Assigned>

Assigns the selected digital channel to the indicated bus, displays it, and enables the bus if the bus was disabled. That is, `BUS<m>:PARallel:DISPlay:SHDI` and `BUS<m>:PARallel:STATe` are set to ON automatically.

If another active bus already uses the selected digital channel, the instrument disables the other bus to avoid conflicts.

For parallel bus 1, the `BUS:PAR:BIT[:STATe]` command has the same effect as `DIGital<m>:DISPlay`.

Suffix:

<m>	1..4 Selects the parallel bus.
<n>	0..15 Selects the digital channel. Each digital channel provides a definite bit of the bus word.

Parameters:

<Assigned> ON | OFF

*RST: OFF

Firmware/Software: V 1.40

BUS<m>:PARallel:THReshold<n> <Threshold>

Sets the logical threshold for the indicated channel group.

Alternatively, you can set the threshold with `BUS<m>:PARallel:TECHnology`. For the parallel bus 1, you can also use `DIGital<m>:THReshold`.

See also: `DIGital<m>:THCoupling`

Suffix:

<m>	1..4 Selects the parallel bus.
<n>	1..4 Selects the channel group: 1 = dig. channels 0..3; 2 = dig. channels 4..7 3 = dig. channels 8..11 4 = dig. channels 12..15

Parameters:

<Threshold>

Range: -8.0 to 8.0
Increment: 200.0e-12
*RST: 0
Default unit: V

Firmware/Software: V 1.40

BUS<m>:PARallel:TECHnology <Technology>

Selects the threshold voltage for various types of integrated circuits and applies it to all digital channels.

Suffix:

<m> 1..4
Selects the parallel bus.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN

V15: TTL
V25: CMOS 5.0 V
V165: CMOS 3.3 V
V125: CMOS 2.5 V
V09: CMOS 1.85 V
VM13: ECL, -1.3 V
V38: PECL
V20: LVPECL
V0: Ground
MAN: Set a user-defined threshold value with `DIGital<m>:THReshold`

*RST: V165

Usage: SCPI confirmed

Firmware/Software: V 1.36

BUS<m>:PARallel:THCoupling <LevelCoupling>

Sets the threshold for all digital channels of the selected bus to the same value. Also the hysteresis value is applied to all digital channels.

Tor parallel bus 1, the command `DIGital<m>:THCoupling` has the same effect.

Suffix:

<m> 1..4
The suffix is irrelevant.

Parameters:

<LevelCoupling> ON | OFF

*RST: ON

Firmware/Software: V 1.30

BUS<m>:PARallel:HYSTeresis<n> <Hysteresis>

Defines the size of the hysteresis for the channel group to avoid the change of signal states due to noise.

For the parallel bus 1, you can also use `DIGital<m>:HYSTeresis`.

Suffix:

<m> 1..4
Selects the parallel bus.

<n> 1..4
Selects the channel group:
1 = dig. channels 0..3;
2 = dig. channels 4..7
3 = dig. channels 8..11
4 = dig. channels 12..15

Parameters:
<Hysteresis> MAXIMUM | MAXimum | ROBUST | ROBust | NORMAL | NORMal

MAXIMUM = MAXimum
Maximum value that is possible and useful for the signal and its settings

ROBUST = ROBust
Different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system.

NORMAL = NORMal
The instrument sets a value suitable for the signal and its settings.

Firmware/Software: V 1.40

BUS<m>:PARallel:BIT<n>:DESKew <Deskew>

Sets an individual delay for each digital channel to time-align it with other digital channels. The deskew value compensates delays that are known from the circuit specifics or caused by the different length of cables.

For the parallel bus 1, you can also use `DIGital<m>:DESKew`.

Suffix:
<m> 1..4
Selects the parallel bus.

<n> 0..15
Number of the digital channel

Parameters:
<Deskew> Range: -200E-9 to 200E-9
Increment: 200E-12
*RST: 0
Default unit: s

BUS<m>:PARallel:DESoffset <DeskewOffset>

Sets a general delay for all digital channels. The resulting deskew of a digital channel is the sum of this general value and the individual value set with `BUS<m>:PARallel:BIT<n>:DESKew`.

Suffix:
<m> 1..4
Selects the parallel bus.

Parameters:

<DeskewOffset>	Range: -200E-9 to 200E-9 Increment: 200E-12 *RST: 0 Default unit: s

---

BUS<m>:PARallel:BIT<n>:LABel <Label>

Sets a name for the indicated digital channel. The name is displayed in the diagram.

For the parallel bus 1, you can also use `DIGital<m>:LABel`.

Suffix:

<m>	1..4 Selects the parallel bus.
<n>	0..15 Number of the digital channel

Parameters:

<Label>	String containing the channel name

Firmware/Software: V 1.40

BUS<m>:PARallel:DISPlay:SHDI <ShowDigitalSigns>

If enabled, the selected digital signals are shown in the diagram. Each channel is displayed as a logic signal.

See also: `DIGital<m>:DISPlay`

Suffix:

<m>	1..4 Selects the parallel bus.

Parameters:

<ShowDigitalSigns>	ON | OFF *RST: OFF

Firmware/Software: V 1.30

BUS<m>:PARallel:DISPlay:SHBU <ShowBus>

Shows or hides the indicated parallel bus. If enabled, the resulting bus signal and bus values are displayed in the diagram.

Suffix:

<m>	1..4 Selects the parallel bus.

Parameters:

<ShowBus>	ON | OFF *RST: OFF

Firmware/Software: V 1.30

BUS<m>:PARallel:DISPlay:BTYP <BusRepresentation>

Selects the display type of the indicated parallel bus.

Suffix:
<m> 1..4
Selects the parallel bus.

Parameters:
<BusRepresentation> COMB | ANALog

COMB
Displays the decoded bus signal with bus values.

ANALog
Displays the bus value as amplitude, similar to an analog waveform.

*RST: COMB

Firmware/Software: V 1.30

BUS<m>:PARallel:CLON <Clocked>

Defines if the bus is a clocked bus - one of the digital channels serves as clock of the bus.

Suffix:
<m> 1 | 2
Selects the parallel bus. The clocked bus is available on parallel buses 1 and 2.

Parameters:
<Clocked> ON | OFF

*RST: OFF

Firmware/Software: V 1.36

BUS<m>:PARallel:CLOCk <ClockSource>

Selects the digital channel used as clock of the indicated parallel bus.

Suffix:
<m> 1 | 2
Selects the parallel bus. The clocked bus is available on parallel buses 1 and 2.

Parameters:
<ClockSource> D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Clock channel

*RST: D1

Firmware/Software: V 1.30

BUS<m>:PARallel:CLSLope <ClockSlope>

Selects the slope of the clock signal at which all digital channels of the bus are analyzed.

Suffix:

<m> 1 | 2
Selects the parallel bus. The clocked bus is available on parallel buses 1 and 2.

Parameters:

<ClockSlope> POSitive | NEGative | EITHer
*RST: POSitive

Firmware/Software: V 1.36

BUS<m>:PARallel:CLEar

Removes all assigned digital channels from the bus

Suffix:

<m> 1..4
Selects the parallel bus.

Usage: Event

Firmware/Software: V 1.30

16.18.3 Digital Resolution

ACQuire:DRESolution?

Returns the current digital resolution of the digital channels.

Return values:

<DigitalRes> Default unit: s

Usage: Query only

ACQuire:POINts:DVALue?

Returns the current digital record length used by each digital channel.

Return values:

<DigitalRecLength>	Range:	1000 to 200E6
	Increment:	2
	*RST:	1000
	Default unit:	Sa

Usage: Query only

16.18.4 Trigger Settings for Digital Signals and Parallel Buses

In all `TRIGger<m>:PARallel` commands, the trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on digital signals and parallel buses.

16.18.4.1 General Commands

TRIGger<m>:SOURce <SourceDetailed>

Selects the source of the trigger signal.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = not available
Available values depend on the selected trigger source. For input channels CHAN1...4, a trigger sequence can be configured.
For all other trigger sources, only suffix 1 is allowed.
See also: `TRIGger<m>:SEQuence:MODE`

Parameters:

<SourceDetailed> CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 | EXTernanalog | LINE | SBUS | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | LOGIC | MSOB1 | MSOB2 | MSOB3 | MSOB4

CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4
Input channels

EXTernanalog
External analog signal connected to the External Trigger Input. For this source, only the analog edge trigger is available.

LINE
The instrument generates the trigger from the AC power input and synchronizes the signal to the AC power frequency.

SBUS
Serial bus

D0...D15
Digital channels (option R&S RTE-B1)
See also: Chapter 16.18.4, "Trigger Settings for Digital Signals and Parallel Buses", on page 1543

LOGIc
Logic combination of digital channels, used as trigger source (option R&S RTE-B1)

MSOB1 | MSOB2 | MSOB3 | MSOB4
Parallel bus (option R&S RTE-B1)

*RST: CHAN1

TRIGger<m>:PARallel:TYPE <Type>

Selects the trigger type to trigger on digital channels and parallel buses.

To trigger on analog channels or the external trigger input, use `TRIGger<m>:TYPE`.

Parameters:

<Type> EDGE | WIDTh | TIMeout | DATatoclock | STATe | PATTern | SERPattern

*RST: EDGE

TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue] <ClockSource>
TRIGger<m>:PARallel:STATe:CSOurce:VALue <ClockSource>
TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue] <ClockSource>

Selects the digital channel of the clock signal.

Parameters:

<ClockSource> D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: D0

TRIGger<m>:PARallel:EDGE:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:WIDTh:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:STATe:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine] <LogicalExpr>

Defines a logical combination of several digital channels as trigger condition if `TRIGger<m>:SOURce` is set to LOGIC.

Parameters:

<LogicalExpr> String with logical expression

Example: `TRIGger:PARallel:EDGE:EXPRession 'D1 and D2'`

Usage: SCPI confirmed

16.18.4.2 Edge Trigger

See also:

- `TRIGger<m>:PARallel:EDGE:EXPRession[:DEFine]` on page 1545

TRIGger<m>:PARallel:EDGE:SLOPe <Slope>

Defines the edge - the state transition - of the signal to trigger on a single digital channel (a logic bit), or a logical combination of digital channels.

Parameters:

<Slope> POSitive | NEGative | EITHer

*RST: POSitive

16.18.4.3 Width Trigger

See also:

- `TRIGger<m>:PARallel:WIDTh:EXPRession[:DEFine]` on page 1545

TRIGger<m>:PARallel:WIDTh:POLarity <Polarity>

Sets the polarity of a pulse. When triggering on a positive pulse, the trigger event occurs on the high to low transition of the pulse if the timing condition is true. When triggering on a negative pulse, the trigger event occurs on the low to high transition of the pulse if the timing condition is true.

Parameters:

<Polarity> POSitive | NEGative | EITHer

*RST: POSitive

TRIGger<m>:PARallel:WIDTh:RANGe <RangeMode>

Selects how the range of a pulse width is defined:

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin | OUTSide
Pulses inside or outside a given time range. The time range *Width ± Delta* is defined by `TRIGger<m>:PARallel:WIDTh:WIDTh` and `TRIGger<m>:PARallel:WIDTh:DELTa`.

SHORter | LONGer
Pulses shorter or longer than a given width defined by `TRIGger<m>:PARallel:WIDTh:WIDTh`

*RST: WITHin

TRIGger<m>:PARallel:WIDTh:WIDTh <Width>

Sets the limit for the pulse width.

The effect depends on `TRIGger<m>:PARallel:WIDTh:RANGe`.

- For the ranges SHORter and LONGer, the width defines the maximum and minimum pulse width, respectively.
- For the ranges WITHin and OUTSide, the width defines the center of a range which is defined by the limits `TRIGger<m>:PARallel:WIDTh:DELTa`.

Parameters:

<Width> Range: 200E-12 to 10000
Increment: 200E-9
*RST: 5E-9
Default unit: s

TRIGger<m>:PARallel:WIDTh:DELTa <WidthDelta>

Defines a range around the given width value. the setting is relevant if `TRIGger<m>:PARallel:WIDTh:RANGe` is set to WITHin or OUTSide. The width is set with `TRIGger<m>:PARallel:WIDTh:WIDTh`.

Parameters:

<WidthDelta>	Range: 0 to 432 Increment: 600E-12 *RST: 0 Default unit: s

16.18.4.4 Timeout Trigger

See also:

- TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine] on page 1545

TRIGger<m>:PARallel:TIMeout:RANGe <TimeoutMode>

Sets the state condition.

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

HIGH
The level of a digital channel stays above the threshold, or the logical expression for LOGic trigger source is true.

LOW
The level of a digital channel stays below the threshold, or the logical expression for LOGic trigger source is false.

EITHer
The signal state remains unchanged.

*RST: HIGH

TRIGger<m>:PARallel:TIMeout:TIME <Time>

Defines the time limit for the timeout at which the instrument triggers.

Parameters:

<Time>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 100E-9 Default unit: s

16.18.4.5 Data2Clock Trigger

See also:

- TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue] on page 1544

TRIGger<m>:PARallel:DATatoclock:CSOurce:EDGE <ClockEdge>

Sets the edge of the clock signal. The crossing of the clock edge and the logical threshold defines the time reference point for the setup and hold time measurement.

Parameters:

<ClockEdge>	POSitive | NEGative | EITHer	
	*RST:	POSitive

TRIGger<m>:PARallel:DATatoclock:STIMe <SetupTime>

Sets the minimum time *before* the clock edge while data should be stable and not change its state.

See also: "Setup time" on page 766

Parameters:

<SetupTime>	Range:	-99.8E-9 to 100E-9
	Increment:	1E-9
	*RST:	0
	Default unit:	s

TRIGger<m>:PARallel:DATatoclock:HTIMe <HoldTime>

Sets the minimum time *after* the clock edge while data should be stable and not change its state.

See also: "Hold time" on page 766

Parameters:

<HoldTime>	Range:	-99.8E-9 to 100E-9
	Increment:	1E-9
	*RST:	0
	Default unit:	s

16.18.4.6 State Trigger

See also:

- `TRIGger<m>:PARallel:STATe:CSOurce:VALue` on page 1544
- `TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 1545

TRIGger<m>:PARallel:STATe:CSOurce:EDGE <Slope>

Sets the edge of the clock signal. The crossing of the clock edge and the logical threshold defines the time at which the logical states and the bus value are analyzed.

Parameters:

<Slope>	POSitive | NEGative | EITHer *RST: POSitive

TRIGger<m>:PARallel:STATe:BIT<n> <Bit>

Sets the required state for each digital channel that is used in the bus.

Suffix:

<n>	0..15 Number of the digital channel

Parameters:

<Bit>	HIGH | LOW | DONTCARE | DONTcare Bit value: 1 (HIGH), 0 (LOW), or X (DONTCARE = DONTcare)

16.18.4.7 Pattern Trigger

TRIGger<m>:PARallel:PATTern:BIT<n> <Bit>

Sets the required state for each digital channel that is used in the bus.

Suffix:

<n>	0..15 Number of the digital channel

Parameters:

<Bit>	HIGH | LOW | DONTCARE | DONTcare Bit value: 1 (HIGH), 0 (LOW), or X (DONTCARE = DONTcare)

TRIGger<m>:PARallel:PATTern:MODE <Mode>

Sets the mode of the timing condition.

Parameters:

<Mode> OFF | TIMeout | WIDTh

OFF
No timing condition, only the logical pattern condition is relevant.

TIMeout
Defines a minimum time qualification to avoid triggering on unstable or transitional conditions. Use `TRIGger<m>:PARallel:PATTern:TIMeout:MODE` and `TRIGger<m>:PARallel:PATTern:TIMeout[:TIME]` to specify the timeout.

WIDTh
Sets a pulse width as timing condition. The pulse starts when the pattern comes true, and the trigger event occurs when the pattern comes false during the specified time limit. Use `TRIGger<m>:PARallel:PATTern:WIDTh:RANGe`, `TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh]`, and `TRIGger<m>:PARallel:PATTern:WIDTh:DELTa` to specify the width.

*RST: OFF

TRIGger<m>:PARallel:PATTern:TIMeout:MODE <TimeoutMode>

Sets the state condition for the timeout qualification if `TRIGger<m>:PARallel:PATTern:MODE` is set to TIMeout. To set the time limit, use `TRIGger<m>:PARallel:PATTern:TIMeout[:TIME]`.

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

HIGH: The pattern stays true for the specified time.
LOW: The pattern stays false for the specified time.
EITHER: The pattern remains unchanged for the specified time.

*RST: HIGH

TRIGger<m>:PARallel:PATTern:TIMeout[:TIME] <Time>

Defines the time limit for the timeout at which the instrument triggers.

Parameters:

<Time> Range: 100E-12 to 10000
Increment: 100E-9
*RST: 100E-9
Default unit: s

TRIGger<m>:PARallel:PATTern:WIDTh:RANGe <WidthRangeMode>

Selects how the range of a pulse width is defined if `TRIGger<m>:PARallel:PATTern:MODE` is set to WIDTh.

Parameters:
<WidthRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers when the pattern comes false inside a given time range. The time limit is defined by `TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh]` and `TRIGger<m>:PARallel:PATTern:WIDTh:DELTa` (*Width ± Delta*).

OUTSide
Triggers when the pattern comes false before or after the given time range. The time limit definition is the same as for WITHin range.

SHORter | LONGer
Triggers when the pattern comes false before or after the given width has expired. Width is set with `TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh]`.

*RST: WITHin

TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh] <Width>

The effect depend on the setting of the `TRIGger<m>:PARallel:PATTern:WIDTh:RANGe`command.

For the ranges SHOrter and LONGer, the width defines the maximum and minimum time limit, respectively.

For the ranges WITHin and OUTSide, the width defines the center of a range which is defined by the limits "±Delta".

Parameters:
<Width> Range: 100E-12 to 10000
Increment: 100E-9
*RST: 5E-9
Default unit: s

TRIGger<m>:PARallel:PATTern:WIDTh:DELTa <WidthDelta>

Defines a range around the width value set with `TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh]`.

Parameters:
<WidthDelta> Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

16.18.4.8 Serial Pattern Trigger

See also:

- `TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue]` on page 1544

- `TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine]` on page 1545

TRIGger<m>:PARallel:SPATtern:CSOurce:EDGE <ClockEdge>

Sets the edge of the clock signal. The bit value is determined at the crossing of the clock edge and the logical threshold.

Parameters:

<ClockEdge> POSitive | NEGative | EITHer

*RST: POSitive

TRIGger<m>:PARallel:SPATtern:PATTern <Pattern>

Defines the serial bit string on which to trigger.

Parameters:

<Pattern> Numeric or string pattern, see Chapter 16.4.6, "Bit Pattern Parameter", on page 881. The bit value X (don't care) is not allowed.

16.18.5 MSO Data

To export data of digital channels and parallel buses to file, use the following commands:

- `EXPort:WAVeform:SOURce` on page 1146
- `BUSFormat` on page 1164
- `EXPort:WAVeform:NAME` on page 1147
- `EXPort:WAVeform:SAVE` on page 1148

The remote export for transmission from the instrument to the controlling computer is performed using the following commands:

`FORMat[:DATA]` on page 887

and

BUSFormat <DataFormat>

Sets the number format for decoded data values in the "Decode table" and on the display for all parallel and serial buses.

For serial buses, the command overwrites the the bus-specific format setting `BUS<m>:FORMat`.

For parallel buses, the command sets also the number representation for data export. In case of export to BIN file or remote data transfer, SIGN returns signed values, and all other formats return unsigned values.

Parameters:
<DataFormat> HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG
ASCII = ASCii
*RST: HEX

Usage: Asynchronous command

Firmware/Software: FW 1.45

DIGital<m>:DATA:HEADer?

Returns the header of digital channel data

Table 16-10: Header data

Position	Meaning	Example
1	XStart, acquisition time before trigger, in s	-5E-008 = - 50 ns
2	XStop, acquisition time after trigger, in s	5E-008 = 50 ns
3	Record length of the waveform in Samples	1000
4	Number of values per sample interval. For digital data the result is 1.	1

Suffix:
<m> 0..15
Number of the digital channel

Usage: Query only
SCPI confirmed

DIGital<m>:DATA[:VALues]?

Returns the data of the indicated digital channel for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]` and `BUSFormat`.

Suffix:
<m> 0..15
Selects the digital channel.

Return values:
<Data> List of values according to the format settings.

Usage: Query only

BUS<m>:PARallel:DATA:HEADer?

Returns the header data of the indicated bus.

For a detailed description, see `DIGital<m>:DATA:HEADer?`.

Suffix:
<m> 1..4
Selects the parallel bus.

Usage: Query only
SCPI confirmed

Firmware/Software: V 2.40

BUS<m>:PARallel:DATA[:VALues]?

Returns the data of the indicated parallel bus.

Requirements:

- `BUS<m>:PARallel:STATe` is set to `ON`.
- `BUS<m>:PARallel:DISPlay:SHBU` is set to `ON`.
- `FORMat[:DATA]` is set to `ASCII`.
  The data formats REAL, INT8 and INT16 are not supported.

To set the number format, use `BUSFormat`.

Suffix:
<m> 1..4
Selects the parallel bus.

Parameters:
<Data> List of decimal values (signed or unsigned).

Usage: Query only

Firmware/Software: V 2.40

16.19 Power Analysis (Option R&S RTE-K31)

16.19.1 General

POWer:ENABle

Activates the power mode and initializes the power measurements. If the power mode is disabled, the instrument does not accept any `POWer` command.

Use `POWer:ENABle` after each `*RST`.

Example: See Chapter 16.3.7.1, "Auto Deskew", on page 876

Usage: Event

POWer:SOURce:CURRent<1..2> <CurrentSource>

Sets the channel for the current source.

Parameters:

<CurrentSource> CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4

CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4

Usage: Asynchronous command

POWer:SOURce:VOLTage<1..4> <VoltageSource>

Sets the channel for the voltage source input.

Parameters:

<VoltageSource> CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4

CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4

Usage: Asynchronous command

16.19.2 Deskew

Programming example: Chapter 16.3.7.1, "Auto Deskew", on page 876

POWer:DESKew:CURRent

Applies the result of the auto deskew to the "Skew offset" value.

Usage: Event

POWer:DESKew:EXECute

Starts the auto deskew.

Usage: Event

POWer:DESKew:RESet <OverwriteCurrSkew>

Overwrites the present skew setup.

Parameters:

<OverwriteCurrSkew> ON | OFF

*RST: ON

POWer:DESKew:TIME?

Queries the result of the auto deskew.

Return values:

<AutoDeskewOffs> Range: -100E-9 to 100E-9

*RST: 0

Default unit: s

Usage: Query only

POWer:DESKew:UDPReset <UserDefinedPreset>

Activates or deactivates a user defined setup. If ON, the instrument setup including probe setup and the deskew values are written to a user defined preset file (saveset) that can be loaded using `MMEMory:RCL` on page 1143.

The default path is:

`C:\Users\Public\Documents\Rohde-Schwarz\RTE\SaveSets\`

Parameters:
<UserDefinedPreset> ON | OFF
*RST: ON

16.19.3 Report

POWer:REPort:CONTent:HSETup <ContentHorizSetup>
POWer:REPort:CONTent:MSETup <ContentMeasSetup>
POWer:REPort:CONTent:MSIGnal <ContentMeasuredSigns>
POWer:REPort:CONTent:RESU <ContentResults>
POWer:REPort:CONTent:SETTings <ContentSettings>

POWer:REPort:CONTent:TSETup <ContentTrigSetup>
POWer:REPort:CONTent:VSETup <ContentVertSetup>

Sets how often the respective content is shown in the final report.

Parameters:
<ContentVertSetup> ALWAYS | NEVER | ONCE
*RST: ONCE

POWer:REPort:CONTent:TITLe <ContentTitle>

Includes the title page in the report.

Parameters:
<ContentTitle> ON | OFF
*RST: ON

POWer:REPort:DESCription <String>
POWer:REPort:DUT <String>
POWer:REPort:SITE <String>
POWer:REPort:TEMPerature <String>
POWer:REPort:USER <String>

The content of the strings is shown at the title page of a report if the title page is included in the report.

Parameters:
<String>

POWer:REPort:FONT:COLO <FontColor>

Sets the font color.

Parameters:
<FontColor> Range: 0 to 4294967295
Increment: 1
*RST: 0

POWer:REPort:FONT:FAMI <FontFamily>

Selects the font family. You can choose between Arial and Helvetica.

Parameters:
<FontFamily> ARIAL | HELV
*RST: ARIAL

POWer:REPort:FONT:SIZE <FontSize>

Sets the font size.

Parameters:

<FontSize>	Range:	10 to 30
	Increment:	1
	*RST:	12

POWer:REPort:LOGO <LogoFile>

Selects a path to a logo picture file.

Parameters:

<LogoFile>

POWer:REPort:PAPersize <PaperSize>

Set the layout of your report.

Parameters:

<PaperSize>	A4 | USL	
	*RST:	A4

POWer:REPort:FILE:NAME <Path>

Defines the path and file name of the report file that is to be created, saved, or deleted.

Parameters:

<Path> String containing path and file name

POWer:REPort:FILE:DELete

Deletes the selected report file.

Usage: Event

POWer:REPort:FILE:NEW

Creates a new report file.

Usage: Event

POWer:REPort:FILE:SAVE

Saves the report file.

Usage: Event

POWer:REPort:TEST:ADD <MeasType>
POWer:REPort:TEST:INSert <MeasType>, <Index>
POWer:REPort:TEST:REMove <MeasType>, <Index>

Manage reports.

Setting parameters:

<MeasType> QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC

QUAL
Power Quality

RUSH
Inrush Current

HARM
Current Harmonic

MODU
Modulation Analysis

DONR
Dynamic ON Resistance

SLEW
Slew Rate

SOA
Safe Operating Area (S.O.A.)

TURN
Turn On/Off

SWIT
Switching Loss

EFF
Power Efficiency

RIPP
Ripple

TRANS
Transient Response

SPEC
Spectrum

<Index>

Usage: Setting only

POWer:REPort:INVert <InvertScreenshotColor>
POWer:REPort:TEST:DSEA <MeasType>
POWer:REPort:TEST:ISE <MeasType>
POWer:REPort:TEST:SEA <MeasType>
POWer:REPort:TEST:RSE <MeasType>

Manage the selection of reports.

Parameters:

<MeasType> QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC

QUAL
Power Quality

RUSH
Inrush Current

HARM
Current Harmonic

MODU
Modulation Analysis

DONR
Dynamic ON Resistance

SLEW
Slew Rate

SOA
Safe Operating Area (S.O.A.)

TURN
Turn On/Off

SWIT
Switching Loss

EFF
Power Efficiency

RIPP
Ripple

TRANS
Transient Response

SPEC
Spectrum

POWer:REPort:TEST:DIRectory <MeasType>, <DirectoryPath>
POWer:REPort:TEST:DIRectory? <MeasType>

Selects the directory, in which the reports are saved.

Setting parameters:
<DirectoryPath>

Parameters for setting and query:
<MeasType> QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC

POWer:REPort:TEST:COMMent <MeasType>, <Comment>
POWer:REPort:TEST:COMMent? <MeasType>

Sets a comment for the report.

Setting parameters:
<Comment>

Parameters for setting and query:

<MeasType> QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC

POWer:REPort:TEST:COUNt <MeasType>

Parameters:

<MeasType> QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC

Return values:
<Count>

POWer:REPort:TEST:LSENd? <MeasType>

Query parameters:

<MeasType> QUAL | RUSH | HARM | MODU | DONR | SLEW | SOA | TURN | SWIT | EFF | RIPP | TRANS | SPEC

Usage: Query only

16.19.4 Power Quality

POWer:QUALity:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale> AUTO | MANUAL

*RST: MANUAL

POWer:QUALity:EXECute

Starts the power quality measurement.

Usage: Event

POWer:QUALity:FREQ <Frequency>

Sets the input frequency of the source signal in Hz.

Parameters:

<Frequency> F50 | F60 | F360 | F400 | F650 | F800 | NFF650 | WFF800 | FCUS

NFF650: 360 to 650 Hz
WFF800: 360 to 800 Hz
FCUS: user-defined frequency to be set using `POWer:QUALity:FCUS`.

*RST: F50

POWer:QUALity:FCUS <CustomFrequency>

Sets the user-defined frequency if `POWer:QUALity:FREQ` is set to `FCUS`.

Parameters:

<CustomFrequency> Range: 1 to 5000
Increment: 1
*RST: 16.666
Default unit: Hz

Firmware/Software: Version 2.70

POWer:QUALity:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:QUALity:RESult:CURRent:CRESTfactor?
POWer:QUALity:RESult:CURRent:FREQuency?
POWer:QUALity:RESult:CURRent:PEAK?
POWer:QUALity:RESult:CURRent:RMS?
POWer:QUALity:RESult:POWer:APParent?
POWer:QUALity:RESult:POWer:PFACtor?
POWer:QUALity:RESult:POWer:PHASe?
POWer:QUALity:RESult:POWer:REACtive?

POWer:QUALity:RESult:POWer:REALpower?
POWer:QUALity:RESult:VOLTage:CREStfactor?
POWer:QUALity:RESult:VOLTage:FREQuency?
POWer:QUALity:RESult:VOLTage:PEAK?
POWer:QUALity:RESult:VOLTage:RMS?

Returns the value of the respective result.

Return values:

<RMS> Range: -1000 to 1000
*RST: 1
Default unit: V

Usage: Query only

16.19.5 Inrush Current

This measurement is a single shot measurement. To start the measurement, use the `RUNS` command.

POWer:INRush:ADD

Adds a gate.

Usage: Event

POWer:INRush:INSert <GateIndex>

Inserts a gate.

Setting parameters:

<GateIndex>

Usage: Setting only

POWer:INRush:REMove <GateIndex>

Removes a gate

Setting parameters:
<GateIndex>

Usage: Setting only

POWer:INRush:COUNt?

Queiries the number of inrush current gates.

Return values:
<Count>

Usage: Query only

POWer:INRush:EXECute

Starts the inrush current measurement.

Usage: Event

POWer:INRush:GATE<m>:STARt <StartTime>
POWer:INRush:GATE<m>:STOP <StopTime>

Sets the measuring time for the selected gate.

Suffix:
<m> *

Parameters:
<StopTime> Range: 0 to 10
Increment: 0
*RST: 100E-6
Default unit: s

POWer:INRush:GATE<m>:VALue <Value>

Returns the value of the inrush current.

Suffix:
<m> *

Parameters:
<Value> Range: -1000 to 1000
Increment: 0
*RST: 0
Default unit: A

POWer:INRush:MAXCurrent <MaxExpCurr>

Sets the maximum expected current for the vertical scale.

Parameters:

<MaxExpCurr>	Range:	-1000 to 1000
	Increment:	0
	*RST:	10
	Default unit:	A

POWer:INRush:TRIGger <TrigCurrValue>

Sets the current value for the trigger.

Parameters:

<TrigCurrValue>	Range:	-1000 to 1000
	Increment:	0
	*RST:	1
	Default unit:	A

POWer:INRush:REPort:ADD

Adds the result to the report list.

Usage: Event

16.19.6 Current Harmonic

POWer:HARMonics:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL	
	*RST:	MANUAL

POWer:HARMonics:DOFR <160>
POWer:HARMonics:ENFR <61000>
POWer:HARMonics:MIFR <1399>

Selects the frequency of the input signal.

Parameters:

<1399>	F400 | F60	
	*RST:	F400

POWer:HARMonics:EVAL <Current>

Sets the evaluation of the reults for "Standard" > "RTCA DO-160".

Parameters:

<Current>	REVISED | NOREVISED	
	*RST:	NOREVISED

POWer:HARMonics:EXECute

Starts the current harmonic measurement.

Usage: Event

POWer:HARMonics:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:HARMonics:RESult<m>:FREQuency<n>:VALue?
POWer:HARMonics:RESult<m>:MAXValue<n>:VALue?
POWer:HARMonics:RESult<m>:STDinuse?
POWer:HARMonics:RESult<m>:STDValue<n>:VALue?
POWer:HARMonics:RESult<m>:VALue<n>:VALue?

Returns the value of the respective result.

Suffix:

<m>	1..2
<n>	*

Return values:

<Value>	Range:	-1000 to 1000
	*RST:	0
	Default unit:	A

Usage: Query only

POWer:HARMonics:STAN <Use>

Sets a standard for the current harmonic measurement.

Parameters:

<Use> ENA | ENB | ENC | END | MIL | RTC

*RST: ENA

POWer:HARMonics:VOLT <Result>

Selects if the voltage results are displayed or not for "Standard" > "RTCA DO-160" and enabled "Evaluation with voltage source and revised current law".

Parameters:

<Result> VOLTDISP | NOVOLTDISP

*RST: NOVOLTDISP

Example:

```
POW:HARM:STAN RTC
POW:HARM:EVAL REVISED
POW:HARM:VOLT NOVOLTDISP
```

selects an evaluation with the revised current law and no voltage display

16.19.7 Modulation Analysis

This measurement is a single shot measurement. To start the measurement, use the `RUNS` command.

POWer:MODulation:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale> AUTO | MANUAL

*RST: MANUAL

POWer:MODulation:DHIStogram <DispHistg>

Activates or deactivates the display of a histogram.

Parameters:

<DispHistg> ON | OFF

*RST: ON

POWer:MODulation:EXECute

Starts the modulation analysis measurement.

Usage: Event
Asynchronous command

POWer:MODulation:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:MODulation:RESult:ACTual? <MeasType>
POWer:MODulation:RESult:AVG? <MeasType>
POWer:MODulation:RESult:EVTCount? <MeasType>
POWer:MODulation:RESult:NPEak? <MeasType>
POWer:MODulation:RESult:PPEak? <MeasType>
POWer:MODulation:RESult:RMS? <MeasType>
POWer:MODulation:RESult:STDDev? <MeasType>
POWer:MODulation:RESult:WFMCount? <MeasType>

Return the specified statistic result of the specified measurement type.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<MeasType> FREQ | DUTY

Usage: Query only

POWer:MODulation:SOURce <Source>

Selects the source for the measurement.

Parameters:

<Source>	CURRENT | VOLTAGE	
	*RST:	VOLTAGE

POWer:MODulation:TYPE <AnalysisType>

Sets the type of measurement.

Parameters:

<AnalysisType>	TURNON | CONT	
	*RST:	CONT

16.19.8 Dynamic ON Resistance

POWer:DONRes:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL	
	*RST:	MANUAL

POWer:DONRes:AVG <Average>

Enables/disables averaging.

Parameters:

<Average>	ON | OFF	
	*RST:	ON

POWer:DONRes:EXECute

Starts the dynamic on resistance measurement.

Usage: Event
Asynchronous command

POWer:DONRes:GATE<m>:STARt <Start>
POWer:DONRes:GATE<m>:STOP <Stop>

Sets the value for the cursor.

Suffix:

<m> 1..2

Parameters:

<Stop>

POWer:DONRes:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:DONRes:RESult:RESistance?

Returns the the dynamic on resistance value.

Return values:

<Resistance> Range: -100E+24 to 100E+24
*RST: 0
Default unit: \x2126

Usage: Query only

16.19.9 Slew Rate

POWer:SLEWrate:SOURce <Source>

Selects the source for the slew rate measurement.

Parameters:

<Source>	CURRENT | VOLTAGE *RST: VOLTAGE

POWer:SLEWrate:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale>	AUTO | MANUAL *RST: MANUAL

POWer:SLEWrate:AVGDeriv <AvgDerivative>

Activates or deactivates average.

Parameters:

<AvgDerivative>	ON | OFF *RST: ON

POWer:SLEWrate:EXECute

Starts the slew rate measurement.

Usage: Event

ACQuire:AREset:MODE <ArithRst>

Defines when the envelope and average evaluation restarts.

Parameters:

<ArithRst> NONE | TIME | WFMS

TIME
Restarts the envelope and average calculation after the time defined with `ACQuire:AREset:TIME`.

WFMS
Restarts the envelope and average calculation after a number of acquired waveforms.

*RST: NONE

Firmware/Software: V 1.36

ACQuire:AREset:TIME <EnvelopeTimeout>

Defines the time after which the envelope and average evaluation restarts.

The setting is relevant if ACQuire:ARESet:MODE is set to TIME.

Parameters:

<EnvelopeTimeout> Range: 0.1 to 10000
Increment: 0.01
*RST: 0.1
Default unit: s

Firmware/Software: V 1.36

ACQuire:ARESet:COUNt <NofWaveforms>

Defines the number of acquired waveforms after which the envelope and average evaluation restarts.

The setting is relevant if ACQuire:ARESet:MODE is set to WFMS.

Parameters:

<NofWaveforms> Range: 2 to 16777215
Increment: 10
*RST: 1000

Firmware/Software: V 2.70
Replaces the command ACQuire:ARESet:WFMCount

POWer:SLEWrate:GATE:STARt <T0>
POWer:SLEWrate:GATE:STOP <T1>

Sets the value for the cursor.

Parameters:

<T1>

POWer:SLEWrate:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:SLEWrate:RESult:ACTual? <MeasType>
POWer:SLEWrate:RESult:AVG? <MeasType>
POWer:SLEWrate:RESult:EVTCount? <MeasType>
POWer:SLEWrate:RESult:NPEak? <MeasType>
POWer:SLEWrate:RESult:PPEak? <MeasType>
POWer:SLEWrate:RESult:RMS? <MeasType>
POWer:SLEWrate:RESult:STDDev? <MeasType>
POWer:SLEWrate:RESult:WFMCount? <MeasType>

Return the specified statistic result of the specified measurement type.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results

- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:

<MeasType> MIN | MAX

Usage: Query only

16.19.10 S.O.A

POWer:SOA:EXECute

Starts the safe operating area measurement.

Usage: Event

POWer:SOA:LINear:ADD
POWer:SOA:LOGarithmic:ADD

Adds a point.

Usage: Event

POWer:SOA:LINear:COUNt?
POWer:SOA:LOGarithmic:COUNt?

Queries the number of points.

Return values:
<Count>

Usage: Query only

POWer:SOA:LINear:REMove <GateIndex>
POWer:SOA:LOGarithmic:REMove <GateIndex>

Removes a point.

Setting parameters:
<GateIndex>

Usage: Setting only

POWer:SOA:LINear:INSert <GateIndex>
POWer:SOA:LOGarithmic:INSert <GateIndex>

Inserts a point.

Setting parameters:
<GateIndex>

Usage: Setting only

POWer:SOA:LINear:POINt<m>:CURRent <Amp>
POWer:SOA:LOGarithmic:POINt<m>:CURRent <Amp>

Sets the current value for the respective point.

Suffix:
<m> *

Parameters:
<Amp> Range: 0.01 to 1000
Increment: 0
*RST: 0.01
Default unit: A

POWer:SOA:LINear:POINt<m>:VOLTage <Volt>
POWer:SOA:LOGarithmic:POINt<m>:VOLTage <Volt>

Sets the voltage value for the respective point.

Suffix:
<m> *

Parameters:
<Volt> Range: 1E-3 to 1000
Increment: 0
*RST: 1E-3
Default unit: V

POWer:SOA:MASK <Test>

Activates or deactivates a mask.

Parameters:

<Test>	ON | OFF	
	*RST:	OFF

POWer:SOA:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:SOA:SCALe <Scale>

Sets the scale for the measurement.

Parameters:

<Scale>	LOG | LINEAR	
	*RST:	LOG

POWer:SOA:SWITch <Switch>

Switches between linear and logarithmic scale.

Parameters:

<Switch>	LOGLINEAR | LINEARLOG	
	*RST:	LOGLINEAR

16.19.11 Turn On/Off

This measurement is a single shot measurement. To start the measurement, use the `RUNS` command.

POWer:ONOFf:ATOFf <ACTrigLevOff>
POWer:ONOFf:ATON <ACTrigLevOn>

Triggers the beginning of the measurements at the moment the AC input voltage reaches the set value.

Parameters:

<ACTrigLevOn> Range: -1E+6 to 1E+6
Increment: 1E-3
*RST: 10
Default unit: V

POWer:ONOFf:DTOFf <ACTrigLevOff>
POWer:ONOFf:DTON <ACTrigLevOn>

Triggers the beginning of the measurements at the moment the DC input voltage reaches the set value.

Parameters:

<ACTrigLevOn> Range: -1E+6 to 1E+6
*RST: 10
Default unit: V

POWer:ONOFf:DSOFf <DCSteadyStateLevOff>
POWer:ONOFf:DSON <DCSteadyStateLevOn>

Sets the percentage of the steady state level of the DC output that has to be reached.

Parameters:

<DCSteadyStateLevOn> Range: 0 to 100
Increment: 1
*RST: 90
Default unit: %

POWer:ONOFf:EXECute

Starts the turn on/off measurement.

Usage: Event

POWer:ONOFf:INPut <InputType>

Sets the input type.

Parameters:

<InputType> AC | DC
*RST: AC

POWer:ONOFf:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:ONOFf:RESult:TOFF?
POWer:ONOFf:RESult:TON?

Returns the result time.

Return values:

<TurnOnTime>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

POWer:ONOFf:TIME <Time>

Sets the time, the start of the measurement of the turn off time is delay with, after the trigger point.

Parameters:

<Time>
Range: 100E-12 to 10000
Increment: 100E-9
*RST: 0.1
Default unit: s

POWer:ONOFf:TYPE <MeasType>

Selects the measurement type.

Parameters:

<MeasType> TON | TOFF

TON - "Turn on" measurement
TOFF - "Turn off" measurement

*RST: TON

16.19.12 Switching Loss

POWer:SWITching:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale> AUTO | MANUAL

*RST: MANUAL

POWer:SWITching:EXECute

Starts the switching loss measurement.

Usage: Event
Asynchronous command

POWer:SWITching:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:SWITching:SWIFrequency <SwitchingFreq>

Sets the switching frequency.

Parameters:

<SwitchingFreq> Range: 1 to 500E+9
Increment: 1000
*RST: 10E+6
Default unit: Hz

POWer:SWITching:SWIT <MeasureSwitchingFreq>

Activates or deactivates the measurements of the switching frequency.

Parameters:

<MeasureSwitchingFreq> ON | OFF
*RST: ON

POWer:SWITching:COND <MeasureConduction>
POWer:SWITching:NCON <MeasureNonConduction>
POWer:SWITching:TON <MeasureTurnOn>
POWer:SWITching:TOFF <MeasureTurnOff>
POWer:SWITching:TOTal <MeasureTotal>

Enables the measurement during the respective period.

Parameters:

<MeasureTotal> ON | OFF
*RST: ON

POWer:SWITching:GATE:COND:STARt <T1>
POWer:SWITching:GATE:COND:STOP <T2>
POWer:SWITching:GATE:NCON:STARt <T3>
POWer:SWITching:GATE:TOFF:STARt <T2>
POWer:SWITching:GATE:TOFF:STOP <T3>
POWer:SWITching:GATE:TON:STARt <T0>
POWer:SWITching:GATE:TON:STOP <T1>

Sets the value for the respective cursor.

Parameters:

<T1>

POWer:SWITching:RESult:ENERgy:ACTual? <MeasType>
POWer:SWITching:RESult:ENERgy:AVG? <MeasType>
POWer:SWITching:RESult:ENERgy:EVTCount? <MeasType>
POWer:SWITching:RESult:ENERgy:NPEak? <MeasType>
POWer:SWITching:RESult:ENERgy:PPEak? <MeasType>
POWer:SWITching:RESult:ENERgy:RMS? <MeasType>
POWer:SWITching:RESult:ENERgy:STDDev? <MeasType>
POWer:SWITching:RESult:ENERgy:WFMCount? <MeasType>

Return the specified statistic result of the specified measurement type.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:
<MeasType> SWF | TON | TOF | CON | NCO | TOT

Usage: Query only

POWer:SWITching:RESult:POWer:ACTual? <MeasType>
POWer:SWITching:RESult:POWer:AVG? <MeasType>
POWer:SWITching:RESult:POWer:EVTCount? <MeasType>
POWer:SWITching:RESult:POWer:NPEak? <MeasType>
POWer:SWITching:RESult:POWer:PPEak? <MeasType>
POWer:SWITching:RESult:POWer:RMS? <MeasType>
POWer:SWITching:RESult:POWer:STDDev? <MeasType>
POWer:SWITching:RESult:POWer:WFMCount? <MeasType>

Return the specified statistic result of the specified measurement type.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Query parameters:
<MeasType> SWF | TON | TOF | CON | NCO | TOT

Usage: Query only

16.19.13 Power Efficiency

POWer:EFFiciency:AUTO <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale> AUTO | MANUAL

*RST: MANUAL

POWer:EFFiciency:EXECute

Starts the power efficiency measurement.

Usage: Event

POWer:EFFiciency:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:EFFiciency:RESult<m>:ACTual?
POWer:EFFiciency:RESult<m>:AVG?
POWer:EFFiciency:RESult<m>:EVTCount?
POWer:EFFiciency:RESult<m>:NPEak?
POWer:EFFiciency:RESult<m>:PPEak?
POWer:EFFiciency:RESult<m>:RMS?
POWer:EFFiciency:RESult<m>:STDDev?
POWer:EFFiciency:RESult<m>:WFMCount?

Return the specified statistic result of the specified measurement type.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Suffix:

<m> 1..3

Return values:

<WaveformsCount> Range: 0 to 4E+9

*RST: 0

Usage: Query only

16.19.14 Ripple

POWer:RIPPle:AUToscale <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale> AUTO | MANUAL

*RST: MANUAL

POWer:RIPPle:CURRent <TwoChMeas>

Activates or deactivates the input current.

Parameters:

<TwoChMeas> ON | OFF

*RST: ON

POWer:RIPPle:EXECute

Starts the ripple measurement.

Usage: Event

POWer:RIPPle:FREQuency <SmpsFrequency>

Sets the SMPS switching frequency.

Parameters:

<SmpsFrequency>	Range:	1 to 100E+9
	Increment:	1
	*RST:	1E+6
	Default unit:	Hz

POWer:RIPPle:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:RIPPle:RESult:FREQuency[:ACTual]?
POWer:RIPPle:RESult:FREQuency:AVG?
POWer:RIPPle:RESult:FREQuency:EVTCount?
POWer:RIPPle:RESult:FREQuency:NPEak?
POWer:RIPPle:RESult:FREQuency:PPEak?
POWer:RIPPle:RESult:FREQuency:RMS?
POWer:RIPPle:RESult:FREQuency:STDDev?
POWer:RIPPle:RESult:FREQuency:WFMCount?

Return the specified statistic result of the frequency of the signal. The result is based on the period measurement.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Return values:
<VoltageMeasType> VOLTage | CURRent

Usage: Query only

POWer:RIPPle:RESult:MAXimum[:ACTual]?
POWer:RIPPle:RESult:MAXimum:AVG?
POWer:RIPPle:RESult:MAXimum:EVTCount?
POWer:RIPPle:RESult:MAXimum:NPEak?
POWer:RIPPle:RESult:MAXimum:PPEak?
POWer:RIPPle:RESult:MAXimum:RMS?
POWer:RIPPle:RESult:MAXimum:STDDev?
POWer:RIPPle:RESult:MAXimum:WFMCount?

Return the specified statistic result for the maximum value of the waveform.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results

- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Return values:
<VoltageMeasType> VOLTage | CURRent

Usage: Query only

POWer:RIPPle:RESult:MINimum[:ACTual]?
POWer:RIPPle:RESult:MINimum:AVG?
POWer:RIPPle:RESult:MINimum:EVTCount?
POWer:RIPPle:RESult:MINimum:NPEak?
POWer:RIPPle:RESult:MINimum:PPEak?
POWer:RIPPle:RESult:MINimum:RMS?
POWer:RIPPle:RESult:MINimum:STDDev?
POWer:RIPPle:RESult:MINimum:WFMCount?

Return the specified statistic result for the minimum value of the waveform.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Return values:
<VoltageMeasType> VOLTage | CURRent

Usage: Query only

POWer:RIPPle:RESult:NDCYcle[:ACTual]?
POWer:RIPPle:RESult:NDCYcle:AVG?
POWer:RIPPle:RESult:NDCYcle:EVTCount?
POWer:RIPPle:RESult:NDCYcle:NPEak?
POWer:RIPPle:RESult:NDCYcle:PPEak?
POWer:RIPPle:RESult:NDCYcle:RMS?
POWer:RIPPle:RESult:NDCYcle:STDDev?
POWer:RIPPle:RESult:NDCYcle:WFMCount?

Return the specified statistic result for the negative duty cycle. The measurement requires at least one complete period of a triggered signal.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results

- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Return values:
<VoltageMeasType> VOLTage | CURRent

Usage: Query only

POWer:RIPPle:RESult:PDCYcle[:ACTual]?
POWer:RIPPle:RESult:PDCYcle:AVG?
POWer:RIPPle:RESult:PDCYcle:EVTCount?
POWer:RIPPle:RESult:PDCYcle:NPEak?
POWer:RIPPle:RESult:PDCYcle:PPEak?
POWer:RIPPle:RESult:PDCYcle:RMS?
POWer:RIPPle:RESult:PDCYcle:STDDev?
POWer:RIPPle:RESult:PDCYcle:WFMCount?

Return the specified statistic result for the positive duty cycle. The measurement requires at least one complete period of a triggered signal.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Return values:
<VoltageMeasType> VOLTage | CURRent

Usage: Query only

POWer:RIPPle:RESult:PDEL[:ACTual]?
POWer:RIPPle:RESult:PDEL:AVG?
POWer:RIPPle:RESult:PDEL:EVTCount?
POWer:RIPPle:RESult:PDEL:NPEak?
POWer:RIPPle:RESult:PDEL:PPEak?
POWer:RIPPle:RESult:PDEL:RMS?
POWer:RIPPle:RESult:PDEL:STDDev?
POWer:RIPPle:RESult:PDEL:WFMCount?

Return the specified statistic result for the peak to peak measurement.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results

- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Return values:
<VoltageMeasType> VOLTage | CURRent

Usage: Query only

POWer:RIPPle:RESult:PERiod[:ACTual]?
POWer:RIPPle:RESult:PERiod:AVG?
POWer:RIPPle:RESult:PERiod:EVTCount?
POWer:RIPPle:RESult:PERiod:NPEak?
POWer:RIPPle:RESult:PERiod:PPEak?
POWer:RIPPle:RESult:PERiod:RMS?
POWer:RIPPle:RESult:PERiod:STDDev?
POWer:RIPPle:RESult:PERiod:WFMCount?

Return the specified statistic result for the period, the length of the left-most signal period of the waveform.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Return values:
<VoltageMeasType> VOLTage | CURRent

Usage: Query only

POWer:RIPPle:RESult:STDDev[:ACTual]?
POWer:RIPPle:RESult:STDDev:AVG?
POWer:RIPPle:RESult:STDDev:EVTCount?
POWer:RIPPle:RESult:STDDev:NPEak?
POWer:RIPPle:RESult:STDDev:PPEak?
POWer:RIPPle:RESult:STDDev:RMS?
POWer:RIPPle:RESult:STDDev:STDDev?
POWer:RIPPle:RESult:STDDev:WFMCount?

Return the specified statistic result for the standard deviation of the long-term measurement results.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results

- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

Return values:

<VoltageMeasType> VOLTage | CURRent

Usage: Query only

16.19.15 Transient Response

This measurement is a single shot measurement. To start the measurement, use the `RUNS` command.

Programming example: Chapter 16.3.7.2, "Transient Response Measurement", on page 877

POWer:TRANsient:AUToscale <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale> AUTO | MANUAL

*RST: MANUAL

POWer:TRANsient:EXECute

Starts the transient response measurement.

Usage: Event

POWer:TRANsient:FREQuency <SmpsFrequency>

Sets the SMPS switching frequency.

Parameters:

<SmpsFrequency>	Range:	1 to 100E+6
	Increment:	1
	*RST:	1E+6
	Default unit:	Hz

POWer:TRANsient:HYSTeresis <ExpOutputSignTolTube>

Specifies a tolerated error band for the signal level.

Parameters:

<ExpOutputSignTolTube>	Range:	0 to 50
	Increment:	1
	*RST:	10
	Default unit:	%

POWer:TRANsient:INPut <ThreeChMeas>

Activates or deactivates the input voltage.

Parameters:

<ThreeChMeas>	ON | OFF	
	*RST:	OFF

POWer:TRANsient:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:TRANsient:RESult[:ACTual]? <MeasType>

Returns the results of the transient response measurement.

Query parameters:

<MeasType> OVERshoot | RTIMe | DELay | PEAKtime | SETTling

Usage: Query only

POWer:TRANsient:SIGHigh <ExpHighOutputSignLev>

Sets the expected signal high voltage value.

Parameters:

<ExpHighOutputSignLev>	Range:	-1000 to 1000
	Increment:	1E-3
	*RST:	1
	Default unit:	V

POWer:TRANsient:SIGLow <ExpLowOutputSignLev>

Sets the expected signal low voltage value.

Parameters:

<ExpLowOutputSignLev> Range: -1000 to 1000
Increment: 1E-3
*RST: 0
Default unit: V

POWer:TRANsient:TRGChannel <TriggerSource>

Sets the source channel of the trigger.

Parameters:

<TriggerSource> CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4

CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4
Only the measurement source channels can be used as trigger source.

*RST: CHAN1

POWer:TRANsient:TRGLevel <TriggerLevel>

Parameters:

<TriggerLevel> Range: -1000 to 1000
Increment: 1E-3
*RST: 0
Default unit: V

POWer:TRANsient:TRGSlope <TriggerSlope>

Sets the edge type for the trigger event.

Parameters:

<TriggerSlope> POSitive | NEGative | EITHer

*RST: POSitive

16.19.16 Spectrum

POWer:SPECtrum:AUToscale <Autoscale>

Selects the scaling for the display of the results.

Parameters:

<Autoscale> AUTO | MANUAL

*RST: MANUAL

POWer:SPECtrum:EXECute

Starts the spectrum measurement.

Usage: Event

POWer:SPECtrum:FREQuency <SmpsFrequency>

Sets the SMPS switching frequency.

Parameters:

<SmpsFrequency> Range: 1 to 100E+6
Increment: 1
*RST: 1E+6
Default unit: Hz

POWer:SPECtrum:REPort:ADD

Adds the result to the report list.

Usage: Event

POWer:SPECtrum:RCOunt?

Returns the total number of harmonics.

Return values:

<ResultCount>

Usage: Query only

POWer:SPECtrum:RESult<m>:FREQuency?

Returns the result frequency of the m-th result value.

Suffix:

<m> 1..*

Return values:

<Frequency>

Usage: Query only

POWer:SPECtrum:RESult<m>:LEVel?

Returns the result level of the m-th result value.

Suffix:
<m> 1..*

Return values:
<Level>

Usage: Query only

16.20 Maintenance

DIAGnostic:SERVice:WFAModel?

Returns the model name of the oscilloscope.

Return values:
<WFAModel> RTO1012 | RTO1014 | RTO1022 | RTO1024 | RTO1044 | RTO1002 | RTO1004 | RTO1094 | RTO2012 | RTO2014 | RTO2022 | RTO2024 | RTO2032 | RTO2034 | RTO2044 | RTO2062 | RTO2004 | RTE1022 | RTE1024 | RTE1032 | RTE1034 | RTE1052 | RTE1054 | RTE1102 | RTE1104 | RTE1102N | RTE1104N | RTE1152 | RTE1154 | RTE1202 | RTE1204

*RST: RTO1024

Usage: Query only

DIAGnostic:SERVice:WFASeries?

Returns the model series of the oscilloscope.

Return values:
<WFASeries> RTO | RTE

*RST: RTO

Usage: Query only

DIAGnostic:SERVice:WFAType?

Returns the instrument family of the oscilloscope.

Return values:

<WFAType> RTO | RTO2000 | RTE

*RST: RTO2000

Usage: Query only

DIAGnostic:SERVice:STST:EXECute

Starts the selftest.

Usage: Event
Asynchronous command

DIAGnostic:SERVice:STST:STATe?

Returns the summary result of the selftest.

Return values:

<State> PSSD | FAILed | UNDefined

*RST: UNDefined

Usage: Query only

DIAGnostic:SERVice:PWD <Password>

Sets the password to enter the service mode.

Setting parameters:

<Password> Password string

Usage: Setting only

16.21 Status Reporting

This chapter describes the remote commands that are used to read the status registers.

For information on structure, hierarchy, and contents of the status registers, see Chapter C, "Remote Control - Status Reporting System", on page 1629.

16.21.1 STATus:OPERation Register

`STATus:OPERation` commands provide information on the activity of the instrument.

See also: Chapter C.3.4, "STATus:OPERation Register", on page 1634

STATus:OPERation:CONDition?
STATus:OPERation[:EVENt]?

The CONDition command returns information on actions the instrument is currently executing. The contents of the register is retained.

The EVENt command returns information on actions the instrument has executed since the last reading. Reading the EVENt register deletes its contents.

Bits:

- 0 = ALIGnment
- 2 = AUToset
- 3= WTRIgger (wait for trigger)
- 4= MEASuring

Usage: Query only

16.21.2 STATus:QUEStionable Registers

The commands of the `STATus:QUEStionable` subsystem control the status reporting structures of the STATus:QUEStionable registers.

See also: Chapter C.3.5, "STATus:QUEStionable Register", on page 1635

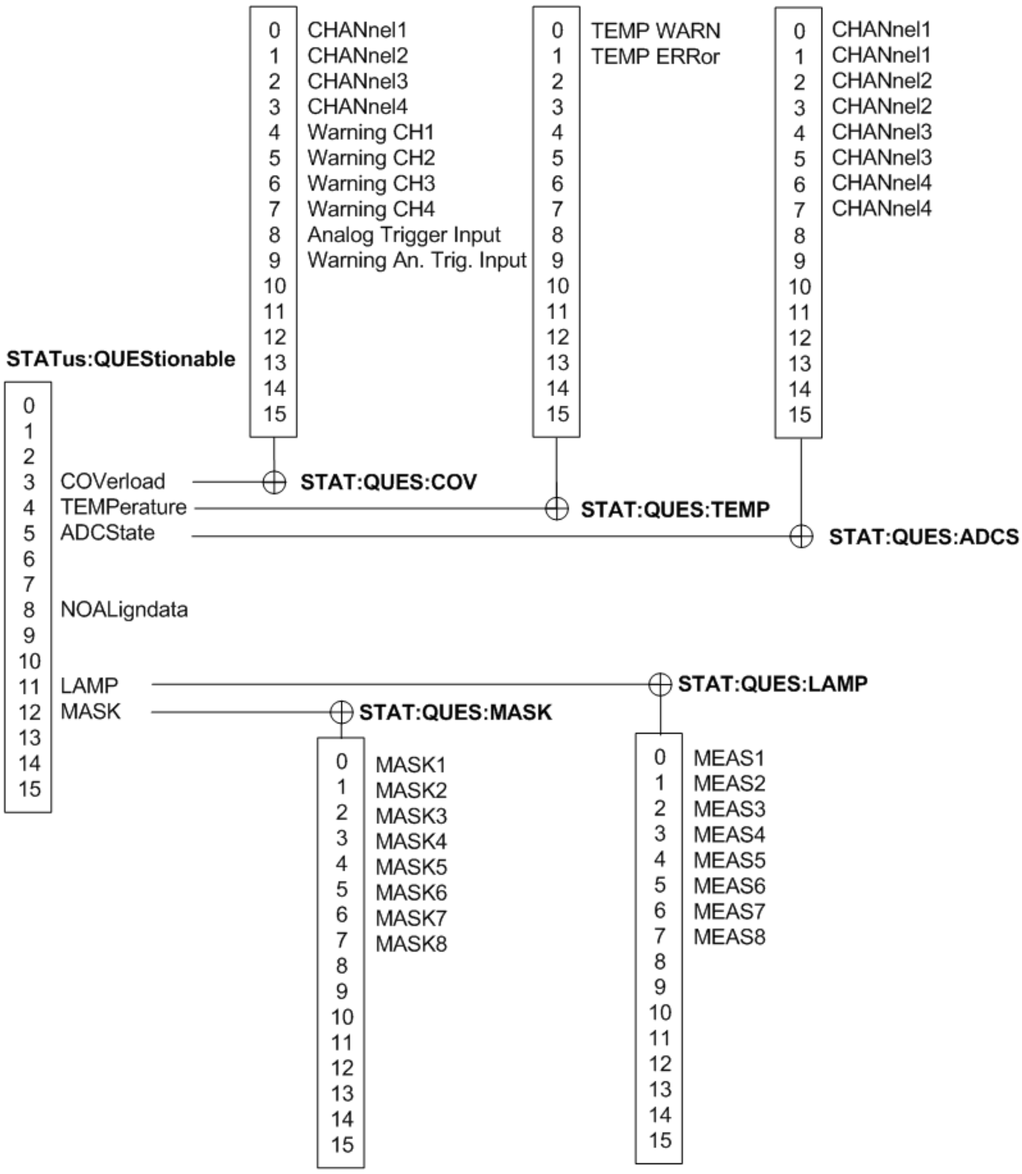


Figure 16-1: Overview of the STATus:QUEStionable register

The following commands are available:

STATus:QUEStionable:COVerload:CONDition?
STATus:QUEStionable:TEMPerature:CONDition?
STATus:QUEStionable:ADCState:CONDition?
STATus:QUEStionable:MASK:CONDition?

Returns the contents of the CONDition part of the status register to check for questionable instrument or measurement states. Reading the CONDition registers does not delete the contents.

Usage: Query only
SCPI confirmed

STATus:QUEStionable:COVerload:ENABle <Value>
STATus:QUEStionable:TEMPerature:ENABle <Value>
STATus:QUEStionable:ADCState:ENABle <Value>
STATus:QUEStionable:MASK:ENABle <Value>

Sets the ENABle part that allows true conditions in the EVENt part to be reported in the summary bit. If a bit is set to 1 in the enable part and its associated event bit transitions to true, a positive transition occurs in the summary bit and is reported to the next higher level.

Parameters:
<Value> Bit mask in decimal representation

Example: `STATus:QUEStionable:MASK:ENABle 24`
Set bits no. 3 and 4 of the STATus:QUEStionable:MASK:ENABle register part: $24 = 8 + 16 = 2^3 + 2^4$

Usage: SCPI confirmed

STATus:QUEStionable:COVerload[:EVENt]?
STATus:QUEStionable:TEMPerature[:EVENt]?
STATus:QUEStionable:ADCState[:EVENt]?
STATus:QUEStionable:MASK[:EVENt]?

Returns the contents of the EVENt part of the status register to check whether an event has occurred since the last reading. Reading an EVENt register deletes its contents.

Usage: Query only
SCPI confirmed

STATus:QUEStionable:COVerload:NTRansition <Value>
STATus:QUEStionable:TEMPerature:NTRansition <Value>
STATus:QUEStionable:ADCState:NTRansition <Value>
STATus:QUEStionable:MASK:NTRansition <Value>

Sets the negative transition filter. If a bit is set, a 1 to 0 transition in the corresponding bit of the condition register causes a 1 to be written in the corresponding bit of the event register.

Parameters:

<Value> Bit mask in decimal representation

Example: `STATus:QUEStionable:MASK:NTRansition 24`
Set bits no. 3 and 4 of the STATus:QUEStionable:MASK:NTRansition register part: $24 = 8 + 16 = 2^3 + 2^4$

Usage: SCPI confirmed

STATus:QUEStionable:COVerload:PTRansition <Value>
STATus:QUEStionable:TEMPerature:PTRansition <Value>
STATus:QUEStionable:ADCState:PTRansition <Value>
STATus:QUEStionable:MASK:PTRansition <Value>

Sets the positive transition filter. If a bit is set, a 0 to 1 transition in the corresponding bit of the condition register causes a 1 to be written in the corresponding bit of the event register.

Parameters:

<Value> Bit mask in decimal representation

Example: `STATus:QUEStionable:MASK:PTRansition 24`
Set bits no. 3 and 4 of the STATus:QUEStionable:MASK:PTRansition register part: $24 = 8 + 16 = 2^3 + 2^4$

Usage: SCPI confirmed

16.22 Remote Trace

The commands in this section configure tracing of the remote control interface and of events. They also configure the display of the SCPI remote trace.

Before you start tracing, configure all settings as desired. Modifying settings while tracing is active may result in loss of already traced data. Useful exception: Selecting a new target file while tracing is allowed. For start mode `EXPLicit` a restart of the instrument resets the settings to the documented default values.

If you want to start tracing already during startup of the instrument, configure all settings (including start mode `AUTO`). Then restart your instrument. Tracing will be started automatically during the restart, using the already configured settings.

If you use an XML file as trace file, ensure that tracing is stopped properly. If tracing is aborted instead of stopped, for example by shutting down the instrument for stop mode `EXPLicit`, the XML file will be invalid, because some tags are not closed.

When the maximum file size is reached (except for stop mode `BUFFerfull`) or if tracing is started with an already existing trace file, a backup of the trace file is created and the file itself is reset and overwritten. When the file is full for the second time or when tracing is started the next time, the first backup file is lost because it is overwritten by the next backup. In order to prevent loss of data, set a sufficient file size, select an appropriate stop mode and archive/copy completed trace files if you want to keep them.

16.22.1 Standard Commands

TRACe:REMote:MODE:FILE:NAME <FilePath>

Sets the directory and file name where the remote trace file is stored.

Parameters:

<FilePath> String parameter

TRACe:REMote:MODE:FILE:FORMat <Format>

Sets the file format of the remote trace file.

Parameters:

<Format> ASCii | XML

TRACe:REMote:MODE:FILE:SIZE <FileSize>

Sets the maximum size of the remote trace file.

Parameters:

<FileSize> String parameter

TRACe:REMote:MODE:FILE:STARtmode <StartMode>

Defines how the remote trace is started.

Parameters:

<StartMode> AUTO | EXPLicit

AUTO
Starts the remote trace immediately.

EXPLicit
Starts remote trace with `TRACe:REMote:MODE:FILE:ENABle ON`

TRACe:REMote:MODE:FILE:STOPmode <StopMode>

Defines when the remote trace is stopped.

Parameters:

<StopMode> AUTO | EXPLicit | ERRor | BUFFerfull

AUTO
Ends the remote trace on device shutdown.

EXPLicit
Ends remote trace with `TRACe:REMote:MODE:FILE:ENABle OFF`

ERRor
Ends remote trace when a SCPI error occurs.

BUFFerfull
Ends remote trace when the maximum file size is reached.

TRACe:REMote:MODE:FILE:ENABle <Enable>

Enables and disables the remote trace to file.

Parameters:

<Enable> ON | OFF

TRACe:REMote:MODE:FILE:FILTer <Input>, <Output>, <Error>, <Trigger>, <DeviceClear>, <StatusRegister>, <Connection>, <RemoteLocalEvents>, <Locking>

Defines the content of the remote trace file.

Parameters:

<Input> ON | OFF

Input data

<Output> ON | OFF

Output data

<Error> ON | OFF

New SCPI error queue entries

<Trigger> ON | OFF

Trigger events

<DeviceClear>	ON | OFF Device clear events
<StatusRegister>	ON | OFF Status register conditions
<Connection>	ON | OFF Open/close connection events
<RemoteLocalEvents>	ON | OFF Local/remote transition events
<Locking>	ON | OFF Remote locking events

16.22.2 Diagnostic Remote Trace Commands

TRACe:REMote:MODE:FILE:DEXecution:DURation <Enable>

Traces the device execution time of a command

Parameters:
<Enable> ON | OFF

TRACe:REMote:MODE:FILE:RPC <Enable>

Enables and disables output of rpc calls to remote trace.

Parameters:
<Enable> ON | OFF

TRACe:REMote:MODE:FILE:PARSer <Enable>

Enables and disables output of parser transitions to remote trace.

Parameters:
<Enable> ON | OFF

TRACe:REMote:MODE:FILE:FUNCtions <Enable>

Enables and disables output of function names to remote trace.

Parameters:
<Enable> ON | OFF

16.23 Deprecated Commands

The following commands are provided for compatibility to previous oscilloscope versions only. For new remote control programs, use the specified alternative commands.

ACQuire:AREset:WFMCount <MaxAcqCount>

The command is obsolete and replaced by `ACQuire:AREset:ACQMax`.

Defines the number of acquired waveforms after which the envelope and average evaluation restarts.

The setting is relevant if `ACQuire:AREset:MODE` is set to `WFMS`.

Parameters:

<MaxAcqCount>	Range:	1 to 16777215
	Increment:	10
	*RST:	1

Firmware/Software: V 1.36

BUS<m>:SWIRe:MINGap <MinGapTime>

Suffix:

<m> 1..4

Parameters:

<MinGapTime>	Range:	1E-9 to 10E-6
	Increment:	100E-9
	*RST:	200E-9
	Default unit:	s

BUS<m>:SWIRe:THRCoupling <ThresCoup>

Enables coupling, i.e. the same threshold and hysteresis value is used for the strob and the data signal.

Suffix:

<m> 1..4

Parameters:

<ThresCoup> ON | OFF

*RST: ON

BUS<m>:SWIRe:THRPreset <ThresholdPreset>

Prests the threshold and hysteresis value of the strobe and data signal.

Suffix:

<m> 1..4

Parameters:

<ThresholdPreset>	V01 | V03 | V2 | MAN *RST: V01

MEASurement<m>:SPECtrum:NREJect <NoiseReject>

Defines the threshold beneath which values are rejected as noise.

Replaced by `MEASurement<m>:SPECtrum:ATHReshold`.

Suffix:

<m>	1..10 The suffix is irrelevant.

Parameters:

<NoiseReject>	Range: 0 to 100 Increment: 1 *RST: 0 Default unit: dB

MEASurement<m>:SPECtrum:THReshold <Value>

Defines a threshold relative to the reference level as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

Suffix:

<m>	1..10 The suffix is irrelevant.

Parameters:

<Value>	Threshold in dB
Firmware/Software:	Version 2.70 The command has been replaced by `MEASurement<m>:SPECtrum:ATHReshold`.

SEARch:TRIGger:INTerval:POLarity <SearchName>,<Slope>
SEARch:TRIGger:INTerval:POLarity? <SearchName>

Sets the edge for the interval detection.

Parameters:

<Slope>	POSitive | NEGative | EITHer POSitive = rising edge, NEGative = falling edge *RST: POSitive

Parameters for setting and query:

<SearchName>	Search definition

Replaced by `SEARch:TRIGger:INTerval:SLOPe`

TRIGger<m>:INTerval:POLarity <Slope>

Sets the edge for the interval detection.

Suffix:

<m>	1..3 1 = A-trigger, 2 | 3 = not availabe

Parameters:

<Slope>	POSitive | NEGative POSitive = rising edge, NEGative = falling edge *RST: POSitive

Replaced by `TRIGger<m>:INTerval:SLOPe`

17 Maintenance

The instrument does not need a periodic maintenance. Only the cleaning of the instrument is essential.

To protect the front panel and to transport the instrument to another workplace safely and easily, accessories are provided:

- Front cover (R&S RTO-Z1, order number 1317.6970.02)
- Soft case (R&S RTE-Z3, order number 1304.9118.02)

Follow the instructions in the service manual and the safety instructions when exchanging modules or ordering spares. The order no. for spare parts is included in the service manual. The service manual includes further information particularly on troubleshooting, repair, exchange of modules, and alignment.

The "Board Detection/Maintenance dialog" box provides further information on your particular instrument configuration which may be helpful in case you require support.

The addresses of Rohde & Schwarz support centers can be found at http://www.customersupport.rohde-schwarz.com. A list of all service centers is available on http://www.services.rohde-schwarz.com.

17.1 Cleaning

The outside of the instrument can be cleaned sufficiently using a soft, lint-free dust cloth. Make sure that the fan openings are not obstructed.

⚠ WARNING

Shock hazard

Before cleaning the instrument, make sure that the instrument is switched off and disconnected from all power supplies.

NOTICE

Instrument damage caused by cleaning agents

Cleaning agents contain substances that may damage the instrument. For example, cleaning agents that contain a solvent may damage the front panel labeling, plastic parts, or the display.

Never use cleaning agents such as solvents (thinners, acetone, etc), acids, bases, or other substances.

The outside of the instrument can be cleaned sufficiently using a soft, lint-free dust cloth.

NOTICE

Risk of instrument damage due to obstructed fans

If the instrument is operated in dusty areas, the fans may become obstructed by dust or other particles in the process of time. Make sure to check and, if necessary, clean the fans regularly to ensure they operate properly at all times. If the instrument is run with obstructed fans for a longer period, it may become overheated which may cause damage.

17.2 Troubleshooting with RTxServiceReporter

The RTxServiceReporter creates and saves a complete bug report with all relevant setup, reporting, and log files. In case of a firmware failure, contact one of the Rohde & Schwarz support centers and send the report file for fast problem analysis.

1. On the R&S RTE display, open the "File" menu and tap "Minimize Application".
2. On the Windows desktop, execute the "RTxServiceReporter".

   The system creates the report and saves it as zip file directly on the Windows desktop.
3. Send the report file to a Rohde & Schwarz support center.

17.3 Data Security

If you have to send the instrument to the service, or if the instrument is used in a secured environment, consider the document "Instrument Security Procedures" that is delivered on the R&S RTE web page.

Instrument configuration data and user data are stored on a removable hard disk only. Thus it is sufficient to remove the hard disk before the instrument leaves a secured environment. Details are given in the document mentioned above.

17.4 Storing and Packing

The storage temperature range of the instrument is given in the data sheet. If the instrument is to be stored for a longer period of time, it must be protected against dust.

Repack the instrument as it was originally packed when transporting or shipping. The two protective foam plastic parts prevent the control elements and connectors from being damaged. The antistatic packing foil avoids any undesired electrostatic charging to occur.

If you do not use the original packaging, use a sturdy cardboard box of suitable size and provide for sufficient padding to prevent the instrument from slipping inside the package. Wrap antistatic packing foil around the instrument to protect it from electrostatic charging.

17.5 Performing a Selftest

The instrument selftest checks the hardware for correct operation. Perform the selftest if you suspect problems in hardware operation.

1. From the "File" menu, select "Selftest".
2. Tap "Selftest".

   The test might take several minutes. The summary result is shown in the "State" field. In case you require support, you may be asked to provide this information.

17.6 Reference for Maintenance Settings

17.6.1 Board Detection/Maintenance

The "Board Detection/Maintenance" dialog box in the "File" menu provides service information for your R&S RTE. In case you require support, you may be asked to provide this information.

17.6.1.1 System Info

This tab provides general information on the hardware configuration, and indicates where system information can be found on the instrument.

17.6.1.2 Mainboard

This tab provides information on the mainboard configuration in your instrument.

17.6.1.3 Frontend

This tab provides information on the frontend configuration in your instrument.

17.6.1.4 Frontpanel

This tab provides information on the frontpanel module installed in your instrument.

17.6.1.5 MSO Option

This tab is only relevant if the MSO option R&S RTE-B1 is installed. The tab provides information on the MSO hardware module that is installed in your instrument.

17.6.1.6 Service

This tab allows the service personnel to enter a password that activates further service functions.

Remote command:

- `DIAGnostic:SERVice:PWD` on page 1594

17.6.2 Selftest

The instrument selftest checks the hardware for correct operation. Perform the selftest if you suspect problems in hardware operation.

Selftest
Starts the selftest.

Remote command:
`*TST?` on page 886

State
Shows the summary result of the selftest: Pass or Fail.

Remote command:
`DIAGnostic:SERVice:STST:STATe?` on page 1594

Result
Opens a log file with detailed information on the selftest steps and hardware components operation. In case you require support, you may be asked to provide this information.

Annex

A Menu Overview

This section provides an overview of the menus together with a short description or link to the description.

A.1 File Menu

Menu item	Description	Corresponding key
File	Chapter 11.2, "Waveforms and Results", on page 409	FILE
Setup	Chapter 3, "Instrument Setup", on page 106	SETUP
Print	Chapter 11.3, "Screenshots", on page 429 Chapter 11.3.2, "Printing Screenshots", on page 433	PRINT
Help	Chapter 2.4.10, "Getting Information and Help", on page 103	HELP
Mode	Chapter 3.6.5, "Options in Beta State", on page 139	MODE
Maintenance	Chapter 17.6.1, "Board Detection/Maintenance", on page 1607	
Selfalignment	Chapter 3.5, "Self-Alignment", on page 132	
Selftest	Chapter 17.6.2, "Selftest", on page 1608	
Demo Board	For internal use only. Opens a setup dialog box for the demo board If a demo board is connected to the instrument.	

Menu item	Description	Corresponding key
Minimize Application	Shows the Windows desktop with the application icon of the R&S RTE firmware.	
Exit	Shuts down the firmware.	

A.2 Horizontal Menu

Menu item	Description	Corresponding key
Setup	Chapter 4.2.1, "Setup", on page 150	HORIZONTAL
Acquisition	Chapter 4.2.2, "Acquisition", on page 154	ACQUISITION
Ultra Segmentation	Chapter 4.2.3, "Ultra Segmentation", on page 158	
Skew	Chapter 4.7.2, "Skew", on page 182	

A.3 Trigger Menu

Menu item	Description	Corresponding key
Setup	Chapter 5.3, "Trigger Types", on page 191	TRIGGER
Noise Reject	Chapter 5.5, "Noise Reject", on page 218	
Holdoff	Chapter 5.4, "Holdoff", on page 216	
Ctrl/Action	Chapter 5.6, "Control / Action", on page 219	
Extern		
Digital Filter	Chapter 4.6, "Digital Filter Setup", on page 180	
Acquisition Info	Shows the current number of acquisitions that have been acquired.	

A.4 Vertical Menu

Menu item	Description	Corresponding key
Channels	Chapter 4.3.1, "Channels", on page 160	CH ×
Coupled Channels		
Power Calculation	Chapter 4.3.3, "Power Calculation", on page 163	
Probe Setup	Chapter 4.5, "Probes", on page 167	
Probe Attributes	Chapter 4.5.5, "Probe Attributes", on page 179	

Menu item	Description	Corresponding key
Calibration Results	Chapter 4.5.6, "Calibration Results", on page 180	
Digital Filter	Chapter 4.6, "Digital Filter Setup", on page 180	

A.5 Math Menu

Menu item	Description	Key / Icon
Math Setup	Chapter 6.3.4, "Math Setup - General Settings", on page 255	MATH
FFT Setup	Chapter 8.1.3.1, "FFT Setup", on page 335	
FFT Overlap		
FFT Gating	Chapter 8.1.3.3, "FFT Gating", on page 341	
FFT Y-Units		
Reference Waveform	Submenu: Setup, Scaling, Original Attributes: Chapter 6.2.2, "Settings for Reference Waveforms", on page 241	

A.6 Cursor Menu

Menu item	Description	Key / Icon
Setup	Chapter 7.1.3.1, "Cursor Setup Tab", on page 273	CURSOR 
Style and Label	Chapter 7.1.3.2, "Cursor Style and Label Tab", on page 275	
Peak Search	Chapter 7.1.3.3, "Peak Search Tab", on page 276	

A.7 Meas Menu

Menu item	Description	Key / Icon
Setup	Chapter 7.2.1.1, "General Measurement Settings", on page 279	MEAS 
Parameters	• Chapter 7.2.5.2, "Amplitude/Time Measurement Settings ", on page 298 • Chapter 7.2.6.2, "Eye Diagram Measurement Settings", on page 306 • Chapter 7.2.7.2, "Spectrum Measurement Settings ", on page 307 • Chapter 7.2.8.3, "Histogram Measurement Settings ", on page 315	
Long Term/Track	Chapter 7.2.9.2, "Long Term/Track Settings", on page 319	
Gate/Display	Chapter 7.2.3.1, "Gate Settings for Measurements", on page 286 Chapter 7.2.2.2, "Result Display Settings", on page 285	
Histogram	Chapter 7.2.8.2, "Histogram Setup", on page 313	
Reference Level	Chapter 7.2.4.1, "Level Settings", on page 290	

A.8 Masks Menu

Menu item	Description	Key / Icon
Test Definition	Chapter 9.2.1, "Test Definition", on page 355	MASKS Opens the last selected tab in the "Masks" dialog box. 
Mask Definition	Chapter 9.2.2.1, "Mask Definition: User Mask", on page 357	
Event Actions / Reset	Chapter 9.2.3, "Event Actions /Reset ", on page 363	
Mask Display	Chapter 9.2.4, "Mask Display", on page 365	

A.9 Search Menu

Menu item	Description	Key / Icon
Setup	Chapter 10.2, "Search Setup", on page 378	SEARCH Opens the last selected tab in the "Search" dialog box.
Gate	Chapter 10.3.1, "Gate Settings", on page 392	

Menu item	Description	Key / Icon
Result Presentation	Chapter 10.4.1, "Result Presentation Settings", on page 394	
Noise Reject	Chapter 10.5.1, "Noise Reject Settings", on page 397	

A.10 Analysis Menu

The content of the menu depends on the installed options.

Menu item	Description	Corresponding key
Power	Chapter 14, "Power Analysis (Option R&S RTE-K31)", on page 775	
Serial Bus		
Configuration	Chapter 12.1.1, "Configuration - General Settings", on page 439	PROTOCOL
Display	Chapter 12.1.2, "Display", on page 440	
Label List	Chapter 12.1.3, "Label Lists", on page 441	
Parallel bus		
Configuration	Chapter 13.1.1, "Parallel Buses - Configuration", on page 751	LOGIC
Digital Probes	Chapter 13.1.2, "Parallel Buses - Digital Probes", on page 756	

A.11 Display Menu

Menu item	Description	Key / Icon
Signal Colors / Persistence	Chapter 3.4.2.1, "Colors / Persistence", on page 116	DISPLAY Opens the last selected tab in the "Display" dialog box.
Color Tables	Chapter 3.4.2.2, "Color Tables", on page 119	
Diagram Layout	Chapter 3.4.2.3, "Diagram Layout", on page 120	
XY-Diagram	Chapter 6.5, "XY-diagram", on page 264	
Labels		
Zoom	Chapter 6.1, "Zoom", on page 227	ZOOM 

Menu item	Description	Key / Icon
Show History	Enables the history mode and opens the quick-access "History" dialog box. Chapter 6.4, "History", on page 258	HISTORY
History Setup	Opens the "History" configuration dialog box without starting the history mode. Chapter 6.4.2, "History Setup", on page 259	
Show Performance	Displays the current performance values of the instrument.	
Clear Screen Results	Deletes all measurement results including long term measurement and statistic results. Also deletes the current measurement and channel waveforms.	
Toolbar	Chapter 2.4.5.2, "Configuring the Toolbar", on page 92	
Show Signal Bar	Switches the signal bar on or off. Chapter 2.4.4, "Using the Signal bar", on page 90	

A.12 Tutorials Menu

Menu item	Description	Corresponding key
Getting Started	Opens a dialog box with tutorial videos that explain how to use the instrument..	

B Remote Control - Basics

B.1 Messages

B.1.1 Instrument Messages

Instrument messages are employed in the same way for all interfaces, if not indicated otherwise in the description.

There are different types of instrument messages, depending on the direction they are sent:

- Commands
- Instrument responses

Commands

Commands (program messages) are messages the controller sends to the instrument. They operate the instrument functions and request information. The commands are subdivided according to two criteria:

- According to the effect they have on the instrument:
  – **Setting commands** cause instrument settings such as a reset of the instrument or setting the frequency.
  – **Queries** cause data to be provided for remote control, e.g. for identification of the instrument or polling a parameter value. Queries are formed by directly appending a question mark to the command header.
- According to their definition in standards:
  – **Common commands**: their function and syntax are precisely defined in standard IEEE 488.2. They are employed identically on all instruments (if implemented). They refer to functions such as management of the standardized status registers, reset and self test.
  – **Instrument control commands** refer to functions depending on the features of the instrument such as frequency settings. Many of these commands have also been standardized by the SCPI committee. These commands are marked as "SCPI compliant" in the command reference chapters. Commands without this SCPI label are device-specific, however, their syntax follows SCPI rules as permitted by the standard.

Instrument responses

Instrument responses (response messages and service requests) are messages the instrument sends to the controller after a query. They can contain measurement results, instrument settings and information on the instrument status.

See also:

- Structure and syntax of the instrument messages are described in Chapter B.2, "SCPI Command Structure", on page 1618.
- Detailed description of all messages: Chapter 16, "Remote Control Commands", on page 863

B.1.2 Interface Massages

Interface messages are transmitted to the instrument on the data lines. They are used to communicate between the controller and the instrument. Interface messages can only be sent by instruments that have GPIB bus functionality.

B.1.2.1 GPIB Interface Messages

Interface messages are transmitted to the instrument on the data lines, with the attention line (ATN) being active (LOW). They are used for communication between the controller and the instrument and can only be sent by a computer which has the function of a GPIB bus controller. GPIB interface messages can be further subdivided into:

- **Universal commands**: act on all instruments connected to the GPIB bus without previous addressing
- **Addressed commands**: only act on instruments previously addressed as listeners

Universal Commands

Universal commands are encoded in the range 10 through 1F hex. They affect all instruments connected to the bus and do not require addressing.

Command	Effect on the instrument
DCL (Device Clear)	Aborts the processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument settings.
IFC (Interface Clear) *)	Resets the interfaces to the default setting.
LLO (Local Lockout)	The LOC/IEC ADDR key is disabled.
SPE (Serial Poll Enable)	Ready for serial poll.
SPD (Serial Poll Disable)	End of serial poll.
PPU (Parallel Poll Unconfigure)	End of the parallel-poll state.
*) IFC is not a real universal command, it is sent via a separate line; however, it also affects all instruments connected to the bus and does not require addressing	

Addressed Commands

Addressed commands are encoded in the range 00 through 0F hex. They only affect instruments addressed as listeners.

Command	Effect on the instrument
GET (Group Execute Trigger)	Triggers a previously active instrument function (e.g. a sweep). The effect of the command is the same as with that of a pulse at the external trigger signal input.
GTL (Go to Local)	Transition to the "local" state (manual control).
GTR (Go to Remote)	Transition to the "remote" state (remote control).
PPC (Parallel Poll Configure)	Configures the instrument for parallel poll.
SDC (Selected Device Clear)	Aborts the processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument setting.

B.1.2.2 LAN Interface Messages

In the LAN connection, the interface messages are called low–level control messages. These messages can be used to emulate interface messages of the GPIB bus.

Command	Long term	Effect on the instrument
&ABO	Abort	Aborts processing of the commands just received.
&DCL	Device Clear	Aborts processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument setting.
&GTL	Go to Local	Transition to the "local" state (manual control). (The instrument automatically returns to remote state when a remote command is sent UNLESS `&NREN` was sent before.)
&GTR	Go to Remote	Enables automatic transition from local state to remote state by a subsequent remote command (after `&NREN` was sent).
&GET	Group Execute Trigger	Triggers a previously active instrument function (e.g. a sweep). The effect of the command is the same as with that of a pulse at the external trigger signal input.
&LLO	Local Lockout	Disables transition from remote control to manual control by means of the front panel keys.
&NREN	Not Remote Enable	Disables automatic transition from local state to remote state by a subsequent remote command. (To re-activate automatic transition use `&GTR`.)
&POL	Serial Poll	Starts a serial poll.

B.2 SCPI Command Structure

SCPI commands consist of a so-called header and, in most cases, one or more parameters. The header and the parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). The headers may consist of several mnemonics (keywords). Queries are formed by appending a question mark directly to the header.

The commands can be either device-specific or device-independent (common commands). Common and device-specific commands differ in their syntax.

B.2.1 Syntax for Common Commands

Common (=device-independent) commands consist of a header preceded by an asterisk (*) and possibly one or more parameters.

Examples:

*RST	RESET	Resets the instrument.
*ESE	EVENT STATUS ENABLE	Sets the bits of the event status enable registers.
*ESR?	EVENT STATUS QUERY	Queries the contents of the event status register.
*IDN?	IDENTIFICATION QUERY	Queries the instrument identification string.

B.2.2 Syntax for Device-Specific Commands

Not all commands used in the following examples are necessarily implemented in the instrument.

For demonstration purposes only, assume the existence of the following commands for this section:

- `DISPlay[:WINDow<1...4>]:MAXimize <Boolean>`
- `FORMat:READings:DATA <type>[,<length>]`
- `HCOPy:DEVice:COLor <Boolean>`
- `HCOPy:DEVice:CMAP:COLor:RGB <red>,<green>,<blue>`
- `HCOPy[:IMMediate]`
- `HCOPy:ITEM:ALL`
- `HCOPy:ITEM:LABel <string>`
- `HCOPy:PAGE:DIMensions:QUADrant[<N>]`
- `HCOPy:PAGE:ORIentation LANDscape | PORTrait`
- `HCOPy:PAGE:SCALe <numeric value>`
- `MMEMory:COPY <file_source>,<file_destination>`
- `SENSE:BANDwidth|BWIDth[:RESolution] <numeric_value>`
- `SENSe:FREQuency:STOP <numeric value>`
- `SENSe:LIST:FREQuency <numeric_value>{,<numeric_value>}`

Long and short form

The mnemonics feature a long form and a short form. The short form is marked by upper case letters, the long form corresponds to the complete word. Either the short form or the long form can be entered; other abbreviations are not permitted.

Example:

`HCOPy:DEVice:COLor ON` is equivalent to `HCOP:DEV:COL ON`.

Case-insensitivity

Upper case and lower case notation only serves to distinguish the two forms in the manual, the instrument itself is case-insensitive.

Numeric suffixes

If a command can be applied to multiple instances of an object, e.g. specific channels or sources, the required instances can be specified by a suffix added to the command. Numeric suffixes are indicated by angular brackets (<1...4>, <n>, <i>) and are replaced by a single value in the command. Entries without a suffix are interpreted as having the suffix 1.

Example:

Definition: `HCOPy:PAGE:DIMensions:QUADrant[<N>]`

Command: `HCOP:PAGE:DIM:QUAD2`

This command refers to the quadrant 2.

Different numbering in remote control

For remote control, the suffix may differ from the number of the corresponding selection used in manual operation. SCPI prescribes that suffix counting starts with 1. Suffix 1 is the default state and used when no specific suffix is specified.

Some standards define a fixed numbering, starting with 0. If the numbering differs in manual operation and remote control, it is indicated for the corresponding command.

Optional mnemonics

Some command systems permit certain mnemonics to be inserted into the header or omitted. These mnemonics are marked by square brackets in the description. The instrument must recognize the long command to comply with the SCPI standard. Some commands are considerably shortened by these optional mnemonics.

Example:

Definition: `HCOPy[:IMMediate]`

Command: `HCOP:IMM` is equivalent to `HCOP`

Optional mnemonics with numeric suffixes

Do not omit an optional mnemonic if it includes a numeric suffix that is relevant for the effect of the command.

Example:

Definition:`DISPlay[:WINDow<1...4>]:MAXimize <Boolean>`

Command: `DISP:MAX ON` refers to window 1.

In order to refer to a window other than 1, you must include the optional `WINDow` parameter with the suffix for the required window.

`DISP:WIND2:MAX ON` refers to window 2.

Parameters

Parameters must be separated from the header by a "white space". If several parameters are specified in a command, they are separated by a comma (,). For a description of the parameter types, refer to Chapter B.2.3, "SCPI Parameters", on page 1621.

Example:

Definition:`HCOPy:DEVice:CMAP:COLor:RGB <red>,<green>,<blue>`

Command:`HCOP:DEV:CMAP:COL:RGB 3,32,44`

Special characters

|	**Parameters**
	A vertical stroke in parameter definitions indicates alternative possibilities in the sense of "or". The effect of the command differs, depending on which parameter is used.
	Example:
	Definition:`HCOPy:PAGE:ORIentation LANDscape | PORTrait`
	Command `HCOP:PAGE:ORI LAND` specifies landscape orientation
	Command `HCOP:PAGE:ORI PORT` specifies portrait orientation
	Mnemonics
	A selection of mnemonics with an identical effect exists for several commands. These mnemonics are indicated in the same line; they are separated by a vertical stroke. Only one of these mnemonics needs to be included in the header of the command. The effect of the command is independent of which of the mnemonics is used.
	Example:
	Definition`SENSE:BANDwidth|BWIDth[:RESolution] <numeric_value>`
	The two following commands with identical meaning can be created:
	`SENS:BAND:RES 1`
	`SENS:BWID:RES 1`

[ ]	Mnemonics in square brackets are optional and may be inserted into the header or omitted. **Example**: `HCOPy[:IMMediate]` `HCOP:IMM` is equivalent to `HCOP`

{ }	Parameters in curly brackets are optional and can be inserted once or several times, or omitted.
	Example: `SENSe:LIST:FREQuency <numeric_value>{,<numeric_value>}`
	The following are valid commands:
	`SENS:LIST:FREQ 10`
	`SENS:LIST:FREQ 10,20`
	`SENS:LIST:FREQ 10,20,30,40`

B.2.3 SCPI Parameters

Many commands are supplemented by a parameter or a list of parameters. The parameters must be separated from the header by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). Allowed parameters are:

- Numeric values
- Special numeric values
- Boolean parameters
- Text
- Character strings
- Block data

The parameters required for each command and the allowed range of values are specified in the command description.

Numeric values

Numeric values can be entered in any form, i.e. with sign, decimal point and exponent. Values exceeding the resolution of the instrument are rounded up or down. The mantissa may comprise up to 255 characters, the exponent must lie inside the value range -32000 to 32000. The exponent is introduced by an "E" or "e". Entry of the exponent alone is not allowed. In the case of physical quantities, the unit can be entered. Allowed unit prefixes are G (giga), MA (mega), MOHM and MHZ are also allowed), K (kilo), M (milli), U (micro) and N (nano). If the unit is missing, the basic unit is used.

Example: `SENS:FREQ:STOP 1.5GHz` = `SENS:FREQ:STOP 1.5E9`

Units

For physical quantities, the unit can be entered. Allowed unit prefixes are:

- G (giga)
- MA (mega), MOHM, MHZ
- K (kilo)
- M (milli)
- U (micro)
- N (nano)

If the unit is missing, the basic unit is used.

Example:

`SENSe:FREQ:STOP 1.5GHz` = `SENSe:FREQ:STOP 1.5E9`

Some settings allow relative values to be stated in percent. According to SCPI, this unit is represented by the `PCT` string.

Example:

`HCOP:PAGE:SCAL 90PCT`

Special numeric values

The texts listed below are interpreted as special numeric values. In the case of a query, the numeric value is provided.

- **MIN/MAX**
  MINimum and MAXimum denote the minimum and maximum value.
- **DEF**
  DEFault denotes a preset value which has been stored in the EPROM. This value conforms to the default setting, as it is called by the *RST command.
- **UP/DOWN**
  UP, DOWN increases or reduces the numeric value by one step. The step width can be specified via an allocated step command for each parameter which can be set via UP, DOWN.
- **INF/NINF**

INFinity, Negative INFinity (NINF) represent the numeric values 9.9E37 or -9.9E37, respectively. INF and NINF are only sent as instrument responses.

- **NAN**
  Not A Number (NAN) represents the value 9.91E37. NAN is only sent as a instrument response. This value is not defined. Possible causes are the division of zero by zero, the subtraction of infinite from infinite and the representation of missing values.

Example:

Setting command: `SENSe:LIST:FREQ MAXimum`

Query: `SENS:LIST:FREQ?, Response: 3.5E9`

Queries for special numeric values

The numeric values associated to `MAXimum/MINimum/DEFault` can be queried by adding the corresponding mnemonics to the command. They must be entered following the quotation mark.

Example: `SENSe:LIST:FREQ? MAXimum`

Returns the maximum numeric value as a result.

Boolean Parameters

Boolean parameters represent two states. The "ON" state (logically true) is represented by "ON" or a numeric value 1. The "OFF" state (logically untrue) is represented by "OFF" or the numeric value 0. The numeric values are provided as the response for a query.

Example:

Setting command: `HCOPy:DEV:COL ON`

Query: `HCOPy:DEV:COL?`

Response: `1`

Text parameters

Text parameters observe the syntactic rules for mnemonics, i.e. they can be entered using a short or long form. Like any parameter, they have to be separated from the header by a white space. In the case of a query, the short form of the text is provided.

Example:

Setting command: `HCOPy:PAGE:ORIentation LANDscape`

Query: `HCOP:PAGE:ORI?`

Response: `LAND`

Character strings

Strings must always be entered in quotation marks (' or ").

Example:

`HCOP:ITEM:LABel "Test1"` or `HCOP:ITEM:LABel 'Test1'`

Block data

Block data is a format which is suitable for the transmission of large amounts of data. A command using a block data parameter has the following structure:

Example:

`FORMat:READings:DATA #45168xxxxxxxx`

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all end or other control signs are ignored until all bytes are transmitted.

#0 specifies a data block of indefinite length. The use of the indefinite format requires a `NL^END` message to terminate the data block. This format is useful when the length of the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

B.2.4 Overview of Syntax Elements

The following table provides an overview of the syntax elements:

:	The colon separates the mnemonics of a command. In a command line the separating semicolon marks the uppermost command level.
;	The semicolon separates two commands of a command line. It does not alter the path.
,	The comma separates several parameters of a command.
?	The question mark forms a query.
*****	The asterisk marks a common command.
' ' **"**	Quotation marks introduce a string and terminate it (both single and double quotation marks are possible).
#	The hash symbol introduces binary, octal, hexadecimal and block data. ● Binary: #B10110 ● Octal: #O7612 ● Hexa: #HF3A7 ● Block: #21312
	A "white space" (ASCII-Code 0 to 9, 11 to 32 decimal, e.g. blank) separates the header from the parameters.

B.2.5 Structure of a command line

A command line may consist of one or several commands. It is terminated by one of the following:

- a <New Line>
- a <New Line> with EOI
- an EOI together with the last data byte

Several commands in a command line must be separated by a semicolon ";". If the next command belongs to a different command system, the semicolon is followed by a colon.

Example:

`MMEM:COPY "Test1","MeasurementXY";:HCOP:ITEM ALL`

This command line contains two commands. The first command belongs to the MMEM system, the second command belongs to the HCOP system.

If the successive commands belong to the same system, having one or several levels in common, the command line can be abbreviated. To this end, the second command after the semicolon starts with the level that lies below the common levels. The colon following the semicolon must be omitted in this case.

Example:

`HCOP:ITEM ALL;:HCOP:IMM`

This command line contains two commands. Both commands are part of the `HCOP` command system, i.e. they have one level in common.

When abbreviating the command line, the second command begins with the level below HCOP. The colon after the semicolon is omitted. The abbreviated form of the command line reads as follows:

`HCOP:ITEM ALL;IMM`

A new command line always begins with the complete path.

Example:

`HCOP:ITEM ALL`

`HCOP:IMM`

B.2.6 Responses to Queries

A query is defined for each setting command unless explicitly specified otherwise. It is formed by adding a question mark to the associated setting command. According to SCPI, the responses to queries are partly subject to stricter rules than in standard IEEE 488.2.

- The requested parameter is transmitted without a header.
  Example: `HCOP:PAGE:ORI?`, Response: `LAND`
- Maximum values, minimum values and all other quantities that are requested via a special text parameter are returned as numeric values.
  Example: `SENSe:FREQuency:STOP? MAX`, Response: `3.5E9`

- Numeric values are output without a unit. Physical quantities are referred to the basic units or to the units set using the `Unit` command. The response `3.5E9` in the previous example stands for 3.5 GHz.
- Truth values (Boolean values) are returned as `0` (for OFF) and `1` (for ON).
  Example:
  Setting command: `HCOPy:DEV:COL ON`
  Query: `HCOPy:DEV:COL?`
  Response: `1`
- Text (character data) is returned in a short form.
  Example:
  Setting command: `HCOPy:PAGE:ORIentation LANDscape`
  Query: `HCOP:PAGE:ORI?`
  Response: `LAND`

B.3 Command Sequence and Synchronization

IEEE 488.2 defines a distinction between overlapped (asynchronous) and sequential commands:

- A sequential command finishes executing before the next command starts executing. Commands that are processed quickly are usually implemented as sequential commands.
- An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. Usually, overlapping commands take longer to process and allow the program to do other tasks while being executed. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially. This method is called synchronization between the controller and the instrument.

Setting commands within one command line, even though they are implemented as sequential commands, are not necessarily serviced in the order in which they have been received. To make sure that commands are carried out in a certain order, each command must be sent in a separate command line.

Example: Commands and queries in one message

Do not combine queries with commands that affect the queried value in one program message because the response to the query is not predictable.

The following commands always return the specified result:

`:CHAN:SCAL 0.01;POS 1`

`:CHAN:SCAL?`

Result:

`0.01` (10 mV/div)

As a rule, send commands and queries in different program messages.

For further information, refer to:

- rohde-schwarz.com/rckb: Rohde & Schwarz web page that provides information on instrument drivers and remote control.
- "Automatic Measurement Control - A tutorial on SCPI and IEEE 488.2" from John M. Pieper (R&S order number 0002.3536.00). The book offers detailed information on concepts and definitions of SCPI.

B.3.1 Preventing Overlapping Execution

To prevent an overlapping execution of commands, one of the commands *OPC, *OPC? or *WAI can be used. All three commands cause a certain action only to be carried out after the hardware has been set. By suitable programming, the controller can be forced to wait for the corresponding action to occur.

*Table B-1: Synchronization using *OPC, *OPC? and *WAI*

Command	Action	Programming the controller
*OPC	Sets the Operation Complete bit in the ESR after all previous commands have been executed.	• Setting bit 0 in the ESE • Setting bit 5 in the SRE • Waiting for service request (SRQ)
*OPC?	Stops command processing until 1 is returned. This is only the case after the Operation Complete bit has been set in the ESR. This bit indicates that the previous setting has been completed.	Sending *OPC? directly after the command whose processing should be terminated before other commands can be executed.
*WAI	Stops further command processing until all commands sent before *WAI have been executed.	Sending *WAI directly after the command whose processing should be terminated before other commands are executed.

Command synchronization using *WAI or *OPC? is a good choice if the overlapped command takes only little time to process. The two synchronization commands simply block overlapped execution of the command. Append the synchronization command to the overlapping command, for example:

```
SINGle; *OPC?
```

For time consuming overlapped commands you can allow the controller or the instrument to do other useful work while waiting for command execution. Use one of the following methods:

*OPC with a service request

1. Set the OPC mask bit (bit no. 0) in the ESE: *ESE 1
2. Set bit no. 5 in the SRE: *SRE 32 to enable ESB service request.
3. Send the overlapped command with *OPC
4. Wait for a service request

   The service request indicates that the overlapped command has finished.

***OPC? with a service request**

1. Set bit no. 4 in the SRE: *SRE 16 to enable MAV service request.
2. Send the overlapped command with *OPC?
3. Wait for a service request

   The service request indicates that the overlapped command has finished.

Event Status Register (ESE)

1. Set the OPC mask bit (bit no. 0) in the ESE: *ESE 1
2. Send the overlapped command without *OPC, *OPC? or *WAI
3. Poll the operation complete state periodically (by means of a timer) using the sequence: *OPC; *ESR?

   A return value (LSB) of 1 indicates that the overlapped command has finished.

B.4 General Programming Recommendations

Initial instrument status before changing settings

Manual operation is designed for maximum possible operating convenience. In contrast, the priority of remote control is the "predictability" of the instrument status. Thus, when a command attempts to define incompatible settings, the command is ignored and the instrument status remains unchanged, i.e. other settings are not automatically adapted. Therefore, control programs should always define an initial instrument status (e.g. using the *RST command) and then implement the required settings.

Command sequence

As a general rule, send commands and queries in different program messages. Otherwise, the result of the query may vary depending on which operation is performed first (see also Preventing Overlapping Execution).

Reacting to malfunctions

The service request is the only possibility for the instrument to become active on its own. Each controller program should instruct the instrument to initiate a service request in case of malfunction. The program should react appropriately to the service request.

Error queues

The error queue should be queried after every service request in the controller program as the entries describe the cause of an error more precisely than the status registers. Especially in the test phase of a controller program the error queue should be queried regularly since faulty commands from the controller to the instrument are recorded there as well.

C Remote Control - Status Reporting System

The status reporting system stores all information on the current operating state of the instrument, and on errors which have occurred. This information is stored in the status registers and in the error queue. Both can be queried via GPIB bus or LAN interface (`STATus`... commands).

C.1 Structure of a SCPI Status Register

Each standard SCPI register consists of 5 parts. Each part has a width of 16 bits and has different functions. The individual bits are independent of each other, i.e. each hardware status is assigned a bit number which is valid for all five parts. Bit 15 (the most significant bit) is set to zero for all parts. Thus the contents of the register parts can be processed by the controller as positive integers.

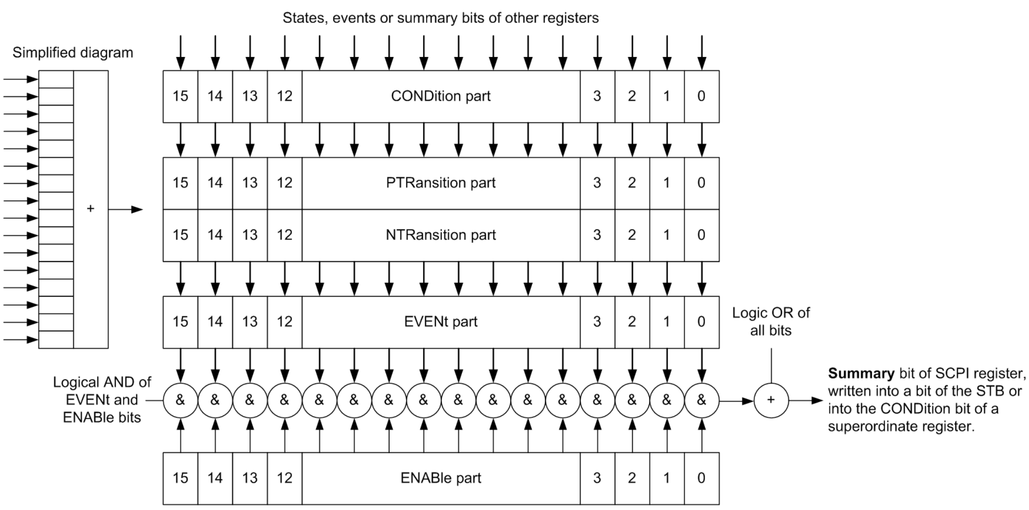


Figure C-1: The status-register model

Description of the five status register parts

The five parts of a SCPI register have different properties and functions:

- **CONDition**
  The `CONDition` part is written into directly by the hardware or the sum bit of the next lower register. Its contents reflect the current instrument status. This register part can only be read, but not written into or cleared. Its contents are not affected by reading.
- **PTRansition / NTRansition**
  The two transition register parts define which state transition of the `CONDition` part (none, 0 to 1, 1 to 0 or both) is stored in the `EVENt` part.
  The **Positive-TRansition** part acts as a transition filter. When a bit of the `CONDition` part is changed from 0 to 1, the associated `PTR` bit decides whether the `EVENt` bit is set to 1.

– PTR bit =1: the EVENt bit is set.
– PTR bit =0: the EVENt bit is not set.

This part can be written into and read as required. Its contents are not affected by reading.
The **Negative-TRansition** part also acts as a transition filter. When a bit of the CONDition part is changed from 1 to 0, the associated NTR bit decides whether the EVENt bit is set to 1.

– NTR bit =1: the EVENt bit is set.
– NTR bit =0: the EVENt bit is not set.

This part can be written into and read as required. Its contents are not affected by reading.

- **EVENt**
The EVENt part indicates whether an event has occurred since the last reading, it is the "memory" of the condition part. It only indicates events passed on by the transition filters. It is permanently updated by the instrument. This part can only be read by the user. Reading the register clears it. This part is often equated with the entire register.
- **ENABle**
The ENABle part determines whether the associated EVENt bit contributes to the sum bit (see below). Each bit of the EVENt part is "ANDed" with the associated ENABle bit (symbol '&'). The results of all logical operations of this part are passed on to the sum bit via an "OR" function (symbol '+').
ENABle bit = 0: the associated EVENt bit does not contribute to the sum bit
ENABle bit = 1: if the associated EVENt bit is "1", the sum bit is set to "1" as well.
This part can be written into and read by the user as required. Its contents are not affected by reading.

Sum bit

The sum bit is obtained from the EVENt and ENABle part for each register. The result is then entered into a bit of the CONDition part of the higher-order register.

The instrument automatically generates the sum bit for each register. Thus an event can lead to a service request throughout all levels of the hierarchy.

C.2 Hierarchy of status registers

As shown in the following figure, the status information is of hierarchical structure.

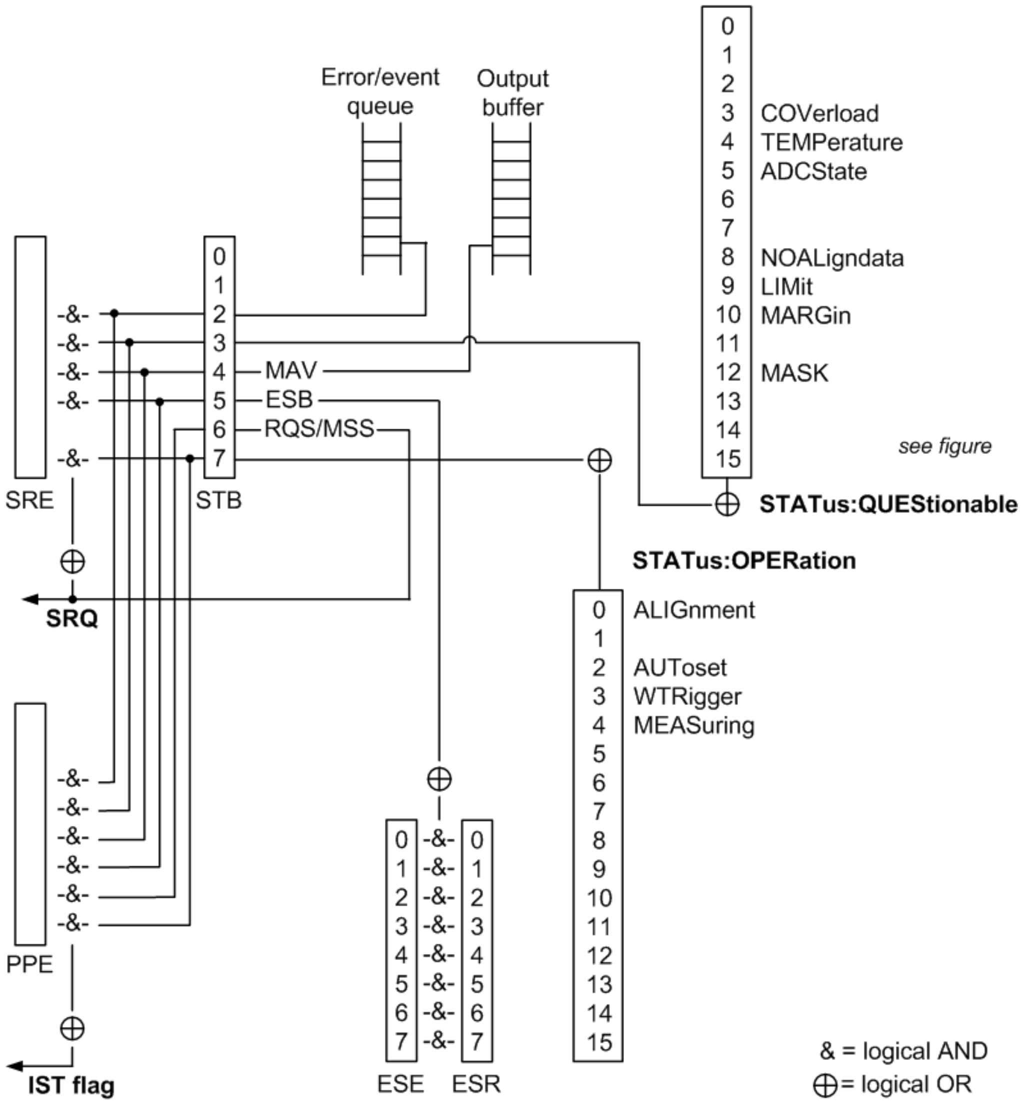


Figure C-2: Overview of the status registers hierarchy

- **STB, SRE**
  The STatus Byte (`STB`) register and its associated mask register Service Request Enable (`SRE`) form the highest level of the status reporting system. The `STB` provides a rough overview of the instrument status, collecting the information of the lower-level registers.
- **ESR, SCPI registers**
  The STB receives its information from the following registers:
  – The Event Status Register (`ESR`) with the associated mask register standard Event Status Enable (`ESE`).
  – The `STATus:OPERation` and `STATus:QUEStionable` registers which are defined by SCPI and contain detailed information on the instrument.
- **IST, PPE**

The `IST` flag ("Individual STatus"), like the `SRQ`, combines the entire instrument status in a single bit. The `PPE` fulfills the same function for the `IST` flag as the `SRE` for the service request.

- **Output buffer**
  The output buffer contains the messages the instrument returns to the controller. It is not part of the status reporting system but determines the value of the `MAV` bit in the `STB` and thus is represented in the overview.

All status registers have the same internal structure.

SRE, ESE

The service request enable register `SRE` can be used as `ENABle` part of the `STB` if the `STB` is structured according to SCPI. By analogy, the `ESE` can be used as the `ENABle` part of the `ESR`.

C.3 Contents of the Status Registers

In the following sections, the contents of the status registers are described in more detail.

C.3.1 Status Byte (STB) and Service Request Enable Register (SRE)

The `STatus Byte` (STB) is already defined in IEEE 488.2. It provides a rough overview of the instrument status by collecting the pieces of information of the lower registers. A special feature is that bit 6 acts as the sum bit of the remaining bits of the status byte.

The STB can thus be compared with the `CONDition` part of an SCPI register and assumes the highest level within the SCPI hierarchy.

The STB is read using the command `*STB?` or a serial poll.

The `STatus Byte` (STB) is linked to the `Service Request Enable` (SRE) register. Each bit of the STB is assigned a bit in the SRE. Bit 6 of the SRE is ignored. If a bit is set in the SRE and the associated bit in the STB changes from 0 to 1, a service request (SRQ) is generated. The SRE can be set using the command `*SRE` and read using the command `*SRE?`.

Table C-1: Meaning of the bits used in the status byte

Bit No.	Meaning
0...1	Not used
2	Error Queue not empty The bit is set when an entry is made in the error queue. If this bit is enabled by the SRE, each entry of the error queue generates a service request. Thus an error can be recognized and specified in greater detail by polling the error queue. The poll provides an informative error message. This procedure is to be recommended since it considerably reduces the problems involved with remote control.

Bit No.	Meaning
3	QUEStionable status register summary bit The bit is set if an EVENt bit is set in the QUEStionable status register and the associated ENABle bit is set to 1. A set bit indicates a questionable instrument status, which can be specified in greater detail by querying the STATus:QUEStionable status register.
4	MAV bit (message available) The bit is set if a message is available in the output queue which can be read. This bit can be used to enable data to be automatically read from the instrument to the controller.
5	ESB bit Sum bit of the event status register. It is set if one of the bits in the event status register is set and enabled in the event status enable register. Setting of this bit indicates a serious error which can be specified in greater detail by polling the event status register.
6	MSS bit (master status summary bit) The bit is set if the instrument triggers a service request. This is the case if one of the other bits of this registers is set together with its mask bit in the service request enable register SRE.
7	STATus:OPERation status register summary bit The bit is set if an EVENt bit is set in the OPERation status register and the associated ENABle bit is set to 1. A set bit indicates that the instrument is just performing an action. The type of action can be determined by querying the STATus:OPERation status register.

C.3.2 IST Flag and Parallel Poll Enable Register (PPE)

As with the SRQ, the IST flag combines the entire status information in a single bit. It can be read by means of a parallel poll (see Chapter C.4.3, "Parallel Poll", on page 1641) or using the command *IST?.

The parallel poll enable register (PPE) determines which bits of the STB contribute to the IST flag. The bits of the STB are "ANDed" with the corresponding bits of the PPE, with bit 6 being used as well in contrast to the SRE. The IST flag results from the "ORing" of all results. The PPE can be set using commands *PRE and read using command *PRE?.

C.3.3 Event Status Register (ESR) and Event Status Enable Register (ESE)

The ESR is defined in IEEE 488.2. It can be compared with the EVENt part of a SCPI register. The event status register can be read out using command *ESR?.

The ESE corresponds to the ENABle part of a SCPI register. If a bit is set in the ESE and the associated bit in the ESR changes from 0 to 1, the ESB bit in the STB is set. The ESE register can be set using the command *ESE and read using the command *ESE?.

Table C-2: Meaning of the bits used in the event status register

Bit No.	Meaning
0	Operation Complete This bit is set on receipt of the command *OPC exactly when all previous commands have been executed.
1	Not used
2	Query Error This bit is set if either the controller wants to read data from the instrument without having sent a query, or if it does not fetch requested data and sends new instructions to the instrument instead. The cause is often a query which is faulty and hence cannot be executed.
3	Device-dependent Error This bit is set if a device-dependent error occurs. An error message with a number between -300 and -399 or a positive error number, which denotes the error in greater detail, is entered into the error queue.
4	Execution Error This bit is set if a received command is syntactically correct but cannot be performed for other reasons. An error message with a number between -200 and -300, which denotes the error in greater detail, is entered into the error queue.
5	Command Error This bit is set if a command is received, which is undefined or syntactically incorrect. An error message with a number between -100 and -200, which denotes the error in greater detail, is entered into the error queue.
6	User Request This bit is set when the instrument is switched over to manual control.
7	Power On (supply voltage on) This bit is set on switching on the instrument.

C.3.4 STATus:OPERation Register

In the `CONDition` part, this register contains information on which actions the instrument is executing. In the `EVENt` part, it contains information on which actions the instrument has executed since the last reading.

It can be read using the commands `STATus:OPERation:CONDition?` or `STATus:OPERation[:EVENt]?`, see also Chapter 16.21.1, "STATus:OPERation Register", on page 1594.

Table C-3: Bits in the STATus:OPERation register

Bit No.	Meaning
0	`ALIGnment` This bit is set as long as the instrument is performing a self-alignment.
1	Not used
2	`AUToset` This bit is set while the instrument is performing an auto setup.

Bit No.	Meaning
3	`WTRIgger` This bit is set while the instrument is waiting for the trigger.
4	`MEASuring` The bit is set as long as an acquisition - sampling and postprocessing - is running. In run continuous mode, the bit is always set.
5 - 15	Not used

C.3.5 STATus:QUEStionable Register

This register contains information about indefinite states which may occur if the unit is operated without meeting the specifications. It can be read using the commands `STATus:QUEStionable:CONDition?` and `STATus:QUEStionable[:EVENt]?`

The remote commands for the STATus:QUEStionable register are described in Chapter 16.21.2, "STATus:QUEStionable Registers", on page 1595.

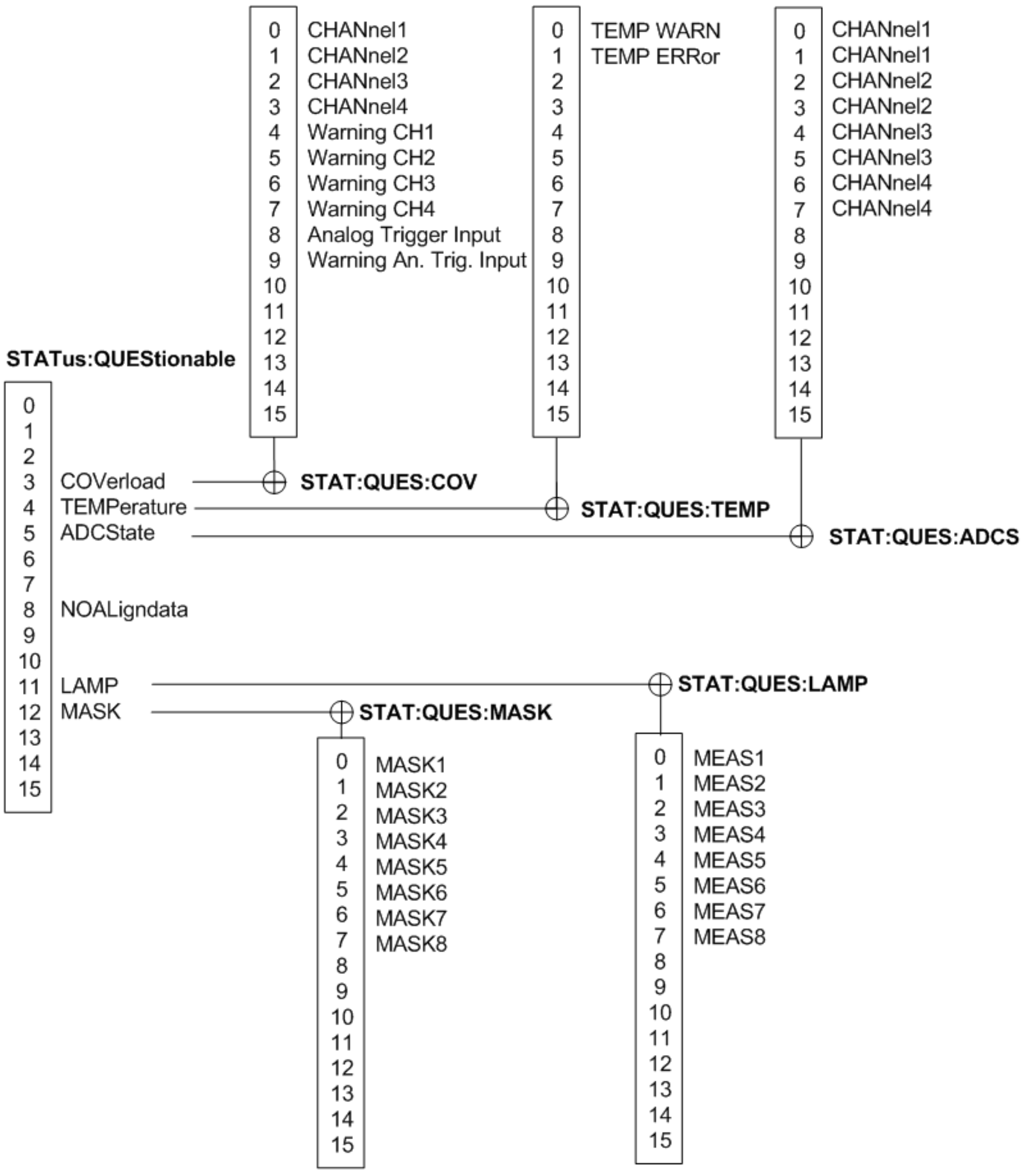


Figure C-3: Overview of the STATus:QUEStionable register

Table C-4: Bits in the STATus:QUEStionable register

Bit No.	Meaning
0 to 2	not used
3	`COVerload` This bit is set if a questionable channel overload occurs (see Chapter C.3.5.1, "STATus:QUEStionable:COVerload register", on page 1637).
4	`TEMPerature` This bit is set if a questionable temperature occurs (see Chapter C.3.5.2, "STATus:QUEStionable:TEMPerature register", on page 1638).

Bit No.	Meaning
5	`ADCState` The bit is set if the signal is clipped on the upper or lower edge of the screen - an overflow of the ADC occurs (see Chapter C.3.5.3, "STATus:QUEStionable:ADCState Register", on page 1638).
6	`FREQuency` This bit is set if there is anything wrong with the frequency of the local oscillator or the reference frequency (see Chapter C.3.5.4, "STATus:QUEStionable:FREQuency Register", on page 1638).
7	Not used
8	`NOALigndata` This bit is set if no alignment data is available - the instrument is uncalibrated.
9 to 10	not used
11	`LAMP` (Low AMPlitude) This bit is set if the magnitude of the signal is too low to get reliable measurement results. See Chapter C.3.5.5, "STATus:QUEStionable:LAMP Register", on page 1638.
12	`MASK` This bit is set if a mask value is violated (see Chapter C.3.5.6, "STATus:QUEStionable:MASK register", on page 1639
13	`PLLunlock` See Chapter C.3.5.7, "STATus:QUEStionable:PLLunlock Register", on page 1639.
14	Not used
15	This bit is always 0.

C.3.5.1 STATus:QUEStionable:COVerload register

This register contains all information about overload of the channels. The bit is set if the assigned channel is overloaded, or if an overload risk occured (overload warning).

Table C-5: Bits in the STATus:QUEStionable:COVerload register

Bit No.	Meaning
0	Overload on `CHANnel1`
1	Overload on `CHANnel2`
2	Overload on `CHANnel3`
3	Overload on `CHANnel4`
4	Overload warning for `CHANnel1`
5	Overload warning for `CHANnel2`
6	Overload warning for `CHANnel3`
7	Overload warning for `CHANnel4`

Bit No.	Meaning
8	Overload on external trigger input
9	Overload warning for external trigger input

C.3.5.2 STATus:QUEStionable:TEMPerature register

This register contains information about the instrument's temperature.

Table C-6: Bits in the STATus:QUEStionable:TEMPerature register

Bit No.	Meaning
0	`TEMP WARN` This bit is set if a temperature warning on channel 1, 2, 3 or 4 occured.
1	`TEMP ERRor` This bit is set if a temperature error on channel 1, 2, 3 or 4 occured.

C.3.5.3 STATus:QUEStionable:ADCState Register

This register contains all information about overflow of the ADC.

The bit is set if the assigned channel signal is clipped on the upper or lower edge of the screen. In this case, the signal does not fit in the range of the ADC and an overflow occurs.

Table C-7: Bits in the STATus:QUEStionable:ADCState register

Bit No.	Meaning
0 and 1	Overflow (Clipping) on `CHANnel1`
2 and 3	Overflow (Clipping) on `CHANnel2`
4 and 5	Overflow (Clipping) on `CHANnel3`
6 and 7	Overflow (Clipping) on `CHANnel4`

C.3.5.4 STATus:QUEStionable:FREQuency Register

Table C-8: Bits in the STATus:QUEStionable:FREQuency register

Bit No.	Meaning
0	Oven cold. This bit is set if the reference oscillator has not yet attained its operating temperature.

C.3.5.5 STATus:QUEStionable:LAMP Register

The LAMP (Low AMPlitude) bit is set if the magnitude of the signal is too low to get reliable measurement results.

Table C-9: Bits in the STATus:QUEStionable:LAMP register

Bit No.	Meaning
0	MEAS1
1	MEAS2
2	MEAS3
3	MEAS4
4	MEAS5
5	MEAS6
6	MEAS7
7	MEAS8

C.3.5.6 STATus:QUEStionable:MASK register

This register contains information about the violation of masks. This bit is set if the assigned mask is violated.

Table C-10: Bits in the STATus:QUEStionable:MASK register

Bit No.	Meaning
0	MASK1
1	MASK2
2	MASK3
3	MASK4
4	MASK5
5	MASK6
6	MASK7
7	MASK8

C.3.5.7 STATus:QUEStionable:PLLunlock Register

This register contains information about ...

Table C-11: Bits in the STATus:QUEStionable:PLLunlock register

Bit No.	Meaning
1	PLL100
2	PLL250
3	PLL312
4	PLL500
5	PLL800
6	PLLCal

Bit No.	Meaning
7	PLL10G
8	PLLGBSync

C.4 Application of the Status Reporting System

The purpose of the status reporting system is to monitor the status of one or several devices in a measuring system. To do this and react appropriately, the controller must receive and evaluate the information of all devices. The following standard methods are used:

- **Service request** (SRQ) initiated by the instrument
- **Serial poll** of all devices in the bus system, initiated by the controller in order to find out who sent a SRQ and why
- **Parallel poll** of all devices
- Query of a **specific instrument status** by means of commands
- Query of the **error queue**

C.4.1 Service Request

Under certain circumstances, the instrument can send a service request (SRQ) to the controller. Usually this service request initiates an interrupt at the controller, to which the control program can react appropriately. As evident from Figure C-2, an SRQ is always initiated if one or several of bits 2, 3, 4, 5 or 7 of the status byte are set and enabled in the SRE. Each of these bits combines the information of a further register, the error queue or the output buffer. The `ENABle` parts of the status registers can be set such that arbitrary bits in an arbitrary status register initiate an SRQ. In order to make use of the possibilities of the service request effectively, all bits should be set to "1" in enable registers SRE and ESE.

The SRQ is the only possibility for the instrument to become active on its own. Each controller program should cause the instrument to initiate a service request if errors occur. The program should react appropriately to the service request.

C.4.2 Serial Poll

In a serial poll, just as with command `*STB`, the status byte of an instrument is queried. However, the query is realized via interface messages and is thus clearly faster.

The serial poll method is defined in IEEE 488.1 and used to be the only standard possibility for different instruments to poll the status byte. The method also works for instruments which do not adhere to SCPI or IEEE 488.2.

The serial poll is mainly used to obtain a fast overview of the state of several instruments connected to the controller.

C.4.3 Parallel Poll

In a parallel poll, up to eight instruments are simultaneously requested by the controller using a single command to transmit 1 bit of information each on the data lines, i.e., to set the data line allocated to each instrument to a logical "0" or "1".

In addition to the SRE register, which determines the conditions under which an SRQ is generated, there is a Parallel Poll Enable register (PPE) which is ANDed with the STB bit by bit, considering bit 6 as well. This register is ANDed with the STB bit by bit, considering bit 6 as well. The results are ORed, the result is possibly inverted and then sent as a response to the parallel poll of the controller. The result can also be queried without parallel poll using the command `*IST?`.

The instrument first has to be set for the parallel poll using the command `PPC`. This command allocates a data line to the instrument and determines whether the response is to be inverted. The parallel poll itself is executed using `PPE`.

The parallel poll method is mainly used to find out quickly which one of the instruments connected to the controller has sent a service request. To this effect, SRE and PPE must be set to the same value.

C.4.4 Query of an instrument status

Each part of any status register can be read using queries. There are two types of commands:

- The common commands `*ESR?`, `*IDN?`, `*IST?`, `*STB?` query the higher-level registers.
- The commands of the `STATus` system query the SCPI registers (`STATus:QUEStionable`...)

The returned value is always a decimal number that represents the bit pattern of the queried register. This number is evaluated by the controller program.

Queries are usually used after an SRQ in order to obtain more detailed information on the cause of the SRQ.

C.4.4.1 Decimal representation of a bit pattern

The STB and ESR registers contain 8 bits, the SCPI registers 16 bits. The contents of a status register are specified and transferred as a single decimal number. To make this possible, each bit is assigned a weighted value. The decimal number is calculated as the sum of the weighted values of all bits in the register that are set to 1.

Bits	0	1	2	3	4	5	6	7	...
Weight	1	2	4	8	16	32	64	128	...

Example:

The decimal value 40 = 32 + 8 indicates that bits no. 3 and 5 in the status register (e.g. the `QUEStionable` status summary bit and the `ESB` bit in the `STatus` Byte) are set.

C.4.5 Error Queue

Each error state in the instrument leads to an entry in the error queue. The entries of the error queue are detailed plain text error messages that can be looked up in the Error Log or queried via remote control using `SYSTem:ERRor[:NEXT]?`. Each call of `SYSTem:ERRor[:NEXT]?` provides one entry from the error queue. If no error messages are stored there any more, the instrument responds with 0, "No error".

The error queue should be queried after every SRQ in the controller program as the entries describe the cause of an error more precisely than the status registers. Especially in the test phase of a controller program the error queue should be queried regularly since faulty commands from the controller to the instrument are recorded there as well.

C.5 Reset Values of the Status Reporting System

The following table contains the different commands and events causing the status reporting system to be reset. None of the commands, except `*RST` and `SYSTem:PRESet`, influence the functional instrument settings. In particular, `DCL` does not change the instrument settings.

Table C-12: Resest of the status reporting system

Event	**Switching on supply voltage** **Power-On-Status-Clear**		**DCL, SDC** **(Device Clear, Selected Device Clear)**	***RST or SYS-Tem:PRE-Set**	**STA-Tus:PRE-Set**	***CLS**
Effect	**0**	**1**				
Clear STB, ESR	-	yes	-	-	-	yes
Clear SRE, ESE	-	yes	-	-	-	-
Clear PPE	-	yes	-	-	-	-
Clear EVENt parts of the registers	-	yes	-	-	-	yes
Clear ENABle parts of all OPERation and QUEStionable registers; Fill ENABle parts of all other registers with "1".	-	yes	-	-	yes	-
Fill PTRansition parts with "1"; Clear NTRansition parts	-	yes	-	-	yes	-

Event	Switching on supply voltage Power-On-Status-Clear		DCL, SDC (Device Clear, Selected Device Clear)	*RST or SYSTem:PRESet	STATus:PRESet	*CLS
Effect	**0**	**1**				
Clear error queue	yes	yes	-	-	-	yes
Clear output buffer	yes	yes	yes	1)	1)	1)
Clear command processing and input buffer	yes	yes	yes	-	-	-
1) The first command in a command line that immediately follows a <PROGRAM MESSAGE TERMINATOR> clears the output buffer.						

List of Commands

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