R&S®RTO Digital Oscilloscope User Manual

1304.8711.02 — 02.01

Test & Measurement

User Manual

ROHDE&SCHWARZ

This manual describes the following R&S®RTO models:

- R&S®RTO1012 (1304.6002K12)
- R&S®RTO1014 (1304.6002K14)
- R&S®RTO1022 (1304.6002K22)
- R&S®RTO1024 (1304.6002K24)

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

- R&S®RTO-B4 (1304.8305.02)
- R&S®RTO-K1 (1304.8511.02)
- R&S®RTO-K2 (1304.8528.02)

The firmware of the instrument makes use of several valuable open source software packages. For information, see the "Open Source Acknowledgement" on the user documentation CD-ROM (included in delivery).
Rohde & Schwarz would like to thank the open source community for their valuable contribution to embedded computing.

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The following abbreviations are used throughout this manual: R&S®RTO is abbreviated as R&S RTO.

Contents

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 attached 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.

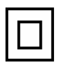
Furthermore, it is your responsibility to use the product in an appropriate manner. This product is designed for use solely in industrial and laboratory environments or, if expressly permitted, also in the field and must not be used in any way that may cause personal injury or property damage. You are responsible if the product is used for any intention 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 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.

Symbols and safety labels

							
Notice, general danger location Observe product documentation	Caution when handling heavy equipment	Danger of electric shock	Warning! Hot surface	PE terminal	Ground	Ground terminal	Be careful when handling electrostatic sensitive devices

					
ON/OFF supply voltage	Standby indication	Direct current (DC)	Alternating current (AC)	Direct/alternating current (DC/AC)	Device fully protected by double (reinforced) insulation

Tags and their meaning

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

DANGER	indicates a hazardous situation which, if not avoided, will result in death or serious injury.
WARNING	indicates a hazardous situation which, if not avoided, could result in death or serious injury.
CAUTION	indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
NOTICE	indicates the possibility of incorrect operation which can result in damage to the product. In the product documentation, the word ATTENTION is used synonymously.

These tags 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 tags described here are always used only in connection with the related product documentation and the related product. The use of tags 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, pollution severity 2, overvoltage category 2, 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.
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 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 death.

Electrical safety

If the information on electrical safety is not observed either at all 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 AC 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 an earthing contact and protective earth connection.
3. Intentionally breaking the protective earth connection 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 the product does not have a power switch for disconnection from the AC supply network, the plug of the connecting cable is regarded as the disconnecting device. In such cases, always ensure that the power plug is easily reachable and accessible at all times (corresponding to the length of connecting cable, approx. 2 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, a disconnecting device must be provided at the system level.
5. Never use the product if the power cable is damaged. Check the power cable on a regular basis to ensure that it is in proper operating condition. By taking appropriate safety measures and carefully laying the power cable, you can ensure that the cable will not 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 fused 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. 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, fusing, 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 IEC60950-1/EN60950-1 or IEC61010-1/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 PE terminal on site and the product's PE 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 fused 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", 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. 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).

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, PE 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. Keep cells and batteries out of the hands of children. If a cell or a battery has been swallowed, seek medical aid immediately.
5. Cells and batteries must not be exposed to any mechanical shocks that are stronger than permitted.
6. 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.
7. 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.
8. 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

1. 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.
2. 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.

Informaciones elementales de seguridad

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

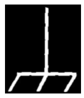
El principio del grupo de empresas Rohde & Schwarz consiste en tener nuestros productos siempre al día con los estándares de seguridad y de ofrecer a nuestros clientes el máximo grado de seguridad. Nuestros productos y todos los equipos adicionales son siempre fabricados y examinados según las normas 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 adjunto 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.

Símbolos y definiciones de seguridad

							
Aviso: punto de peligro general Observar la documentación del producto	Atención en el manejo de dispositivos de peso elevado	Peligro de choque eléctrico	Advertencia: superficie caliente	Conexión a conductor de protección	Conexión a tierra	Conexión a masa	Aviso: Cuidado en el manejo de dispositivos sensibles a la electrostática (ESD)

					
Tensión de alimentación de PUESTA EN MARCHA / PARADA	Indicación de estado de espera (Standby)	Corriente continua (DC)	Corriente alterna (AC)	Corriente continua / Corriente alterna (DC/AC)	El aparato está protegido en su totalidad por un aislamiento doble (reforzado)

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	PELIGRO identifica un peligro inminente con riesgo elevado que provocará muerte o lesiones graves si no se evita.
ADVERTENCIA	ADVERTENCIA identifica un posible peligro con riesgo medio de provocar muerte o lesiones (graves) si no se evita.
ATENCIÓN	ATENCIÓN identifica un peligro con riesgo reducido de provocar lesiones leves o moderadas si no se evita.
AVISO	AVISO indica la posibilidad de utilizar mal el producto y, como consecuencia, dañarlo. 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, grado de suciedad 2, categoría de sobrecarga eléctrica 2, 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.
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, pueden causarse lesiones o 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, se deberá considerar el enchufe del cable de conexión como interruptor. En estos casos se deberá asegurar que el enchufe siempre sea de fácil acceso (de acuerdo con la longitud del cable de conexión, aproximadamente 2 m). Los interruptores de función o electrónicos no son aptos para el corte de la red eléctrica. Si los productos sin interruptor están integrados 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", 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. 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).

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. Mantener baterías y celdas fuera del alcance de los niños. En caso de ingestión de una celda o batería, avisar inmediatamente a un médico.
5. Las celdas o baterías no deben someterse a impactos mecánicos fuertes indebidos.

6. 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.
7. 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).
8. 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.

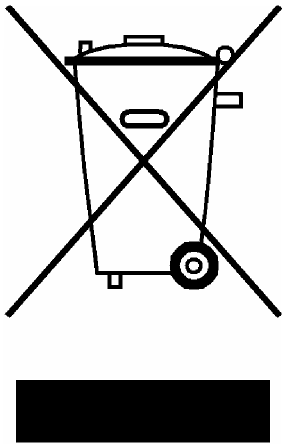
Eliminación

1. 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.
2. 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.

Customer Information Regarding Product Disposal

The German Electrical and Electronic Equipment (ElektroG) Act is an implementation of the following EC directives:

- 2002/96/EC on waste electrical and electronic equipment (WEEE) and
- 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS).



Product labeling in accordance with EN 50419

Once the lifetime of a product has ended, this product must not be disposed of in the standard domestic refuse. Even disposal via the municipal collection points for waste electrical and electronic equipment is not permitted.

Rohde & Schwarz GmbH & Co. KG has developed a disposal concept for the environmental-friendly disposal or recycling of waste material and fully assumes its obligation as a producer to take back and dispose of electrical and electronic waste in accordance with the ElektroG Act.

Please contact your local service representative to dispose of the product.

ROHDE&SCHWARZ

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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.

Europe, Africa, Middle East

Phone +49 89 4129 12345
customersupport@rohde-schwarz.com

North America

Phone 1-888-TEST-RSA (1-888-837-8772)
customer.support@rsa.rohde-schwarz.com

Latin America

Phone +1-410-910-7988
customersupport.la@rohde-schwarz.com

Asia/Pacific

Phone +65 65 13 04 88
customersupport.asia@rohde-schwarz.com

ROHDE&SCHWARZ

1171.0200.22-05.00

Qualitätszertifikat
Certificate of quality
Certificat de qualité

Certified Quality System
ISO 9001

Certified Environmental System
ISO 14001

Sehr geehrter Kunde,
Sie haben sich für den Kauf eines Rohde & Schwarz-Produktes entschieden. Hiermit erhalten Sie ein nach modernsten Fertigungsmethoden hergestelltes Produkt. Es wurde nach den Regeln unseres Qualitätsmanagementsystems entwickelt, gefertigt und geprüft. Das Rohde & Schwarz-Qualitätsmanagementsystem ist u.a. nach ISO 9001 und ISO 14001 zertifiziert.

Der Umwelt verpflichtet
- Energie-effiziente, RoHS-konforme Produkte
- Kontinuierliche Weiterentwicklung nachhaltiger Umweltkonzepte
- ISO 14001-zertifiziertes Umweltmanagementsystem

Dear Customer,
You have decided to buy a Rohde & Schwarz product. You are thus assured of receiving a product that is manufactured using the most modern methods available. This product was developed, manufactured and tested in compliance with our quality management system standards. The Rohde & Schwarz quality management system is certified according to standards such as ISO 9001 and ISO 14001.

Environmental commitment
- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system

Cher client,
Vous avez choisi d'acheter un produit Rohde & Schwarz. Vous disposez donc d'un produit fabriqué d'après les méthodes les plus avancées. Le développement, la fabrication et les tests respectent nos normes de gestion qualité. Le système de gestion qualité de Rohde & Schwarz a été homologué, entre autres, conformément aux normes ISO 9001 et ISO 14001.

Engagement écologique
- Produits à efficience énergétique
- Amélioration continue de la durabilité environnementale
- Système de gestion de l'environnement certifié selon ISO 14001

ROHDE & SCHWARZ

1171.0200.11 V 04.01

ROHDE&SCHWARZ

CE Declaration of Conformity

CE

Certificate No.: 2010-45

This is to certify that:

Equipment type	Stock No.	Designation
RTO	1304.6002.XX	RTO

complies with the provisions of the Directive of the Council of the European Union on the approximation of the laws of the Member States

- relating to electrical equipment for use within defined voltage limits (2006/95/EC)
- relating to electromagnetic compatibility (2004/108/EC)

Conformity is proven by compliance with the following standards:

EN 61010-1: 2001
EN 61326-1: 2006
EN 61326-2-1: 2006
EN 55011: 2007 + A2: 2007, Class A
EN 61000-3-2: 2006
EN 61000-3-3: 1995 + A1: 2001 + A2: 2005

For the assessment of electromagnetic compatibility, the limits of radio interference for Class A equipment as well as the immunity to interference for operation in industry have been used as a basis.

ROHDE & SCHWARZ GmbH & Co. KG
Mühldorfstr. 15, D-81671 München

Munich, 2010-05-26 Central Quality Management MF-QZ / Radde

1 Preface

1.1 Documentation Overview

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

- Online Help system on the instrument
- "Getting Started" printed manual
- Documentation CD-ROM with:
  - Getting Started
  - User Manual
  - Service manual
  - Data sheet and product brochure
  - Links to useful sites on the R&S internet

Online Help

The Online Help is embedded in the instrument's firmware. It offers quick, context-sensitive access to the complete information needed for operation and programming.

Getting Started

This manual is delivered with the instrument in printed form and in PDF format on the Documentation CD-ROM. It provides the information needed to set up and start working with the instrument. Basic operations and typical measurement examples are described. The manual includes also general information, e.g., Safety Instructions.

User Manual

The User Manual is available in PDF format - in printable form - on the Documentation CD-ROM delivered with the instrument. In this manual, all instrument functions are described in detail. Furthermore, it provides an introduction to remote control and a complete description of the remote control commands with programming examples. Information on maintenance, instrument interfaces and error messages is also given.

Service Manual

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

1.2 Conventions Used in the Documentation

1.2.1 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.

1.2.2 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 touch screen 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 device 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 device or on a keyboard.

2 Acquisition and Setup

This chapter describes the horizontal and vertical settings as well as the acquisition and probe setup.

2.1 Basics

This chapter provides background information on the essential settings in the vertical and horizontal systems, on acquisition setup and probing.

2.1.1 Vertical System

The controls and parameters of the vertical system are used to scale and position the waveform vertically.

2.1.1.1 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.

2.1.1.2 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, waveforms should cover most of the height of the diagram.

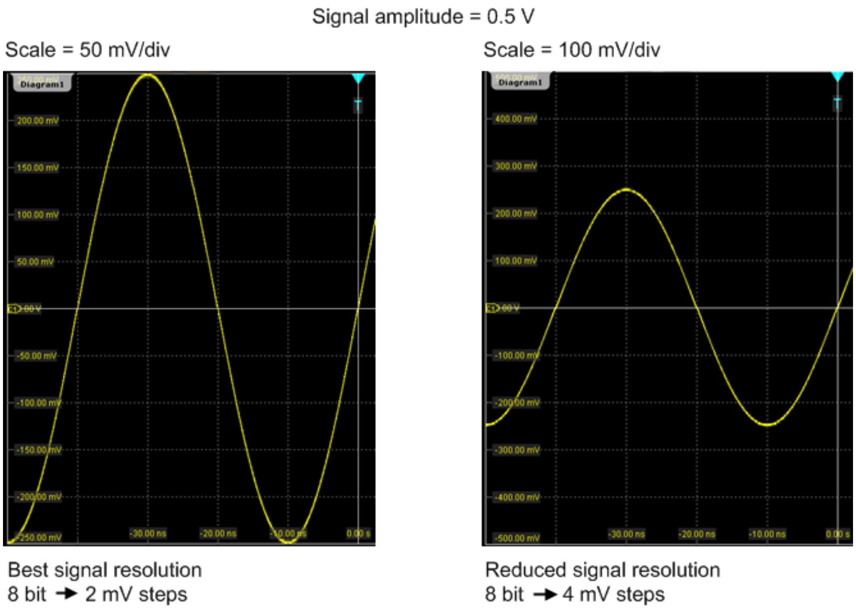


Fig. 2-1: Input range and resolution of the ADC

With R&S RTO, 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.

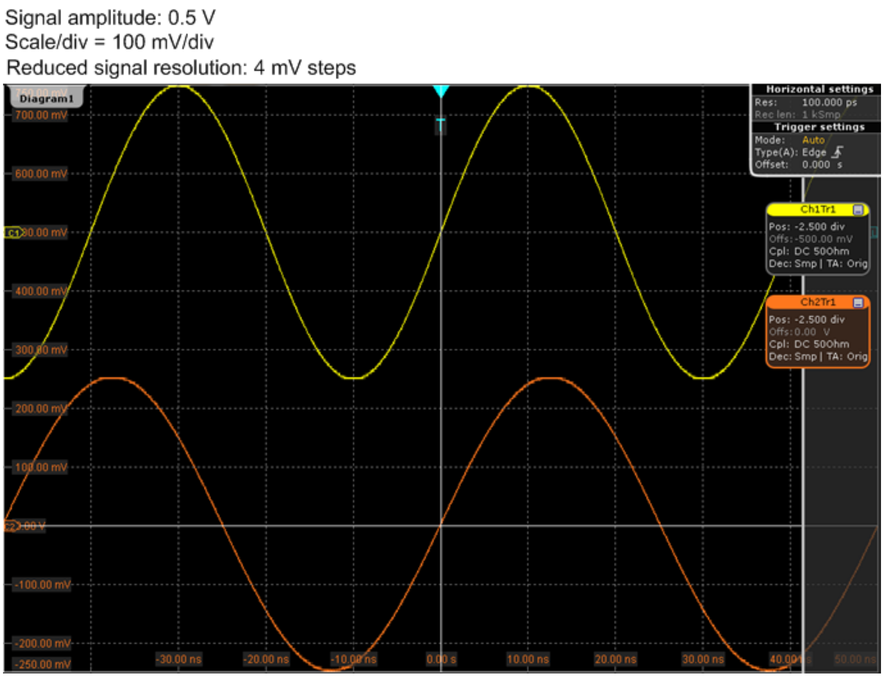


Fig. 2-2: Traditional setup of multiple waveforms in one diagram: reduced resolution

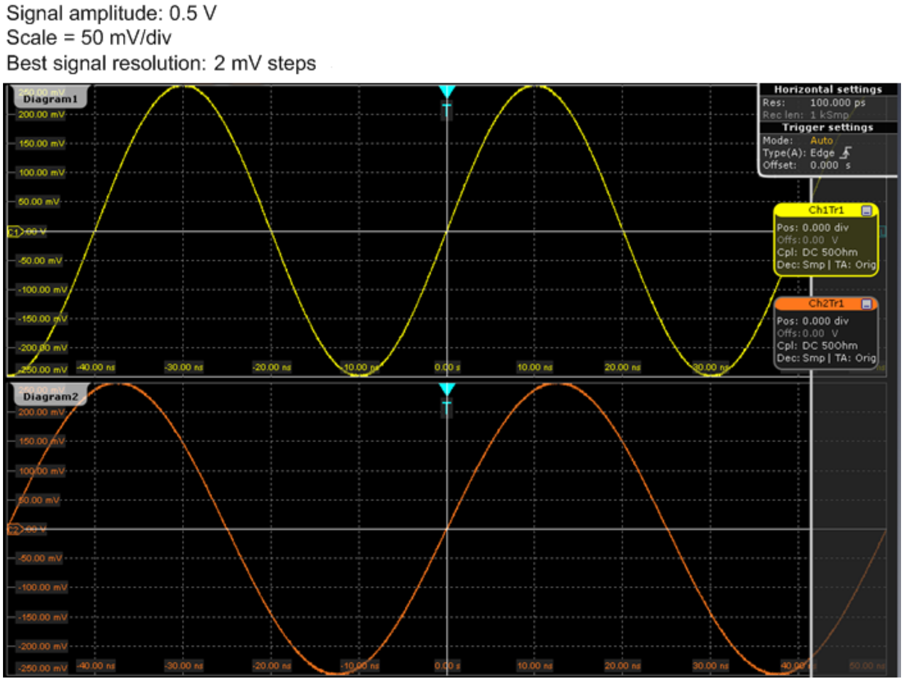


Fig. 2-3: R&S RTO setup of multiple waveforms in separate diagrams: best resolution

2.1.1.3 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 rule of thumb, 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 maintain the oscilloscope bandwidth, that is, to reduce the effect of the probe on the system bandwidth, the probe bandwidth should exceed the bandwidth of the oscilloscope, the recommended factor is 1.5 x oscilloscope bandwidth.

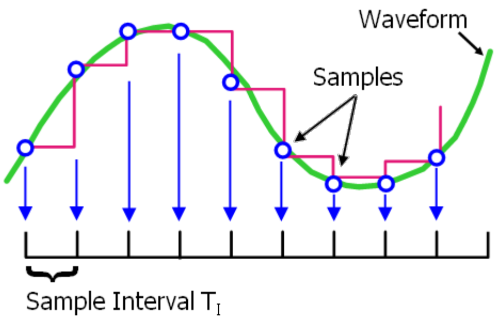
See also: chapter 2.1.4.1, "Voltage Probes", on page 20

2.1.2 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.

2.1.2.1 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 usually 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**, and 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.

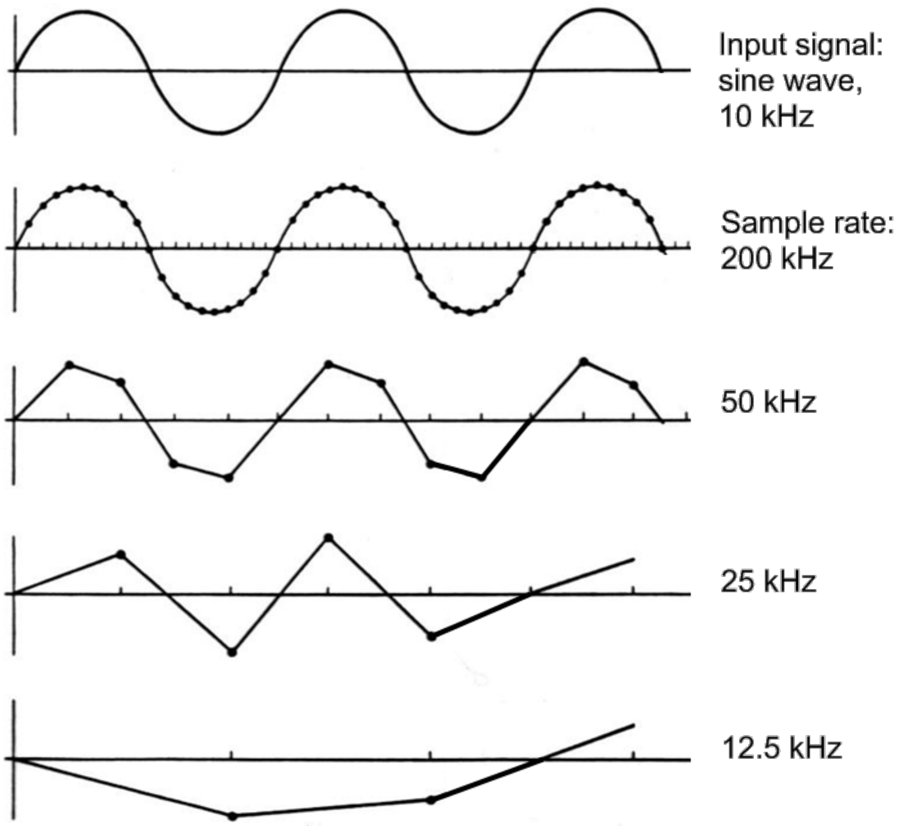


Fig. 2-4: Waveforms acquired with different sample rates

This means that 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.

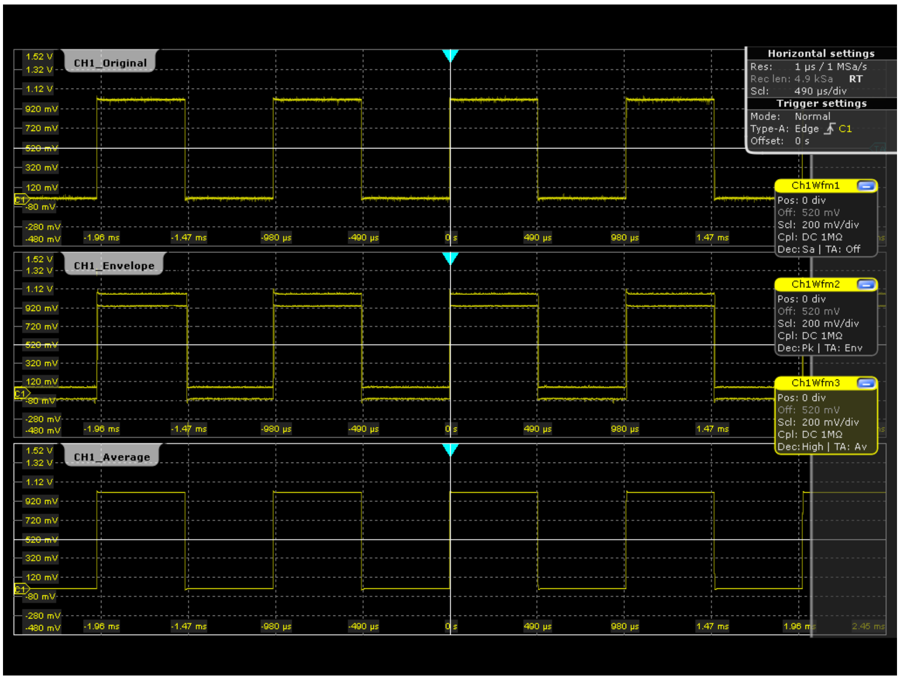
2.1.2.2 Acquisition Settings

The sample rate can be the same as the constant ADC sample rate, or higher, or lower. To get a higher sample rate, methods of **resolution enhancement** are used: interpolation and equivalent time sampling. 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.

The R&S RTO provides the following acquisition features:

- You can combine resolution enhancement and waveform decimation modes with waveform arithmetic.
- You can display up to three waveforms from one input signal and apply different decimation and arithmetic to each waveform.



2.1.2.3 Acquisition Control

You can run the R&S RTO in two ways:

- Continuous: the instrument acquires data until you stop it manually.
- NxSingle: the instrument samples and processes a specified number of acquisitions.

The determining point of an acquisition is the trigger. It defines the time-zero 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 will 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.

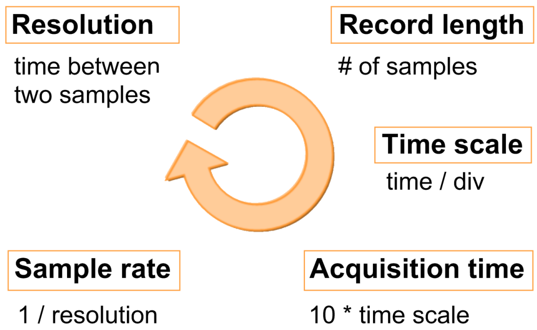
In practice, both trigger modes are useful: The auto mode lets you see the signal with very little adjustment, while the normal mode selects the interesting part of the waveform. If you want to acquire a specified number of waveforms with NxSingle, make sure to select the normal trigger mode. Thus you get only the required number of interesting acquisitions.

See also: chapter 3, "Triggers", on page 48

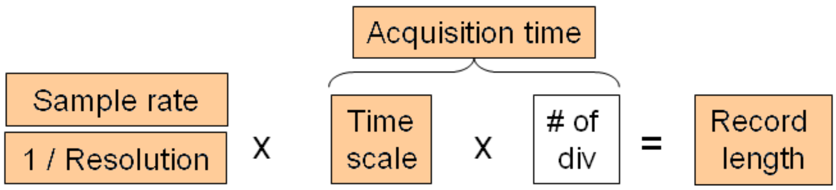
2.1.3 Horizontal System

2.1.3.1 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 should remain constant.

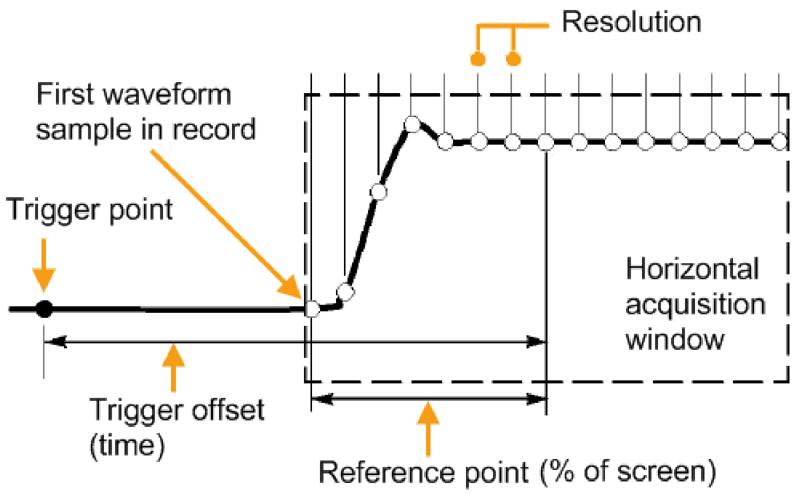
- With constant resolution, increasing the time scale also increases the record length, and vice versa. You can limit the record length to a maximum value.
- With constant record length, increasing the time scale coarsens the resolution, that is, the time between two waveform samples gets longer.

For both settings, the "Auto adjustment" ensures a sufficient resolution to prevent undersampling.

2.1.3.2 Horizontal Position

As described before in chapter 2.1.2.3, "Acquisition Control", on page 18, the trigger defines the time-zero point in the waveform record.

Two parameters set the position of the horizontal acquisition window in relation to the trigger point: **reference point** and **trigger offset**. With these parameters you choose the part of the waveform you want to see: around the trigger, before, or after the trigger.



2.1.4 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.

2.1.4.1 Voltage Probes

The following table provides an overview on common voltage probes and their usage.

Table 2-1: Voltage probes overview

Probe type	Attenuation	Typical bandwidth range	Oscilloscope input	Usage
Passive, high impe-dance	1:1	10 MHz	1 MΩ	Low speed, low level signals
Passive, high impe-dance	10:1	500 MHz	1 MΩ	General purpose
Passive, low impe-dance	10:1	up to 10 GHz	50 Ω	High frequency
Active, single-ended	10:1	up to 10 GHz	50 Ω	High speed

For a list of recommended probes refer to the R&S RTO product brochure.

Besides the possible input voltage range, two factors are very 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:
  $$(1/BW_{system}) = \sqrt{(1/BW_{probe})^2 + (1/BW_{scope})^2}$$
  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
- Compensation needs to be executed when the probe 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 will preserve the harmonics and thus the waveform integrity.

Active voltage probes

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.
- The operating voltage range has to be observed.
- The probe impedance depends on the signal frequency.

RT-ZS single-ended active probes provide special features for easier use and precise measurements:

- The micro button on the probe head remotely controls important functions on the instrument, like running and stopping the acquisition, autoset, auto zero 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.
- Auto Zero automatically corrects the zero error of the probe to optimize measurement results at small signal levels.

2.2 Setting Up the Waveform

This chapter contains the fundamental procedures for setting up the acquisition and adjusting the channel waveforms.

2.2.1 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 N.

   The instrument recognizes the probe and turns the channel on.

2. Press the AUTOSET button on the left of the display.

2.2.2 Adjusting the Signal Input Manually

1. Connect the probe to the input connector CH N.

   The instrument recognizes the probe and turns the channel on.
2. On the "Horizontal" menu, tap "Time Base".
3. Set the "Time scale" and the "Reference point".
4. Tap the "Resolution" tab.
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.

2.2.3 Setting the Acquisition

Prerequisites:

- Probes are connected.
- Vertical and horizontal settings are adjusted.

The settings are described in chapter 2.3.1.3, "Acquisition", on page 30.

1. On the "Horizontal" menu, tap "Acquisition".
2. Select the "Enhancement".
   If "Interpolated time" is set, select also the "Interpolation mode".

   Enhancement affects all waveforms of all channels. The instrument uses enhancement settings if the "ADC sample rate" is less than the "Sample rate"; otherwise these settings are ignored.
3. To configure the waveform-specific acquisition settings, select the "Channel" tab and activate the waveform.
   You can set up and display up to three waveforms per channel.
4. Select the "Decimation" - for example, Peak detect or High res.
5. Select the "Wfm Arithmetic" - for example, Average or Envelope.
   The instrument precludes incompatible combinations, like "Peak detect" with "Average".
6. If "Average" is selected for a waveform, enter the "Average count", that is the number of waveforms used for average calculation.
7. Set the reset condition for the average and envelope calculation:

a) If "Time" is selected, enter the "Reset time".
b) If "Waveforms" is selected, enter the "Reset count".

2.2.4 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 AUTO/NORMAL 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. On the "Trigger" menu, tap "Trigger Events Setup".
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.

2.2.5 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. For details, see "Mode" on page 28.

To set the roll mode manually

1. Press the HORIZONTAL key.
2. In the "Roll mode" section of the "Time Base" tab, set "Mode" to "Auto".
3. In the "Min roll mode gain" field, enter the acquisition time at which the instrument starts the roll mode.

2.2.6 Deskewing Channels

If several channels are involved in a measurement setup, it is recommended that you use cables of the same length to ensure synchronous waveforms and trigger signals. Sometimes the setup requires cables of different length which cause a time delay. To align the signals, you can determine and set the deskew time.

See also: chapter 2.3.6, "Calibration Settings", on page 45

1. Connect the probes to the channel inputs and the other ends to the AUX OUT 50Ω output.
2. On the "File" menu, tap "Calibration Settings".
3. Configure the settings to determine the skew offset:
   - "Enable" = On
   - "Source" = Meas.
   - "Frequency" = 1 GHz or 10 MHz
   - "Operating mode" = Skew
   - "Destination" = External
4. On the "Horizontal" menu, tap "Skew".
5. Enable "Use skew offset".
6. Tap the "Skew offset" field and adjust the value until the waveforms on the screen match exactly.

2.2.7 Using Ultra Segmentation

Ultra Segmentation reduces the dead time between two waveform acquisition cycles.

The settings are described in chapter 2.3.1.4, "Ultra Segmentation", on page 34.

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.

2.2.8 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 2.3.4, "Digital Filter Setup", on page 43.

To filter the input channels only

1. On the "Vertical" menu, tap "Digital Filter Setup".
2. Set the "Trigger coupling" to "Off".
3. Select the "Characteristics" - the filter type - for channel ½ and for channel 3/4: Highpass or Lowpass.
4. Enter the "Cut-off" frequency for each filter.
5. Enable "Use filter" for each channel to be filtered.

To filter the trigger signal

1. On the "Vertical" menu, tap "Digital Filter Setup".
2. Select the type of the "Trigger coupling".
3. Set the frequency limit for the filter: "HF reject BW" or "LF reject BW".
4. To filter the input channels too, enable "Use filter" for each channel to be filtered. The trigger filter settings are applied also to these input channels.

2.3 Reference for Acquisition and Setup

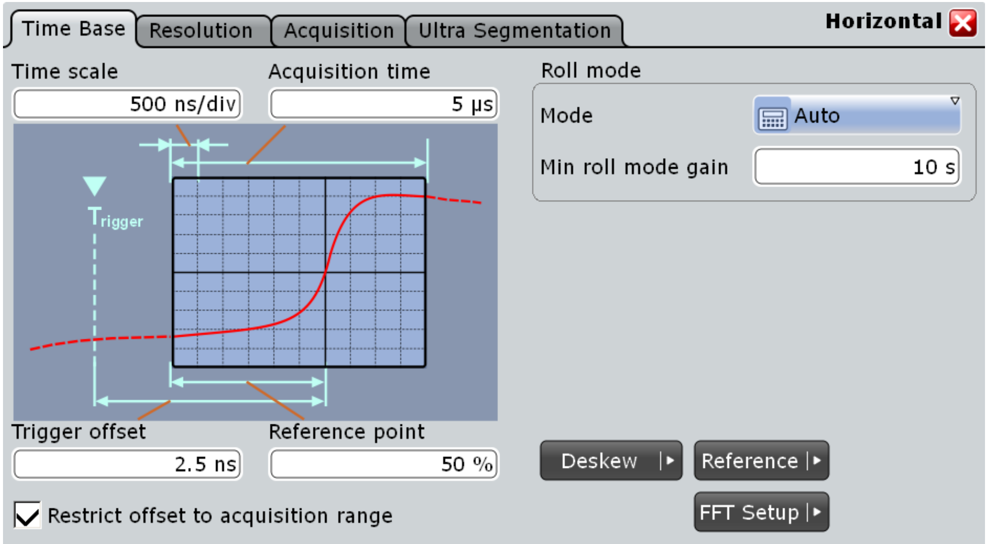
2.3.1 Horizontal Settings

The "Horizontal" menu provides the time base and acquisition configuration for channel and FFT waveforms:

2.3.1.1 Time Base

The "Time Base" tab in the "Horizontal" dialog box provides the basic settings for the time axis and the roll mode settings.

For background information, see chapter 2.1.3, "Horizontal System", on page 19.



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.

SCPI command:
`TIMebase:SCALe` on page 338

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.

SCPI command:
`TIMebase:RANGe` on page 339

Trigger offset
Adds a time offset to the reference point to choose the part of the waveform to be captured and shown in the diagram. Thus, you can set the trigger outside the diagram and analyze the signal some time before or after the trigger. Positive values move the trigger to the right of the reference point to show the pre-trigger part of the signal.

SCPI command:
`TIMebase:POSition` on page 339

Reference point
Sets the zero point of the time scale in % of the display between 10% and 90%. The reference point defines which part of the waveform is shown. If the "Trigger offset" is zero, the trigger point matches the reference point.

SCPI command:
`TIMebase:REFerence` on page 340

Restrict offset to acquisition range
Ensures that the trigger occurs within one acquisition cycle. If enabled, the trigger cannot be set outside the waveform diagram.

SCPI command:
`TRIGger<m>:OFFSet:LIMited` on page 394

Mode
Activates the automatic roll mode. If set to "Auto", the instrument activates the roll mode under specific conditions. In roll mode, the instrument shows the waveforms immediately, without waiting for the complete acquisition of the waveform record. If the process is slow - that is if the time scale is large - 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 is activated automatically if the following conditions are fulfilled:
- Acquisition time exceeds the "Min roll mode gain" value
- Record length is ≤1 MSa
- 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

The roll mode has following restrictions:
- Persistance is disabled
- History is not available

SCPI command:
`TIMebase:ROLL:ENABle` on page 340

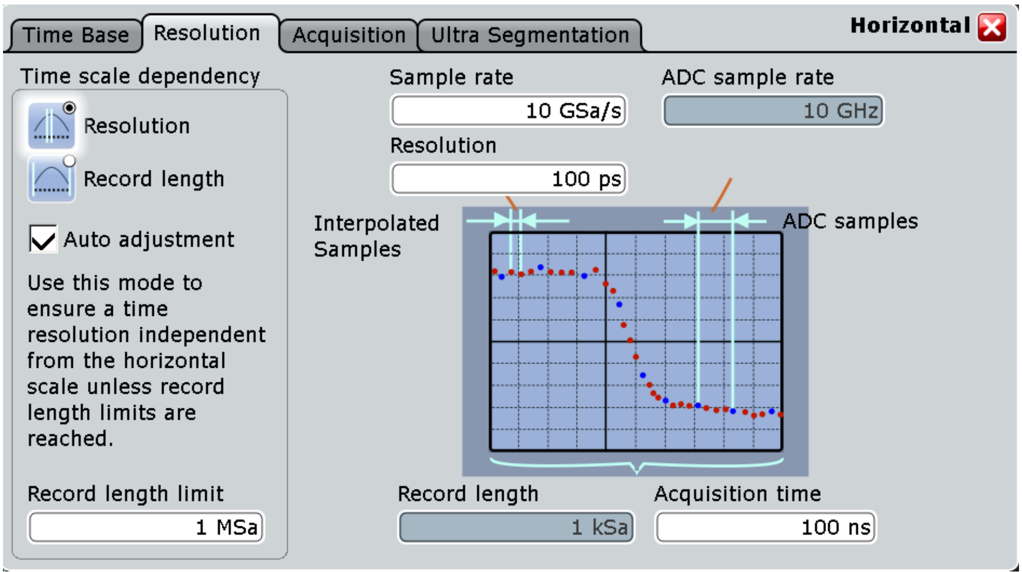
Min roll mode gain
The instrument can activate the roll mode automatically if the acquisition time exceeds the threshold given here.

SCPI command:
`TIMebase:ROLL:MTIMe` on page 340

2.3.1.2 Resolution

The settings in the "Resolution" tab mainly define the precision of the waveform record.

The resolution settings interact, changing one parameter affects one or more of the other parameters as well. For background information, see chapter 2.1.3, "Horizontal System", on page 19.



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 resolution enhancement (interpolation and equivalent-time sampling), and the reduction of waveform points by decimation.

SCPI command:
`ACQuire:SRATe` on page 341

ADC sample rate
Shows the number of points that are sampled by the ADC in one second. The ADC sample rate is a constant of the instrument.

SCPI command:
`ACQuire:POINts:ARATe` on page 341

Resolution
Sets the time between two waveform samples. A fine resolution with low values produces a more precise waveform record.

SCPI command:
`ACQuire:RESolution` on page 342

Record length
Indicates the number of waveform samples that build the waveform across the acquisition time.

SCPI command:
`ACQuire:POINts[:VALue]` on page 342

Acquisition time

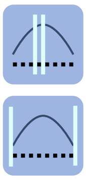
Shows the time of one acquisition, that is the time across the 10 divisions of the diagram:

Acquisition time = Time scale * 10 divisions

Changing the acquisition time changes the time scale too.

SCPI command:

`TIMebase:RANGe` on page 339



Resolution / Record length (Time scale 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.

SCPI command:

`ACQuire:POINts:AUTO` on page 341

Auto adjustment (Time scale 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 (Time scale dependency)

Record length limit (Time scale 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.

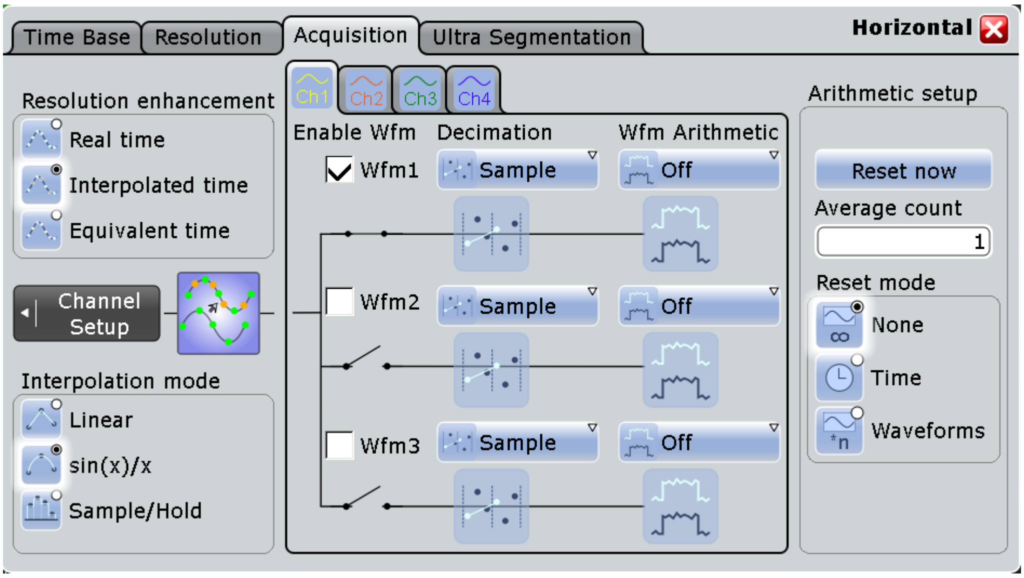
See also:

- Resolution / Record length (Time scale dependency)
  Auto adjustment (Time scale dependency)

2.3.1.3 Acquisition

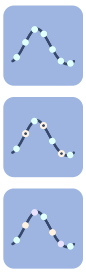
Acquisition settings control how the waveform is built from the acquired samples. You can display up to three waveforms from one input signal and apply different decimation and arithmetic to each waveform.

For background information, see chapter 2.1.2, "Sampling and Acquisition", on page 15.



Channel-dependent settings

The "Decimation" and "Wfm arithmetic" are specific for each waveform. Make sure to select the channel tab first, then set up the waveforms.



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 channels and waveform. 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, 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 mode.

"Equivalent time" This method requires repetitive, stable signals. It is used to capture fast signals whose frequency components are higher than the "ADC sample rate". Equivalent-time sampling constructs a picture of a repetitive signal by capturing a little bit of information from each repetition. Each sample is taken with some time difference after the trigger, and the time difference varies with each repetition of the signal. After a number of acquisitions, the oscilloscope builds the waveform from the sampled points.

The R&S RTO uses the sequential equivalent-time sampling method. When a trigger occurs, a sample is taken after a very short delay time. At the next trigger, this delay time is incremented by a precisely defined Δt, and the next sample is taken. This process is repeated until the waveform is complete. Sequential equivalent-time sampling provides very good time resolution and accuracy.

SCPI command:

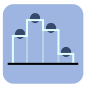
`ACQuire:MODE` on page 342

Interpolation mode

Selects the interpolation method if "Interpolated time" is set for enhancement.

"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 actually measured samples.

SCPI command:

`ACQuire:INTerpolate` on page 343

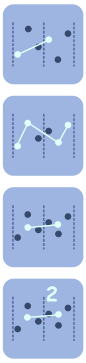
Enable Wfm

Activates or deactivates the individual waveforms of the selected channel.

For each channel, up to three waveforms can be shown and analyzed. The decimation mode and the trace arithmetic are specific for each waveform. So you can analyze several aspects of the signal: For example, waveform1 shows the peaks, and waveform2 shows the average of the signal.

SCPI command:

`CHANnel<m>[:WAVeform<n>][:STATe]` on page 343



Decimation

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 RTO uses decimation, if the waveform "Sample rate" is less than the "ADC sample rate". In this case, enhancement settings are ignored. The decimation mode ist waveform-specific, you can select another mode for each waveform.

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.

SCPI command:

`CHANnel<m>[:WAVeform<n>]:TYPE` on page 343

Wfm Arithmetic

Waveform arithmetic builds the resulting waveform from several consecutive acquisitions of the signal. This setting is waveform-specific. The arithmetic works with enhanced 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 are processed.

"Envelope" Detects the minimum and maximum values in an 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).
The envelope is built until the restart criterion is reached, see "Reset mode" on page 34.

"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", and the "Reset mode" defines the restart condition.

SCPI command:

`CHANnel<m>[:WAVeform<n>]:ARIThmetics` on page 344

Reset Now
Forces the immediate restart of the envelope and average calculation for all waveforms, ignoring the reset settings.

Average count
The "Average count" has a double effect:
- It defines the number of waveforms used to calculate the average waveform.
- It sets the number of waveforms acquired with RUN N× SINGLE.

Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the "Average count" is, the better the noise is reduced.

SCPI command:
`ACQuire:COUNt` on page 345

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".

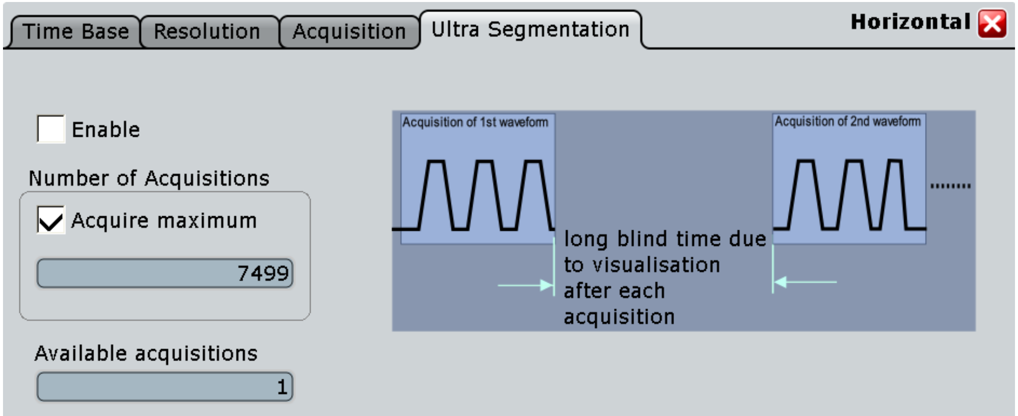
2.3.1.4 Ultra Segmentation

In normal acquisition mode, only a short time is used for sampling; processing and display takes most of the time. The processing and display time is dead time causing a gap in the recorded signal. The normal acquisition mode misses very short time and infrequent events occurring during the dead time.

With Ultra Segmentation, a number of triggered acquisitions is captured very fast, with hardly any dead time between the acquisitions. The data is processed and displayed when the acquisition of the series has been completed.

The acquisition series is written in one large waveform record in the sample memory, thus the memory size limits the number of acquisitions in a series.

To view the complete series, use the history function.



Enable

Switches the Ultra Segmentation mode on and off.

SCPI command:

`ACQuire:SEGMented:STATe` on page 345

Acquire maximum

The number of acquisitions in a Ultra Segmentation acquisition series depends on the record length. The maximum number is *Record length / No of samples per acquisition cycle*.

If the option "Acquire maximum" is selected, the maximum possible number of acquisitions in a series is used.

If the option is disabled, you can enter a number of acquisitions to be acquired with Ultra Segmentation. This number is the Average count.

SCPI command:

`ACQuire:SEGMented:MAX` on page 345

Available acquisitions

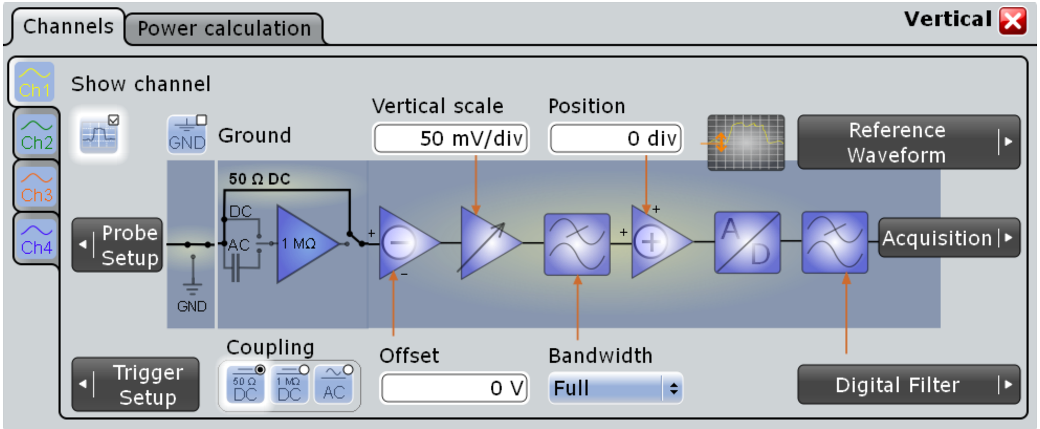
Displays the number of acquisitions currently saved in the sample memory. This memory is also used to save an Ultra Segmentation acquisition series, so the number also shows the current number of acquisitions in an Ultra Segmentation acquisition series.

2.3.2 Vertical Settings

The "Vertical" menu contains all channel-dependent settings and information.

2.3.2.1 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.

SCPI command:

`CHANnel<m>:STATe` on page 346

Ground

Connects the input to the ground.

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 2.3.4, "Digital Filter Setup", on page 43.

"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.

SCPI command:

`CHANnel<m>:COUPling` on page 346

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 re-positioned within the diagram area. Negative offset values move the waveform up, 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".

SCPI command:
`CHANnel<m>:OFFSet` on page 347

Vertical scale
Defines the vertical scale in Volts per division. Increasing the scale compresses the display of the signal.

SCPI command:
`CHANnel<m>:SCALe` on page 346

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 2.1.1.3, "Bandwidth", on page 15

"Full"	At full bandwidth, all frequencies in the specified range are acquired and displayed. Full bandwidth is used for most applications.
"800 MHz, 200MHz, 20MHz"	Frequencies above the selected limit are removed to reduce noise at different levels.

SCPI command:
`CHANnel<m>:BANDwidth` on page 348

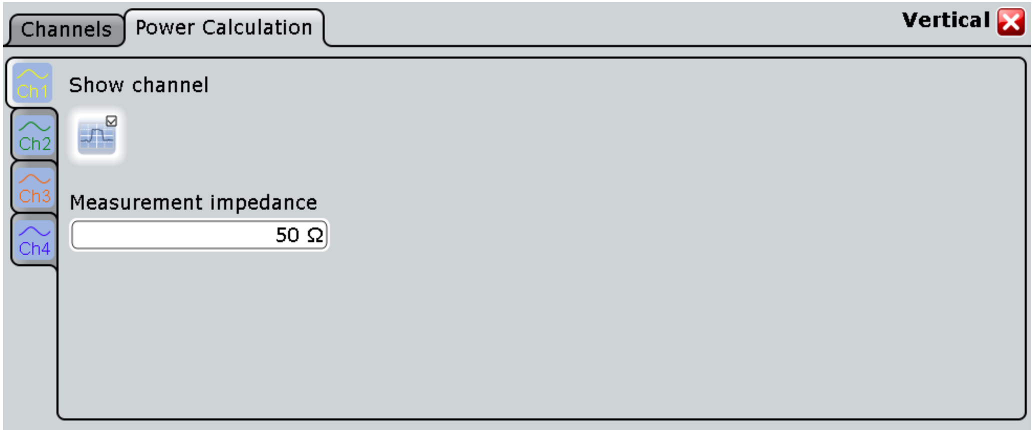
Position
Moves the selected signal up or down in the diagram. The visual effect is the same as for Offset but the waveform is adjusted at a later time in the signal flow. While the offset sets a voltage, position is a graphical setting given in divisions.

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".

SCPI command:
`CHANnel<m>:POSition` on page 347

2.3.2.2 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.

SCPI command:

`CHANnel<m>:STATe` on page 346

Measurement impedance

Sets the impedance of the channel for power calculations and measurements.

SCPI command:

`CHANnel<m>:IMPedance` on page 348

2.3.3 Probes

With R&S RTO, you can use various probe types, most of all these are passive and active voltage probes. The "Probes" dialog box provides all probe-relevant information.

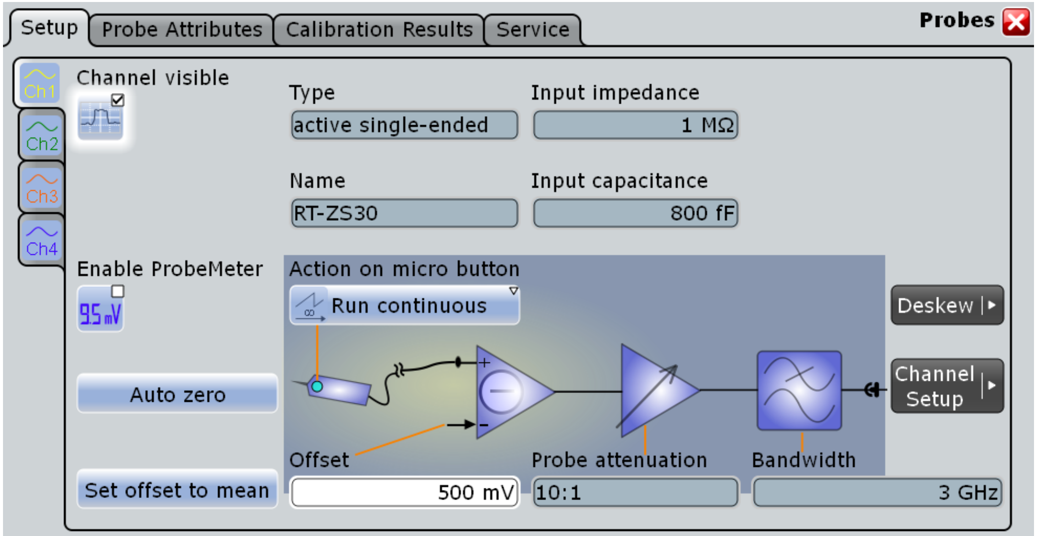
For background information, see chapter 2.1.4, "Probes", on page 20.

For passive probes, the probe attenuation is read out and shown in the "Setup" tab. Passive probes require compensation.

When you connect an R&S RT-ZSxx active probe to a channel input of the R&S RTO, the oscilloscope recognizes the probe, 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 by the R&S RTO. If you connect the probe the next time to the same channel, the information is fetched and used.

2.3.3.1 Setup

The "Setup" tab provides settings and information on probe configuration.



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.

SCPI command:
CHANnel<m>:STATe on page 346

Type, Name, Input impedance, Input capacitance, Bandwidth
Shows the characteristics of the attached R&S probe for information.

SCPI command:
PROBe<m>:SETup:TYPE on page 353
PROBe<m>:SETup:NAME on page 354
PROBe<m>:SETup:IMPedance on page 354
PROBe<m>:SETup:CAPacitance on page 354
PROBe<m>:SETup:BANDwidth on page 354

Offset
See "Offset" on page 36.

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 supports quick and convenient measurements of input signals with different DC offsets.

SCPI command:
PROBe<m>:SETup:OFFSet:TOMean on page 352

Auto Zero
Corrects the zero error of the probe to optimize measurement results at small signal levels.

The zero error of R&S active probes is very small. In comparison, differences in DUT and oscilloscope ground levels may cause larger zero errors affecting the waveform. If the DUT is ground-referenced, the Auto Zero function can improve the measurement results.

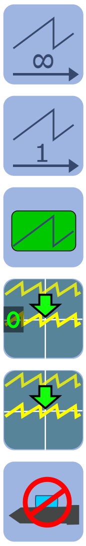
To correct the zero error, short the signal pin and the ground pin together and connect them to the ground of the DUT. Then tap "Auto Zero", or use the Micro Button.

SCPI command:
`PROBe<m>:SETup:OFFSet:AZERo` on page 352

Probe attenuation
Shows the attenuation of the active or passive probe.

If you connect passive probes other than R&S ZPxx, check whether the attenuation is indicated correctly.

SCPI command:
`PROBe<m>:SETup:ATTenuation` on page 353



Action on micro button
Active R&S probes have a configurable Micro Button on the probe head. Pressing this button, you can perform an action on the instrument directly from the probe.

Select the action that you want to start from the probe:

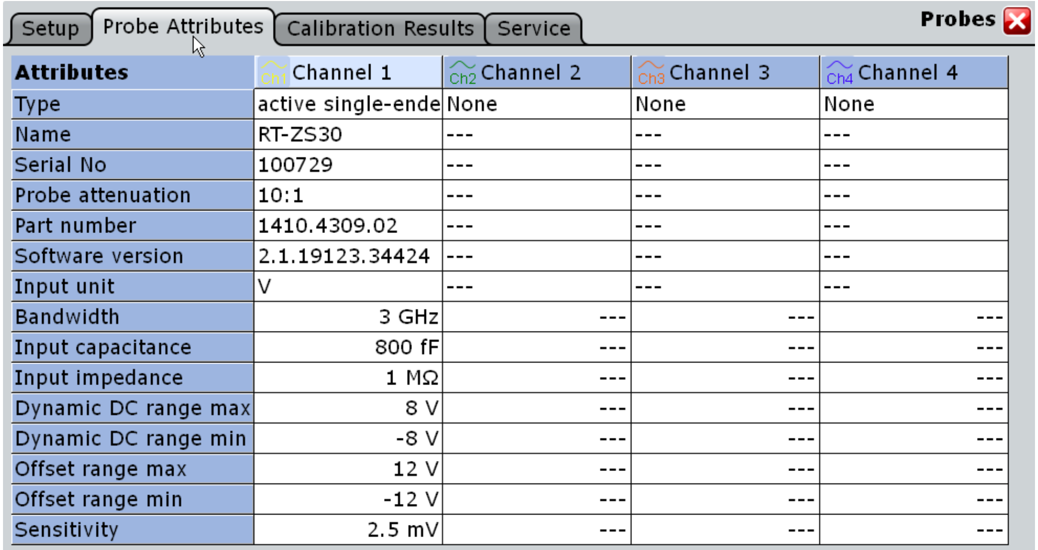
"Run Continuous"	is the default assignment. The acquisition is running as long as you press the micro button again.
"Run single"	starts one acquisition.
"Auto set"	starts the autoset procedure.
"Auto Zero"	See: "Auto Zero" on page 40.
"Set offset to mean"	See: "Set offset to mean" on page 39.
"No action"	Select this option to prevent unwanted actions due to unintended usage of the micro button.

SCPI command:
`PROBe<m>:SETup:MODE` on page 352

Probe Meter active
Enbles the integrated R&S Probe Meter of active R&S probes. This voltmeter measures DC voltages between the probe tip and ground connection with very high precision and enables ground-referenced measurements of voltages. The DC measurement is performed continuously and in parallel to the measurements of the oscilloscope. The measured DC value is displayed in a result box on the screen.

2.3.3.2 Probe Attributes

The "Probe Attributes" tab provides an overview of all R&S probes connected to an input channel.



Attributes	Channel 1	Channel 2	Channel 3	Channel 4
Type	active single-ende	None	None	None
Name	RT-ZS30	---	---	---
Serial No	100729	---	---	---
Probe attenuation	10:1	---	---	---
Part number	1410.4309.02	---	---	---
Software version	2.1.19123.34424	---	---	---
Input unit	V	---	---	---
Bandwidth	3 GHz	---	---	---
Input capacitance	800 fF	---	---	---
Input impedance	1 MΩ	---	---	---
Dynamic DC range max	8 V	---	---	---
Dynamic DC range min	-8 V	---	---	---
Offset range max	12 V	---	---	---
Offset range min	-12 V	---	---	---
Sensitivity	2.5 mV	---	---	---

Probe attributes

For a specification of the probe parameters refer to the data sheet.

SCPI command:

`PROBe<m>:ID:SWVersion` on page 355

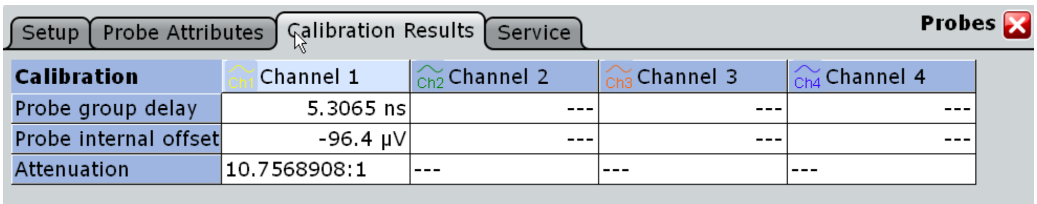
`PROBe<m>:ID:PRDate` on page 355

`PROBe<m>:ID:PARTnumber` on page 355

`PROBe<m>:ID:SRNumber` on page 356

2.3.3.3 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	Channel 1	Channel 2	Channel 3	Channel 4
Probe group delay	5.3065 ns	---	---	---
Probe internal offset	-96.4 µV	---	---	---
Attenuation	10.7568908:1	---	---	---

Probe Group Delay

...

Probe Internal Offset

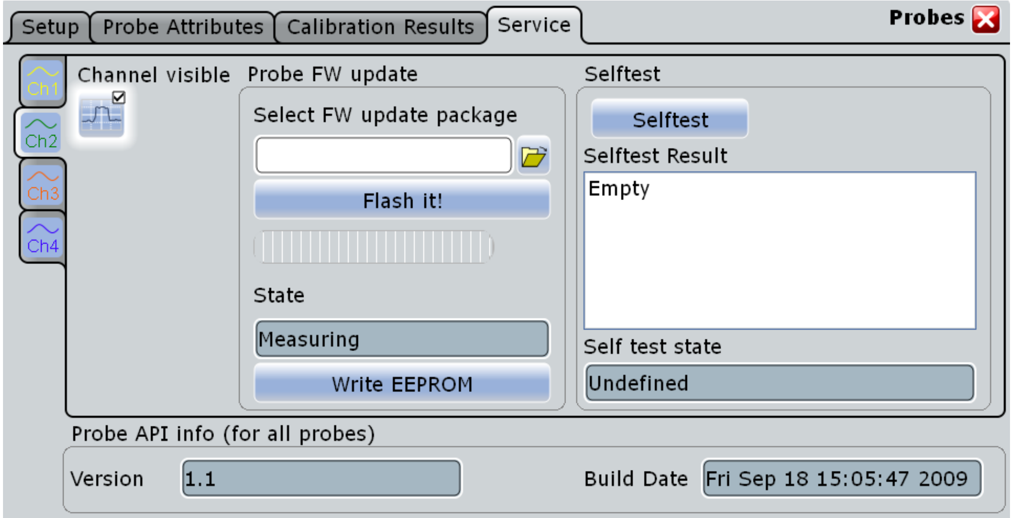
...

Attenuation

Shows the attenuation of the probe. This value is also shown in the "Setup" tab.

2.3.3.4 Service

The "Service" tab supports the update of the probe's firmware, provides a selftest and other functions that are useful in case of service.



Probe FW update

A new firmware for R&S probes is delivered together with the R&S RTO firmware. To install the new probe firmware, you download it from the instrument to the probe.

Note: The installation of a new firmware resets all settings.

- Select the firmware package with "Select FW update package".
- Tap "Flash it!".

The current installation progress is shown on the progress bar.

The "State" field below the progress bar shows the following update states:

"Measuring"

"Updating" The update is running.

"Failed" The update has failed.

SCPI command:

`PROBe<m>:SERVice:FW:PATH` on page 357

`PROBe<m>:SERVice:FW:FLASh` on page 357

`PROBe<m>:SERVice:STATe` on page 357

Selftest

The selftest is a functional test of the probe's hardware and software.

You start the probe selftest by tapping the "Selftest" button. The state of the selftest procedure ist shown in "Self test state". When the selftest is finished, the result appears in "Selftest result".

SCPI command:

`PROBe<m>:SERVice:STESt:RUN` on page 356

`PROBe<m>:SERVice:STESt:STATus` on page 356

`PROBe<m>:SERVice:STESt[:RESult]` on page 356

Write EEPROM

Probe API info
Shows the "Version" and the "Build Date" of the probe API for service information.

2.3.4 Digital Filter Setup

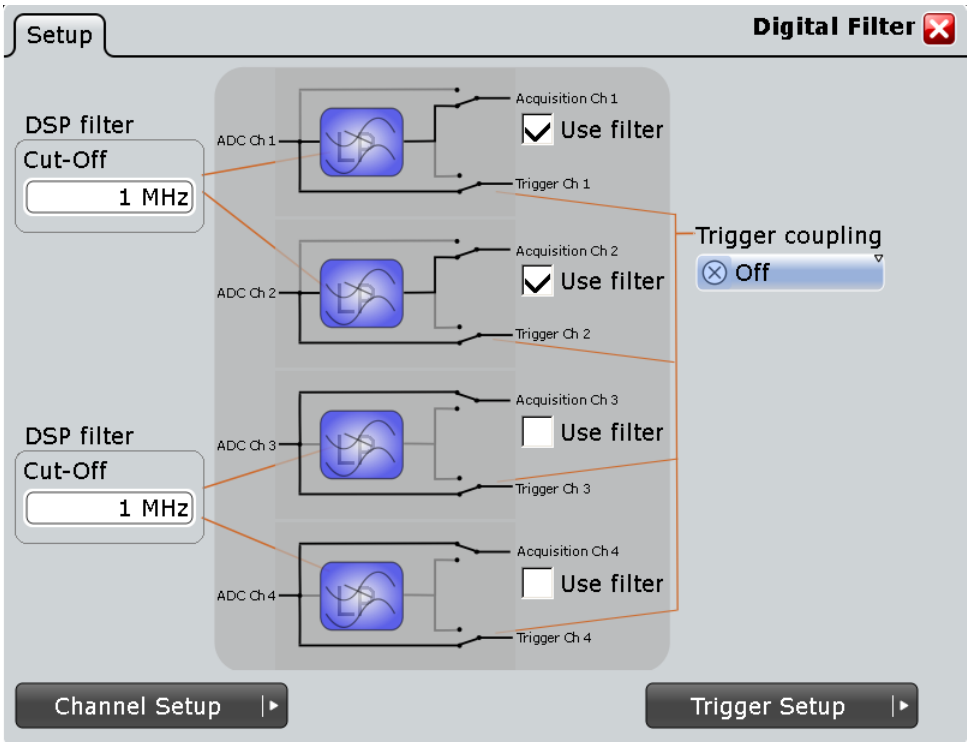
After processing by the A/D converter, the channel and trigger signals are digitized signals. These digitized signals can be filtered to reject high frequency - also known as Digital Signal Processing (DSP). You can filter the acquisition channels as well as the trigger channel signal.

If you filter only the input channels, you can apply different filters - one filter for channels 1 and 2 and - for 4-channel models - another filter for channels 3 and 4.

If you filter the trigger channel, the same filter must be used for the input channels to ensure that all signals suit for analysis. The instrument offers only permitted combinations and triggers on the filtered signal.

Example:

RF reject for the trigger signal ensures that triggering will not be caused by unexpected glitches.



Use filter
Enables the DSP filter.

The number of filters depends on the instrument model:
- R&S RTO1022 and R&S RTO1024 have a filter for each input channel.
- R&S RTO1012 and R&S RTO1014 have filters affecting two channels: One filter for Ch1 and Ch2, and the second filter for Ch3 and Ch4 (R&S RTO1014 only).

Cut-off
Sets the limit frequency of the Lowpass filter for input channels.

The filter value is applied to two channels in R&S RTO1022 and R&S RTO1024, or applied to all available channels in R&S RTO1012 and R&S RTO1014.

Trigger coupling
Selects the filter for the trigger channel(s). Other channels must use the same filter, or proceed unfiltered.

"Off"	The trigger signal is not filtered, and the acquisition channels can be filtered independently.
"RF reject"	frequencies higher the "HF reject BW" are rejected, lower frequencies pass the filter.

RF reject BW
Sets the limit frequency for "RF reject" trigger coupling. This limit is applied to the trigger channel and to the acquisition channels enabled for filtering.

2.3.5 Horizontal Accuracy

The Horizontal Accuracy contains standard and optional settings to improve measurement and analysis accuracy and to reduce jitter effects.

2.3.5.1 Reference (OCXO Option)

The option RTO-B4 provides an Oven Controlled Crystal Oscillator (OCXO) that produces a 10 MHz internal reference signal with very precise and stable frequency. With this option, you can also use an external reference signal. The input and output connectors for the external reference signal are located on the rear panel alongside the external trigger input.

Detected
Indicates if the OCXO option is installed and detected by the instrument.

Oven hot
Indicates when the oven has reached its nominal temperature and is operating with the specified accuracy.

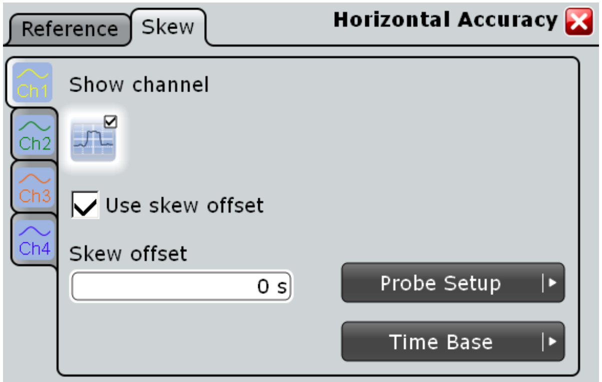
External reference
Sets the frequency of an external reference input signal that is connected to the external reference input on the rear panel of R&S RTO. A frequency range from 1 MHz to 20 MHz is supported.

Use external reference
Enables the use of the external reference signal instead of the internal OCXO reference.

If an external reference is used, the frequency of the reference output signal is the same as of the reference input signal. Otherwise, the frequency of the reference output signal is 10 MHz, that is the frequency of the OCXO.

2.3.5.2 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.

SCPI command:
`CHANnel<m>:STATe` on page 346

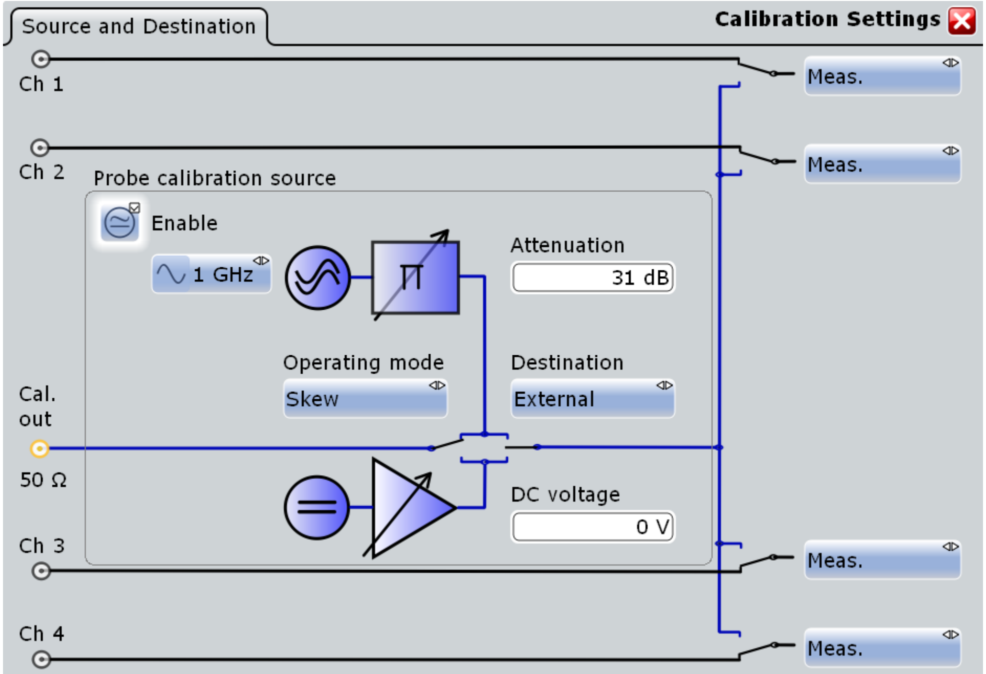
Use skew offset
If enabled, the "Skew offset" value is used for compensation. This improves horizontal and trigger accuracy.

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.

2.3.6 Calibration Settings

The settings in the "Calibration Settings" dialog box help to align channels if cables of different length are connected to the input connectors.

See also: chapter 2.2.6, "Deskewing Channels", on page 25



Enable

Switches the internal calibration signal on or off.

Source

Sets the source for the channel waveforms:

"Meas." Signal from the input connector to determine the skew offset.

"Cal. source" Internal calibration source used internally for self-alignment.

Frequency

Sets the frequency of the internal calibration signal. Possible values are a 1 GHz sine wave or a 10 MHz square wave.

SCPI command:

`CALibration:SOURce:FREQuency` on page 357

Attenuation

Sets the AC level.

Operating mode

To determine the skew offset, use the "Skew" operating mode. It uses the internal channel alignment for best results.

SCPI command:

`CALibration:SOURce:MODE` on page 358

Destination
Sets the output for the calbration signal. "External" routes the signal to the AUX OUT 50Ω OUTPUT.

SCPI command:
`CALibration:SOURce:SKEW:DESTination` on page 358

DC voltage
Sets the DC level.

3 Triggers

3.1 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 logic signals.

Trigger

A trigger occurs if the complete set of trigger conditions is satisfied. It establishes the time-zero 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 will not accept another trigger until the acquisition is complete and the holdoff time has expired.

Trigger conditions

A simple set of trigger conditions includes:

- Source of the trigger signal, its coupling and filtering
- Trigger type and its setup
- Horizontal position of the trigger: trigger offset and reference point
- Trigger mode

The R&S RTO provides various trigger types for troubleshooting and signal analysis, for example, edge trigger, glitch trigger, interval trigger, slew rate trigger, and pattern trigger.

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 will cause the trigger
- Qualification to consider the states of digital signals on other input channels and their logical combination
- Trigger sequences to combine two events

Trigger event

In particular for advanced trigger settings, it is important to distinguish between the trigger and the event. An event is the fulfillment of the event conditions, but an event may not be the trigger. Only if the additional criteria are met - hysteresis, holdoff, and/or additional events in a trigger sequence - the trigger occurs.

Event-specific conditions are:

- Trigger source

- Trigger type and its setup
- Qualification

Trigger sequence

A complex trigger sequence joins two separate events with a delay time and a reset time or reset event. This combination is called "A → B → R" trigger sequence. Similar setups are also known as multi-step trigger or A/B trigger.

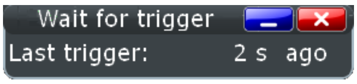
The combination of one event with holdoff conditions defines a simple "A only" sequence.

Trigger information

Information on the most important trigger settings are 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 and trigger sequence
- Trigger type, edge/polarity and trigger source for A- and B-event
- Trigger offset

When no trigger has been found for longer than one second, a message box appears that shows the time elapsed since the last trigger.



External trigger input, analog and digital trigger signals

In R&S RTO, the trigger types use either an analog or a digitized signal as the trigger signal.

If the trigger source is a channel input, the trigger types use a 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 RTO trigger types use the digitized trigger signal.

If the trigger source is the EXT TRIGGER INPUT on the rear panel, only the analog edge trigger is available that use directly the analog input signal. For this analog trigger signal, qualification and the "A → B → R" sequence are not available.

3.2 Setting Up the Trigger

This chapter provides step-by-step procedures for the important stages of trigger setup. The dialog boxes and settings are described in detail in chapter 3.3, "Reference for Triggers", on page 52.

3.2.1 Configuring the Trigger Event

Prerequisites:

- Horizontal and vertical settings are set appropriately to the signals.
- The acquisition is running, the RUN CONT key lights green.

For details on event settings, see chapter 3.3.1, "Events", on page 53.

Proceed as follows:

1. Press the TRIGGER key on the front panel.

   The "Trigger" dialog box opens with the "Events" tab.
2. At the left hand-side, select the vertical tab of the event you want to set up: "A Trigger", "B Trigger", or "R Trigger".
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 "Events" 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.
   To let the instrument find the trigger level, tap "Find level".
   See: chapter 3.3.1, "Events", on page 53
7. If you want to set the "Normal" trigger mode, do either of the following:
   - Press the AUTO/NORMAL key on the front panel until NORMAL lights up.
   - Tap the "Normal" button in the "Control" tab.

3.2.2 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 3.3.5, "Trigger Position", on page 77.

1. Press the TRIGGER key and select the "Trigger Position" tab.

Alternatively, tap the "Trigger" menu and then "Trigger Position".

2. Set the "Reference point" and the "Trigger offset".
   If you want to set the trigger position outside the waveform display, disable "Restrict offset to acquisition range".

3.2.3 Using Holdoff

Holdoff conditions define a waiting time after the current trigger until the next trigger can be recognized. Holdoff is an optional setting to the A-event. You find the holdoff settings in the "Sequence" tab with "A only" trigger sequence selected.

For details on holdoff settings, see "Holdoff mode" on page 75.

1. Press the TRIGGER key and select the "Sequence" tab.
   Alternatively, tap the "Trigger" menu and then "Trigger Sequence".
2. Select the "Trigger sequence": "A only".
3. Select the "Holdoff mode".
4. Enter the "Holdoff settings" belonging to the selected mode.

3.2.4 Setting Up a Trigger Sequence

The complete configuration of a complex "A → B → R" trigger sequence consists of:

- A-event setup
- B-event setup in the same way as for the A-event
- Optional delay time to connect the A- and B-event
- Optional reset by timeout and/or R-trigger

For details on sequence settings, see chapter 3.3.4, "Sequence", on page 74.

1. Press the TRIGGER key and select the "Sequence" tab.
   Alternatively, tap the "Trigger" menu and then "Trigger Sequence".
2. Select the type of the "Trigger sequence": "A → B → R".
3. Tap the "A Event Setup" button and set up the first event.
   See: chapter 3.2.1, "Configuring the Trigger Event", on page 50.
4. In the "Events" tab, select the "B Trigger" tab and set up the edge trigger. Other trigger types are not available for the B-event.
5. Select the "Sequence" tab.
6. Optionally, set the "Delay" the instrument waits after an A event until it recognizes B events.
7. Set the "B event count". The last B event causes the trigger.

8. Additionally, you can define a reset condition: "Enable reset by timeout" and/or "Enable reset event". The sequence restarts with the A-event if no B-event occurs and the reset condition is fulfilled.
   a) If "Enable reset by timeout" is selected, enter the time in "Reset timeout".
   b) If "Enable reset event" is selected, tap the "R Event Setup" button and set up the reset event.
   The trigger types and settings are restricted dependent on the A and B event settings. The instrument provides only possible, reasonable combinations.

3.2.5 Qualifying the Trigger

Qualification considers the states of digital signals on other input channels and their logical combination as an additional trigger event condition. For example, an edge trigger is configured for channel 1, and the instrument triggers only if the signal on channel 2 is high.

If the trigger source is "Extern", qualification is not available.

For details on qualification settings, see chapter 3.3.2, "Trigger Qualification", on page 70.

1. Press the TRIGGER key and select the Trigger Qualification tab.
   Alternatively, tap the "Trigger" menu and then "Trigger Qualification.".
2. At the left hand-side, select the vertical tab of the event you want to qualify: "A Trigger", or "B Trigger". For the R-event, qualification is not available.
3. Select the channel(s) with the digital input signal to be used as qualifying signal(s). Channels used as trigger source for the current event cannot be used for qualification and appear dimmed.
4. Check and set the trigger levels for all used channels, that is, the thresholds for digitization of analog signals.
   You can set all levels to the currently selected value if you select "Couple levels".
5. Set the boolean operation for each channel.
6. If more than one channel is selected, set the logical combination of the channel states.
7. Tap "Qualify" to enable the qualification.

3.3 Reference for Triggers

The setup of a trigger contains mandatory and optional settings. The usage of optional settings depends on the signal characteristics and the test setup.

Mandatory settings are:

- Trigger source: "Source" on page 54
- Trigger type and its setup: "Type" on page 54

This is the critical part of the oscilloscope setup to capture the relevant part of the waveform.

- Trigger mode: "Trigger mode" on page 78
- Trigger position: chapter 3.3.5, "Trigger Position", on page 77

Optional settings are:

- Noise rejection settings: chapter 3.3.3, "Noise Reject", on page 73
- Trigger sequence, a combination of two trigger events: chapter 3.3.4, "Sequence", on page 74
- Qualification: combination of the trigger signal with the state of other channel signals: chapter 3.3.2, "Trigger Qualification", on page 70
- Digital Filter Setup: additional filtering of the trigger signal: chapter 2.3.4, "Digital Filter Setup", on page 43

3.3.1 Events

The setup of the trigger type is the most important part of the trigger definition. It determines the method to identify specific signal phenomena. In principle, all trigger types are available for all events in a trigger sequence, that is, you can combine different types with A-, B-, and R-event. The instrument checks the trigger settings for compatibility and feasibility and disables settings that do not fit the previous settings in the sequence.

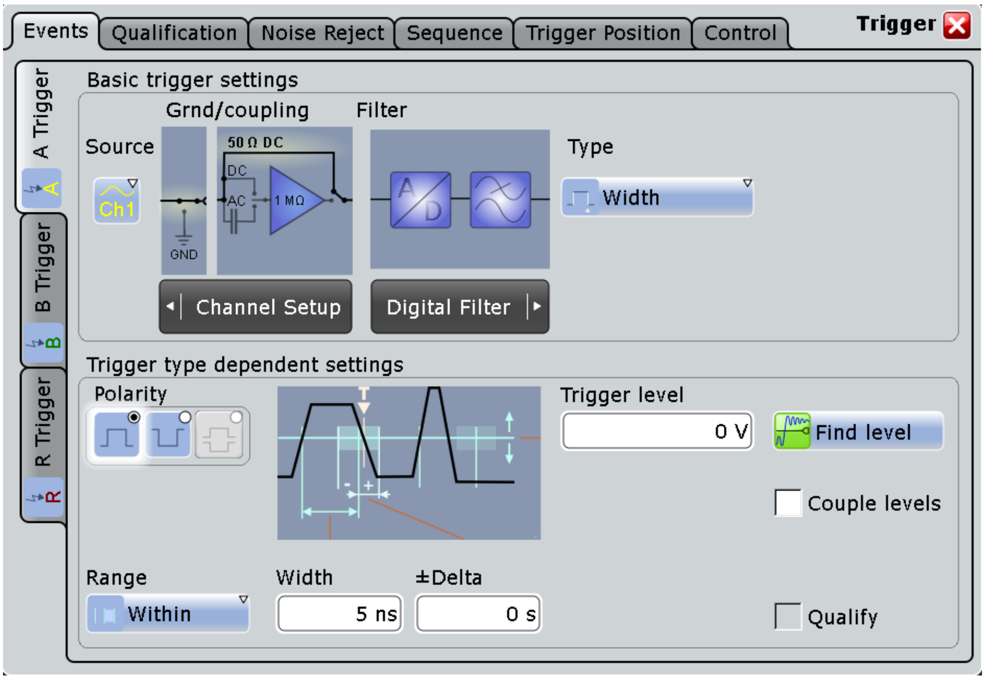
Make sure that the correct trigger tab is selected on the left before you enter the settings.

The settings in the "Event" tab are:

3.3.1.1 Basic Trigger Settings

The basic trigger settings are the trigger source and the trigger type, including the trigger level. These settings are specific for each event in a trigger sequence, that is, specific for A-, B- and R-events. For the trigger source, the current ground/coupling settings are displayed, filtering is also possible.

Additionally, you can let the R&S RTO find the trigger level, set the trigger levels to the same value for all channels and enable trigger qualification. These settings are located under "Trigger type dependent settings".



Source

Selects the source of the trigger signal for the current trigger event. The source can be one of the input channels, a serial bus, or an external analog signal connected to the External Trigger Input on the rear panel. The trigger source works even if it is not displayed in a diagram. It should be synchronized to the signal to be displayed and analyzed.

The external trigger source is supported for the A-event. It is not available if the trigger sequence "A → B → R" is selected, or if qualification is enabled.

SCPI command:

TRIGger<m>:SOURce on page 359

Type

Selects the trigger type specific for each event in a trigger sequence. The current trigger type is shown on the button.

The following trigger types are available:

- Edge, see page 56
- Glitch, see page 57
- Width, see page 58
- Runt, see page 59
- Window, see page 61
- Timeout, see page 62
- Interval, see page 63
- Slew Rate, see page 65
- Data2Clock, see page 66
- Pattern, see page 68

- Serial Pattern, see page 69

Restrictions:

- If the external trigger input is used, only the edge trigger is available. It uses the analog trigger signal instead if the digitized one.
- For the B-event, only edge trigger is available.
- For the R-event (reset), the trigger types and settings are restricted dependent on the A and B event settings. The instrument provides only possible, reasonable combinations.

SCPI command:

`TRIGger<m>:TYPE` on page 359

Ground

If the selected trigger source is the external trigger input, you can connect the trigger input to the ground.

SCPI command:

`TRIGger<m>:ANEDge:GND` on page 364

Coupling

If the selected trigger source is the external trigger input, the analog trigger signal is used, and you can set the coupling for this input.

"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.

SCPI command:

`TRIGger<m>:ANEDge:COUPling` on page 362

Filter

If the selected trigger source is the external trigger input, the analog trigger signal is used for triggering, and you can directly select an additional filter to reject high or low frequencies.

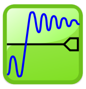
For all trigger types using the digitized signal, you can add a digital filter using the Digital Filter Setup. See: chapter 2.3.4, "Digital Filter Setup", on page 43.

"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.

SCPI command:
`TRIGger<m>:ANEDge:FILTer` on page 363
`TRIGger<m>:ANEDge:CUToff:HIGHpass` on page 362
`TRIGger<m>:ANEDge:CUToff:LOWPass` on page 363



Find level
Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*. The function is not available for an external trigger source.

SCPI command:
`TRIGger<m>:FINDlevel` on page 360

Qualify
Enables the settings for trigger qualification that are defined in the "Qualification" tab. Qualification adds additional trigger conditions considering the logic states of other digital channel signals.

The checkmark is only active if at least one qualification channel is selected.

Qualification is available for many trigger types: Edge, Glitch, Width, Runt, Window, Timeout, and Interval.

Qualification is not possible for the R-event.

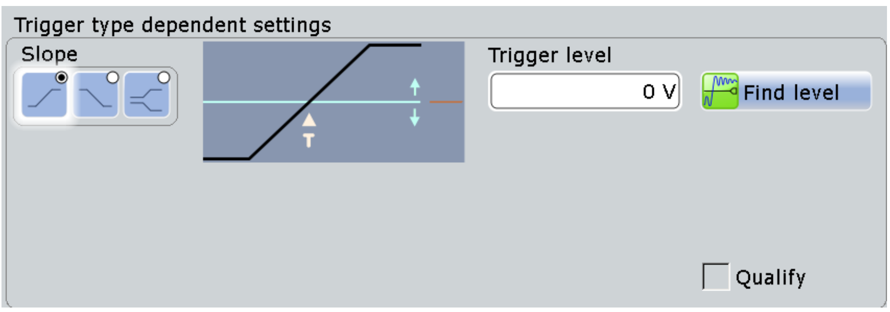
See also: chapter 3.3.2, "Trigger Qualification", on page 70.

3.3.1.2 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 event occurs 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 EXT TRIGGER INPUT, the analog trigger signal is used, and the coupling and filter for this signal is set directly in the trigger setup.



Slope

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. This option is not available if the trigger source is the external trigger input.

SCPI command:

`TRIGger<m>:EDGE:SLOPe` on page 361

`TRIGger<m>:ANEDge:SLOPe` on page 364

`TRIGger<m>:SLEW:SLOPe` on page 375

Trigger level

Sets the voltage level for the trigger event. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display).

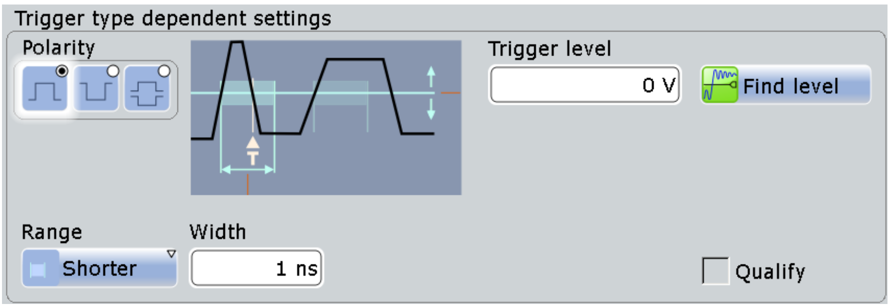
SCPI command:

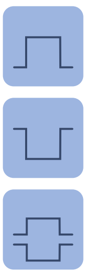
`TRIGger<m>:LEVel<n>[:VALue]` on page 360

`TRIGger<m>:EXTanalog:LEVel` on page 362

3.3.1.3 Glitch

The glitch trigger event 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

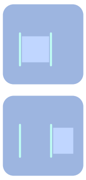
Indicates the polarity of a pulse, that is the direction of the first pulse slope.

"Positive"	Selects positive going pulses.
"Negative"	Selects negative going pulses.
"Either"	Selects both positive and negative going pulses.

SCPI command:

`TRIGger<m>:GLITch:RANGe` on page 365

`TRIGger<m>:RUNT:POLarity` on page 367



Range
Selects which glitches are identified: shorter or longer than the specified "Width".

SCPI command:
TRIGger<m>:GLITch:RANGe on page 365

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.

SCPI command:
TRIGger<m>:GLITch:WIDTh on page 365

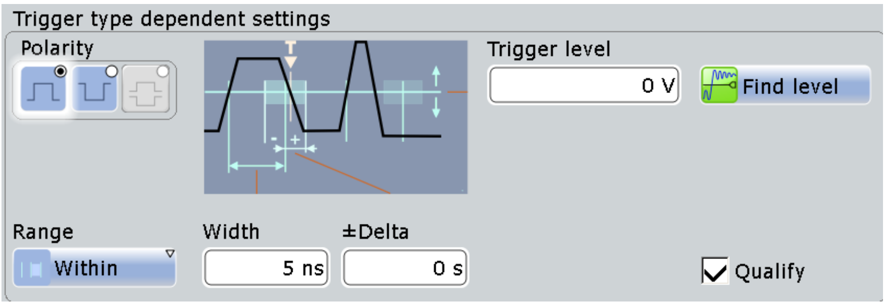
Trigger level
Sets the voltage level for the trigger event. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display).

SCPI command:
TRIGger<m>:LEVel<n>[:VALue] on page 360

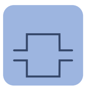
3.3.1.4 Width

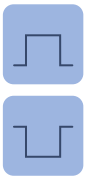
The width trigger detects pulses with a pulse width (duration) inside or outside the allowed time limits. The instrument triggers if the pulse is too long to cross the specified voltage threshold twice, if it is too short, or if it is outside or inside the time range. The pulse width is measured at the trigger level.

Using the width trigger, you can define the pulse width more precisely than with the glitch trigger. However, with 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").



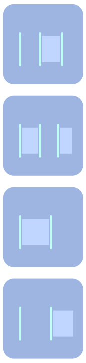


Polarity
Indicates the polarity of a pulse, that is the direction of the first pulse slope.

"Positive" Triggers on positive going pulses.

"Negative" Triggers on negative going pulses.

SCPI command:
`TRIGger<m>:WIDTh:POLarity` on page 366
`TRIGger<m>:INTerval:POLarity` on page 374



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".

SCPI command:
`TRIGger<m>:WIDTh:RANGe` on page 366

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.

SCPI command:
`TRIGger<m>:WIDTh:WIDTh` on page 366

±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".

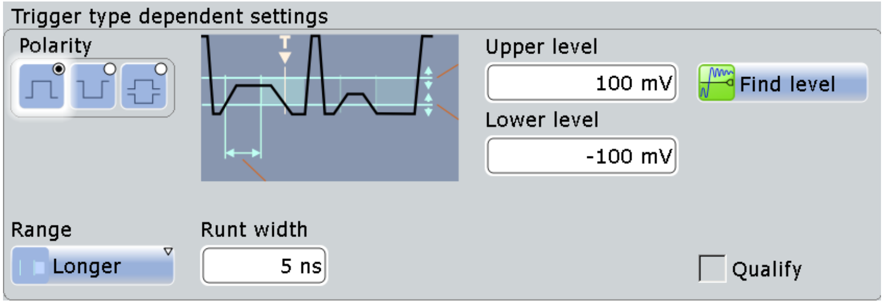
The combination "Range" = Outside and "±Delta" = 0 means to trigger on pulse widths ∓ "Width".

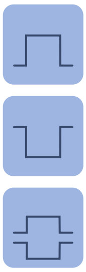
Trigger level
Sets the voltage level for the trigger event. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display).

SCPI command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 360

3.3.1.5 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.

SCPI command:

`TRIGger<m>:GLITch:RANGe` on page 365

`TRIGger<m>:RUNT:POLarity` on page 367

Upper level

Sets the upper voltage threshold.

SCPI command:

`TRIGger<m>:LEVel<n>:RUNT:UPPer` on page 368

Lower level

Sets the lower voltage threshold.

SCPI command:

`TRIGger<m>:LEVel<n>:RUNT:LOWer` on page 368

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.

SCPI command:

`TRIGger<m>:RUNT:RANGe` on page 368

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".

SCPI command:
`TRIGger<m>:RUNT:WIDTh` on page 369

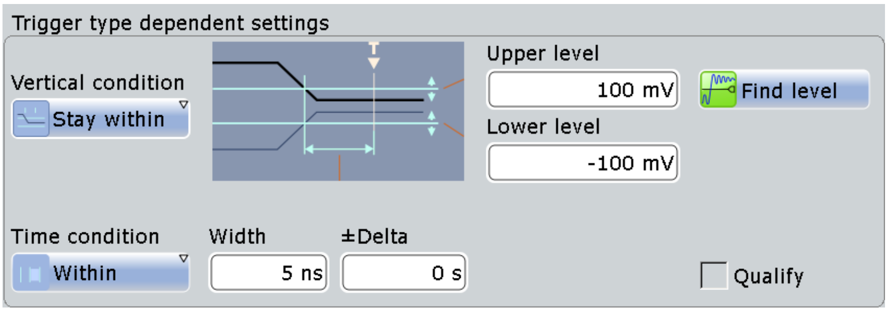
±Delta
Defines a range around the given runt width.

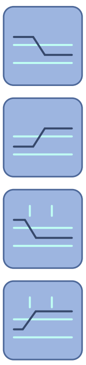
SCPI command:
`TRIGger<m>:RUNT:DELTa` on page 369

3.3.1.6 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 event 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".

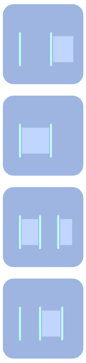
SCPI command:
`TRIGger<m>:WINDow:RANGe` on page 371

Upper level
Sets the upper voltage limit for the window.

SCPI command:
`TRIGger<m>:LEVel<n>:WINDow:UPPer` on page 370

Lower level
Sets the lower voltage limit for the window.

SCPI command:
`TRIGger<m>:LEVel<n>:WINDow:LOWer` on page 370



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 before the specified "Width" time is reached.

SCPI command:
`TRIGger<m>:WINDow:TIME` on page 371

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.

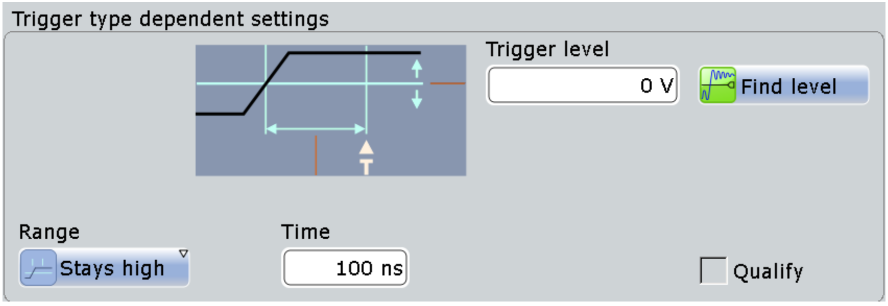
SCPI command:
`TRIGger<m>:WINDow:WIDTh` on page 372

±Delta
Defines a range around the "Width" value.

SCPI command:
`TRIGger<m>:WINDow:DELTa` on page 372

3.3.1.7 Timeout

The timeout trigger event checks if the signal stays above or below the threshold voltage for a specified time lapse. In other words, the event occurs if the trigger source does not have the expected transition within the specified time.



Trigger level
Sets the voltage level for the trigger event. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display).

SCPI command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 360

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.

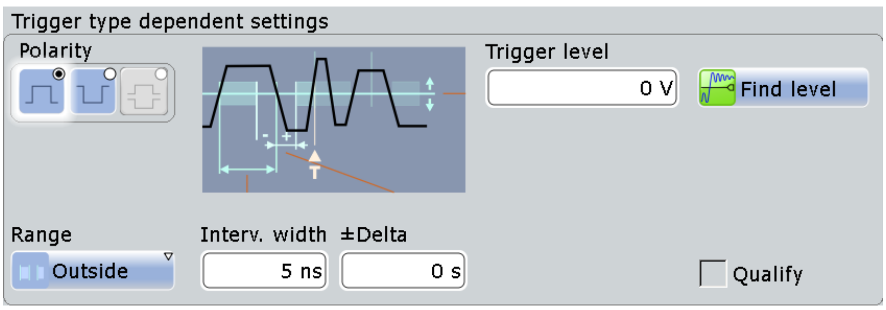
SCPI command:
`TRIGger<m>:TIMeout:RANGe` on page 373

Time
Defines the time limit for the timeout at which the instrument triggers.

SCPI command:
`TRIGger<m>:TIMeout:TIME` on page 373

3.3.1.8 Interval

The interval trigger analyzes the time between two pulses.



While the interval trigger can only analyze **either** positive **or** negative polarity, searching for an interval 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.

SCPI command:
`TRIGger<m>:WIDTh:POLarity` on page 366
`TRIGger<m>:INTerval:POLarity` on page 374

Trigger level
Sets the voltage level for the trigger event. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display).

SCPI command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 360

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".

SCPI command:
`TRIGger<m>:INTerval:RANGe` on page 374

Interv. width
Defines the time between two pulses.

SCPI command:
`TRIGger<m>:INTerval:WIDTh` on page 374

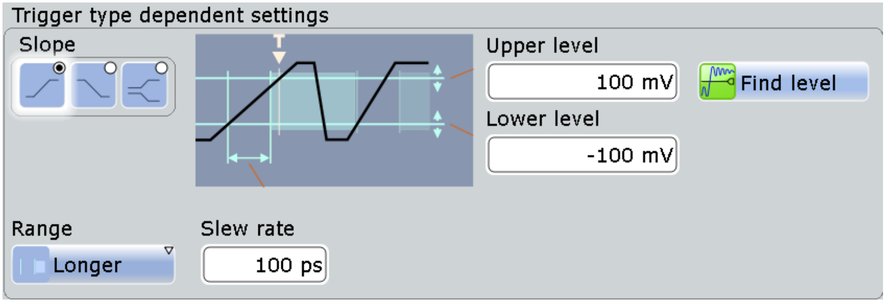
±Delta
Defines a range around the "Interval width" value.

SCPI command:
`TRIGger<m>:INTerval:DELTa` on page 375

3.3.1.9 Slew Rate

The slew rate trigger, also known as transition trigger, can detect fast or slow edges selectively. It triggers on edges, if the transition time from the lower to higher voltage level (or vice versa) is shorter or longer as defined, or outside a specified time range.

The trigger event finds slew rates faster than expected or permissible to avoid over-shooting and other interfering effects. It also detects very slow edges violating the timing in pulse series.



Slope

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. This option is not available if the trigger source is the external trigger input.

SCPI command:

`TRIGger<m>:EDGE:SLOPe` on page 361

`TRIGger<m>:ANEDge:SLOPe` on page 364

`TRIGger<m>:SLEW:SLOPe` on page 375

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.

SCPI command:

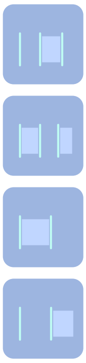
`TRIGger<m>:LEVel<n>:SLEW:UPPer` on page 376

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.

SCPI command:

`TRIGger<m>:LEVel<n>:SLEW:LOWer` on page 376



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 - and 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.

SCPI command:

`TRIGger<m>:SLEW:RANGe` on page 376

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.

SCPI command:

`TRIGger<m>:SLEW:RATE` on page 377

±Delta

Defines a time range around the given slew rate.

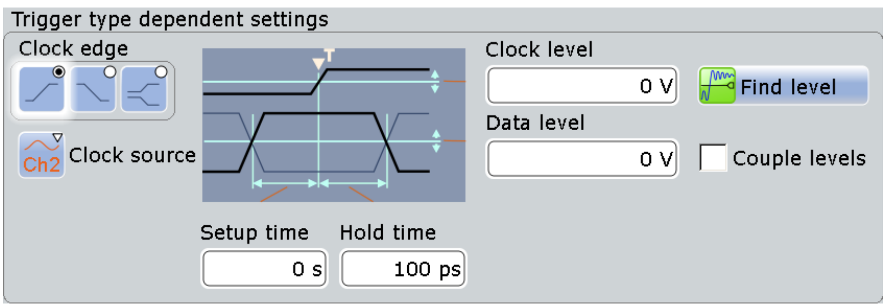
SCPI command:

`TRIGger<m>:SLEW:DELTa` on page 377

3.3.1.10 Data2Clock

With the Data2Clock event - also known as setup/hold - 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 inband signals.

The event 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.

SCPI command:

TRIGger<m>:DATatoclock:CSOurce[:VALue] on page 378

TRIGger<m>:SPATtern:CSOurce[:VALue] on page 382

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.

SCPI command:

TRIGger<m>:DATatoclock:CSOurce:EDGE on page 378

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.

SCPI command:

TRIGger<m>:DATatoclock:CSOurce:LEVel on page 379

Data level

Sets the voltage level for the data signal. At this level, the setup and hold time is measured.

SCPI command:

TRIGger<m>:LEVel<n>[:VALue] on page 360

Couple levels

Sets the trigger levels for all channels to the value of the currently selected trigger source. The function affects only the levels defined for the selected event.

If the levels are coupled, also the hysteresis is the same for all trigger sources - channels, external trigger input and buses.

In trigger sequences, event coupling of trigger levels is possible: "Couple levels of all events" on page 76

SCPI command:

TRIGger<m>:SCOupling on page 361

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. 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.

SCPI command:

TRIGger<m>:DATatoclock:STIMe on page 379

Hold time
Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

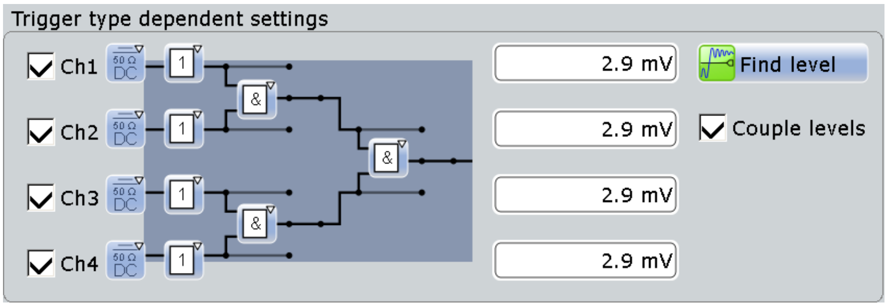
The hold time can be negative. In this case, the setup time is always positive. The setup/hold interval starts before the clock edge (setup time) and ends before the clock edge (hold time). If you change the negative hold time, the setup time is adjusted by the intrument.

SCPI command:
TRIGger<m>:DATatoclock:HTIMe on page 379

3.3.1.11 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 very 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.



For details on pattern definition, see "Pattern" on page 71.

Trigger Levels
Defines the trigger levels for all input channels. 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" on page 67.

State timing
"State timing" adds additional time limitation to the state pattern. You find this setting in the "Qualification" tab.

"Off" No time limitation. The event occurs if the pattern condition is fulfilled.

"Timeout" Defines how long the result of the state pattern condition must be true or false.

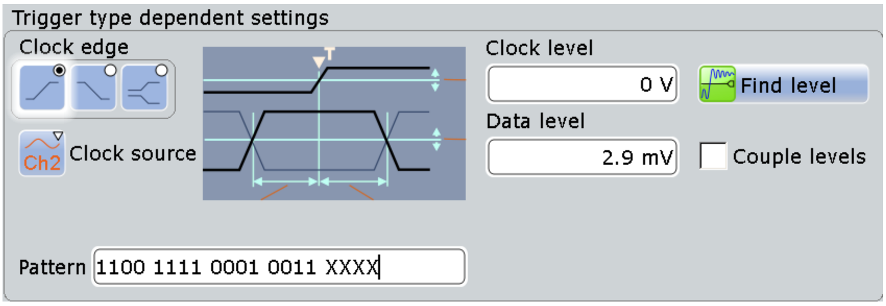
"Width" Defines a time range for keeping up the true result of the state pattern condition. The range is defined in the same way as for width and interval triggers, see "Range" on page 59.

SCPI command:
TRIGger<m>:PATTern:MODE on page 380
TRIGger<m>:PATTern:TIMeout:MODE on page 380
TRIGger<m>:PATTern:TIMeout[:TIME] on page 381
TRIGger<m>:PATTern:WIDTh:DELTa on page 382
TRIGger<m>:PATTern:WIDTh:RANGe on page 381
TRIGger<m>:PATTern:WIDTh[:WIDTh] on page 382

3.3.1.12 Serial Pattern

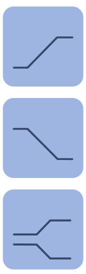
The serial pattern event is used to trigger on signals with serial data patterns in relation to a clock signal - for example, on bus signals like the I²C bus.

For convenient and comprehensive triggering on specific serial data, options for serial protocol analysis are provided, see chapter 9, "Protocol Analysis", on page 230.



Clock source
Selects the input channel of the clock signal.

SCPI command:
TRIGger<m>:DATatoclock:CSOurce[:VALue] on page 378
TRIGger<m>:SPATtern:CSOurce[:VALue] on page 382



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.

SCPI command:
TRIGger<m>:SPATtern:CSOurce:EDGE on page 383

Clock level

Sets the voltage level for the clock signal.

SCPI command:

`TRIGger<m>:SPATtern:CSOurce:LEVel` on page 383

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.

SCPI command:

`TRIGger<m>:LEVel<n>[:VALue]` on page 360

Couple levels

Sets the trigger levels for all channels to the value of the currently selected trigger source. The function affects only the levels defined for the selected event.

If the levels are coupled, also the hysteresis is the same for all trigger sources - channels, external trigger input and buses.

In trigger sequences, event coupling of trigger levels is possible: "Couple levels of all events" on page 76

SCPI command:

`TRIGger<m>:SCOupling` on page 361

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.

See also: chapter 9.1.3, "Bit Pattern Editor", on page 232.

In binary format, an *X* indicates that the logical level for the bit is not relevant (don't care).

SCPI command:

`TRIGger<m>:SPATtern:PATTern` on page 383

3.3.1.13 Triggering on Serial Buses

Protocol analysis including configuration, triggering, and decoding is described in chapter 9, "Protocol Analysis", on page 230

For specific information on triggering on serial buses, see:

- chapter 9.2.3.2, "I²C Trigger", on page 237
- chapter 9.3.3.2, "SPI Trigger", on page 248
- chapter 9.4.2.2, "UART Trigger", on page 255

3.3.2 Trigger Qualification

By qualifying a trigger event, you can logically combine the trigger signal with the state of other digital channel signals.

The instrument triggers if both of the following apply:

- The basic conditions of the trigger event definition are fulfilled.
- The logical conditions of the trigger qualification are true.

The A-event and B-event in a trigger sequence can have their own trigger qualification. Qualification is not supported with slew rate, Data2Clock, and serial pattern trigger types.

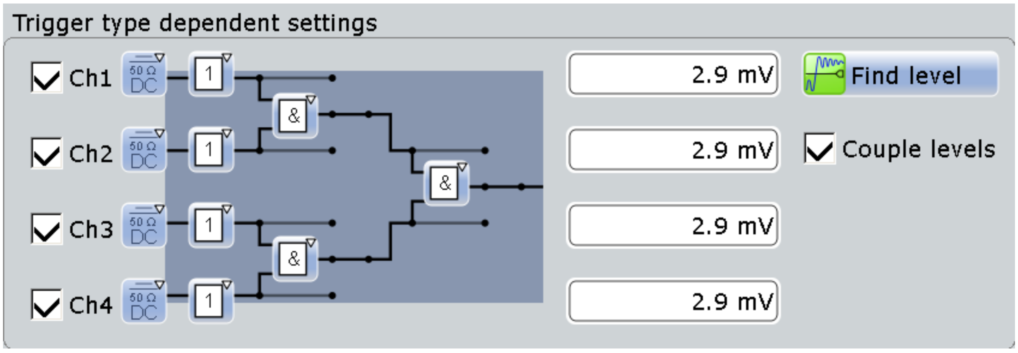
► To enable the qualification settings, select Qualify.

Example: Trigger on write access of a specific device of a bus system

In circuits using SPI, several slave devices use the same lines for reading and writing data, and each slave has its own select line. To trigger on write access of specific slave, the write line is the trigger source and the select line of the slave is set as qualifiying condition.

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

SCPI command:
TRIGger<m>:QUALify<n>:A:LOGic on page 386
TRIGger<m>:QUALify<n>:A[:ENABle] on page 385
TRIGger<m>:QUALify<n>:AB:LOGic on page 386
TRIGger<m>:QUALify<n>:ABCD:LOGic on page 386
TRIGger<m>:QUALify<n>:B:LOGic on page 386
TRIGger<m>:QUALify<n>:B[:ENABle] on page 385
TRIGger<m>:QUALify<n>:C:LOGic on page 386
TRIGger<m>:QUALify<n>:C[:ENABle] on page 385
TRIGger<m>:QUALify<n>:CD:LOGic on page 386
TRIGger<m>:QUALify<n>:D:LOGic on page 386
TRIGger<m>:QUALify<n>:D[:ENABle] on page 385
TRIGger<m>:QUALify<n>:STATe on page 385
TRIGger<m>:ECOupling on page 361

Trigger Levels
Provides an overview of the current trigger levels of all input channels. For qualification and the pattern trigger, the trigger level is a decision treshold: 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.

Couple levels
Sets the trigger levels for all channels to the value of the currently selected trigger source. The function affects only the levels defined for the selected event.

If the levels are coupled, also the hysteresis is the same for all trigger sources - channels, external trigger input and buses.

In trigger sequences, event coupling of trigger levels is possible: "Couple levels of all events" on page 76

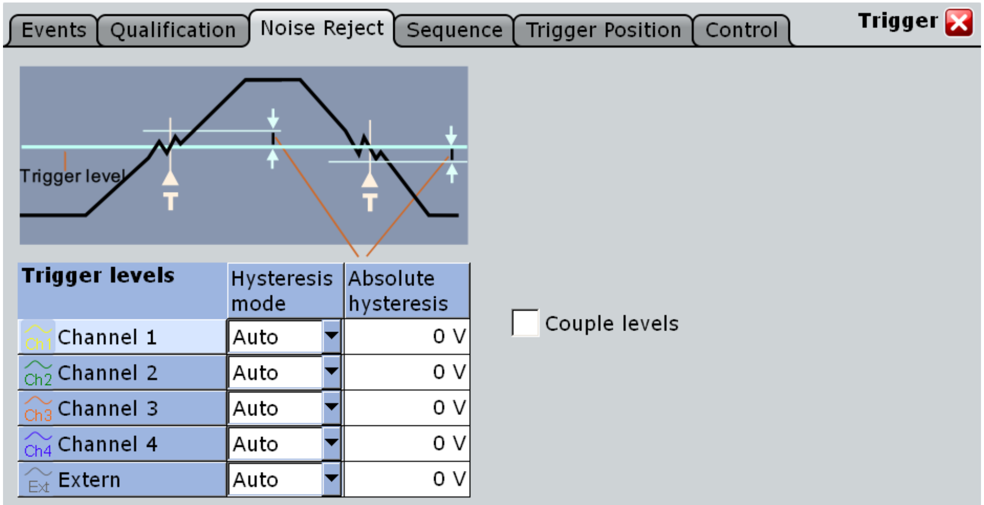
SCPI command:
TRIGger<m>:SCOupling on page 361

Qualify
Enables the settings for trigger qualification. As soon as a qualification pattern is defined, the option is selected by default.

3.3.3 Noise Reject

The rejection of noise by settting 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, or couple the trigger levels and set the same hysteresis for all channels.



Hysteresis mode

Selects how the hysteresis is set.

"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 in "Absolute hysteresis".

"Manual" The hysteresis is defined directly with "Absolute hysteresis".

SCPI command:

`TRIGger<m>:LEVel<n>:NOISe[:STATe]` on page 387

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.

SCPI command:

`TRIGger<m>:LEVel<n>:NOISe:ABSolute` on page 387

Couple levels

Sets the trigger levels for all channels to the value of the currently selected trigger source. The function affects only the levels defined for the selected event.

If the levels are coupled, also the hysteresis is the same for all trigger sources - channels, external trigger input and buses.

In trigger sequences, event coupling of trigger levels is possible: "Couple levels of all events" on page 76

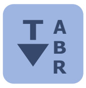
SCPI command:

`TRIGger<m>:SCOupling` on page 361

3.3.4 Sequence

A trigger sequence consists of at least one trigger event and additional conditions defining when the trigger occurs.

The simple sequence "A only" contains an A-event and the holdoff setting as optional condition.



The complex trigger sequence "A → B → R" consists of two events - A and B - and an optional reset condition. After the A-event conditions have been met, the B-event with independent conditions is enabled. A- and B-events are configured in the same way.

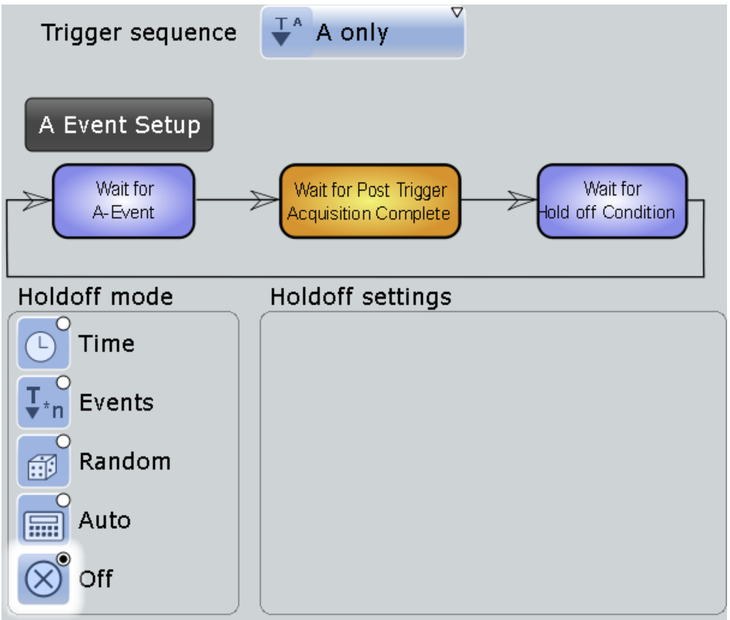
Without any reset, the instrument waits until one or a specified number of B-events occurs that causes the trigger, and then the sequence starts again. If you expect, for example, an irregular B-trigger event, you can configure a reset condition to restart the sequence with the A-event. The reset condition can be a simple timeout, or a trigger event that is defined in the same way as the A- and B-trigger events.

The instrument checks the trigger settings for compatibility and disables settings that do not fit the previous settings in the sequence.

See also: chapter 3.2.4, "Setting Up a Trigger Sequence", on page 51.

3.3.4.1 A Only

The "A only" sequence contains an A-event and the holdoff setting as optional condition.



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.

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

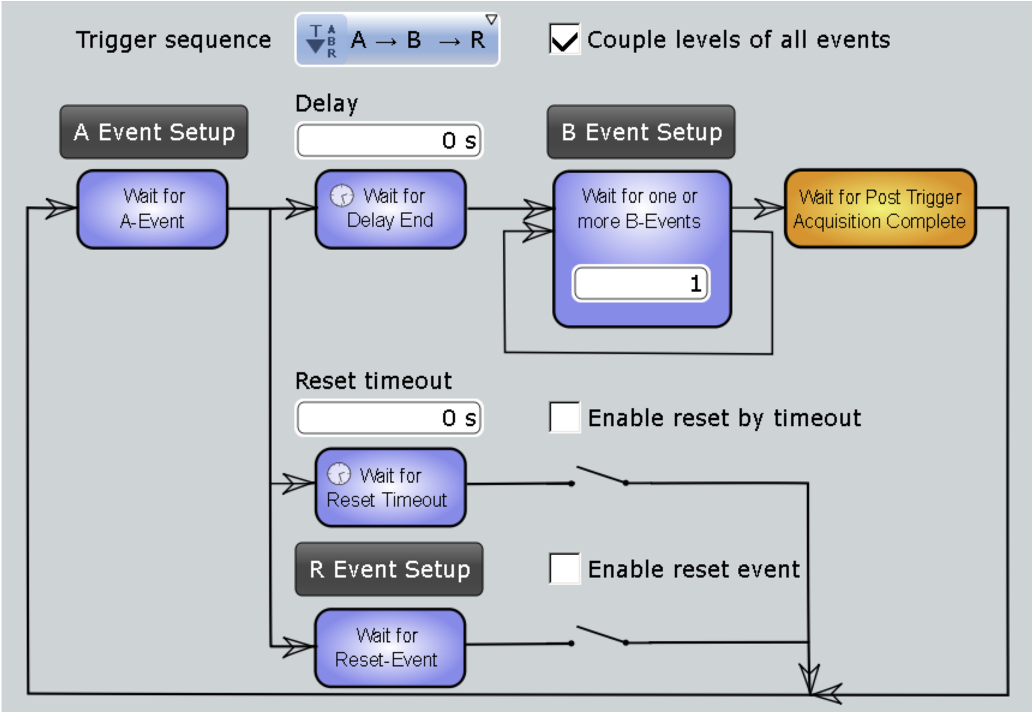
SCPI command:

`TRIGger<m>:HOLDoff:MODE` on page 390
`TRIGger<m>:HOLDoff:TIME` on page 391
`TRIGger<m>:HOLDoff:EVENts` on page 392
`TRIGger<m>:HOLDoff:MAX` on page 392
`TRIGger<m>:HOLDoff:MIN` on page 392
`TRIGger<m>:HOLDoff:AUTotime` on page 393
`TRIGger<m>:HOLDoff:SCALing` on page 393

3.3.4.2 A - B - R

The complex trigger sequence "A → B → R" consists of two trigger events - A and B - and an optional reset condition.

See also: chapter 3.2.4, "Setting Up a Trigger Sequence", on page 51.



Couple levels of all events
Sets the channel trigger levels of the A-, B-, and R-event to the values of the current event (per channel).

Example:

If the "A Trigger" tab is selected in the "Events" tab, and the trigger level for Ch1 is 70 mV, the event coupling sets the trigger levels for Ch1 in the B- and R-events also to 70 mV.

SCPI command:
`TRIGger<m>:ECOupling` on page 361

Delay
Sets the time the instrument waits after an A-event until it recognizes B-events.

SCPI command:
`TRIGger<m>:SEQuence:DELay` on page 389

Wait for one or more B-events
Sets the number of B-events to be fulfilled after an A-event. The last B-event causes the trigger. The waiting time for B-events can be restricted with a reset condition: timeout or reset event.

SCPI command:
`TRIGger<m>:SEQuence:COUNt` on page 389

Enable reset by timeout, Reset timeout

If enabled, the instrument waits for the specified time for the specified number of B-events. If no trigger occurs during that time, the sequence is restarted with the A-event.

SCPI command:

`TRIGger<m>:SEQuence:RESet:TIMeout[:ENABle]` on page 389

`TRIGger<m>:SEQuence:RESet:TIMeout:TIME` on page 390

Enable reset event

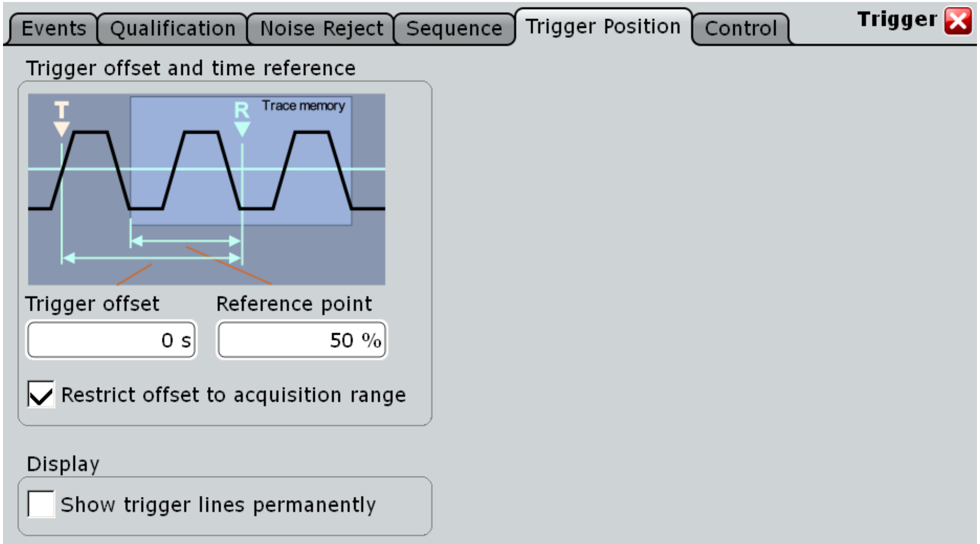
If enabled, the trigger sequence is restarted by the R-event if the specified number of B-event does not occur before the R-event conditions are fulfilled.

SCPI command:

`TRIGger<m>:SEQuence:RESet:EVENt` on page 389

3.3.5 Trigger Position

The horizontal position is the location of the trigger in the waveform record. It is defined by two parameters: the "Reference point" and the "Trigger offset". They determine how much the instrument acquires before and after the trigger, and which data is shown in the diagram.



The pretrigger part of the waveform can help troubleshooting, for example, to find the cause of a glitch. The posttrigger part shows what follows the trigger.

Trigger offset

Adds a time offset to the reference point to choose the part of the waveform to be captured and shown in the diagram. Thus, you can set the trigger outside the diagram and analyze the signal some time before or after the trigger. Positive values move the trigger to the right of the reference point to show the pre-trigger part of the signal.

SCPI command:

`TIMebase:POSition` on page 339

Reference point
Sets the zero point of the time scale in % of the display between 10% and 90%. The reference point defines which part of the waveform is shown. If the "Trigger offset" is zero, the trigger point matches the reference point.

SCPI command:
`TIMebase:REFerence` on page 340

Restrict offset to acquisition range
Ensures that the trigger occurs within one acquisition cycle. If enabled, the trigger cannot be set outside the waveform diagram.

SCPI command:
`TRIGger<m>:OFFSet:LIMited` on page 394

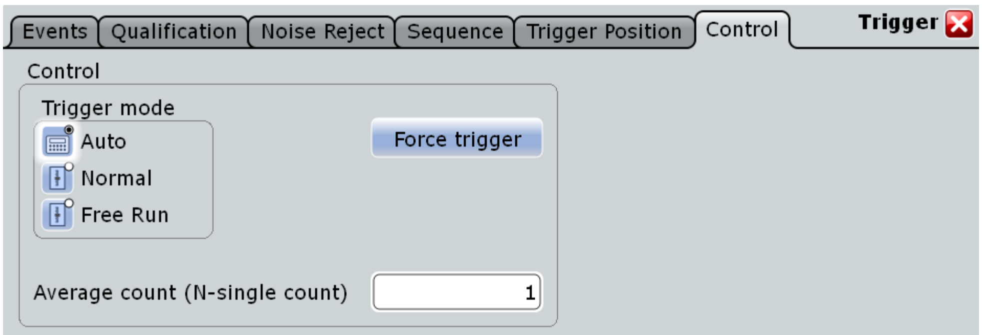
Show trigger lines permanently
Displays the trigger levels in the diagrams until you disable this option.

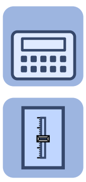
SCPI command:
`DISPlay:TRIGger:LINes` on page 359

3.3.6 Control

The settings and functions of trigger control define when the instrument triggers. They affect all kinds of trigger events and all triggers in a trigger sequence.

In addition to the settings in the dialog box, you need the RUN keys on the front panel to start and stop the triggering and thus the acquisition.





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.

SCPI command:
`TRIGger<m>:MODE` on page 395

Average count

The "Average count" has a double effect:

- It defines the number of waveforms used to calculate the average waveform.
- It sets the number of waveforms acquired with RUN N× SINGLE.

Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the "Average count" is, the better the noise is reduced.

SCPI command:
`ACQuire:COUNt` on page 345

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.

SCPI command:
`TRIGger<m>:FORCe` on page 395

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".

SCPI command:
`RUN` on page 338
`SINGle` on page 338
`STOP` on page 338

4 Display

4.1 Display Customization

4.1.1 Display Settings

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. In addition, the timebase label and trigger label provide general information for all displayed channels.

The signal bar can be manually switched on and off or automatically hided.

Toolbar

The toolbar contains icons for 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 configure user-defined diagram names.

Waveforms

For waveforms, you can adjust the persistence, the waveform style and the signal colors. Signal colors change the waveform display by means of color tables defining the color of waveform pixels depending on the cumulative occurance of the associated values. For each waveform you can assign a different color table.

The following default color tables are provided:

- "Temperature": shade of color changes gradually from blue (low temperature) to red (high temperature) with increasing cumulative occurance.
- "False colors": color changes gradually in a wide color spectrum with increasing cumulative occurance.
- Spectrum: colors used to display the wave lengths of the light are assigned to the cumulative occurance. High cumulative occurance is displayed blue like high wave lenght.

- Single event: single events and very seldom events appear yellow, a higher cumulative occurance is shown with blue color. This view helps to indentify specific events.

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.

4.1.2 Adjusting the Display

To change the diagram name

► Double-tap the diagram tab name. The on-screen keyboard opens to enter the new name.

4.1.2.1 Editing Signal Colors

For each waveform, you can 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.

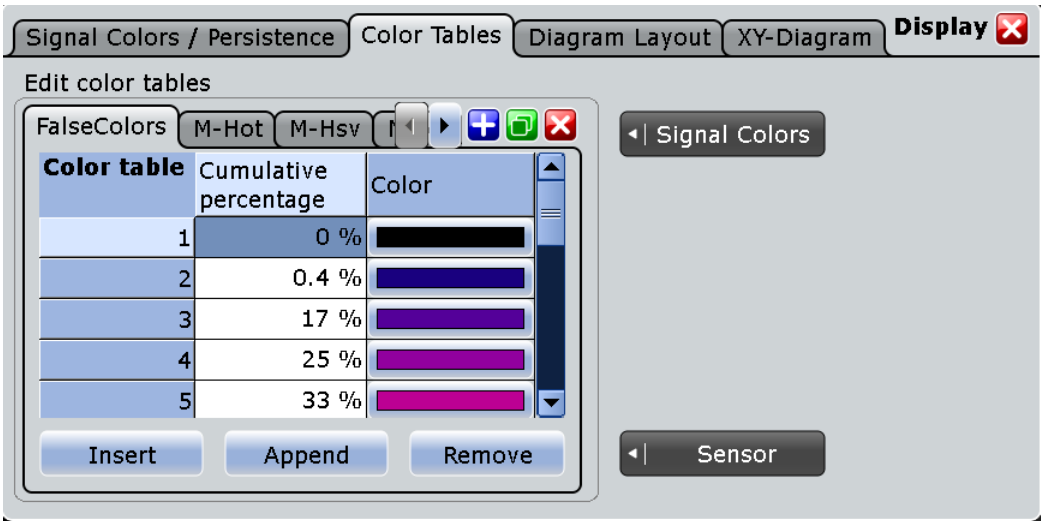
The exact mapping of the cumulative value occurences according to the assigned color table is guaranteed only if the intensity is set to 50%. All other intensity values falsify the mapping but may improve the visibility of the signal.

See also: "Intensity" on page 86.

For details on signal color settings, see chapter 4.1.3.2, "Color Tables", on page 88.

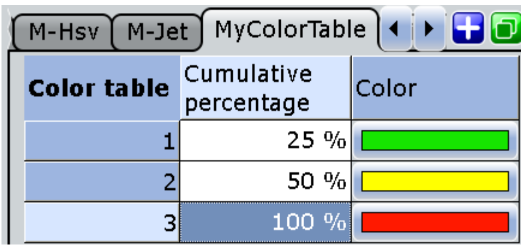
To edit a color table

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 occurance 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 and tap "Insert".
   - To remove an entry, tap the entry, then tap "Remove".
4. Assign a color to each entry: Tap the "Color" cell and select a predefined color, or define your own color.

Example:



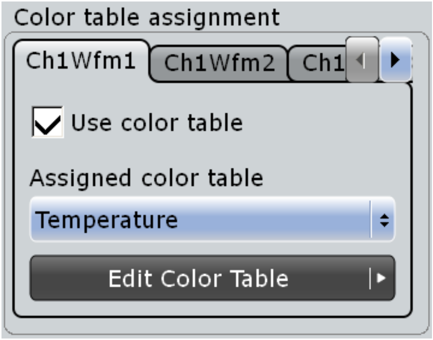
In this example, values with a cumulative occurance under 25% (very short or rare display) are displayed green, whereas values with an occurance of 40% are yellow-green, and values with an occurance of 90% (displayed almost for the entire duration of the signal) are a deep shade of orange.

To create a new 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 waveform.

   The waveform colors are displayed according to the definition in the color table.

4.1.2.2 Using the Signal bar

The signal bar can hold a large number of signal and result icons. Signal icons represent the waveforms, while result icons are minimized result boxes showing measurement and search results. If the signal bar contains more than five icons, not all icons are visible on the display.

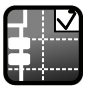
To scroll the signal bar

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

If you need the complete screen to see the diagrams, you can switch off the signal bar completely or fade it automatically.

To switch the signal bar on and off

► 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 and trigger label on the top and drag the signal bar 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 is not hidden 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 opacity": Opacity of the hidden signal bar on a scale from 30% (high transparency) to 80% (lower transparency and better visibility)
   - 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 to be used.
5. To use a color that is not yet defined, tap "Userdefined Colors" and define the new color's 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.

4.1.2.3 Configuring Dialog 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 dialogs

1. Press SETUP.
2. In the "Screen" tab, enter the desired font size in points for all dialog box texts. Most dialog boxes are optimized for a font size of 19 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.

4.1.2.4 Configuring the Toolbar

You can configure which icons are visible on the toolbar and which are hidden, so that only the ones you use are displayed. Furthermore, you can define whether or not the current date and time are displayed on the toolbar.

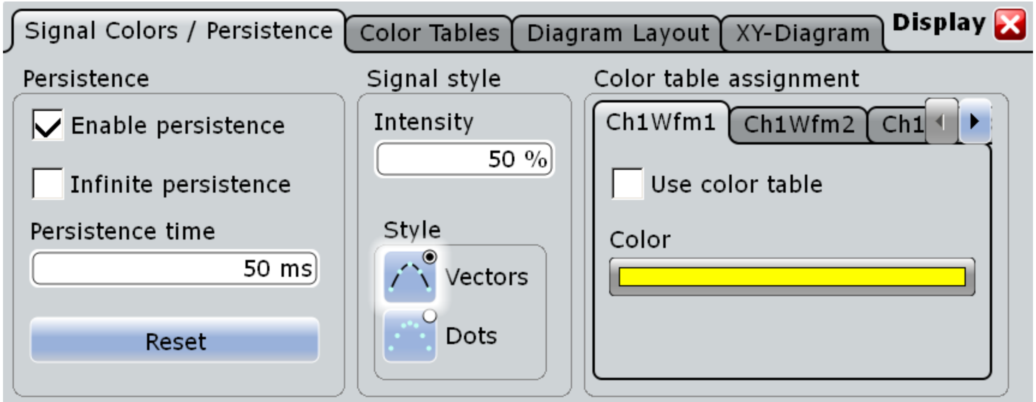
1. From the "Display" menu, select "Toolbar".
2. For each available icon, select the "Visible" option for those to be displayed.
   To display all available icons, tap "Show All".
   To hide all available icons, tap "Hide All".
3. Enable the "Show date and time" option to display the current date and time on the toolbar.

4.1.3 Reference for 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.

4.1.3.1 Signal Colors / Persistence

The "Signal 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.

SCPI command:
DISPlay:PERSistence[:STATe] on page 396

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

SCPI command:
DISPlay:PERSistence:INFinite on page 396

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

SCPI command:
DISPlay:PERSistence:TIME on page 396

Reset
Resets the display, removing persistent values.

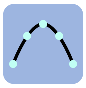
SCPI command:
DISPlay:PERSistence:RESet on page 397

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 occurences 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 4.1.2.1, "Editing Signal Colors ", on page 81.

SCPI command:
`DISPlay:INTensity` on page 397

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 acquision 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, and the waveform on the screen might look like a line.
Consider also the "Interpolation mode" on page 32.

SCPI command:
`DISPlay:DIAGram:STYLe` on page 397

Color
Shows the default color of the selected waveform. The color cannot be changed.

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

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

SCPI command:
`DISPlay:COLor:SIGNal<m>:USE` on page 398

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:
- each waveform of any channel
- a reference waveform
- the results of a mathematical function
- a stored measurement
- an xy-diagram

The following default color tables are provided:
- "Temperature": shade of color changes gradually from blue (low temperature) to red (high temperature) with increasing cumulative occurance.
- "False colors": color changes gradually in a wide color spectrum with increasing cumulative occurance.

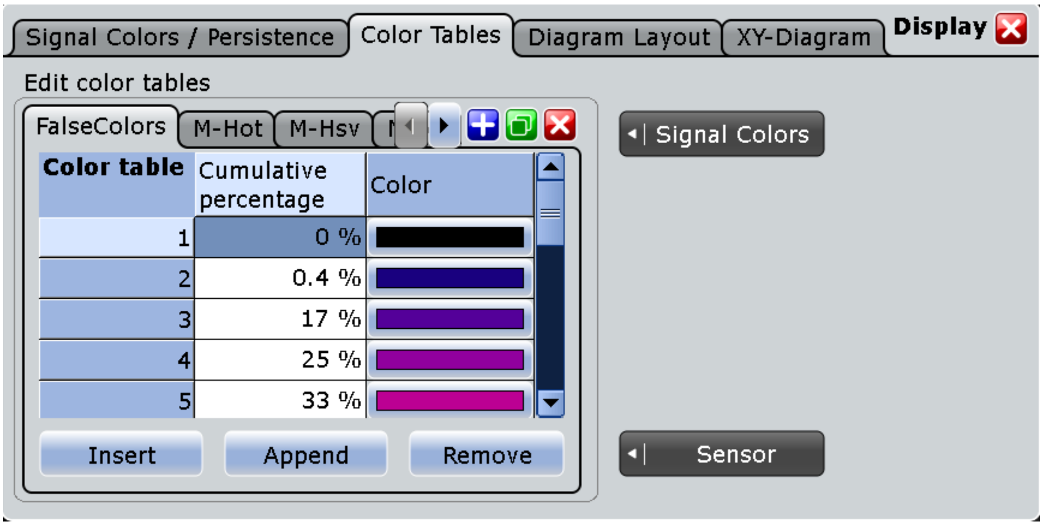
- Spectrum: colors used to display the wave lengths of the light are assigned to the cumulative occurance. High cumulative occurance is displayed blue like high wave lenght.
- Single event: single events and very seldom events appear yellow, a higher cumulative occurance is shown with blue color. This view helps to indentify specific events.

SCPI command:

DISPlay:COLor:SIGNal<m>:ASSign on page 397

4.1.3.2 Color Tables

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



The following default color tables are provided:

- Temperature
- False colors
- Spectrum
- Single event
- M-Hot
- M-Hsv
- M-Jet

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 4.1.2.1, "Editing Signal Colors ", on page 81
- Assigned color table

Remote commands

The following remote commands can be used to configure color tables:

DISPlay:COLor:PALette:COUNt on page 399

DISPlay:COLor:PALette:ADD on page 398

DISPlay:COLor:PALette:REMove on page 398

DISPlay:COLor:PALette:POINt:INSert on page 399

DISPlay:COLor:PALette:POINt:ADD on page 399

DISPlay:COLor:PALette:POINt[:VALue] on page 399

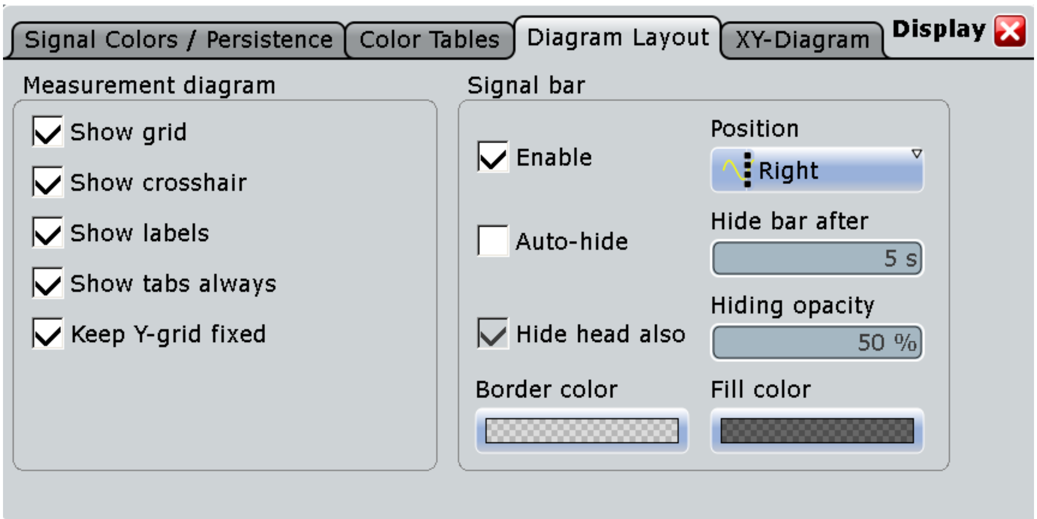
DISPlay:COLor:PALette:POINt:COUNt on page 400

DISPlay:COLor:PALette:POINt:REMove on page 399

DISPlay:COLor:PALette:COUNt on page 399

4.1.3.3 Diagram Layout

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



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.

SCPI command:
DISPlay:DIAGram:GRID on page 400

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.

SCPI command:

`DISPlay:DIAGram:CROSshair` on page 401

Show labels

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

SCPI command:

`DISPlay:DIAGram:LABels` on page 401

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 those in a tabbed diagram. In tabbed diagrams, the tab titles are required to change the tabs.

SCPI command:

`DISPlay:DIAGram:TITLe` on page 401

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. This reflects the behavior of traditional oscilloscopes.

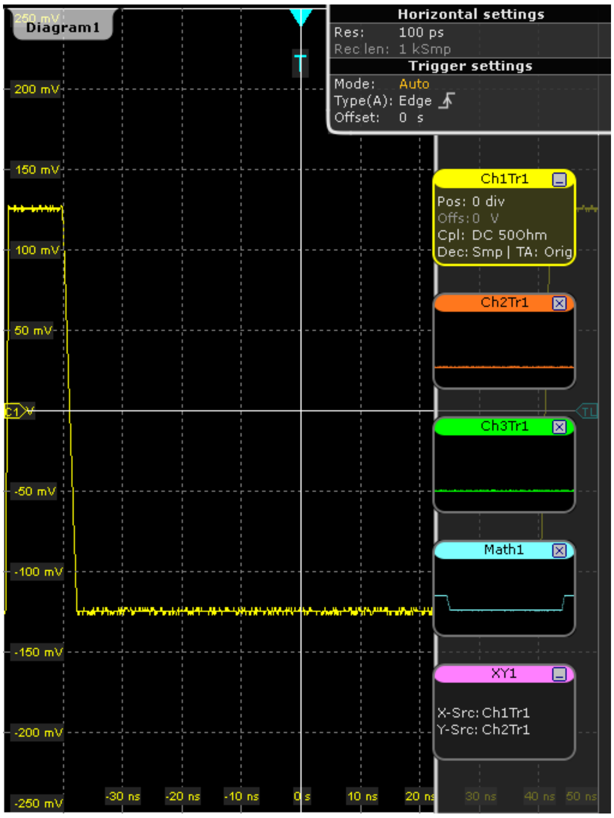
SCPI command:

`DISPlay:DIAGram:YFIXed` on page 401

Enable

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. In addition, the timebase label and trigger label provide general information for all displayed channels.



SCPI command:
DISPlay:SIGBar[:STATe] on page 401

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

SCPI command:
DISPlay:SIGBar:POSition on page 402

Auto-hide
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.

SCPI command:
DISPlay:SIGBar:HIDE[:AUTO] on page 402

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

SCPI command:
DISPlay:SIGBar:HIDE:TIME on page 402

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

SCPI command:
DISPlay:SIGBar:HIDE:HEAD on page 402

Hiding transparency
Sets the transparency of the signal bar. The minimum value is 30%, the maximum value is 70% for the least visibility of the signal bar.

SCPI command:
DISPlay:SIGBar:HIDE:OPACity on page 403

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

For details see "To change the colors" on page 84.

SCPI command:
DISPlay:SIGBar:COLor:BORDer on page 403

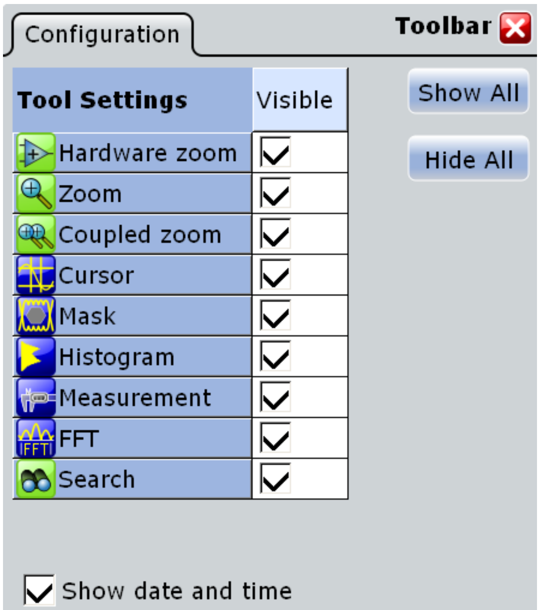
Fill color
Opens a color selection dialog box to define the fill color of the signal bar.

For details see "To change the colors" on page 84.

SCPI command:
DISPlay:SIGBar:COLor:FILL on page 403

4.1.3.4 Toolbar

The "Toolbar" dialog box is displayed when you select "Toolbar" in the "Display" menu. Here you can configure the contents of the toolbar.



Tool Settings
Defines the visibility of selected toolbar icons.

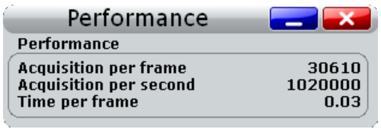
Show All
Displays all available toolbar icons.

Hide All
Hides all toolbar icons.

Show date/time
Displays the current date and time on the toolbar.

4.1.3.5 Performance

Information on the current acquisition performance values of the R&S RTO is available by selecting the "Display > Performance" menu entry.



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 recoprocal "Time per frame". If the time scale decreases, and thus the number of Acquisitions per second also decreases, the number od acquisisions per frame can drop to 1.

4.1.3.6 Clear Screen Results

The function "Clear screen results" in the "Display" menu resets all results in all measurement result boxes including long term measurement and statistic results and deletes the current measurement waveforms.

4.2 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.

4.2.1 Methods of Zooming

The R&S RTO provides the usual way 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:

- **Graphically** by drawing and moving the zoom area on the touch screen – a very quick and simple method for hardware zoom and zoom diagrams
- **Numerically** by entering x- and y-values in a dialog box – a more precise method 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.

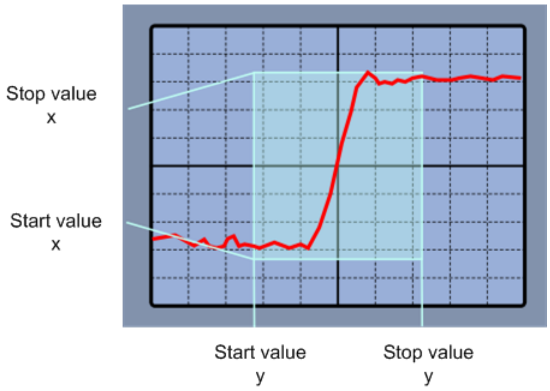


Fig. 4-1: Numeric zoom using start and stop values

  – 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.

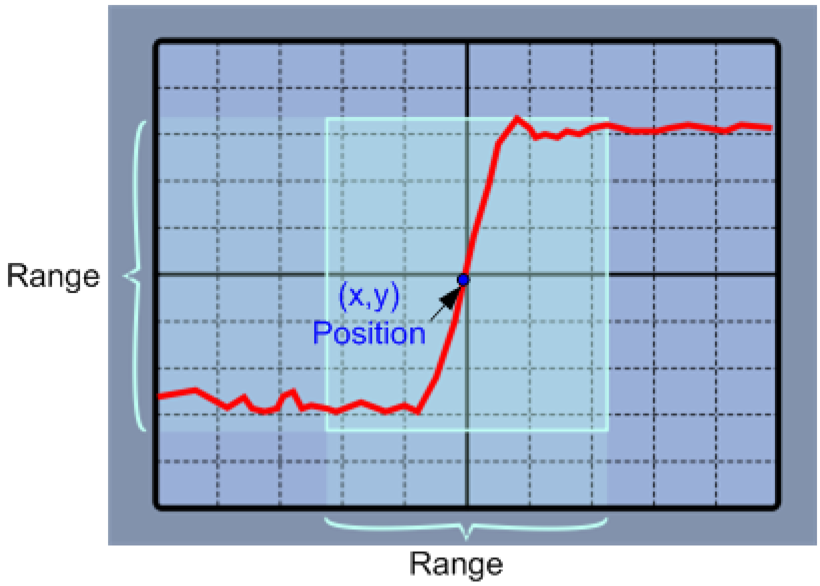


Fig. 4-2: Numeric zoom using position and range

4.2.2 Zooming for Details

Use one of the following zooming methods:

- To define the zoom area graphically
- 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

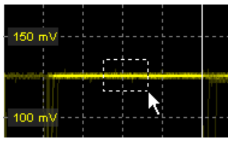
To define the zoom area graphically

For graphical zooming, you use your finger on the screen, or the navigation knob.

1. On the toolbar, tap the "Zoom" icon.

2. In the active signal you want to zoom into, touch 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 touch screen, 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.

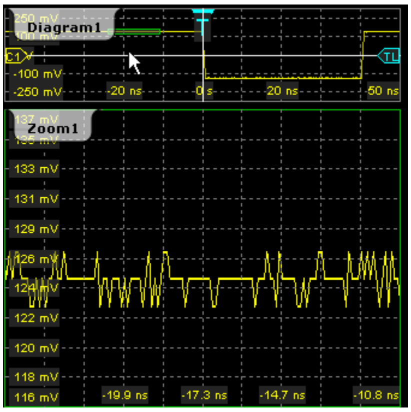
   

   Fig. 4-3: Zoom diagram and overview diagram

3. If the zoom area is not yet placed ideally, adjust the position by dragging or with the navigation knob.
   - Drag the rectangle in the overview to the correct position.
   - Turn the navigation knob to shift the zoom area. Press the knob to toggle between vertical and horizontal move.

4. If the size or shape of the zoom area is not yet ideal, tap the rectangle in the overview diagram. The rectangle is replaced by 4 lines that indicate the edges of the zoom area.

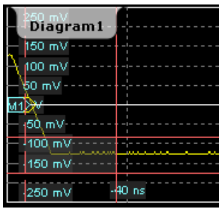


Fig. 4-4: Zoom area indicated by edges

Tip: Tapping the zoom area toggles between area and edge adjustment.

5. Shift the individual edges to change the size and shape of the zoom area.
   a) Tap the edge you want to move, or press the navigation knob until the required edge is selected.
   b) Move the edge by dragging it, or turn the navigation knob.

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 define the zoom area numerically using start-stop values

1. On the "Display" menu, tap "Zoom".
2. Select the Start/Stop tab.
   The fields in this dialog box only become editable after you have created a zoom area using the "Zoom" tool in the tool bar, or after you have created a new zoom definition.
   To create a new zoom definition:
   a) Tap the "Add" icon.
   b) Enter a name for the new zoom diagram using the displayed on-screen keyboard.
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 4-1).
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 4-3).

Displaying the center point or start/stop positions

Depending on the definition mode of the zoom area, the position of the center point or the start or stop position is temporarily displayed in the data entry field in the upper left corner of the screen if you do one of the following:

- Change the "Vertical mode" or "Horizontal mode" setting.
- Press the "Navigation" rotary knob while the "Zoom" dialog box is open.
- Tap the zoom area in the diagram overview.

The data entry field disappears again after a few seconds. To toggle the display between the x- and y-values of the position, press the "Navigation" rotary knob.

To define the zoom area numerically using position and range values

1. On the "Display" menu, tap "Zoom".
2. Select the Position/Range tab.
   The fields in this dialog box only become editable after you have created a zoom area using the "Zoom" tool in the tool bar, or after you have created a new zoom definition. To create a new zoom definition:
   a) Tap the "Add" icon.
   b) Enter a name for the new zoom diagram using the displayed on-screen keyboard.
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 4-2).
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. Graphically, simply repeat the steps described in To define the zoom area graphically - 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. Tap the "Copy" icon to copy the current zoom area definition or 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.

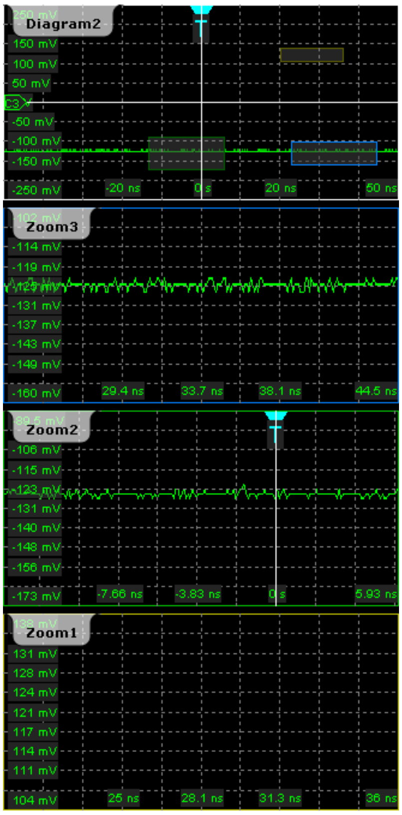


Fig. 4-5: Multiple zoom diagrams

To define coupled zoom areas

You can define multiple zoom areas for one diagram that are coupled, i.e. if you change the size of one zoom area, the size of all coupled zoom areas is changed as well. This 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, select 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 edit the zoom area size for any of the coupled zoom areas in the "Zoom" dialog box (for example the range) or by dragging the edges on the touch screen, the settings are changed for all of them.

To close the zoom diagram

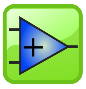
► Tap the "Delete" icon on the toolbar, then tap the zoom diagram.

  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 - to display the selected area in the diagram instaed 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 is displayed to indicate 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.

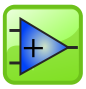
4.2.3 Reference for Zoom

The zoom area, i.e. the section to be enlarged, can be defined using two different methods:

- Specifying **start and stop values** for the x- and y-axes; the acquired data within those values is zoomed.
- Specifying the x- and y-**position** of one point in the diagram plus a **range** for the x- and y-axes; the area defined by that center point and the ranges is zoomed.

Note that the fields in this tab only become editable after you have created a zoom area using the "Zoom" tool in the tool bar, or after you have created a new zoom definition via the "Add" icon in the dialog box.

4.2.3.1 Zoom Functions on the Toolbar



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.

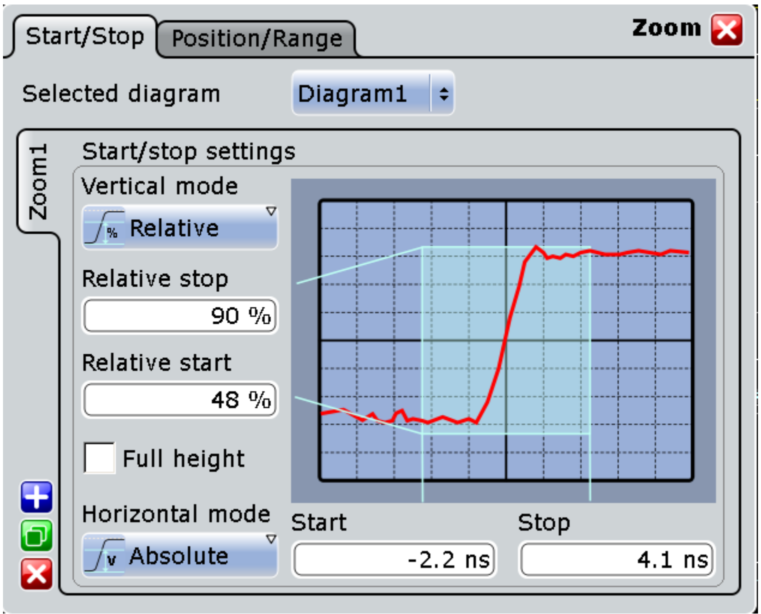
To return to the previous display, use the "Undo" function.

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

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.

4.2.3.2 Start/Stop

The "Start/Stop" tab allows you to specify start and stop values for the x- and y-axes. The acquired data within those values is zoomed.



Selected diagram
Indicates which of the diagrams (waveframes) is selected for zooming.

Vertical mode
Defines whether absolute or relative values are used to specify the y-axis values.

SCPI command:

`LAYout:ZOOM:VERTical:MODE` on page 412
`SEARch:RESDiagram:VERT:MODE` on page 533

Stop / Relative stop

Defines the upper limit of the zoom area on the y-axis.

SCPI command:

LAYout:ZOOM:VERTical:RELative:STOP on page 415
LAYout:ZOOM:VERTical:ABSolute:STOP on page 413

Start / Relative start

Defines the lower limit of the zoom area on the y-axis.

SCPI command:

LAYout:ZOOM:VERTical:RELative:STARt on page 415
LAYout:ZOOM:VERTical:ABSolute:STARt on page 413

Full height

Uses the full diagram height for the zoom area. Only horizontal zoom settings can be changed.

Horizontal mode

Defines whether absolute or relative values are used to specify the x-axis values.

SCPI command:

LAYout:ZOOM:HORZ:MODE on page 409
SEARch:RESDiagram:HORZ:MODE on page 531

Start / Relative start

Defines the lower limit of the zoom area on the x-axis.

SCPI command:

LAYout:ZOOM:HORZ:ABSolute:STARt on page 410
LAYout:ZOOM:HORZ:RELative:STARt on page 411

Stop / Relative stop

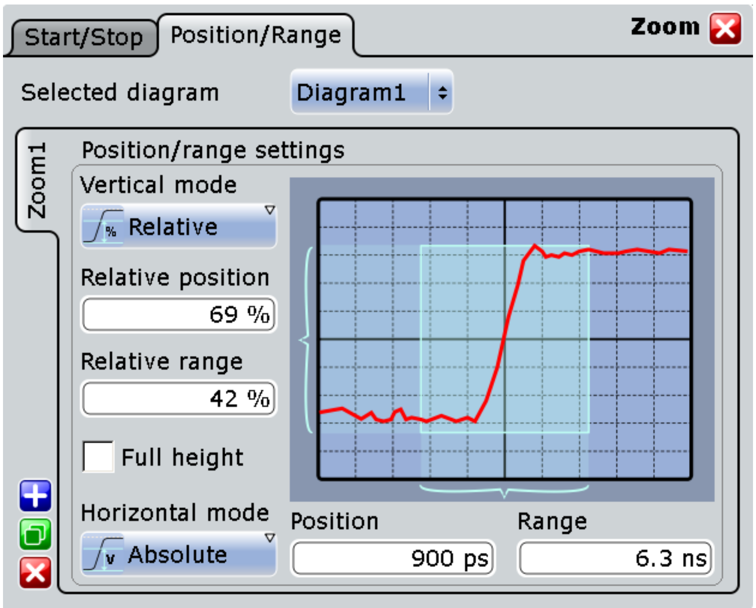
Defines the upper limit of the zoom area on the x-axis.

SCPI command:

LAYout:ZOOM:HORZ:ABSolute:STOP on page 410
LAYout:ZOOM:HORZ:RELative:STOP on page 412

4.2.3.3 Position/Range

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 mode
Defines whether absolute or relative values are used to specify the y-axis values.

SCPI command:

`LAYout:ZOOM:VERTical:MODE` on page 412

`SEARch:RESDiagram:VERT:MODE` on page 533

Position / Relative position
Defines the y-value of the centerpoint of the zoom area.

SCPI command:

`LAYout:ZOOM:VERTical:ABSolute:POSition` on page 412

`LAYout:ZOOM:VERTical:RELative:POSition` on page 414

`SEARch:RESDiagram:VERT:ABSolute:POSition` on page 532

`SEARch:RESDiagram:VERT:RELative:POSition` on page 533

Range / Relative Range
Defines the height of the zoom area.

SCPI command:

`LAYout:ZOOM:VERTical:RELative:SPAN` on page 414

`LAYout:ZOOM:VERTical:ABSolute:SPAN` on page 413

`SEARch:RESDiagram:VERT:ABSolute:SPAN` on page 533

`SEARch:RESDiagram:VERT:RELative:SPAN` on page 534

Full height
Uses the full diagram height for the zoom area. Only horizontal zoom settings can be changed.

Horizontal mode
Defines whether absolute or relative values are used to specify the x-axis values.

SCPI command:
`LAYout:ZOOM:HORZ:MODE` on page 409
`SEARch:RESDiagram:HORZ:MODE` on page 531

Position / Relative position
Defines the x-value of the centerpoint of the zoom area.

SCPI command:
`LAYout:ZOOM:HORZ:ABSolute:POSition` on page 409
`LAYout:ZOOM:HORZ:RELative:POSition` on page 410

Range / Relative Range
Defines the width of the zoom area.

SCPI command:
`LAYout:ZOOM:HORZ:ABSolute:SPAN` on page 409
`LAYout:ZOOM:HORZ:RELative:SPAN` on page 411
`SEARch:RESDiagram:HORZ:ABSolute:SPAN` on page 531
`SEARch:RESDiagram:HORZ:RELative:SPAN` on page 532

4.3 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.

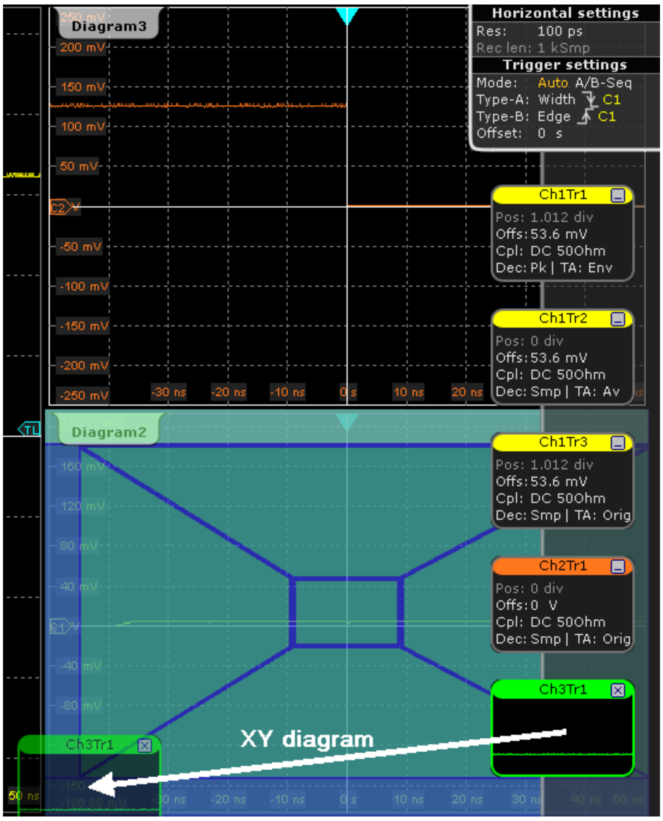
4.3.1 Displaying an XY-diagram

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

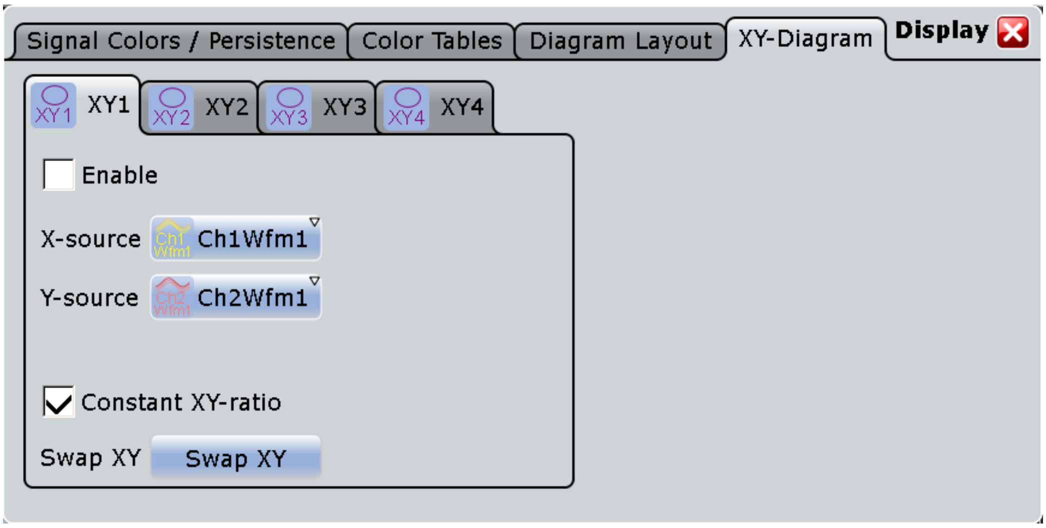
1. On the "Display" menu, tap "XY-diagram".
2. Activate the "State" option.
3. In the "X-source" field, define the signal source that supplies the x-values of the XY-diagram. Select one of the following:
   - One of the waveforms of any channel
   - A reference waveform
   - The results of a mathematical 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.

4.3.2 Reference for XY-diagram

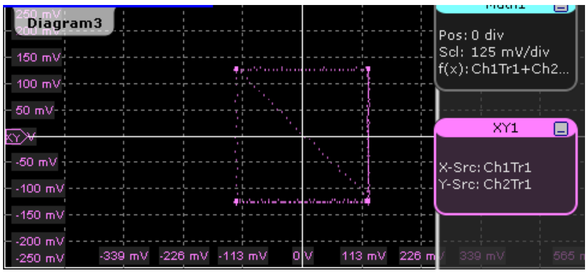
You can display up to four different XY-diagrams that use the voltage level of a waveform as the x-axis, rather then a time base.

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.



SCPI command:

WAVeform<m>:XYCurve:STATe on page 406

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

SCPI command:

WAVeform<m>:XYCurve:XSOurce on page 406

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

SCPI command:

WAVeform<m>:XYCurve:YSOurce on page 407

Constant XY-ratio

If enabled, the x- and y-axes maintain a constant ratio in the diagram.

SCPI command:

WAVeform<m>:XYCurve:RATio on page 406

Swap XY

Replaces the source of the x-axis with the source of the y-axis and vice versa.

SCPI command:

WAVeform<m>:XYCurve:SWAP on page 406

4.4 History

If a continuous acquisition runs, the acquired data is stored in the sample memory and the current acquisition is shown on the display. The history accesses the samples that were stored before the current acquisition, 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 the acquisition was stopped and a new acquisition is started with RUN CONT or RUN ×SINGLE, the memory is cleared and written anew.

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.

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. The memory can be enhanced with optional memory extension: 50 MSa with RTO-B101 100 MSa with RTO-B102.

Quick-access History dialog box

When you press the HISTORY key on the front panel, the quick-access "History" dialog box is displayed. This small 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. To display the full configuration dialog box, tap the icon, or press the HISTORY key again.

4.4.1 Using History

You can access the history waveforms in two ways:

- Display a particular acquisition.
- Replay all or a section of the saved waveforms to track the signal run.

To open the history and get information

1. Press the HISTORY key on the front panel. The quick-access "History" dialog box is displayed.
   Press the HISTORY key again. The full "History" configuration dialog box is displayed.
   Alternatively, tap the "Display" menu and then "History". The "History" configuration dialog box is displayed.

   The HISTORY key is illuminated as long as the history mode is active.
2. 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.
2. Tap "Play" to start.

Alternatively, you can start the history display from the "History" configuration dialog box.

1. In the "History" configuration dialog box, select the "Viewer" tab.
2. Select "Show history" to enable the history display.
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

1. In the "History" configuration dialog box, select the "Viewer" tab.
2. Select "Show history" to enable the history display.

   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 display

► In the Viewer tab, disable "Show history".

The quick-access dialog box is closed.

4.4.2 Reference for History

4.4.2.1 Quick Access History Dialog Box

The quick-access dialog box is displayed when the "Show history" option is active. It remains visible on the screen during acquisition, providing quick access to the history's "Play" button.

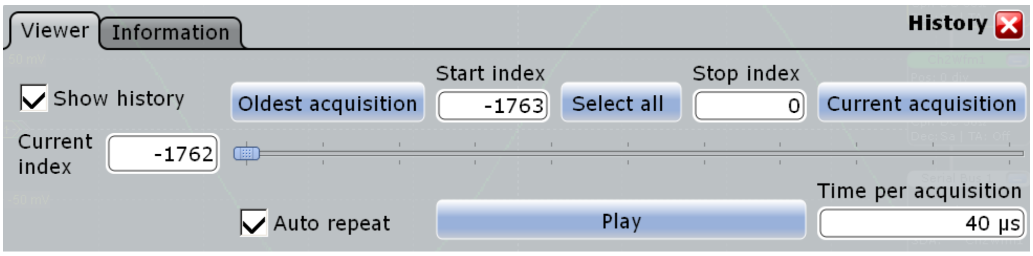
Current index
Accesses a particular acquisition in the memory to display it.

If a replay is running, the field shows the number of the currently shown acquisition.

Play
Starts and stops the replay of the indicated saved waveforms.

4.4.2.2 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 ×SINGLE action, the memory content changes.

Show history
Enables or disables the history display.

Oldest acquisition
Accesses the oldest acquisition in the sample memory and displays it.

Current acquisition
Accesses the latest acquisition in the sample memory and displays it.

Current index
Accesses a particular acquisition in the memory to display it.

If a replay is running, the field shows the number of the currently shown acquisition.

Start index
Sets the start point for the history replay. Enter *0* for the oldest acquisition, or the number of a dedicated start acquisition.

Stop index
Sets the end point for the history viewer. Enter the number of the stop acquisition.

Select all
All acquisitions saved in the memory will be shown in the viewer.

Play
Starts and stops the replay of the indicated saved waveforms.

Time per acquisition
Sets the display time for one acquisition. The shorter the time, the faster is the replay.

Auto repeat
If selected, the replay of the history waveform sequence repeats automatically. Otherwise, the replay stops at the "Stop index".

4.4.2.3 Information

Max. acquisition count
Displays the maximum number of acquisitions that can be saved in the history memory.

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 also shows the current number of acquisitions in an Ultra Segmentation acquisition series.

5 Measurements

Using the R&S RTO 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 (CURSOR key): measurements can be configured for up to four 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; the results are displayed in a result box. The MEAS key starts the default measurement for the active waveform. If a measurement is still running, the key opens the configuration dialog box.

5.1 Measurement Types and Results

Various measurement types are available, depending on the selected source.

Time domain

- Amplitude vs. time measurements
- Eye/Jitter measurements
- Histograms

Frequency domain

- Spectrum measurements

In addition, cursor measurements can be performed for any waveform.

Measurement Results Display

The results of automatic and cursor measurements are displayed in a result box on the screen. For each measurement, a separate result box is displayed. Which results are displayed depends on the measurement type and is described in detail in the following chapters.

The result box is displayed automatically when an automatic or cursor measurement is enabled, and can be displayed at any time by pressing the MEAS or CURSOR keys. 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, see "Displaying results" in the "Getting Started" manual.

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

The function "Clear screen results" in the "Display" menu resets all results in all measurement result boxes including long term measurement and statistic results and deletes the current measurement waveforms.

Status icons

Status information on the measurement is indicated by the following icons in the result box:

Icon	Description
	Limit check ok
	Limit check margin failed
	Limit check limit failed
	Limit check passed, but meas result cannot be determined correctly due to insufficient amplitude level
	Meas result cannot be determined correctly due to insufficient amplitude level (limit check disabled)

Intermediate results

You can display auxiliary result lines and reference levels required to perform some measurement types (e.g. signal thresholds) in the source diagram.

Statistics

If statistics are enabled for the measurement, the following information is provided in the result box for each measurement type.

Label	Description
Actual	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

Multiple measurements

By default, only one measurement is performed for each active type for best performance. However, you can enable multiple measurement, for example to measure the rise time for several cycles in one waveform. This is particularly useful when statistics are evaluated.

Environment sensors

Environment sensors can provide additional information during a measurement, e.g. the temperature. The collected data can be displayed as a background color in the waveform diagram. Thus you can analyze, for example, temperature-dependant behavior during a measurement.

5.1.1 Amplitude vs. Time Measurements

For amplitude vs. time waveforms, several different mesaurements can be performed.

Table 5-1: Amplitude vs. time measurement types

	Meas. type	**Description/Result**
1	High	The high signal level
2	Low	The low signal level
3	Amplitude	The amplitude of the signal
4	Max	The maximum value of the waveform
5	Min	The minimum value of the waveform
6	Peak to peak	The peak-to-peak value of the waveform
7	Mean	The mean value of the waveform
8	RMS	The RMS (Root Mean Square) value of the voltage
9	σ (S-dev)	The standard deviation of the waveform
10	Pos. overshoot	The positive overshoot of a square wave
11	Neg. overshoot	The negative overshoot of a square wave
12	Area	The area beneath the waveform (integral)
13	Rise time	The rise time of the left-most rising edge of the waveform. The rise time is determined as the time it takes the signal to rise from 10% to 90% of its amplitude.
14	Fall time	The falling time of the left-most falling edge of the waveform. The falling time is determined as the time it takes the signal to fall from 90% to 10% of its amplitude.
15	Pos. pulse	The width of a positive pulse. A positive pulse consists of a rising edge followed by a falling edge. The measurement requires at least one complete period of a triggered signal.
16	Neg. pulse	The width of a negative pulse. A negative pulse consists of a falling edge followed by a rising edge. The measurement requires at least one complete period of a triggered signal.

	Meas. type	Description/Result
17	Period	The length of the left-most signal period of the waveform
18	Frequency	The frequency of the signal. The result is based on the length of the left-most signal period of the waveform.
19	Pos. duty cycle	The positive duty cycle. To do so, the share of the positive alternation within a period is measured and is placed in relation to the signal period. The measurement requires at least one complete period of a triggered signal.
20	Neg. duty cycle	The negative duty cycle. To do so, the share of the negative alternation within a period is measured and is placed in relation to the signal period. The measurement requires at least one complete period of a triggered signal.
21	Cycle area	The area (integral) beneath one cycle
22	Cycle mean	The mean value of one cycle
23	Cycle RMS	The RMS (Root Mean Square) value of one cycle
24	Cycle σ (S-dev)	The standard deviation of one cycle
25	Pulse count	The number of impulses of the waveform. The mean value of the signal is determined. If the signal passes the mean value, an edge is counted. The impulse is counted if a rising edge and a falling edge are detected.
26	Delay	The difference between the trigger times of two waveforms
27	Phase	The phase difference between two waveforms (delay/period * 360)
28	Burst width	The duration of one burst, measured from the first edge to the last
29	Pos. switching	The number of transitions of the signal from low level to high level in the waveform (rising edge). To do so, the mean value of the signal is determined. If the signal passes the mean value, a rising edge is counted.
30	Neg. switching	The number of transitions of the signal from high level to low level in the waveform (falling edge). To do so, the mean value of the signal is determined. If the signal passes the mean value, a falling edge is counted.
31	ProbeMeter	The DC voltage from the connected probe

For details on setting up amplitude vs. time measurements see chapter 5.2.2.1, "Performing Amplitude vs. Time Measurements", on page 123.

5.1.2 Eye/Jitter Measurements

The eye diagram is a significant means of visualizing jitter and allows you to analyze the reasons for it. Characteristic values can be identified in the eye diagram, and by creating histograms of the eye diagram, important jitter parameters can be determined.

In the R&S RTO, the eye diagram is automatically set up for jitter measurements. The following characteristic values and jitter parameters can be determined:

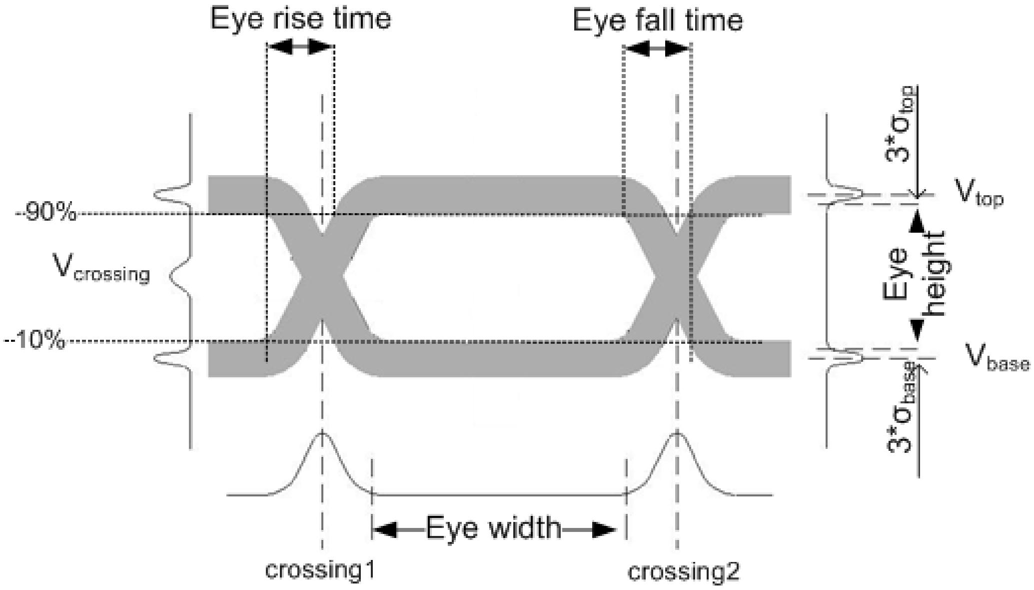


Fig. 5-1: Basic eye diagram characteristics

The sequential numbers in the following table refer to the suffix required for remote control commands for eye jitter measurements (see `MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:LIMit` on page 434 and following).

Table 5-2: Eye/jitter measurement types

	Meas. type	Description/Result
2	Extinction ratio (%)	Top level / Base level in percent ($V_{top}/V_{tobasep}$*100)
3	Extinction ratio (dB)	Top level / Base level in dB 10*log (V_{top}/V_{base})
4	Eye height	Vertical eye size (V_{top} – 3 * σ_top) – (V_{base} + 3 * σ_base)
5	Eye width	Horizontal eye size
6	Eye top	Upper reference level (V_{top}, high level)
7	Eye base	Lower reference level (V_{base}, low level)
10	Q factor	(V_{top} – V_{base})/(σ_top + σ_base)
14	Noise (RMS)	Average of top and base deviation
15	S/N ratio	Signal-to-Noise Ratio 20 * log (Eye height / NoiseRMS)
16	Duty cycle distortion	Eye Rise Time / Eye Fall Time
17	Eye rise time	Duration for signal to rise from 10% to 90%
18	Eye fall time	Duration for signal to fall from 90% to 10%

	Meas. type	Description/Result
19	Eye bit rate	Frequency between two crossings
20	Eye amplitude	V_{top}-V_{base}
28	Jitter (peak to peak)	Average of the jitter for both crossing points.
29	Jitter (6*σ)	Jitter *6
30	Jitter (RMS)	Average deviation of the time from the virtual crossing point.

For details on setting up eye/jitter measurements see chapter 5.2.2.2, "Performing Eye/ Jitter Measurements", on page 124.

5.1.3 Histograms

Histograms are used to plot density of data, i.e. to display graphically how often which signal values occur. In the R&S RTO, the histogram can be based on the input signal levels (amplitudes) or the time base in a time domain measurement, or on frequencies or frequency levels in a spectrum measurement.

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.

The following characteristic values can be determined for histograms (illustrated for a horizontal histogram):

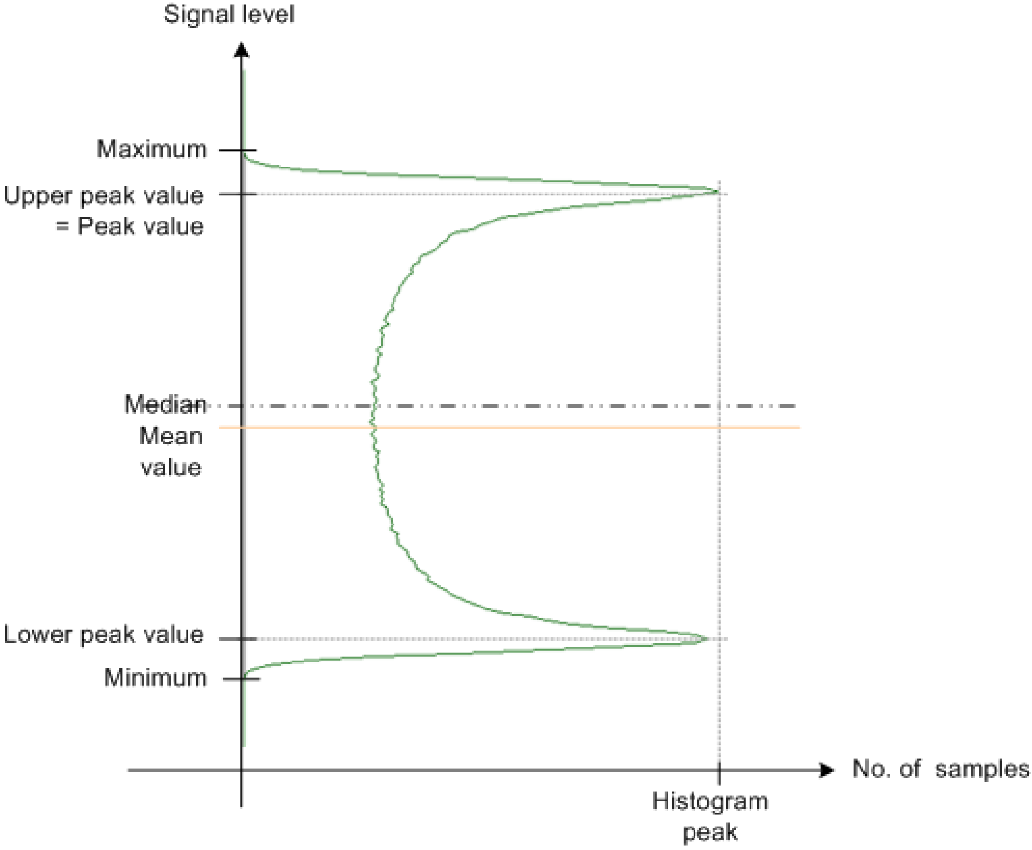


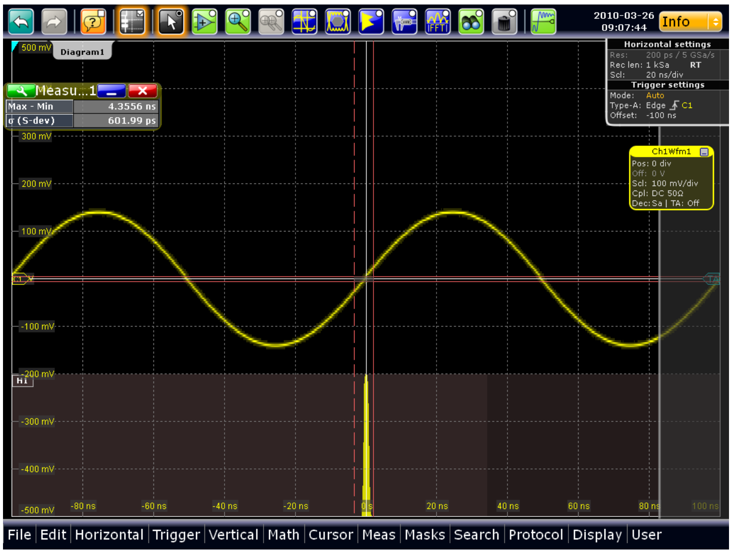
Table 5-3: Histogram measurement types

	Meas. type	Description/Result
1	Waveform count	The number of acquisitions (waveforms) the histogram is based on
2	Waveform samples	The number of samples from the most recent acquisition included in the current histogram
3	Histogram samples	The number of samples from all acquisitions included in the current histogram
4	Histogram peak	The maximum sample value in the histogram
5	Peak value	The signal value at the histogram peak
6	Upper peak value	The signal value at the maximum sample value in the upper half of the histogram
7	Lower peak value	The signal value at the maximum sample value in the lower half of the histogram
8	Maximum	The highest signal value with a probability > 0
9	Minimum	The lowest signal value with a probability > 0
10	Median	The signal value for which half the samples lie above, the other half below in the histogram The sample numbers 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.
11	Max - Min	The range of signal values with a probability > 0

	Meas. type	Description/Result
12	Mean	The weighted arithmetic average of the histogram
13	σ (S-dev)	Standard deviation of the sample numbers
14	Mean ±σ	The range between (mean value + standard deviation) and (mean value - standard deviation)
15	Mean ±2*σ	The range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)
16	Mean ±3*σ	The range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)
17	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.
18	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.



For details on setting up histogram measurements see chapter 5.2.2.4, "Performing Histogram Measurements", on page 127.

5.1.4 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.

Table 5-4: Spectrum measurement types

	Meas. type	Description/Result
1	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
2	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
3	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	Total harmonic distor-tion	Power sum of the harmonic waves divided by the power of the fundamental wave: $THD = \frac{\sum_{n=2}^{\infty} P_n}{P_1}$

For details on setting up spectrum measurements see chapter 5.2.2.3, "Performing Spectrum Measurements", on page 125.

5.1.5 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 four sets of cursors can be configured and displayed. Each set of cursors consists of a pair of horizontal or vertical cursors, or both. Cursors can be coupled so that the initially defined distance is always maintained.

For details on setting up cursor measurements see chapter 5.2.1, "Performing Cursor Measurements", on page 119.

Cursor Measurements Results

For each measurement, a separate result box is displayed. The following information may be provided in the result box, depending on the selected source.

Label	Description
t1, t2	The time at the position of the vertical cursors.
V1, V2	The value of the waveform at the position of the horizontal cursors.
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

Label	Description
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
Peak	Peak search function (for spectrum results only, see chapter 5.3.1.3, "Peak Search Tab", on page 138)

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, C3.1, C3.2, C4.1, C4.2.

5.2 Configuring and Performing Measurements

Basic measurements can be performed and displayed simply by tapping the "Measurement" or "Cursor" icons on the toolbar and then the waveform to be measured. In order to configure more complex or additional measurement types, setup dialog boxes are available.

From the result box, the settings dialog box can be opened using the icon.

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 "Displaying results" in the "Getting Started" manual.

5.2.1 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 four 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.

To display cursors and perform a simple cursor measurement

1. Press the CURSOR key.
   Alternatively, tap the "Cursor" icon on the toolbar.

   The cursor lines appear in the active diagram and the "Cursor Results" box opens.
2. Tap the waveform for which you want to set the cursors, or draw a rectangle on the screen to position the cursor lines.

The cursor lines appear in the selected diagram and the "Cursor Results" box opens.

You can move the cursor lines in the diagram manually, or adjust the cursor type and position in the result box.
For details on the result box, see chapter 5.1.5, "Cursor measurements", on page 118.

To configure 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 5.3.1.3, "Peak Search Tab", on page 138.

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 the cursor results see chapter 5.1.5, "Cursor measurements", on page 118.

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.

To configure 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.

The cursor display can be configured.

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".

5.2.2 Performing Automatic Measurements

Up to eight automatic measurements can be configured and performed simultaneously with the data acquisition; the results are displayed in a result box.

Automatic measurements are configured in the "Measurements" dialog box.

The results of an optionally connected environment sensor can also be taken into consideration in the results display of the measurement.

To start an automatic measurement

There are three different methods to start an automatic measurement, each with slightly different effects:

- 

  Tapping the "Measurement" icon on the toolbar and then the source waveform.
  The default measurement for the selected waveform is started and the result box is displayed.
- If no measurement is currently running: by pressing the MEAS key on the front panel.
  The default measurement for the currently selected waveform is started and the result box is displayed.
  (If a measurement is already running, the "Measurement" dialog box for the currently selected measurement is opened.)
- Selecting the "Meas > Setup" menu item and - after configuring the measurement - tapping the "State" option in the "Measurement" dialog box.
  The configured measurement is started and the result box is displayed.

Note that the "Measurement" icon always configures and starts a new **default** measurement for the selected waveform. Any previous configurations for that measurement are overwritten. If no measurement is currently running, pressing the MEAS key has the same effect. To recall a previously configured (disabled) measurement, select the "Meas > Setup" menu item.

To display measurement information in the diagram

You can display auxiliary lines in the source waveform 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 "Setup", or press the MEAS key to open the "Measurement" dialog box.
2. Select the "Gate/Display" tab.
3. Select the tab for the measurement you want to configure.
4. To display an active gate area, select "Show gate".
5. To display intermediate result lines, select "Display result lines".
6. To display reference levels, select "Display reference levels".

To clear the measurement results

1. On the "Display" menu, tap "Clear screen results".

   The results of all measurements are cleared.
2. To restart mesurement statistics, select "Reset now" in the "Measurement Results" box.

The results in the selected measurement result box are cleared.

3. Alternatively, proceed as follows:
   a) Press the MEAS key to open the "Measurement" dialog box.
   b) Select the "Gate/Display" tab.
   c) Select the tab for the measurement you want to clear.
   d) Tap "Clear Results".

   The results in the selected measurement result box are cleared.

5.2.2.1 Performing Amplitude vs. Time Measurements

The most basic measurement you can perform on a waveform is an amplitude vs. time measurement, which provides the amplitude of the signal as a result.

This basic measurement is performed by default when you tap the "Measurement" icon on the toolbar or press the MEAS key for an active time-based waveform.

To perform a simple amplitude measurement

1. Select a time-based waveform on the screen.
2. Press the MEAS key.
   Alternatively, tap the "Measurement" icon on the toolbar.

3. Tap the waveform for which you want to perform the measurement, or draw a rectangle on the screen to define a gate area for which the amplitude is measured.

   The "Amplitude" measurement is selected and enabled for the first available measurement configuration, using the active waveform as the source. If a rectangle was drawn on the screen, a corresponding gate area is defined.
   The "Measurements" result box with the measured amplitude is displayed.
   For details on the result box, see chapter 5.1.5, "Cursor measurements", on page 118.

To configure amplitude vs. time measurements

1. If a measurement was already enabled via the toolbar icon or MEAS key, tap the  icon in the result box, or press the MEAS key to display the "Measurements" dialog box.
   Otherwise, from the "Meas" menu, select "Setup".
2. Select the tab for the measurement you want to configure.
3. Tap "Source" and select the waveform to be used as the measurement source.
   If you enabled the measurement via the toolbar icon or MEAS key, the active waveform is automatically defined as the source. However, you can select any other input channel, math or reference waveform.

4. Optionally, tap "2nd Source" and select a second waveform for a phase or delay measurement.
5. Optionally, define a gate area to restrict the measurement to an extract of the waveform, as described in chapter 5.2.2.7, "Using Gate Areas", on page 132.
   If you enabled the measurement via the toolbar icon and drew a rectangle on the diagram, the gate area is automatically defined and enabled.
6. Select the "Amplitude vs. Time" tab (on the "Setup" tab).
7. Under "Main measurement", select the main measurement type. This measurement is the one referred to if the measurement result is used as a source for math calculations.
   For details on the available measurement types, see chapter 5.1.1, "Amplitude vs. Time Measurements", on page 112.
8. Optionally, tap "Activate" to select further measurement types.

   All active measurement types are displayed in the measurement overview. There you can enable or disable the measurement types individually or all at once, except for the main measurement type.
9. Optionally, define a "Signal threshold". Signal values that do not exceed this threshold are disregarded for the measurement.
10. Optionally, define the level used when measuring the area ("Area level)". By default, the time axis is used.
11. To compile and display statistics for the measurement, select "Statistics".
12. Optionally, perform a limit check as described in chapter 5.2.2.6, "Performing Limit Checks", on page 131.
13. Tap "State" to enable the amplitude vs. time measurement.

    The results of the measurement are displayed in the result box. For details see chapter 5.1.1, "Amplitude vs. Time Measurements", on page 112.

5.2.2.2 Performing Eye/Jitter Measurements

Eye/jitter measurements are configured in the "Measurements" dialog box.

1. From the "Meas" menu, select "Setup" to open the "Measurement" dialog box.
2. Select the tab for the measurement you want to configure.
3. Tap "Source" and select the waveform to be used as the measurement source.
4. Optionally, define a gate area to restrict the measurement to an extract of the waveform, as described in chapter 5.2.2.7, "Using Gate Areas", on page 132.
5. Select the "Eye/Jitter" tab (on the "Setup" tab).

6. Under "Main measurement", select the main measurement type. This measurement is the one referred to if the measurement result is used as a source for math calculations.
   For details on the available measurement types, see chapter 5.1.2, "Eye/Jitter Measurements", on page 113.
7. Optionally, tap "Activate" to select further measurement types.

   All active measurement types are displayed in the measurement overview. There you can enable or disable the measurement types individually or all at once, except for the main measurement type.
8. To compile and display statistics for the measurement, select "Statistics".
9. Optionally, perform a limit check as described in chapter 5.2.2.6, "Performing Limit Checks", on page 131.
10. Optionally, tap "Autoset" to define optimized settings for the eye measurement.
11. Tap "State" to enable the eye/jitter measurement.

    The results of the measurement are displayed in the result box. For details see chapter 5.1.2, "Eye/Jitter Measurements", on page 113.

5.2.2.3 Performing 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.

The default measurement on a spectrum is a "Channel Power" measurement, which provides the integrated power over the sample values as a result.

This measurement is performed when you tap the "Measurement" icon on the toolbar or press the MEAS key for an active spectrum waveform.

To perform a simple spectrum measurement

1. Select a spectrum waveform (math waveform with an FFT operator) on the screen.
2. Press the MEAS key.
   Alternatively, tap the "Measurement" icon on the toolbar.

   
3. Tap the waveform for which you want to perform the measurement, or draw a rectangle on the screen to define a gate area for which the channel power is measured.

   The "Channel Power" measurement is selected and enabled for the first available measurement configuration, using the active waveform as the source.
   The "Measurements" result box with the measured channel power is displayed.
   For details on the result box, see chapter 5.1.4, "Spectrum Measurements", on page 117.

To configure a spectrum measurement

1. Define a math waveform using the FFT operator as described in chapter 6.1.2.3, "Configuring FFT Waveforms", on page 169.
2. If a measurement was already enabled via the toolbar icon or MEAS key, tap the icon in the result box, or press the MEAS key to display the "Measurements" dialog box.
   Otherwise, from the "Meas" menu, select "Setup".
3. Select the tab for the measurement you want to configure.
4. Tap "Source" and select the math waveform configured for FFT.
   If you enabled the measurement via the toolbar icon or MEAS key, the active waveform is automatically defined as the source. However, you can select any other math or reference waveform.
5. Optionally, define a gate area to restrict the measurement to an extract of the waveform, as described in chapter 5.2.2.7, "Using Gate Areas", on page 132.
   If you enabled the measurement via the toolbar icon and drew a rectangle on the diagram, the gate area is automatically defined and enabled.
6. Select the "Spectrum" tab (on the "Setup" tab).
7. Under "Main measurement", select the main measurement type. This measurement is the one referred to if the measurement result is used as a source for math calculations.
   For details on the available measurement types, see chapter 5.1.4, "Spectrum Measurements", on page 117.
8. Optionally, tap "Activate" to select further measurement types.

   All active measurement types are displayed in the measurement overview. There you can enable or disable the measurement types individually or all at once, except for the main measurement type.
9. Enter the additional parameters required for the selected measurement type:
   - For "Bandwidth" measurements, enter the "N db down" value, i.e. the threshold until which the samples to the left and right of the peak value are analyzed.
   - For "Channel Power" measurements, enter the "Channel BW" over which the channel power is calculated, and the "Channel CF", the center frequency from which the channel power is calculated.
   - For "Occupied Bandwidth" measurements, enter the percentage of the total power used to determine the occupied bandwidth in the "Occup. BW" field.
10. Optionally, define a threshold in the "Noise reject" field beneath which values are rejected as noise and disregarded for the measurement.
11. To compile and display statistics for the measurement, select "Statistics".
12. Optionally, perform a limit check as described in chapter 5.2.2.6, "Performing Limit Checks", on page 131.

13. Tap "State" to enable the spectrum measurement.

    The results of the spectrum measurement are displayed in the result box. For details see chapter 5.1.4, "Spectrum Measurements", on page 117.

5.2.2.4 Performing Histogram Measurements

Histograms are required to determine some characteristic values in amplitude vs. time measurements. They can also be used to evaluate the sample value occurances directly.

To define a histogram

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

2. Tap the waveform for which you want to generate the histogram, 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 vertical histogram with the selected waveform as a source is defined and displayed.

3. Alternatively, or to configure the histogram more precisely, select "Meas > Histogram".

   The "Histogram Setup" dialog box is displayed.

4. If no histogram was defined yet, tap the "Add" icon in the upper right corner of the dialog box to create a new tab for histogram configuration.

   To copy an existing histogram and configure a new one based on those settings, tap the "Copy" icon.

5. Enter a name for the histogram using the on-screen keyboard.
   To change the name of a histogram, double-tap the tab label. The on-screen keyboard is displayed.

6. Select a "Source" for the histogram. The source can be any input signal, math or reference waveform.

7. Define the histogram "Mode": vertical for an amplitude, horizontal for a spectrum or time-based histogram.

8. 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.

To configure histogram measurements

1. From the "Meas" menu, select "Setup" to open the "Measurement" dialog box.
2. Select the tab for the measurement you want to configure.
3. Select the "Histogram" tab.
   (If the "Histogram" tab is not available, temporarily select an input channel as the "Source".)
4. Tap "Histogram" and select the histogram to be used as the measurement source.
5. Under "Main measurement", select the main measurement type. This measurement is the one referred to if the measurement result is used as a source for math calculations.
   For details on the available measurement types, see chapter 5.1.3, "Histograms", on page 115.
6. Optionally, tap "Activate" to select further measurement types.

   All active measurement types are displayed in the measurement overview. There you can enable or disable the measurement types individually or all at once, except for the main measurement type.
7. For measurement types "Marker + Probability %" or "Marker - Probability %", define the marker "Reference" for the probability domain. Then define the "Delta" in percent which is to be added or subtracted from the marker value.
8. To compile and display statistics for the measurement, select "Statistics".
9. Optionally, perform a limit check as described in chapter 5.2.2.6, "Performing Limit Checks", on page 131.
10. Tap "State" to enable the histogram measurement.

    The results of the measurement are displayed in the result box. For details see chapter 5.1.3, "Histograms", on page 115.

5.2.2.5 Configuring Reference Levels

Some measurements refer to specific reference or signal levels, e.g. rise time/fall time evaluation or counting pulses. Generally, these settings are determined automatically. However, for irregular data it may be useful to configure them manually, or to define some parameters for automatic determination.

In addition to reference and signal levels you can define hystereses for reference levels, as well as tubes for signal levels. Hystereses are useful for measurements that determine zero-crossings. Tubes define evaluation ranges for measurements that require high level or low level detection. If the signal value remains within the defined tubes, it is considered to be high or low.

Reference levels and intermediate results required for further measurements can be displayed in the source diagram.

Example:

For example, 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.

Furthermore, if the signal levels vary strongly or have large overshoots, the rise and fall levels may be difficult to determine.

Finally, if fixed levels are configured for the connected device, you can define the signal levels in the R&S RTO correspondingly and analyze the resulting measurement data.

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. From the "Meas" menu, select "Reference Level > Levels" to open the "Measurement" 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. Define which signal level is used as a reference. For details see "Signal level mode" on page 158.
6. By default, the lower reference level is defined at 10% of the selected signal level, the middle reference level at 50% and the upper reference level at 90%. Optionally, select other "Relative levels" to be used for evaluation.
7. 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.
   Averaging is not available if "Absolute peaks" are selected as the "Signal level mode".
8. To define a hysteresis for the middle reference level, select the "Hysteresis" tab and enter a percentage of the selected signal level.

   A rise or fall from the middle reference value that does not exceed the hysteresis is rejected and not considered a zero-crossing.
9. To define a tube for the high and low signal levels:
   a) Select the "Tube" tab.
   b) In the "Relative outer" field, define a percentage of the signal level by which the absolute signal level may be larger than high signal level or lower than the low signal level to be considered high or low, respectively.
   c) In the "Relative inner" field, define a percentage of the signal level by which the absolute signal level may be higher than the low signal level or lower than the high signal level to be considered low or high, respectively.

To determine reference and signal levels manually

You can configure the reference levels manually as fixed absolute or relative values.

1. From the "Meas" menu, select "Reference Level > Levels" to open the "Measurement" 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 manual "Reference level mode".
5. Under "Level definition", select whether you want to define the levels using absolute or relative values.
6. Under "User level selection", select whether you want to configure the high and low signal levels ("User signal level") or the lower, middle and upper reference levels ("User reference level").
7. To define high and low signal levels:
   a) Enter the absolute high and low signal levels.
   b) By default, the lower reference level is defined at 10% of the selected signal level, the middle reference level at 50% and the upper reference level at 90%. Optionally, select other "Relative levels", or define absolute "Top distance" and "Bottom distance" values to be used for evaluation.
8. To define lower, middle and upper reference levels:
   a) Enter the absolute upper and lower reference levels.
   b) By default, the lower reference level is defined at 10% of the selected signal level, the middle reference level at 50% and the upper reference level at 90%. Optionally, select other "Relative levels", or define absolute "Top distance" and "Bottom distance" values to be used for evaluation of the high and low signal levels.
9. To define a hysteresis for the middle reference level, select the "Hysteresis" tab and enter a percentage of the selected signal level.

   A rise or fall from the middle reference value that does not exceed the hysteresis is rejected and not considered a zero-crossing.
10. To define a tube for the high and low signal levels:
    a) Select the "Tube" tab.
    b) For relative value definition:
    In the "Relative outer" field, define a percentage of the signal level by which the absolute signal level may be larger than the high signal level or lower than the low signal level to be considered high or low, respectively.
    In the "Relative inner" field, define a percentage of the signal level by which the absolute signal level may be higher than the low signal level or lower than the high signal level to be considered low or high, respectively.

c) For absolute value definition:
In the "Top outer" field, define an area above the high signal level which is still considered to be high level.
In the "Top inner" field, define an area beneath the high signal level which is still considered to be high level.
In the "Bottom inner" field, define an area above the low signal level which is still considered to be low level.
In the "Bottom outer" field, define an area beneath the low signal level which is still considered to be low level.

To display reference levels and intermediate results

1. From the "Meas" menu, select "Setup" to open the "Measurement" dialog box.
2. Select the tab for the measurement you want to configure.
3. Select the "Gate/Display" tab.
4. Enable the "Display result lines" or "Display reference levels" option, or both.

   The reference levels and intermediate results required for further measurements are displayed in the source diagram.

5.2.2.6 Performing Limit Checks

Limit checks allow you to analyze the measured values. If the defined limits are exceeded, specific actions can be initiated. Margins are not as strict as limits and belong to the valid value range, but can also initiate certain actions. Limit checks are available for all automatic measurement types.

To perform a limit check

1. From the "Meas" menu, select "Setup" to open the "Measurement" dialog box.
2. Select the tab for the measurement you want to configure.
3. Under "Limit check", select "Limit only" to distinguish only between valid and non-valid values, or "Margin&Limit" to perform a two-level value check, where the margin is still valid, the limit is not.
4. In the measurement overview, define the upper and lower limits and, if selected, margins for each active measurement type to be checked.
5. In the measurement overview, define the valid value range for each active measurement type to be checked. Note that the margins must always be within the valid value range. If necessary, the limit or margin values are adapted to match the selected valid range.
   For details on the value range definitions see "Limit check" on page 140.
6. Define what happens when the limits and margins defined for a measurement type are exceeded.
   a) Select the "Event Actions" tab.

b) For each action, define whether it is to be initiated:
- if the limits or margins are exceeded
- if the measurement is completed without limit violations
- not at all

c) If "E-mail" is selected, define a recipient address under "E-mail setup".
If "Save Wfm" is selected, define a storage location under "Waveform destination".
If "Print" is selected, configure the print settings as described in chapter 10.1.1, "Configuring Printer Output and Printing", on page 260.

As a result of the limit check, the specified actions are performed and the status is indicated by an icon in the result box (see chapter 5.1, "Measurement Types and Results", on page 110).

5.2.2.7 Using Gate Areas

Gate areas limit the measurement to a user-defined range of the waveform.

For basic amplitude vs. time or channel power measurements the gate area can be defined directly after selecting the corresponding toolbar icon. For all other measurements, or if you want to define a more precise gate area, configuration is done in the "Measurement" dialog box.

1. From the "Meas" menu, select "Setup" to open the "Measurement" dialog box.
2. Select the tab for the measurement you want to configure.
3. Select the "Gate/Display" tab.
4. Define the start and stop values of the gate area by entering either absolute or relative values.
   Alternatively, 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.
5. Tap the "Use gate" icon to enable the gate area usage.
6. Optionally, tap the "Show gate" icon to indicate the gate area in the diagram.

   The measurement is performed on the selected value range of the waveform. If selected, the used range is indicated in the diagram.

5.2.2.8 Performing Long-term Measurements

In order to evaluate statistics for a measurement, it is useful to perform the measurement over a long period of time or for a large number of samples. Intermediate results can be reset after a specified number of acquisitions or a specified period of time in order to evaluate time-dependant behavior. Long-term measurements can be configured for all automatic measurement types.

1. From the "Meas" menu, select "Setup" to open the "Measurement" dialog box.

2. Select the tab for the measurement you want to configure.
3. Select the "Long Term/Statistics" tab.
4. Since the waveform may change in the process of time, enter the vertical scaling as a percentage per division, rather than using an absolute value. A vertical offset is also defined as a percentage.
   Alternatively, tap the "Auto scale" button to have the scaling adapted automatically.
5. Define how many "Measurement points" are to be generated before the measurement is stopped.
6. If the "Reset statistics mode" is set to "Time" (see "Reset statistics mode" on page 153), define a "Total measurement time".
7. Optionally, define statistics settings for the long-term measurement, as described in chapter 5.2.2.9, "Compiling Measurement Statistics", on page 133.
8. Tap the "State" icon to enable the long-term measurement.

   The measurement is performed until the defined number of measurement points have been generated. The display is adapted as the waveform data changes in time.

5.2.2.9 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, see chapter 5.1, "Measurement Types and Results", on page 110.

In order to obtain meaningful results, it may be useful to configure specific measurement settings.

Useful 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 5.2.2.5, "Configuring Reference Levels", on page 128
- Gate areas: restricting the waveform range for measurement can eliminate irregular data, see chapter 5.2.2.7, "Using Gate Areas", on page 132
- Defining a "Signal threshold" for amplitude vs. time measurements or a "Noise Reject" value for spectrum measurements can eliminate noise from the evaluation See "Signal threshold" on page 142 and "Noise reject" on page 146.

To enable statistics

1. From the "Meas" menu, select "Setup" to open the "Measurement" dialog box.
2. Select the tab for the measurement you want to configure.
3. Tap the "Statistics" icon.

To configure long-term statistics compilation

1. From the "Meas" menu, select "Setup" to open the "Measurement" dialog box.
2. Select the tab for the measurement you want to configure.
3. Select the "Long Term/Statistics" tab.
4. Define whether the statistics are to be reset after a defined period of time or number of acquisitions (waveforms), or not at all.
   Resetting the results after a defined period of time allows you to evaluate time-dependent behavior during the measurement, and avoids constantly rising maximum or constantly falling minimum values till the end of the measurement.
   If you select the "Time" reset mode, define a "Total measurement time" in the long-term measurement settings.
5. For averaging operations, define how many statistics values are used to calculate the average.
6. Tap the "Enable Statistics" icon to include statistics in the measurement results.

   As soon as the long-term measurement is performed, the statistics are compiled until the measurement is stopped. If configured, the results are reset each time the reset period or reset count is reached. The results are displayed in the measurement result box.

5.2.2.10 Using Environment Sensors

Environment sensors can provide additional information during a measurement, e.g. the temperature. the collected data can be displayed as a background color in the waveform diagram.

1. From the "Meas" menu, select "Setup" to open the "Measurement" dialog box.
2. Select the "Long Term/Statistics" tab.
3. Select the tab for the measurement you want to configure.
4. Tap the "Use sensor" icon to enable the usage.
5. Select one of the connected environment sensors.
6. Select the sensor channel to be evaluated.
7. Tap the "Setup sensor" button or select the "Sensors" tab to set up the sensor result display.
8. Select the tab for the sensor you want to configure.
9. Select the tab for the channel you want to configure.
   If necessary, create a new tab by tapping the "Add" icon.

Alternatively, copy an existing channel setup by tapping the "Copy" icon.

Enter a name for the new tab.

10. Enter the "Minimum value" and "Maximum value" for the sensor data.
11. Select a color table to be used to display the sensor results.
12. If necessary, edit the color table or create a new one as described in chapter 4.1.2.1, "Editing Signal Colors ", on page 81.

    The background of the waveform diagram for the selected channel is colored according to the assigned color table.

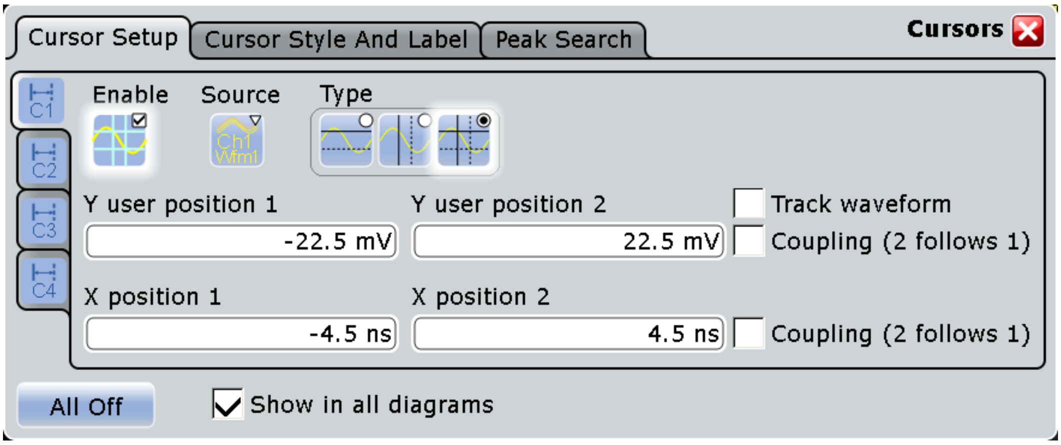
5.3 Reference for Measurements

5.3.1 Reference for Cursor Measurements

Cursor measurements are configured in the "Cursors" dialog box which is opened via the "Cursor > Setup" menu or the "Cursor Results" box, or by pressing the CURSOR key.

5.3.1.1 Cursor Setup Tab

This tab contains general settings for cursor measurements.



C1/C2/C3/C4

The settings for each of the four available cursor measurements 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.

Source

Defines the source of the cursor measurement. Any of the input signal, math, reference or XY waveforms can be selected.

SCPI command:

`CURSor<m>:SOURce` on page 417

Type

Defines the cursor type to be used for the measurement.

"Horizontal cursors"	The horizontal cursors are positioned 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 along the waveform or can be positioned manually. The vertical cursors are positioned manually.

Y user position 1/2

Defines the position of the horizontal cursors in the time domain.

SCPI command:

`CURSor<m>:Y1Position` on page 418

`CURSor<m>:Y2Position` on page 419

Track waveform

The horizontal cursors track the waveform, i.e. cursor 1 indicates the current maximum, cursor 2 indicates the current 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.

SCPI command:

`CURSor<m>:TRACking[:STATe]` on page 417

Coupling

Couples the cursors of a set so that the distance between the two remains the same if one cursor is moved.

X position 1/2

Defines the position of the vertical cursors.

Envelope wfm selection 1/2

If the waveform arithmetics are set to envelope waveform (see "Wfm Arithmetic" on page 33) and "Track waveform" is enabled, this setting defines which horizontal cursor is positioned to the maximum and which to the the minimum envelope values.

These settings are only available if both horizontal and vertical cursors are enabled.

"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.

SCPI command:

`CURSor<m>:X1ENvelope` on page 419

`CURSor<m>:X2ENvelope` on page 420

All Off

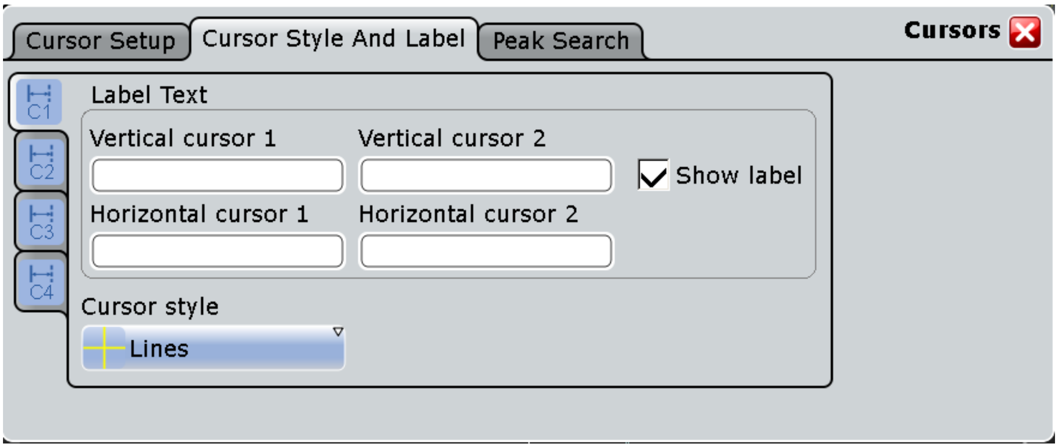
Disables all cursor measurements at once.

Show in all diagrams

Shows the enabled cursor measurements in all active diagrams of the same (time/spectrum) domain.

5.3.1.2 Cursor Style and Label Tab

The settings in this tab configure the display of the cursors.



C1/C2/C3/C4

The settings for each of the four available cursor measurements 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, C3.1, C3.2, C4.1, C4.2.

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.

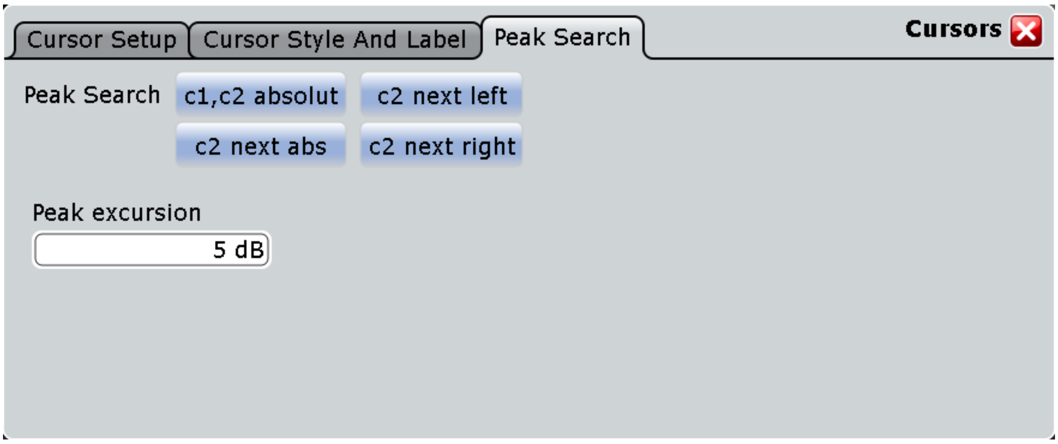
Cursor style

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.

5.3.1.3 Peak Search Tab

The settings on this tab are only available in spectrum mode, i.e. if FFT analysis is selected for a math waveform which is used as the source of the cursor measurement. In this case, the cursors can indicate the results of a peak search on the waveform.



c1, c2 absolute
Both cursors are set to the absolute peak value.

SCPI command:
`CURSor<m>:MAXimum[:PEAK]` on page 421

c2 next left
Cursor 2 is set to the next peak to the left of the current position.

SCPI command:
`CURSor<m>:MAXimum:LEFT` on page 422

c2 next abs
Cursor 2 is set to the next smaller absolute peak (from the current position).

SCPI command:
`CURSor<m>:MAXimum:NEXT` on page 422

c2 next right
Cursor 2 is set to the next peak to the right of the current position.

SCPI command:
`CURSor<m>:MAXimum:RIGHt` on page 422

Peak excursion
Defines 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.

This setting is only available for sources in the frequency domain.

Note that the peak excursion is a global setting and is valid for both cursor measurements and search functions.

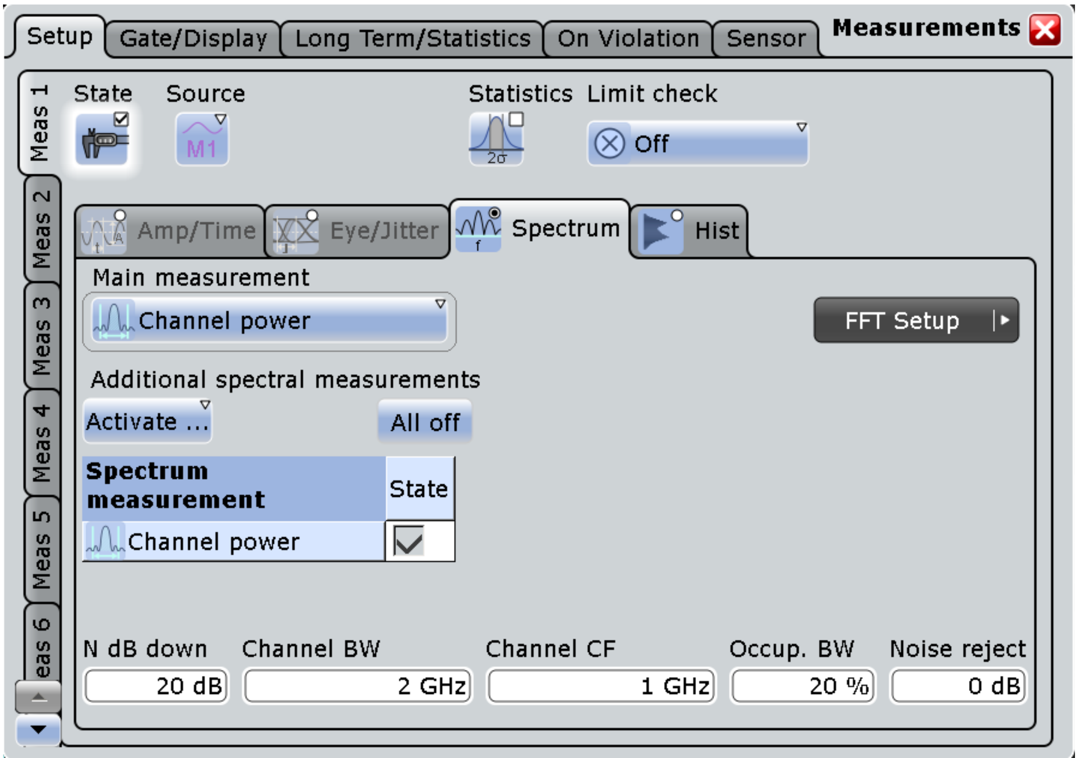
SCPI command:
`CURSor<m>:PEXCursion` on page 422

5.3.2 Reference for Automatic Measurements

Automatic measurements are configured in the "Measurements" dialog box, which is opened via the "Meas > Setup" menu or via the "Measurements" result box, or by pressing the MEAS key. Up to 8 measurement waveforms can be defined. Each measurement waveform is configured in its own tab.

5.3.2.1 Setup Tab

The "Setup" tab contains the basic settings for the main measurement types.



General Settings

General settings relate to all measurement types. Depending on the selected source, not all measurement types are available. In the time domain, amplitude vs. time and eye/jitter measurements are available. In the frequency domain (i.e. for math channels with spectrum results), spectrum measurements are available. For measurements based on histograms, the histogram must be selected (available after the measurement type has been selected).

Meas 1/2/3/4/5/6/7/8
Selects one of the eight available measurement waveforms.

State
Enables the measurement waveform.

SCPI command:
`MEASurement<m>[:ENABle]` on page 423

Source
Defines the source 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.

SCPI command:
`MEASurement<m>:SOURce` on page 423

2nd Source
Defines the second source of the measurement for some amplitude vs. time measurements (e.g. delay, phase). The source can be any input signal, math or reference waveform.

SCPI command:
`MEASurement<m>:SOURce` on page 423

Statistics
Enables the calculation and display of statistics for the measurement results.

SCPI command:
`MEASurement<m>:STATistics[:ENABle]` on page 449
`MEASurement<m>:RESult:AVG` on page 453
`MEASurement<m>:RESult:EVTCount` on page 453
`MEASurement<m>:RESult:NPEak` on page 453
`MEASurement<m>:RESult:PPEak` on page 453
`MEASurement<m>:RESult:RMS` on page 453
`MEASurement<m>:RESult:STDDev` on page 454
`MEASurement<m>:RESult:WFMCount` on page 453
`MEASurement<m>:RESult[:ACTual]` on page 453

Limit check
Enables limit checking. If the measurement results exceed the defined limits or margins, the actions specified under "Event Actions" are performed and an icon is displayed in the result box (see chapter 5.1, "Measurement Types and Results", on page 110). The limits and margins are defined for each measurement type in the measurement overview table. There you can also specify the valid range according to the following definitions:

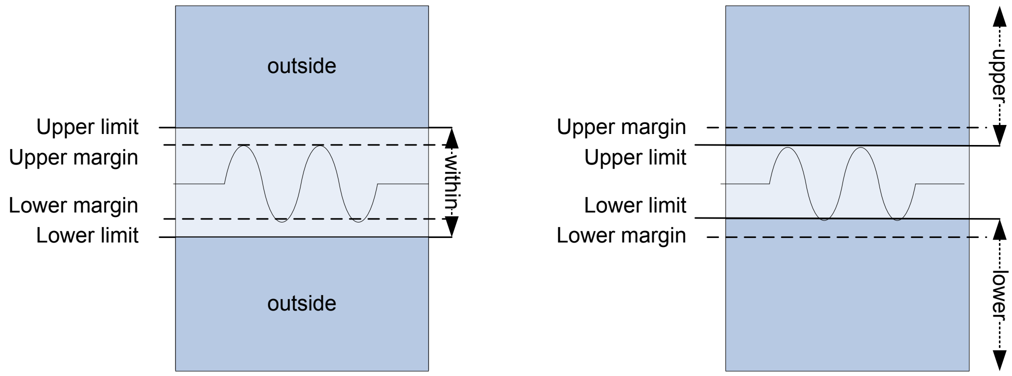


Fig. 5-2: Limit and margin definition

As indicated in Limit and margin definition, limits are stricter than the margins for the value check. Thus, the margins must be within the valid range. If necessary, the limit and margin values are adapted according to the selected valid range.

"Off" No limit check is performed.

"Limit only" Limits are checked for violation.

"Margin and Limit" Margins and limits are checked for violation.

SCPI command:

`MEASurement<m>:AMPTime:LCHeck<n>:LOWer:LIMit` on page 432
`MEASurement<m>:AMPTime:LCHeck<n>:LOWer:MARGin` on page 433
`MEASurement<m>:AMPTime:LCHeck<n>:UPPer:LIMit` on page 432
`MEASurement<m>:AMPTime:LCHeck<n>:UPPer:MARGin` on page 433
`MEASurement<m>:AMPTime:LCHeck<n>:VALid` on page 432
`MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:LIMit` on page 434
`MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:MARGin` on page 435
`MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:LIMit` on page 434
`MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:MARGin` on page 435
`MEASurement<m>:EYEJitter:LCHeck<n>:VALid` on page 434
`MEASurement<m>:HISTogram:LCHeck<n>:LOWer:LIMit` on page 446
`MEASurement<m>:HISTogram:LCHeck<n>:LOWer:MARGin` on page 446
`MEASurement<m>:HISTogram:LCHeck<n>:UPPer:LIMit` on page 446
`MEASurement<m>:HISTogram:LCHeck<n>:UPPer:MARGin` on page 447
`MEASurement<m>:HISTogram:LCHeck<n>:VALid` on page 446
`MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:LIMit` on page 438
`MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:MARGin` on page 438
`MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:LIMit` on page 438
`MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:MARGin` on page 438
`MEASurement<m>:SPECtrum:LCHeck<n>:VALid` on page 437

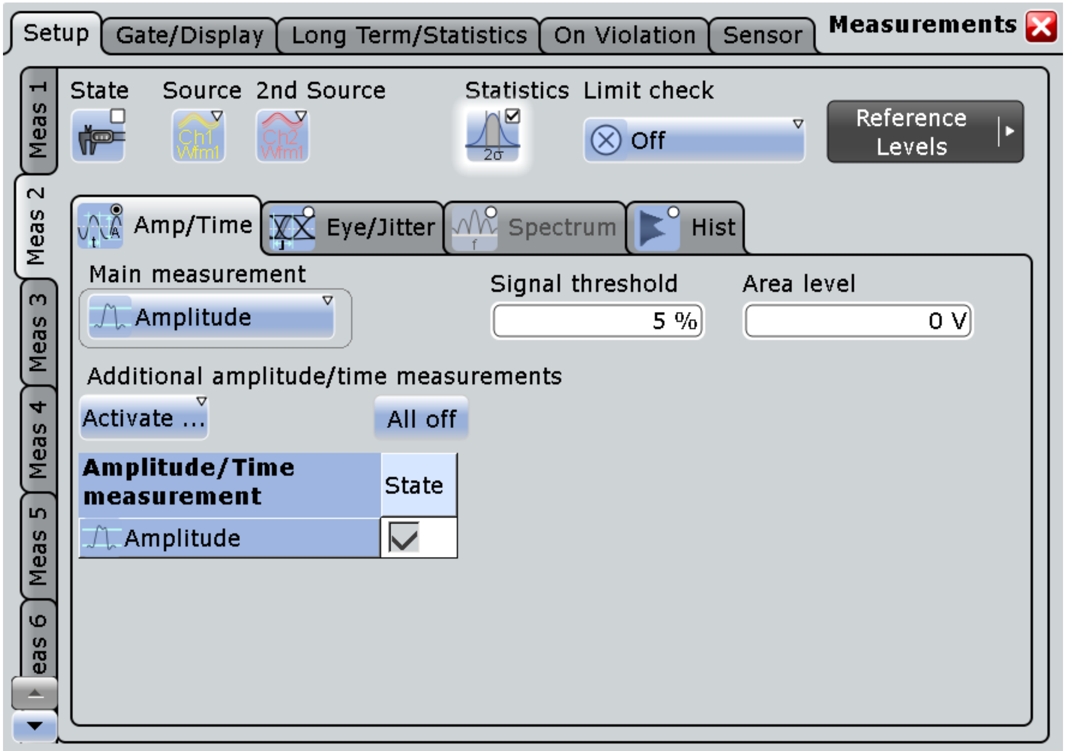
Measurement category

For each measurement category, further settings can be configured on a separate tab. The following categories are available:

- "Amplitude/Time Measurements", on page 142
- "Eye/Jitter Measurements", on page 143
- "Spectrum Measurements", on page 144
- "Histogram Measurements", on page 146

Amplitude/Time Measurements

Amplitude vs. time measurements are only available for sources in the time domain.



Main measurement
Defines the main amplitude vs. time measurement type. This measurement is the one referred to if the measurement waveform is used as a source for math calculations. The main measurement cannot be disabled in the measurement overview.

For details on the available measurement types, see chapter 5.1.1, "Amplitude vs. Time Measurements", on page 112.

SCPI command:
`MEASurement<m>:MAIN` on page 425

Signal threshold
Defines a signal value that must be exceeded for the signal value to be included in the measurement.

SCPI command:
`MEASurement<m>:DETThreshold` on page 431

Area level

The reference level used to integrate the waveform.

SCPI command:

`MEASurement<m>:AMPTime:ALEVel` on page 431

Activate additional amplitude/time measurements

Enables further amplitude/time measurements. The selected measurements are displayed in an overview table. The main measurement is also listed in the overview table, but cannot be disabled here.

The overview table also contains the limit and margin definitions if a limit check is enabled, see "Limit check" on page 140.

For a description of available measurement types, see "Main measurement" on page 142.

In this

SCPI command:

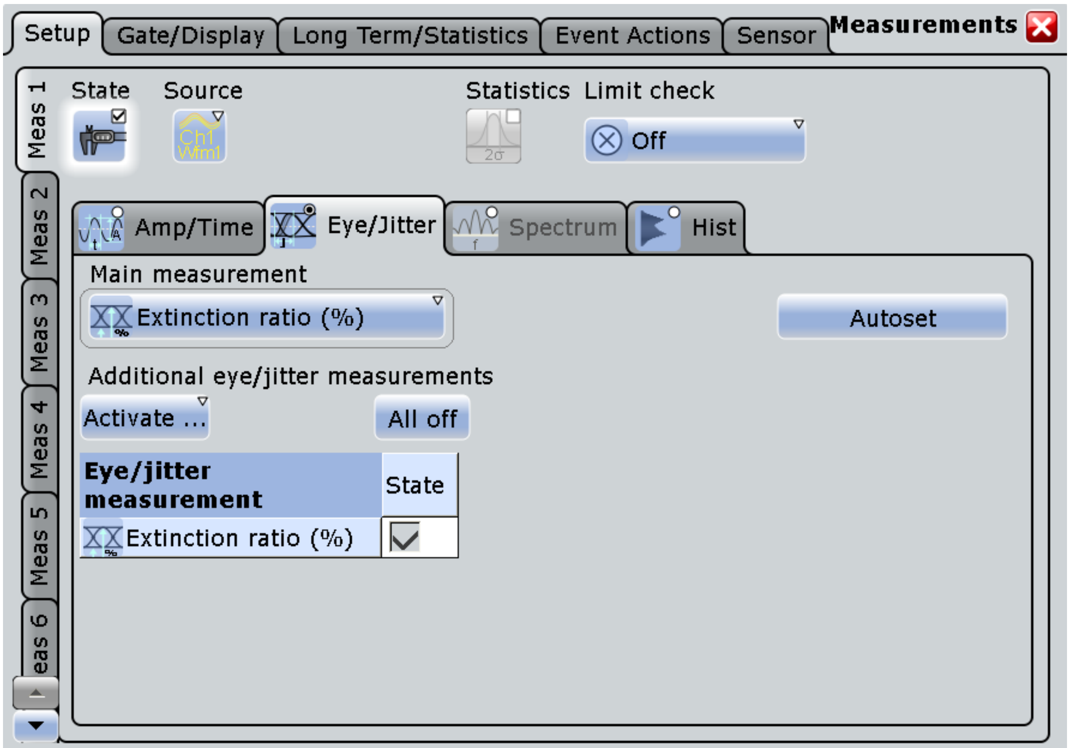
`MEASurement<m>:ADDitional` on page 428

All off

Deactivates all selected measurements in the table.

Eye/Jitter Measurements

Eye/jitter measurements are only available for sources in the time domain.



Main measurement
Defines the main Eye/Jitter measurement type. This measurement is the one referred to if the measurement waveform is used as a source for math calculations. The main measurement cannot be disabled in the measurement overview.

For a description of available measurement types, see chapter 5.1.2, "Eye/Jitter Measurements", on page 113.

SCPI command:
`MEASurement<m>:MAIN` on page 425

Activate additional eye/jitter measurements
Activates further amplitude/time measurements. The selected measurements are displayed in an overview table. The main measurement is also listed in the overview table, but cannot be disabled here.

The overview table also contains the limit and margin definitions if a limit check is enabled, see "Limit check" on page 140.

For a description of available measurement types, see "Main measurement" on page 144.

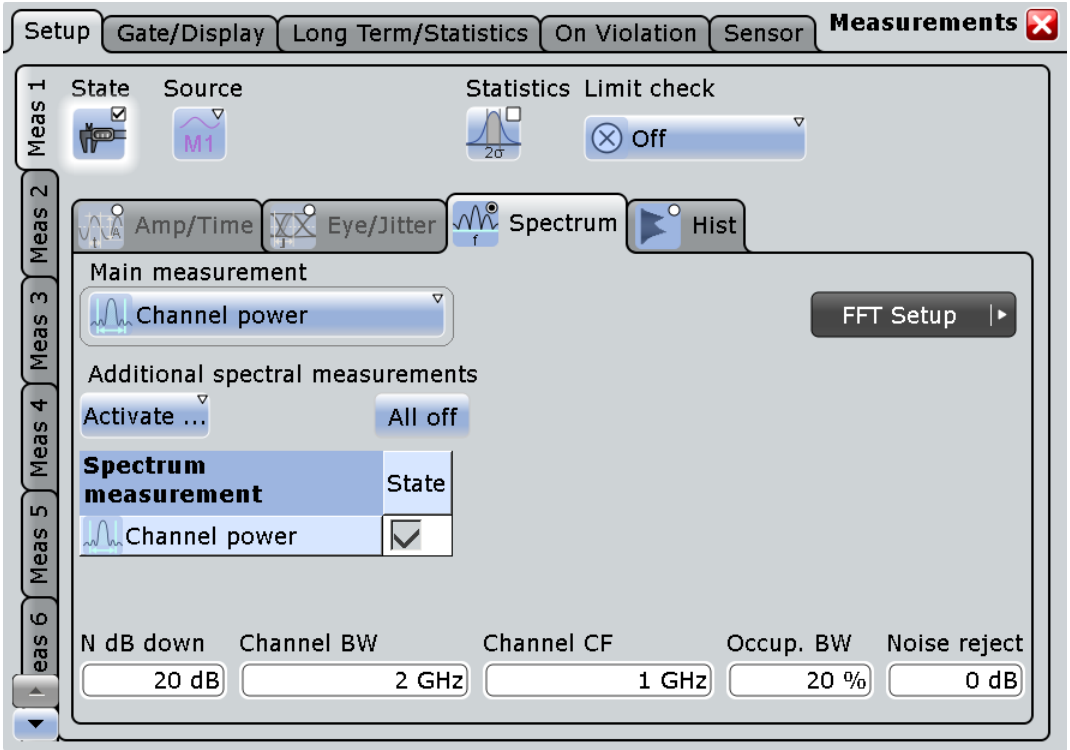
SCPI command:
`MEASurement<m>:ADDitional` on page 428

All off
Deactivates all selected measurements in the table.

Autoset
Defines optimized settings to perform an eye measurement for the selected source.

Spectrum Measurements

Spectrum measurements are only available if a source in the frequency domain is selected, i.e. a math waveform with an FFT operation.



Main measurement

Defines the main spectrum measurement type. This measurement is the one referred to if the measurement waveform is used as a source for math calculations. The main measurement cannot be disabled in the measurement overview.

For a description of available measurement types, see "Spectrum Measurements", on page 144.

SCPI command:

`MEASurement<m>:MAIN` on page 425

Activate additional spectrum measurements

Activates further spectrum measurements. The selected measurements are displayed in an overview table. The main measurement is also listed in the overview table, but cannot be disabled here.

The overview table also contains the limit and margin definitions if a limit check is enabled, see "Limit check" on page 140.

For a description of available measurement types, see "Main measurement" on page 145.

SCPI command:

`MEASurement<m>:ADDitional` on page 428

All off

Deactivates all selected measurements in the table.

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 "(N dB down) Bandwidth".

SCPI command:
`MEASurement<m>:SPECtrum:NDBDown` on page 437

Channel BW
Bandwidth over which the channel power is calculated.

SCPI command:
`MEASurement<m>:SPECtrum:CPOWer:BANDwidth` on page 436

Channel CF
Center frequency from which the channel power is calculated over the specified bandwidth.

SCPI command:
`MEASurement<m>:SPECtrum:CPOWer:CFRequency` on page 436

Occup. BW
Percentage of the total power used to determine the occupied bandwidth.

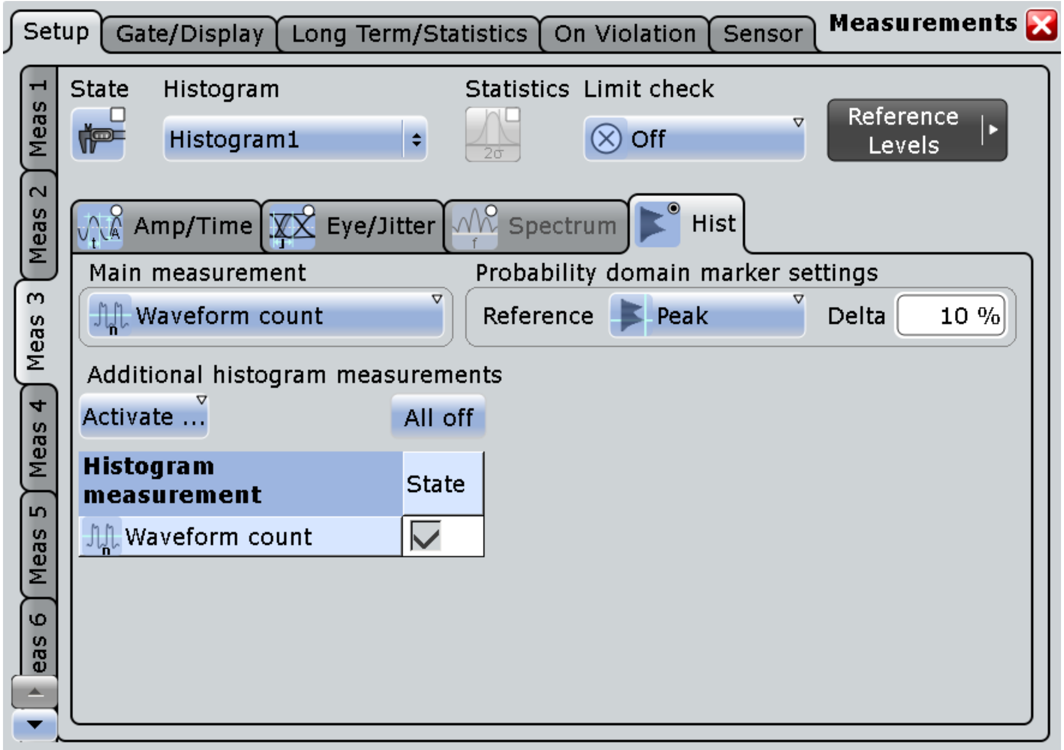
SCPI command:
`MEASurement<m>:SPECtrum:OBANdwidth` on page 436

Noise reject
Threshold beneath which values are rejected as noise.

SCPI command:
`MEASurement<m>:SPECtrum:NREJect` on page 437

Histogram Measurements

You can perform measurements on an existing histogram. Histograms are defined in the "Histogram" dialog box (accessible via the MEAS menu).



Histogram

Selects the histogram on which the measurement is based. Histograms are defined via the "MEAS > Histogram" menu item.

SCPI command:

`MEASurement<m>:HISTogram:SELect` on page 445

Main measurement

Defines the main histogram measurement type. This measurement is the one referred to if the measurement waveform is used as a source for math calculations. The main measurement cannot be disabled in the measurement overview.

For a description of available measurement types, see chapter 5.1.3, "Histograms", on page 115.

SCPI command:

`MEASurement<m>:MAIN` on page 425

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

SCPI command:
MEASurement<m>:HISTogram:PROBability:TYPE on page 445

Delta
Defines a range around the marker.

SCPI command:
MEASurement<m>:HISTogram:PROBability:LIMit on page 445

Activate additional histogram measurements
Activates further histogram measurements. The selected measurements are displayed in an overview table. The main measurement is also listed in the overview table, but cannot be disabled here.

The overview table also contains the limit and margin definitions if a limit check is enabled, see "Limit check" on page 140.

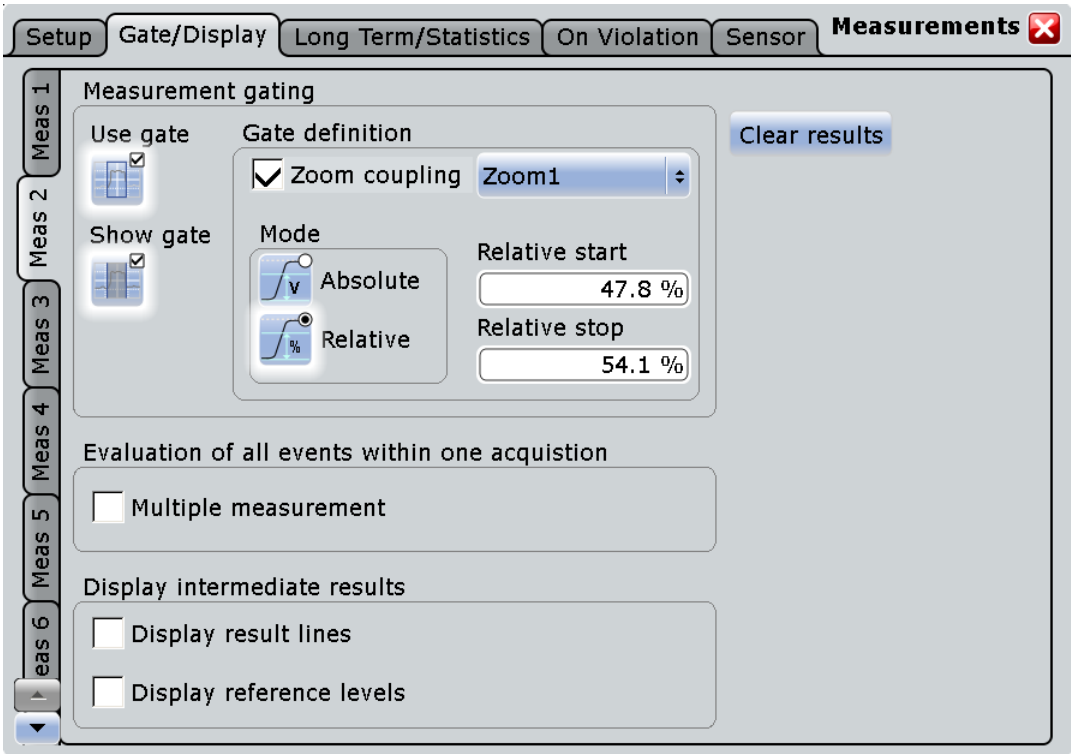
For a description of available measurement types, see "Main measurement" on page 147.

SCPI command:
MEASurement<m>:ADDitional on page 428

All off
Deactivates all selected measurements in the table.

5.3.2.2 Gate/Display Tab

The settings on this tab are only available if a gate is defined for the measurement waveform source.



Meas 1/2/3/4/5/6/7/8

Selects one of the eight available measurement waveforms.

Use Gate

Considers the gating settings of the source waveform for the measurement.

SCPI command:

`MEASurement<m>:GATE[:STATe]` on page 455

Show Gate

Indicates the gate area in the source diagram.

SCPI command:

`CALCulate:MATH<m>:FFT:GATE:SHOW` on page 480

`MEASurement<m>:GATE:SHOW` on page 456

`SEARch:GATE:SHOW` on page 527

Gate Definition

Defines the gate settings for measurement gating.

Zoom Coupling ← Gate Definition
If enabled, the gate area is defined identically to the zoom area for the selected active zoom diagram.

SCPI command:
CALCulate:MATH<m>:FFT:GATE:ZCOupling on page 480
CALCulate:MATH<m>:FFT:GATE:ZDIagram on page 481
MEASurement<m>:GATE:ZCOupling on page 456
MEASurement<m>:GATE:ZDIagram on page 457
SEARch:GATE:ZCOupling on page 528
SEARch:GATE:ZDIagram on page 528

Gate Mode ← Gate Definition
Defines whether the gate settings are configured using absolute or relative values.

"Absolute" Gating is performed between the defined absolute start and stop values.

"Relative" Gating is performed for a percentage of the value range, defined by start and stop values.

SCPI command:
CALCulate:MATH<m>:FFT:GATE:MODE on page 479
MEASurement<m>:GATE:MODE on page 455
SEARch:GATE:MODE on page 526

(Relative) Start ← Gate Definition
Defines the starting value for the gate.

SCPI command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt on page 479
CALCulate:MATH<m>:FFT:GATE:RELative:STARt on page 480
MEASurement<m>:GATE:ABSolute:STARt on page 455
MEASurement<m>:GATE:RELative:STARt on page 455
SEARch:GATE:ABSolute:STARt on page 527
SEARch:GATE:RELative:STARt on page 527

(Relative) Stop ← Gate Definition
Defines the end value for the gate.

SCPI command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP on page 479
CALCulate:MATH<m>:FFT:GATE:RELative:STOP on page 480
MEASurement<m>:GATE:ABSolute:STOP on page 455
MEASurement<m>:GATE:RELative:STOP on page 455
SEARch:GATE:ABSolute:STOP on page 527
SEARch:GATE:RELative:STOP on page 528

Multiple measurement
Performs multiple measurements on the same source waveform, e.g. measures the rise time for all pulses in the waveform, not only the first. This is useful when calculating statistics; however, it reduces the performance of the instrument.

Display result lines

Displays intermediate result lines in the measurement waveform (e.g. signal thresholds) required to obtain the measurement result.

SCPI command:

`MEASurement<m>:DISPlay:RESults` on page 447

Display reference levels

Displays the reference levels used for the measurement in the diagram.

SCPI command:

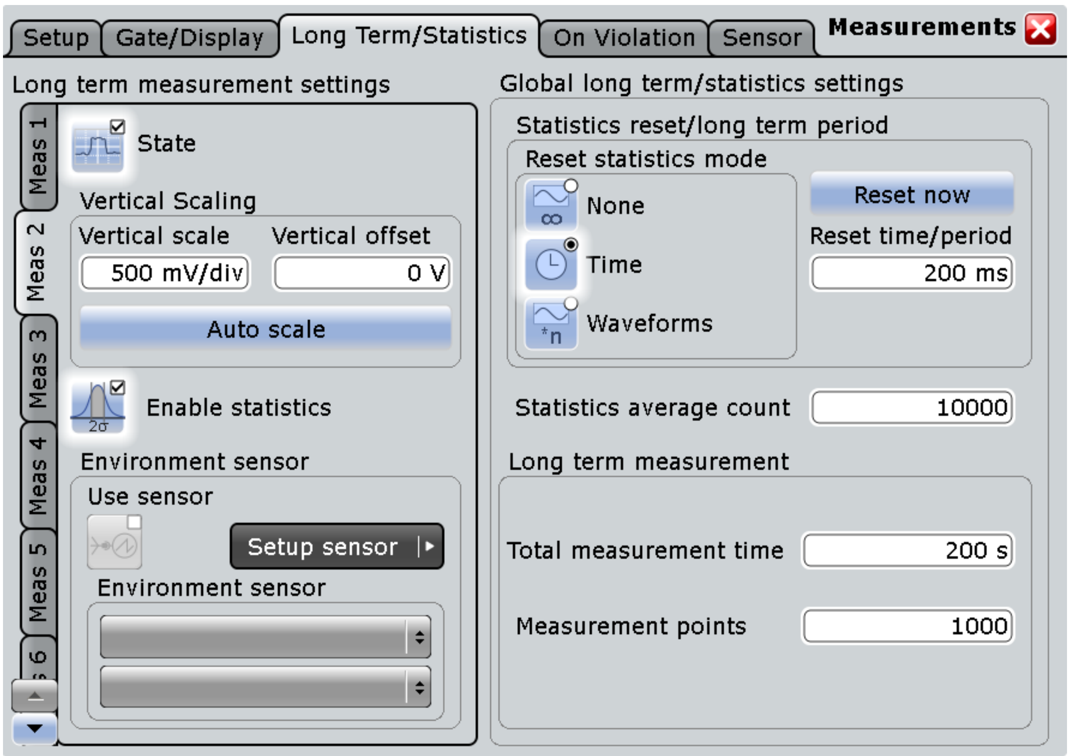
`MEASurement<m>:DISPlay:LEVels` on page 447

Clear Results

Clears the measurement results to begin a new measurement.

5.3.2.3 Long Term/Statistics Tab

The settings in this tab allow you to configure long term measurements, including statistics over a longer period of time.



Meas 1/2/3/4/5/6/7/8

Selects one of the eight available measurement waveforms.

State
Enables long term measurement for a defined number of measurement points or a specified time.

SCPI command:
`MEASurement<m>:LTMeas[:STATe]` on page 452

Statistics
Enables the calculation and display of statistics for the measurement results.

SCPI command:
`MEASurement<m>:STATistics[:ENABle]` on page 449
`MEASurement<m>:RESult:AVG` on page 453
`MEASurement<m>:RESult:EVTCount` on page 453
`MEASurement<m>:RESult:NPEak` on page 453
`MEASurement<m>:RESult:PPEak` on page 453
`MEASurement<m>:RESult:RMS` on page 453
`MEASurement<m>:RESult:STDDev` on page 454
`MEASurement<m>:RESult:WFMCount` on page 453
`MEASurement<m>:RESult[:ACTual]` on page 453

Vertical scale
Defines the vertical scaling per division, so that the scaling can be adapted automatically during the long term measurement period.

SCPI command:
`MEASurement<m>:VERTical:SCALe` on page 451

Vertical offset
Defines a vertical offset for the long term measurement.

SCPI command:
`MEASurement<m>:VERTical:OFFSet` on page 451

Auto scale
Enables automatic vertical scaling so that the scaling is adapted to the current measurement results automatically during the long term measurement period.

SCPI command:
`MEASurement<m>:VERTical:AUTO` on page 451

Use sensor
Enables the evaluation of a connected environment sensor. Sensors are set up in the "Sensors" tab.

SCPI command:
`MEASurement<m>:LTMeas:ENVSensor:STATe` on page 453

Environment sensor
Selects one of the environment sensors connected to a USB port of the R&S RTO.

Environment sensor
Selects one of the environment sensors connected to a USB port of the R&S RTO and the sensor data to be evaluated.

Reset statistics mode
Defines when the statistics for long term measurements are reset.

"None" No reset, the number of measurements considered by the statistics is not limited.

"Time" Resets the statistics after the time defined in "Reset time/period".

"Waveforms" Resets the statistics after a number of measurements defined in "Reset count".

SCPI command:
`MEASurement<m>:STATistics:MODE` on page 449

Reset now
Resets the statistics.

SCPI command:
`MEASurement<m>:STATistics:RESet` on page 450

Reset time/period
Defines the time or period after which the statistics are reset.

SCPI command:
`MEASurement<m>:STATistics:RTIMe` on page 450

Reset count
Defines the number of measurements after which the statistics are reset.

SCPI command:
`MEASurement<m>:STATistics:RCOunt` on page 450

Statistics average count
Defines the number of measurements for which the statistical average is calculated.

SCPI command:

Total measurement time
Defines the total duration of the long term measurement.

This setting is only available if "Reset statistics mode" is set to "Time".

SCPI command:
`MEASurement<m>:LTMeas:TIME` on page 452

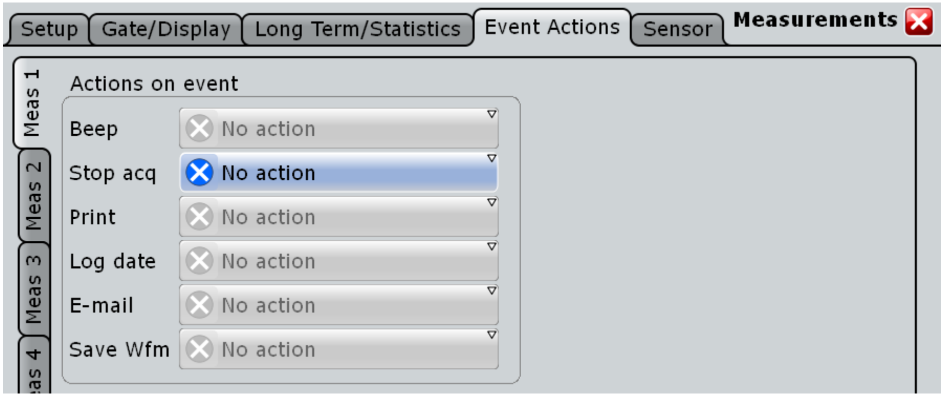
Measurement points
Defines the total number of points to be measured during the long term measurement.

SCPI command:
`MEASurement<m>:LTMeas:COUNt` on page 452

5.3.2.4 Event Actions Tab

The settings in this tab define what happens when the limits and margins defined in the "Setup" tab are exceeded if limit checking is enabled. Independant of these settings, an icon is displayed in the result box, see chapter 5.1, "Measurement Types and Results", on page 110.

Note that the violation actions do not distinguish between a margin violation and a limit violation. However, different icons are displayed in the result box.



Meas 1/2/3/4/5/6/7/8
Selects one of the eight available measurement waveforms.

Beep
Generates a beep sound.

"No function" The action is not initiated.

"On violation" The action is initiated if the limits or margins are exceeded during the measurement.

"On successful completion" The action is initiated if the limits or margins were not exceeded during the entire measurement.

SCPI command:
`MEASurement<m>:ONViolation:BEEP` on page 457

Stop acq
Stops data acquisition.

SCPI command:
`MEASurement<m>:ONViolation:ACQStop` on page 457

Log date, E-mail
Not yet available

Print
Prints a screenshot including the measurement results to the printer defined in the "Print" dialog box (see chapter 10.1.1, "Configuring Printer Output and Printing", on page 260).

SCPI command:
`MEASurement<m>:ONViolation:PRINt` on page 458

Save Wfm
Saves the waveform data to the file specified in FILE > "Save/Recall" > "Waveform".

SCPI command:
`MEASurement<m>:ONViolation:WFMSave` on page 458

5.3.2.5 Sensors Tab

The "Setup" tab contains the basic settings for the main measurement types.

Sensor 1|2|3...
Selects one of the environment sensors connected to the R&S RTO.

Channel 1|2|3|4
Selects one of the channels for the selected sensor if the same sensor can process different types of data.

Actual value
Indicates the currently measured sensor (channel) value.

Minimum value
Defines the minimum sensor (channel) value.

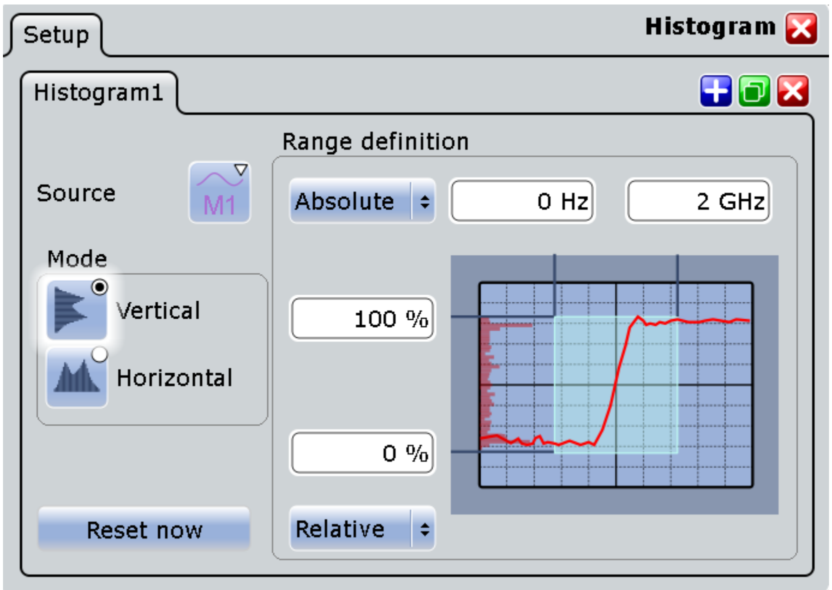
Maximum value
Defines the maximum sensor (channel) value.

Color table reference
Assigns one of the available color tables to the sensor results. The background of the waveform diagram for the selected channel is colored according to the assigned color table.

For details on color tables see chapter 4.1.2.1, "Editing Signal Colors ", on page 81.

5.3.3 Reference for Histograms

In this dialog box you configure histograms on which you can perform further measurements (see chapter 5.1.3, "Histograms", on page 115).



Source
Defines the source of the histogram. Any input signal, math or reference waveform can be selected.

SCPI command:
`LAYout:HISTogram:SOURce` on page 440

Mode
Defines the type of histogram.

"Vertical" Amplitude histogram (horizontal bars across amplitude)

"Horizontal" Time or frequency histogram (vertical bars over time/frequencies)

SCPI command:
`LAYout:HISTogram:MODE` on page 440

Reset now
Resets the values to begin a new histogram.

SCPI command:
`LAYout:HISTogram:RESet` on page 443

Range definition mode (Absolute/Relative)
Defines whether the value range limits are entered as absolute or relative values.

SCPI command:
`LAYout:HISTogram:HORZ:MODE` on page 440
`LAYout:HISTogram:VERTical:MODE` on page 442

Horizontal start/stop value
Defines the horizontal value range of the histogram.

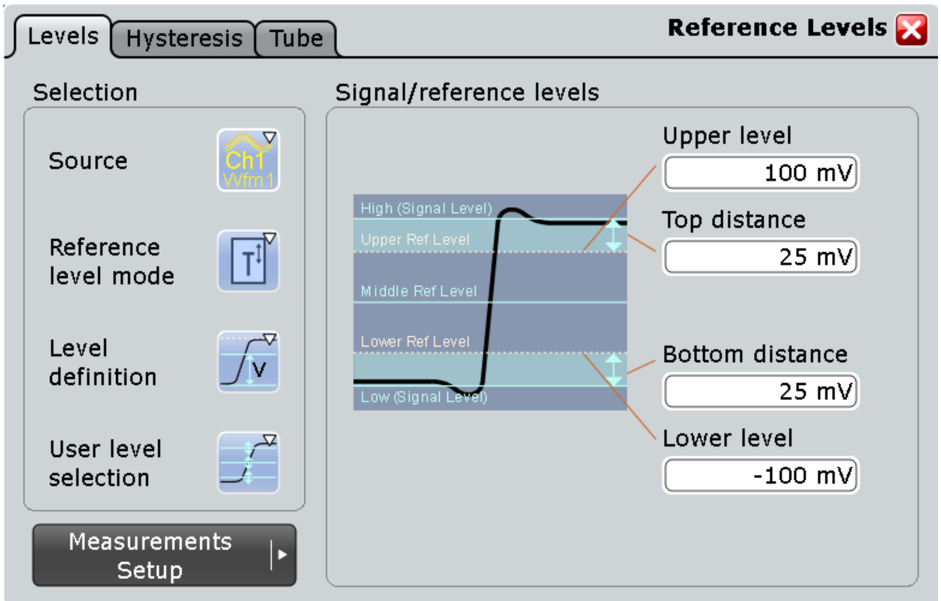
SCPI command:
`LAYout:HISTogram:HORZ:ABSolute:STARt` on page 441
`LAYout:HISTogram:HORZ:ABSolute:STOP` on page 441
`LAYout:HISTogram:HORZ:RELative:STARt` on page 441
`LAYout:HISTogram:HORZ:RELative:STOP` on page 441

Vertical start/stop value
Defines the vertical value range of the histogram.

SCPI command:
`LAYout:HISTogram:VERTical:ABSolute:STARt` on page 442
`LAYout:HISTogram:VERTical:ABSolute:STOP` on page 442
`LAYout:HISTogram:VERTical:RELative:STARt` on page 443
`LAYout:HISTogram:VERTical:RELative:STOP` on page 443

5.3.4 Reference for Reference Level Settings

Some measurements refer to specific reference or signal levels, e.g. rise time/fall time, counting pulses. Generally, these settings are determined automatically. However, for irregular data it may be useful to configure them manually. You can define reference and signal levels, as well as hystereses for reference levels and tubes for signal levels.



5.3.4.1 General Settings

The general settings are the same for all tabs in the "Reference" dialog box.

Source
Defines the source from which the reference is taken. The source can be any signal input, math or reference waveform.

SCPI command:
Suffix <m> in "REFLevel" subsystem, see chapter 14.2.7.12, "Reference Level", on page 458

Reference level mode
Defines whether the reference level is configured manually or automatically.

SCPI command:
`REFLevel<m>:LDETection` on page 458

Signal level mode
Defines which signal level is used as a reference.

This setting is only available for automatic reference level mode.

"Auto select absolute probability"	The most suitable signal level for the selected measurement is used.
"Peak probability"	The signal level with the highest probability value is used.
"Mean probability"	The signal level with mean probability is used.
"Absolute peak"	The absolute peak signal level is used.

SCPI command:
`REFLevel<m>:AUTO:MODE` on page 460

Level definition
Defines whether the reference is configured using absolute or relative values.

SCPI command:
`REFLevel<m>:LMODe` on page 460

User level selection
Defines whether the user-defined signal levels or user-defined reference levels are used for the measurements.

"User signal level" The high and low signal levels are defined by the user.

"User reference level" The reference levels are defined by the user.

SCPI command:
`REFLevel<m>:USRLevel` on page 459

5.3.4.2 Levels Tab

The settings in this tab configure reference and signal levels. Depending on whether absolute or relative "Level definition" is selected, different level types can be defined.

High

The signal value that represents a high level.

SCPI command:

REFLevel<m>:ABSolute:HIGH on page 461

MEASurement<m>:REFLevel:RESult:SIGHigh on page 468

Top distance

The distance between the high signal level and the upper reference level.

SCPI command:

REFLevel<m>:ABSolute:TDIStance on page 462

Bottom distance

The distance between the lower reference level and the low signal value.

SCPI command:

REFLevel<m>:ABSolute:BDIStance on page 462

Low

The signal value that represents a low level.

SCPI command:

REFLevel<m>:ABSolute:LOW on page 462

MEASurement<m>:REFLevel:RESult:SIGLow on page 469

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
- 10/50/90

For example, for "5/50/95":

- lower reference level = 5% of high signal level
- middle reference level = 50% of high signal level
- upper reference level = 95% of high signal level

SCPI command:

REFLevel<m>:RELative:MODE on page 459

Upper level

The upper reference level, required e.g. to determine a rise.

SCPI command:

REFLevel<m>:ABSolute:ULEVel on page 463

MEASurement<m>:REFLevel:RESult:UPPer on page 468

Lower level

The lower reference level, required e.g. to determine a fall.

SCPI command:

REFLevel<m>:ABSolute:LLEVel on page 463

MEASurement<m>:REFLevel:RESult:LOWer on page 467

Histogram averaging

Enables averaging over several histograms to determine the reference levels.

This function is only available in automatic reference level mode.

SCPI command:

REFLevel<m>:AUTO[:STATe] on page 460

Average Count

Defines the number of histograms to calculate the average from.

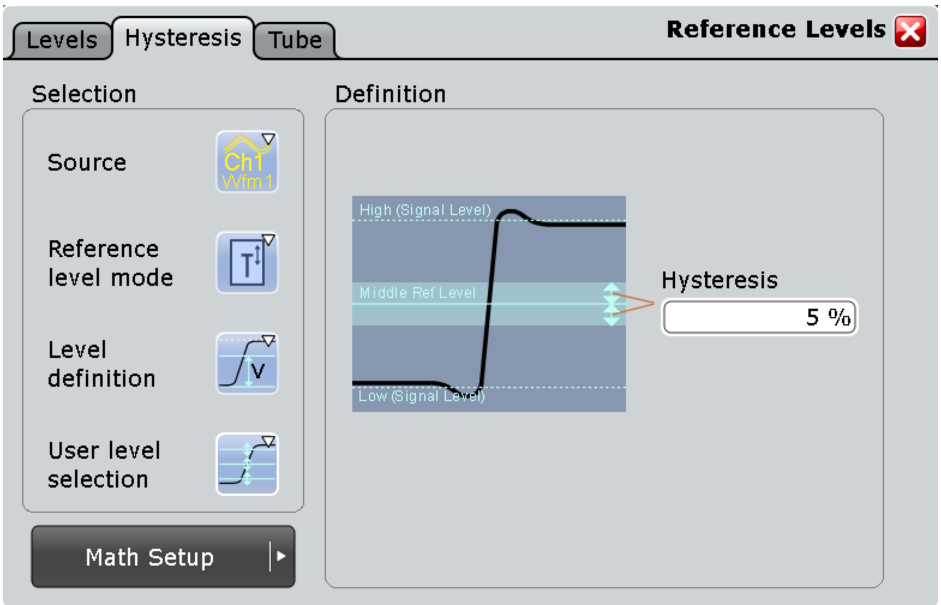
This function is only available in automatic reference level mode.

SCPI command:

REFLevel<m>:AUTO:COUNt on page 461

5.3.4.3 Hysteresis Tab

This tab allows you to define a hysteresis for measurements that determine zero-crossings.



Hysteresis

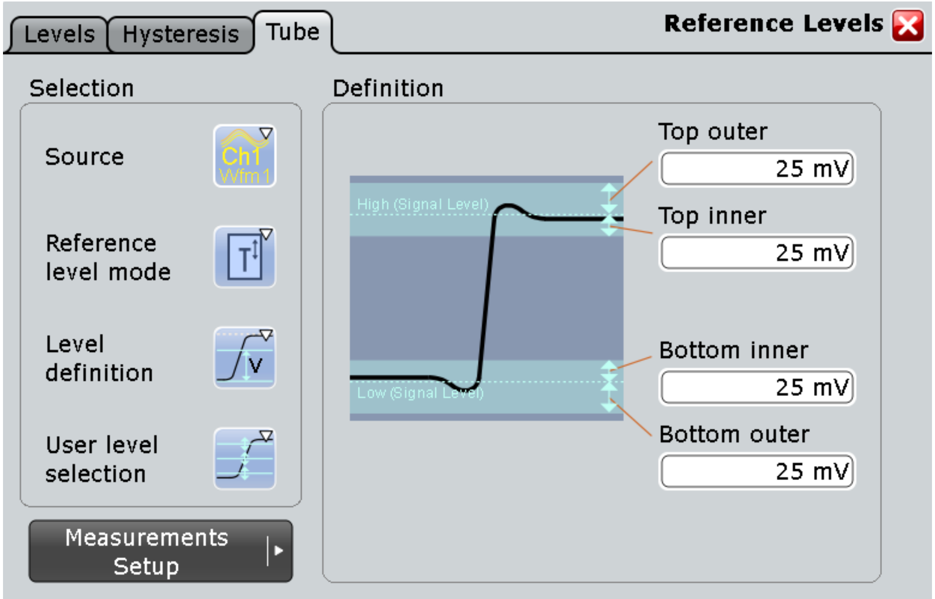
Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

SCPI command:

REFLevel<m>:RELative:HYSTeresis on page 464

5.3.4.4 Tube Tab

This tab allows you to define evaluation tubes for measurements that require high level or low level detection. If the signal value remains within the defined tubes, it is considered to be high or low.



Top outer
Defines an area above the high signal level which is still considered to be high level.

SCPI command:
REFLevel<m>:ABSolute:TOTube on page 465
MEASurement<m>:REFLevel:RESult:TOUTer on page 469

Top inner
Defines an area beneath the high signal level which is still considered to be high level.

SCPI command:
REFLevel<m>:ABSolute:TITube on page 465
MEASurement<m>:REFLevel:RESult:TINNer on page 469

Bottom inner
Defines an area above the low signal level which is still considered to be low level.

SCPI command:
REFLevel<m>:ABSolute:BITube on page 466
MEASurement<m>:REFLevel:RESult:BINNer on page 467

Bottom outer
Defines an area beneath the low signal level which is still considered to be low level.

SCPI command:
REFLevel<m>:ABSolute:BOTube on page 466
MEASurement<m>:REFLevel:RESult:BOUTer on page 467

Relative outer
Defines a percentage of the signal level by which the absolute signal level may be larger than the high signal level or lower than the low signal level to be considered high or low, respectively.

SCPI command:
`REFLevel<m>:RELative:OTUBe` on page 464

Relative inner
Defines a percentage of the signal level by which the absolute signal level may be higher than the low signal level or lower than the high signal level to be considered low or high, respectively.

SCPI command:
`REFLevel<m>:RELative:ITUBe` on page 465

6 Mathematics and Reference Waveforms

In addition to the acquired waveforms you can display stored reference waveforms or calculated data - mathematical waveforms - to compare the current waveform with or to evaluate the acquired data.

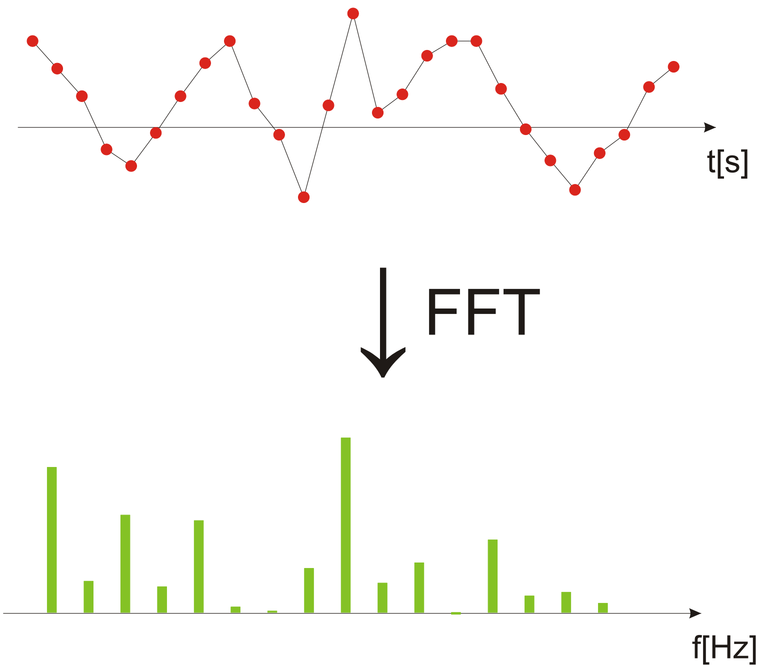
6.1 Mathematical Waveforms

The R&S RTO provides different methods of creating mathematical waveforms:

- Applying mathematical functions to source data
- Performing FFT analysis on source data

6.1.1 General Notes and Restrictions for 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.

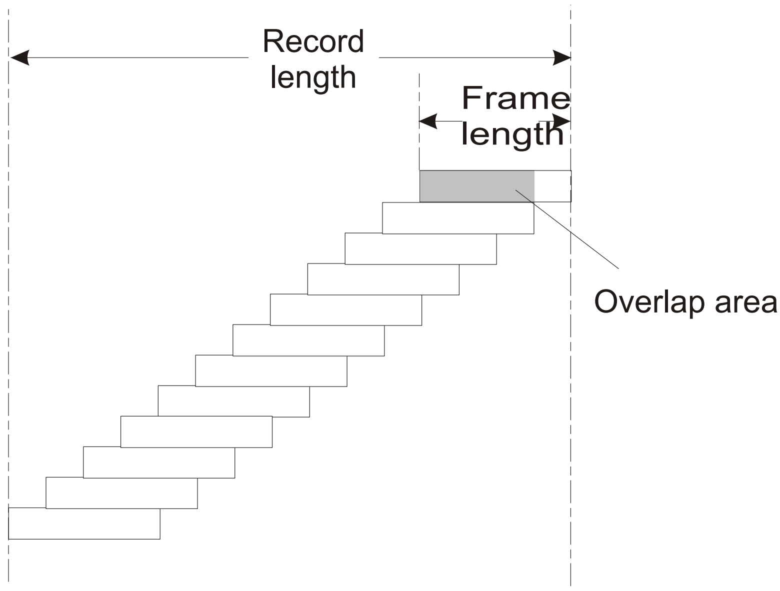


Frames

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 RTO can calculate multiple FFTs per capture by dividing one capture into several frames. Thus, the RTO 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 RTO 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.

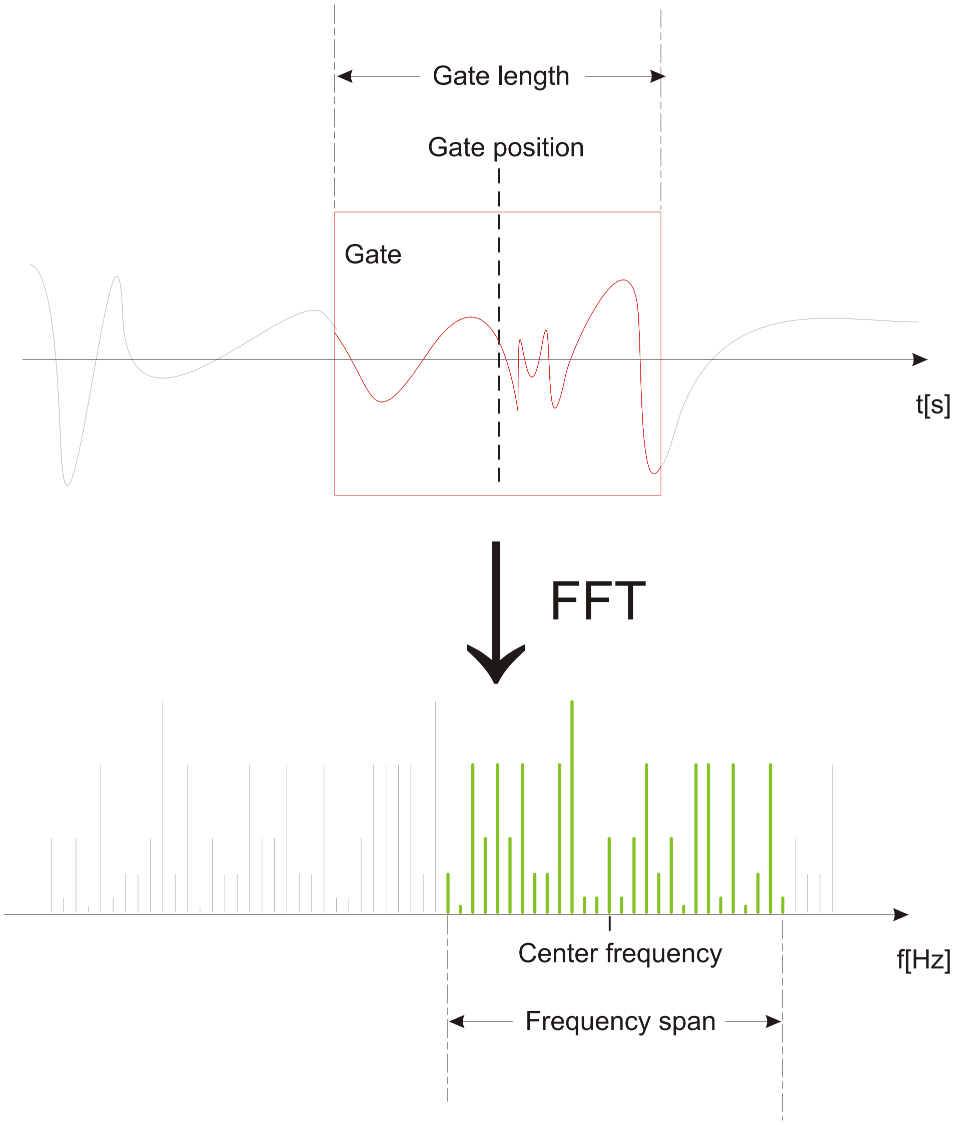
For details, see "Window type" on page 181.

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.

The gate area can be indicated in the signal diagram, if desired.



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

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 "Optimized" 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 RTO 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 a 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

6.1.2 Working with Math Waveforms

You can define up to four math waveforms that can display the results of calculations or FFT analysis.

You can store a math waveform as a reference waveform and restore it any time later, see "To save a reference waveform" on page 188.

6.1.2.1 Displaying Math Waveforms

The math waveforms can be displayed in addition to the signal waveforms.

1. In the "Math" menu, select "Math Setup", or press the MATH key.
2. Define the math expression to be calculated as described in chapter 6.1.2.2, "Editing Formulas for Math Expressions", on page 167 or setup an FFT analysis as described in chapter 6.1.2.3, "Configuring FFT Waveforms", on page 169.
3. In the "Math Setup" dialog box, in the "Setup" tab, tap the "Enable math signal" icon so it is highlighted.

   The math waveform is displayed on the screen.
4. To change the vertical scaling of the math waveform, tap the "Manual" icon, then enter the vertical scale factor (per division) and, if necessary, a vertical offset. By default, automatic scaling is performed.
5. As for signal waveforms, you can change the arithmetic mode for the waveform to display the envelope or an average over several calculations.
   See also: "Wfm Arithmetic" on page 33.
6. Close the "Math Setup" dialog box.

6.1.2.2 Editing Formulas for Math Expressions

You can enter the math waveform definition using two different modes:

- "Optimized": a graphical editor allows you to define the data Source 1 / 2 and Operator for a simple math function quickly
- "Advanced": a formula editor allows you to define sophisticated math functions freely, as required

To define a formula in the optimized graphical editor

1. In the "Math" menu, select "Math Setup", or press the MATH key.
2. In the "Setup" tab, select the "Optimized" tab.
3. Tap the Source 1 / 2 icon and select the signal source(s) to which the math function will be applied. For details on available signal sources see "Source 1 / 2" on page 173.

4. Tap the Operator icon. For details on available operators see "Operator" on page 173
   Note: The "dx/dt" and "FIR filter" operators are not available for sources using the "Envelope" waveform arithmetic function.
5. If the operator requires additional parameters, enter them in the a / b fields.

To define 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 6.1.3.2, "Formula Editor", on page 176.
   Note: Input channels using the "Envelope" waveform arithmetic function cannot be used as a source for integral, derivation, correlation, autocorrelation and FIR filter calculations. Otherwise, the math waveform becomes invalid and is not available for display or further processing.
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 that is to be rescaled 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)`

6.1.2.3 Configuring FFT Waveforms

During FFT analysis, a signal in the time domain is converted to a spectrum of frequencies. A basic FFT 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.

To display a basic FFT 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 FFT waveform is displayed in a new diagram.

2. Alternatively, press the MATH key to open the "Math" dialog box.
3. In the "Setup" tab, in the "Optimized" expression editor, select the input signal as "Source 1".
4. Select "Mag(FFT(x))" as the "Operator".
5. Select the "Enable math signal" icon.
6. If required, edit the FFT waveform parameters as described in To configure the FFT setup.

To configure the FFT setup

1. Select the "FFT Setup" tab of the "Math" dialog box.
2. 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.
   a) Disable the "Span/RBW coupling".
   b) 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.
   c) Change the "Span/RBW ratio". The smaller the ratio, the higher the RBW becomes to display the same frequency span.

d) 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 a high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase performance.

3. 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 181.
4. Select an arithmetic mode for the FFT frames. This mode defines how the individual frame results are combined to a final FFT waveform.
5. Select an overlap factor for neighboring frames.
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.

To configure magnitude results

1. Open the "FFT Magnitude/Phase" 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.
5. In automatic mode, define the size of the "Range" to be displayed.
6. For logarithmic scaling in dB, also define the "Reference level" to be used.

To configure phase results

1. Open the "FFT Magnitude/Phase" 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 restrict the input values (gating)

1. In the "FFT Gating" tab of the "Math" dialog box, define the gate area, i.e. the extract of the time base in the original diagram for which the FFT analysis is to be performed. To do so, use one of the following methods:
   - 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" and then an active zoom diagram.

2. Tap the "Use gate" icon.
3. To indicate the defined gate area in the original diagram, tap the "Show gate" icon.

   The FFT waveform displays the spectrum for the indicated area in the original time base.

To display advanced FFT 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.

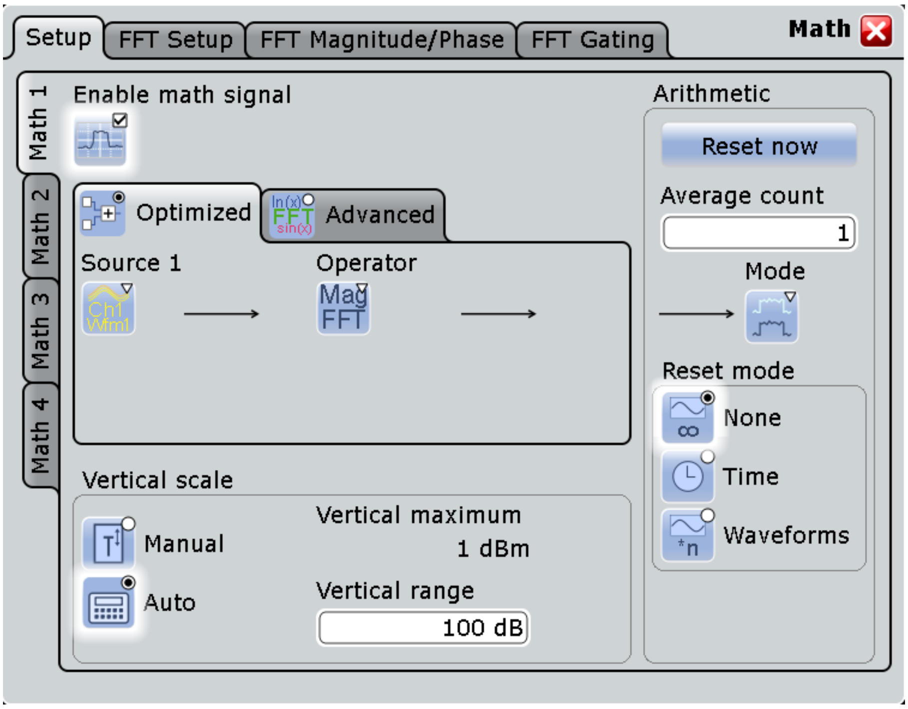
   The "FormulaEditor" is displayed.
3. Tap the "More" key to display further functions in the editor.
4. Tap the required function key.
5. Select the source channel.
6. Close the parenthesis and tap "Enter".

6.1.3 Reference for Math Functions

You can use mathematical functions to define reference waveforms for your measurements, for example, or to implement FFT Analysis. This section describes the individual settings for mathematical functions.

6.1.3.1 Math Setup

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").



Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

SCPI command:

`CALCulate:MATH<m>:STATe` on page 470

Optimized/Advanced

You can enter the math waveform definition using two different modes:

- "Optimized": a graphical editor allows you to define the waveform Source 1 / 2 and Operator for a simple math function quickly
- "Advanced": a formula editor allows you to define sophisticated math functions freely, as required

For details on entering math functions, see chapter 6.1.2.2, "Editing Formulas for Math Expressions", on page 167.

SCPI command:
`CALCulate:MATH<m>[:EXPRession][:DEFine]` on page 471

Source 1 / 2 ← Optimized/Advanced
Defines the signal source to be evaluated by the math function. Select the first trace of one of the 4 available channels.

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.
Input channels using the "Envelope" waveform arithmetic function cannot be used as a source for integral, derivation, correlation, autocorrelation and FIR filter calculations.

For details on entering math functions, see chapter 6.1.2.2, "Editing Formulas for Math Expressions", on page 167.

Operator ← Optimized/Advanced
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. For details on entering math functions, see chapter 6.1.2.2, "Editing Formulas for Math Expressions", on page 167.

"+"	Adds up the sources
"-"	Subtracts source 2 from source 1.
"x"	Multiplies source 1 by source 2.
"-x"	Negates the values of the source.
"|x|"	Determines the absolute value of the source.
"dx/dt"	Differentiates the source value with respect to the time value.
"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 (logarithmus dualis, based on 2).
"ax+b Rescale"	Rescales the source values by a factor "a" and an offset "b".
"FIR filter"	Finite impulse response filter - highpass or lowpass filter for a specified cut-off frequency
"Mag(FFT(x))"	Determines the magnitude of the FFT for the source values.

Noise reject ← Optimized/Advanced

In order 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}), but rather to skip a number of samples inbetween and use a point a few samples further (e.g. x_n-x_{n-3}).

The number of samples entered here defines the number of neighboring samples that are skipped for differentiation. A value of 1 Sa maintains the standard calculation.

Only available for the "dx/dt" operator.

a / b ← Optimized/Advanced

Defines the values for the rescaling function (ax+b), see "Operator" on page 173.

"a"	is the factor the signal source is multiplied with
"b"	is the offset of the signal source on the y-axis

Characteristics ← Optimized/Advanced

Defines whether the FIR filter is a highpass or lowpass filter.

Cut-Off ← Optimized/Advanced

Defines the cut-off frequency for the FIR filter.

Advanced Expression ← Optimized/Advanced

Double-tap the field to display the formula editor. Using the formula editor you can define math functions freely, using a large selection of operators and signal sources. For details on entering math functions, see chapter 6.1.2.2, "Editing Formulas for Math Expressions", on page 167.

Vertical Scale

Functions to set the vertical parameters of the math waveform.

Vertical scale 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. *50mV/div*. In this case, the horizontal grid lines are displayed in intervals of 50mV.

If the Vertical scale mode (Manual/Auto) is set to "Auto", this setting is read-only.

SCPI command:
CALCulate:MATH<m>:VERTical:SCALe on page 472

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 au, positive values move it down.

If the Vertical scale mode (Manual/Auto) is set to "Auto", this setting is read-only.

SCPI command:
CALCulate:MATH<m>:VERTical:OFFSet on page 471

Vertical maximum ← Vertical Scale
For FFT: Maximum value on y-axis for spectrum displays, see chapter 6.1.3.4, "FFT Magnitude/Phase", on page 183.

Vertical range ← Vertical Scale
For FFT: Vertical range for spectrum displays, see chapter 6.1.3.4, "FFT Magnitude/Phase", on page 183.

Arithmetic
Functions to specify the waveform arithmetic for the math waveforms.

Reset Now ← Arithmetic
Forces the immediate restart of the envelope and average calculation for all waveforms, ignoring the reset settings.

Average count ← Arithmetic
The "Average count" has a double effect:

- It defines the number of waveforms used to calculate the average waveform.
- It sets the number of waveforms acquired with RUN N× SINGLE.

Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the "Average count" is, the better the noise is reduced.

SCPI command:
ACQuire:COUNt on page 345

Mode ← Arithmetic
Waveform arithmetics build the resulting waveform from several consecutive acquisitions and subsequent math calculations of the signal. For details see "Wfm Arithmetic" on page 33.

"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

SCPI command:
CALCulate:MATH<m>:ARIThmetics on page 470

Reset mode ← Arithmetic

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".

6.1.3.2 Formula Editor

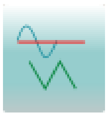
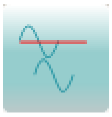
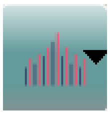
Using the formula editor you can define math functions freely, using a large selection of operators and signal sources. For details on entering math functions, see chapter 6.1.2.2, "Editing Formulas for Math Expressions", on page 167.

Table 6-1: Formula Editor keys and resulting expressions

Icon	Description	Usage/ Comment *FormulaEditor expression*
Basic keys		
(	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

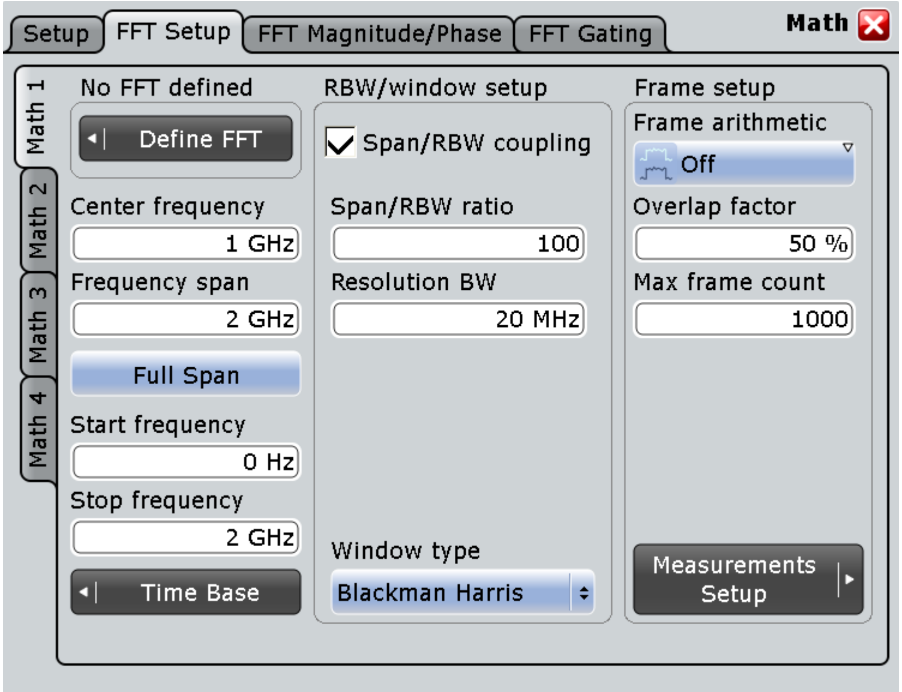
Icon	Description	Usage/ Comment *FormulaEditor expression*
V / A / Ω	units	[<unit>]
]	right square bracket	enclose unit
x^a	exponentiation with base x	x: base, a: exponent *x^a*
/	division	
*	multiplication	
-	subtraction	
+	addition	
0...9	numeric characters	
.	decimal point	
Exp	exponentiation with base 10	*e*
Enter	expression complete	insert expression in Setup dialog
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>]
Signal sources		
Ch	signal channel	*Ch<1...4>Wfm<1...3>*
Math	math channel	*Math<1...4>*
Ref	reference channel	*Ref<1...4>*
Meas	measurement channel	*Meas<1...8>*
Cursor keys		
|←	move cursor to beginning	
←	move cursor 1 step to the left	
→	move cursor 1 step to the right	
→|	move cursor to end	
Algebra		
|x|	absolute x value	*abs(x)*
√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)*

Icon	Description	Usage/ Comment ***FormulaEditor expression***
$\log_2$	binary logarithm (base 2)	*ld(x)*
e^x	exponentiation with base e	*exp(x)*
$\int xdx$	integral of x	*integral(x)*
d/dx	derivation of x	*derivation(x)*
ax+b	scaling of x	*rescale(x,a,b)*
Trigonometry		
sin	sinus	*sin(x)*
cos	cosinus	*cos(x)*
tan	tangens	*tan(x)*
$\sin^{-1}$	arcsin	*arcsin(x)*
$\cos^{-1}$	arccos	*arccos(x)*
$\tan^{-1}$	arctan	*arctan(x)*
sinc	sin(x) / x	*sinc(x)*
Bit operations		
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*
Comparison		
=	equal	=
≠≠	not equal	<>
<	smaller	<
>	greater	>
≤	smaller or equal	<=
≥	greater or equal	>=
More	display additional keys	
More keys		
FFT		

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)*
Trigonometry		
sinh	hyperbolic sinus	*sinh(x)*
cosh	hyperbolic cosinus	*cosh(x)*
tanh	hyperbolic tangens	*tanh(x)*
Correlation		
	correlation	*correlation(x)*
	autocorrelation	*autocorrelation(x)*
	biased / unbiased correlation	*biased(x) / unbiased(x)*
Miscellaneous		
	Electric power	power calculated from voltage, based on measurement impedance (see "Measurement impedance" on page 38) U^2/R *elecpower(x)*

6.1.3.3 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.



Enable Math Signal

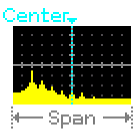
If activated, a diagram for the defined math waveform is displayed on the touch screen.

SCPI command:

CALCulate:MATH<m>:STATe on page 470

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.

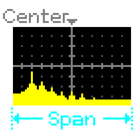


SCPI command:

CALCulate:MATH<m>:FFT:CFRequency on page 474

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.



SCPI command:

CALCulate:MATH<m>:FFT:SPAN on page 475

Full span
Displays the full frequency span.

SCPI command:
CALCulate:MATH<m>:FFT:FULLspan on page 475

Start frequency
Defines the start frequency of the displayed frequency span.

SCPI command:
CALCulate:MATH<m>:FFT:STARt on page 473

Stop frequency
Defines the stop frequency of the displayed frequency span.

SCPI command:
CALCulate:MATH<m>:FFT:STOP on page 473

Span/RBW Coupling
Couples the frequency span to the "Resolution BW" setting.

SCPI command:
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO on page 476

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.

SCPI command:
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:RATio on page 476

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 6.1.1, "General Notes and Restrictions for FFT Analysis", on page 163.

SCPI command:
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution][:VALue] on page 476
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:ADJusted on page 475

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 RTO 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

SCPI command:
`CALCulate:MATH<m>:FFT:WINDow:TYPE` on page 473

Frame 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 frames, each of which is calculated separately. The frames need not be disjunct, i.e. 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 frame is taken into consideration. In effect, no arithmetics are processed.

"Envelope" Detects the minimum and maximum values for FFT calculation over all frames. 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 frames.

SCPI command:
`CALCulate:MATH<m>:FFT:FRAMe:ARIThmetics` on page 477

Overlap Factor
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.

SCPI command:
`CALCulate:MATH<m>:FFT:FRAMe:OFACtor` on page 478

Max frame count
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.

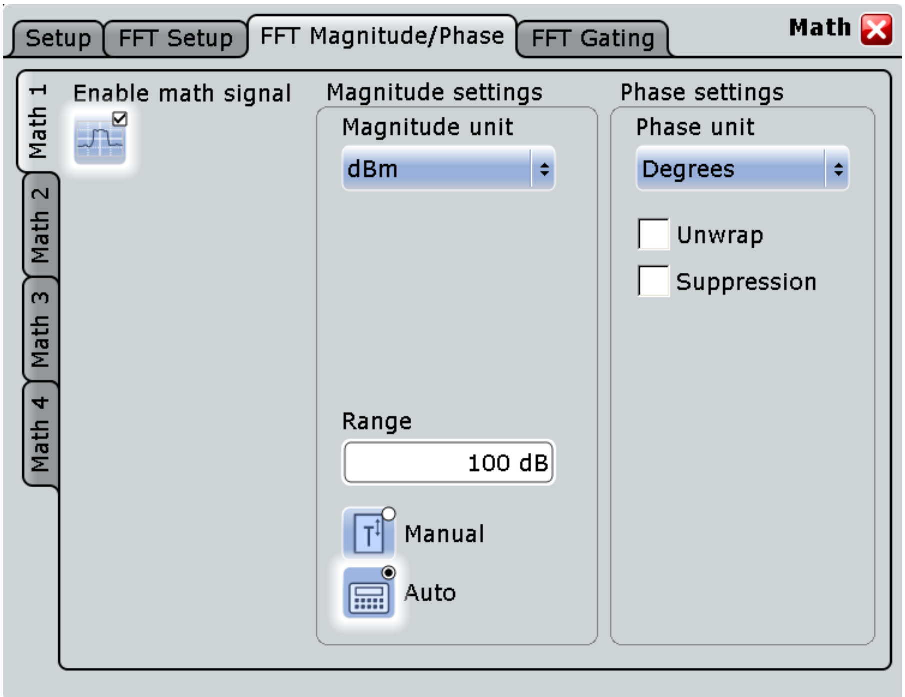
SCPI command:
`CALCulate:MATH<m>:FFT:FRAMe:MAXCount` on page 478

Frame coverage
Due to the Max frame count restriction, the waveform may only be analyzed partially. The "Frame coverage" indicates the percentage of the trace that was analyzed, i.e. which part of the trace was included in the frame calculation.

SCPI command:
`CALCulate:MATH<m>:FFT:FRAMe:COVerage` on page 478

6.1.3.4 FFT Magnitude/Phase

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.

SCPI command:
`CALCulate:MATH<m>:STATe` on page 470

Magnitude unit
Defines the scaling of the y-axis. The display values are valid for 50Ω termination impendance.

"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"	logarithmic scaling; related to 1 µV
"dBmV"	logarithmic scaling; related to 1 mV
"dBV"	logarithmic scaling; related to 1 V

SCPI command:
CALCulate:MATH<m>:FFT:MAGNitude:SCALe on page 482

Reference level
Defines the reference level for dB scaling.

SCPI command:
CALCulate:MATH<m>:FFT:MAGNitude:LEVel on page 481

Vertical scale 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.

SCPI command:
CALCulate:MATH<m>:VERTical:RANGe on page 471

Range
Defines the vertical value range in spectrum mode.

SCPI command:
CALCulate:MATH<m>:FFT:MAGNitude:RANGe on page 482

Phase unit
Defines the scaling unit for phase display.

- Radians

- Degrees

SCPI command:
`CALCulate:MATH<m>:FFT:PHASe:SCALe` on page 482

Unwrap
If enabled, phase shifts due to a limitation of the value range are eliminated.

SCPI command:
`CALCulate:MATH<m>:FFT:PHASe:UNWRap` on page 483

Suppression
Enables noise suppression. Phase calculation is restricted to frequencies with a minimum magnitude, the threshold value.

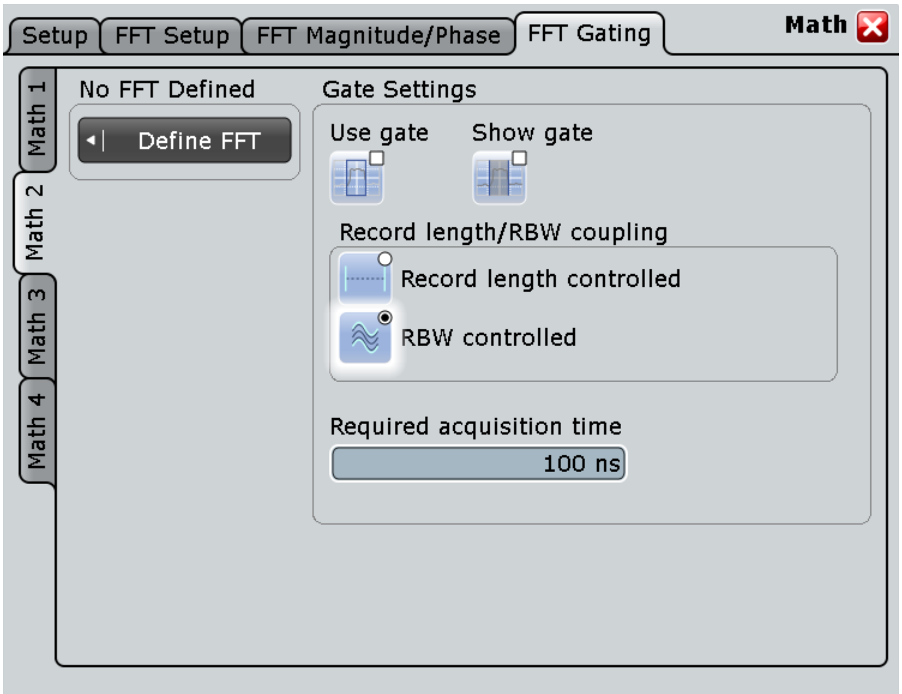
SCPI command:
`CALCulate:MATH<m>:FFT:PHASe:SUPPression` on page 483

Threshold
Defines the minimum frequency magnitude for which phases are calculated. This setting is only available if "Suppression" is enabled.

SCPI command:
`CALCulate:MATH<m>:FFT:PHASe:THReshold` on page 483

6.1.3.5 FFT Gating

FFT gating allows you to restrict FFT analysis to a certain time base of the input signal.



Enable Math Signal
If activated, a diagram for the defined math waveform is displayed on the touch screen.

SCPI command:
`CALCulate:MATH<m>:STATe` on page 470

Use Gate
Enables FFT gating.

If enabled, the "Gate Definition" settings are displayed. If disabled, record length and RBW settings are displayed.

When a gate is used, the RBW is adapted, if necessary. The smaller the gate, the higher the RBW.

For details see chapter 6.1.1, "General Notes and Restrictions for FFT Analysis", on page 163.

Show Gate
Indicates the gate area in the source diagram.

SCPI command:
`CALCulate:MATH<m>:FFT:GATE:SHOW` on page 480
`MEASurement<m>:GATE:SHOW` on page 456
`SEARch:GATE:SHOW` on page 527

Gate Definition
Defines the gate settings for FFT gating.

Zoom Coupling ← Gate Definition
If enabled, the gate area is defined identically to the zoom area for the selected active zoom diagram.

SCPI command:
`CALCulate:MATH<m>:FFT:GATE:ZCOupling` on page 480
`CALCulate:MATH<m>:FFT:GATE:ZDIagram` on page 481
`MEASurement<m>:GATE:ZCOupling` on page 456
`MEASurement<m>:GATE:ZDIagram` on page 457
`SEARch:GATE:ZCOupling` on page 528
`SEARch:GATE:ZDIagram` on page 528

Gate Mode ← Gate Definition
Defines whether the gate settings are configured using absolute or relative values.

"Absolute" Gating is performed between the defined absolute start and stop values.

"Relative" Gating is performed for a percentage of the value range, defined by start and stop values.

SCPI command:
`CALCulate:MATH<m>:FFT:GATE:MODE` on page 479
`MEASurement<m>:GATE:MODE` on page 455
`SEARch:GATE:MODE` on page 526

(Relative) Start ← Gate Definition
Defines the starting value for the gate.

SCPI command:
`CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt` on page 479
`CALCulate:MATH<m>:FFT:GATE:RELative:STARt` on page 480
`MEASurement<m>:GATE:ABSolute:STARt` on page 455
`MEASurement<m>:GATE:RELative:STARt` on page 455
`SEARch:GATE:ABSolute:STARt` on page 527
`SEARch:GATE:RELative:STARt` on page 527

(Relative) Stop ← Gate Definition
Defines the end value for the gate.

SCPI command:
`CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP` on page 479
`CALCulate:MATH<m>:FFT:GATE:RELative:STOP` on page 480
`MEASurement<m>:GATE:ABSolute:STOP` on page 455
`MEASurement<m>:GATE:RELative:STOP` on page 455
`SEARch:GATE:ABSolute:STOP` on page 527
`SEARch:GATE:RELative:STOP` on page 528

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.

For details see chapter 6.1.1, "General Notes and Restrictions for FFT Analysis", on page 163.

"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.

SCPI command:
`CALCulate:MATH<m>:FFT:GATE:COUPling` on page 476

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.

SCPI command:
`TIMebase:RACTime` on page 477

6.2 Reference Waveforms

6.2.1 Working with 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.

To display a reference waveform

Reference waveforms can be displayed in addition to the signal waveforms.

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 189, 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.
5. A reference waveform can have its own scaling settings or it can be scaled according to the source settings. By default, the scaling of the reference waveform is coupled to the source settings. Additionally, it can be stretched or compressed in vertical and horizontal direction.
   If necessary, change the settings on the "Scaling" tab of the "Reference Waveform" dialog box. The original source waveform settings are displayed in the "Original Attributes" tab. To restore the original settings, tap the "Restore settings" button.
   For a description of the scaling settings, see chapter 6.2.2.2, "Scaling", on page 191.

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 10.1.2, "Saving and Loading Waveform Data", on page 261.
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 188.

4. To save the waveform to the currently selected file, select "Save". By default, the prefix for reference waveform files is "RefCurve".
   To save the waveform to a new file, select "Save As" and enter a file name, then select the directory and file type. In order to load the reference waveform on the instrument again later, use the file type `.bin` or `.xml`.

   The source settings of the reference waveform and the current scaling settings are stored to the specified file.

To load a reference waveform

1. In the "Math" menu, select "Reference Waveform > Setup", or press the REF key.

   Tip: Alternatively, you can load a waveform as a reference waveform from the "File" dialog box, see chapter 10.1.2, "Saving and Loading Waveform Data", on page 261.
2. Select the tab for the reference waveform you want to load ("Ref1"-"Ref4").
3. To re-load the currently selected file, tap the "Load" button.
   To open a new file, tap the "Open" button. In the file selection dialog box, select the file that contains the reference waveform (file type `.bin` or `.xml`) and tap "Select".

   The reference waveform with its stored settings is loaded.
4. Tap the "Show reference waveform" icon to display the reference waveform.

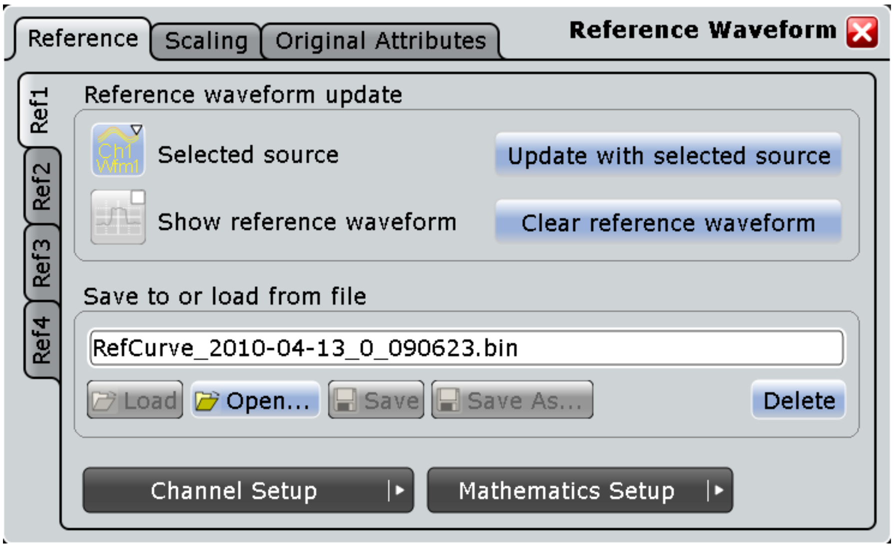
6.2.2 Reference Waveforms

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.

The display of a reference waveform is independent from that of the source waveform; you can move, stretch and compress the curve vertically and horizontally. Reference waveforms are configured in the "Reference Waveform" dialog box, which is displayed when you press the REF key or select "Math > Reference curves" from the menu.

6.2.2.1 Reference tab

In the "Reference" tab, you select the reference waveform and its source.The source is 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.

SCPI command:

`REFCurve<m>:SOURce` on page 485

Update with selected source

Copies the selected source waveform with all its settings to the memory of the reference waveform.

SCPI command:

`REFCurve<m>:UPDate` on page 486

Show reference waveform

Displays the reference waveform in the diagram.

SCPI command:

`REFCurve<m>:STATe` on page 485

Clear reference waveform
The selected reference waveform disappears, its memory is deleted.

SCPI command:
REFCurve<m>:CLEar on page 487

Save and load a reference waveform
Select the file name of the stored reference waveform. Double-tap the file name to open the file selection dialog box.

Note that reference waveforms can be loaded from `.bin` files only.

For details see chapter 10.2.4, "File Selection Dialog", on page 270.

Load ← Save and load a reference waveform
Loads the specified reference waveform.

Open ← Save and load a reference waveform
Opens a file selection dialog box and loads the selected reference waveform file

SCPI command:
REFCurve<m>:OPEN on page 486

Save / Save As ← Save and load a reference waveform
Saves the selected reference waveform with its current "Scaling" settings to the file.

"Save As" opens the file selection dialog box to select the target directory and the file format.

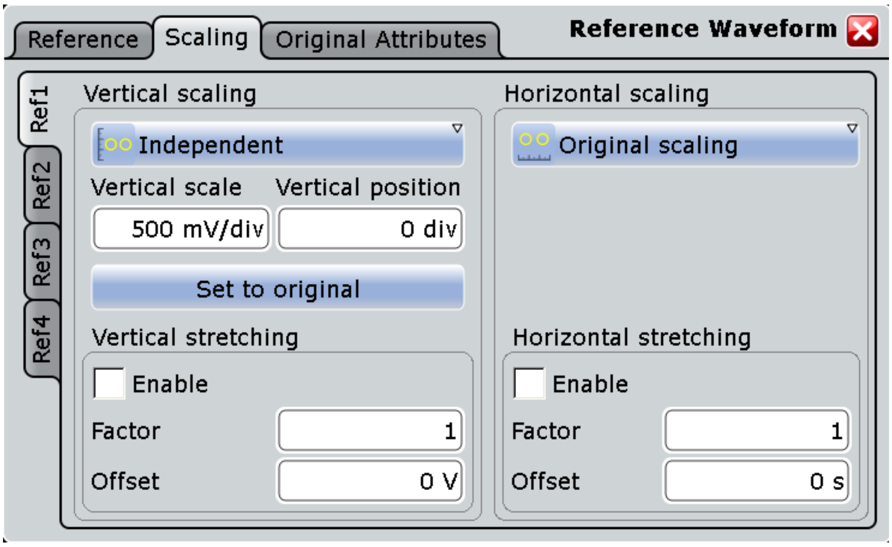
By default, the file name has the prefix "RefCurve_".

Note: XML and CSV formats are meant for further processing in other applications. If you want to load the reference waveform on the R&S RTO again, use the `.bin` format.

SCPI command:
REFCurve<m>:SAVE on page 486
REFCurve<m>:DELete on page 486

6.2.2.2 Scaling

A reference waveform can have its own settings, for example, vertical position und scale. Additionally, it can be stretched or compressed in vertical and horizontal direction. The current settings and the settings of the source waveform are stored.



Vertical Scaling

Selects the type of vertical settings:

"Coupled to source" Vertical position and scale of the source are used.

"Independent" Scaling and position can be set specific to the reference waveform.

SCPI command:

REFCurve<m>:VMODe on page 487

Vertical scale

Sets the scale factor for the reference waveform, if vertical scaling is set to "Independent".

SCPI command:

REFCurve<m>:SCALe on page 488

Vertical position

Moves the reference waveform up or down in the diagram, if vertical scaling is set to "Independent".

SCPI command:

REFCurve<m>:POSition on page 488

Set to original

Restores the settings of the source waveform, if vertical scaling is set to "Independent".

SCPI command:

REFCurve<m>:RESTore on page 487

Vertical Stretching

Stretching changes the display of the waveform independent of the vertical scale and position.

Enable ← Vertical Stretching
Enables and disables the vertical stretching.

SCPI command:
`REFCurve<m>:RESCale:VERTical:STATe` on page 488

Factor ← Vertical Stretching
A factor greater than 1 stretches the waveform vertically, a factor lower than 1 compresses the curve.

SCPI command:
`REFCurve<m>:RESCale:VERTical:FACTor` on page 489

Offset ← Vertical Stretching
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.

SCPI command:
`REFCurve<m>:RESCale:VERTical:OFFSet` on page 489

Horizontal Scaling
Selects the type of horizontal settings:

"Adjust to X-Axis"	The current horizontal settings of the diagram are used.
"Original Scaling"	Horizontal scaling and reference point of the source waveform are used.

SCPI command:
`REFCurve<m>:HMODe` on page 489

Horizontal Stretching
Stretching changes the display of the waveform independent of the horizontal settings of the source waveform and of the horizontal diagram settings.

Enable ← Horizontal Stretching
Enables and disables the horizontal stretching.

SCPI command:
`REFCurve<m>:RESCale:HORizontal:STATe` on page 490

Factor ← Horizontal Stretching
A factor greater than 1 stretches the waveform horizontally, a factor lower than 1 compresses the curve.

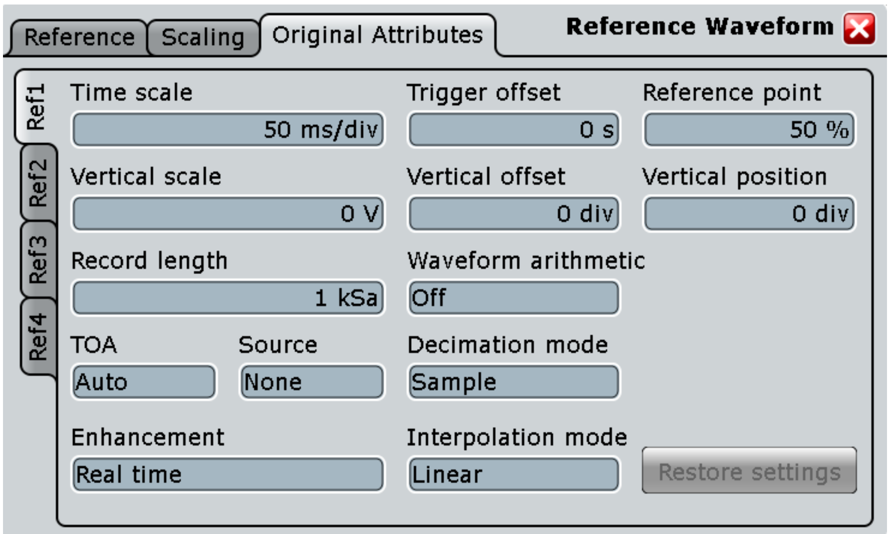
SCPI command:
`REFCurve<m>:RESCale:HORizontal:FACTor` on page 490

Offset ← Horizontal Stretching
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.

SCPI command:
`REFCurve<m>:RESCale:HORizontal:OFFSet` on page 490

6.2.2.3 Original Attributes

As a reference waveform can be scaled, stretched and positioned in the diagram, this tab shows the settings of the original reference waveform for information.



- "Time scale" on page 27
- "Vertical scale" on page 37
- "Resolution / Record length (Time scale dependency)" on page 30
- "Source" on page 190
- "Resolution enhancement" on page 31
- "Trigger offset" on page 27
- "Offset" on page 36
- "Wfm Arithmetic" on page 33
- "Decimation" on page 33
- "Interpolation mode" on page 32
- "Reference point" on page 28
- "Position" on page 37

Restore Settings
Restores the original waveform settings from the source waveform to the reference waveform.

7 Mask Testing

7.1 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 RTO has only a minor impact on the acquisition rate, thus mask violations are detected very fast and reliably.

With R&S RTO, 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. See also: chapter 4.4, "History", on page 106.

Mask test

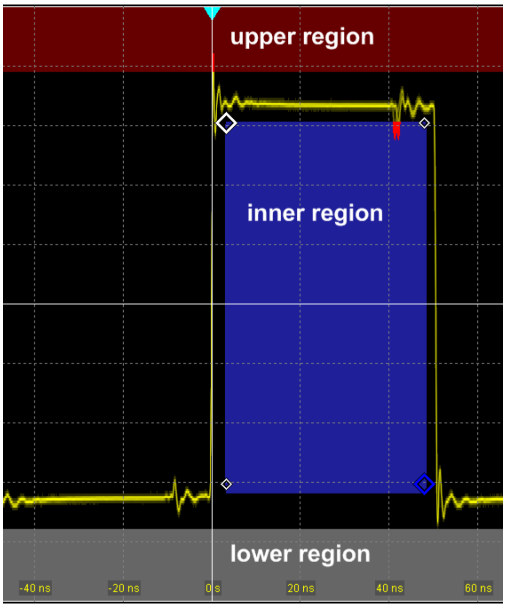
A mask test consists of:

- Mask definition
- Waveform to be tested
- Fail criteria
- Actions to be taken on violation or successful completion

Mask definition: Mask and mask segments

A 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.

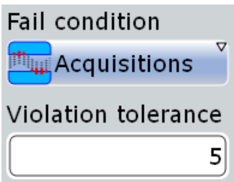


Fail criteria

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 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 test has failed when the sixth acquisition violated the mask.

7.1.1 Results of a Mask Test

The result box of a mask test shows the following test results:

Acq. completed
Number of tested acquisitions.

SCPI command:
`MTESt:RESult:COUNt:WAVeforms` on page 501

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.

See also: chapter 7.2.5, "Running a Mask Test", on page 203.

SCPI command:
`MTESt:RESult:COUNt:REMaining` on page 502

State
Shows if the test is running or has finished. The state is set to "Finished" if no acquisitions remain.

SCPI command:
`MTESt:RESult:STATe` on page 501

Sample hits
Number of samples that hit the mask.

SCPI command:
`MTESt:RESult:COUNt:FAILures` on page 502

Acquisition hits
Number of acquisitions that contained at least one sample hit.

SCPI command:
`MTESt:RESult:COUNt:FWAVeforms` on page 502

Fail rate
Ratio of acquisition hits to the number of tested acquisitions.

SCPI command:
`MTESt:RESult:FRATe` on page 503

Test result
A test has failed if the number of sample hits or acquisition hits exceeds the limit of "Violation tolerance" hits.

SCPI command:
`MTESt:RESult[:RESult]` on page 501

7.2 Working with Masks

7.2.1 Creating New Masks

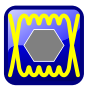
There are two ways to create a new mask:

- Graphical way by tapping the mask points on the touch screen,
- 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 touch screen, 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.
3. To finish the segment and mask definition, double-tap the last point, or tap the "Select" icon on the toolbar.

   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 7.3.2, "Mask Definition", on page 206.

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.

7.2.2 Modifying 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:

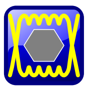
- Move, add, and delete segments
- Move and delete points

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.

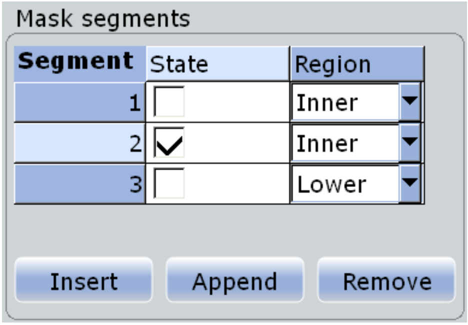
To move a point on the touch screen

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.

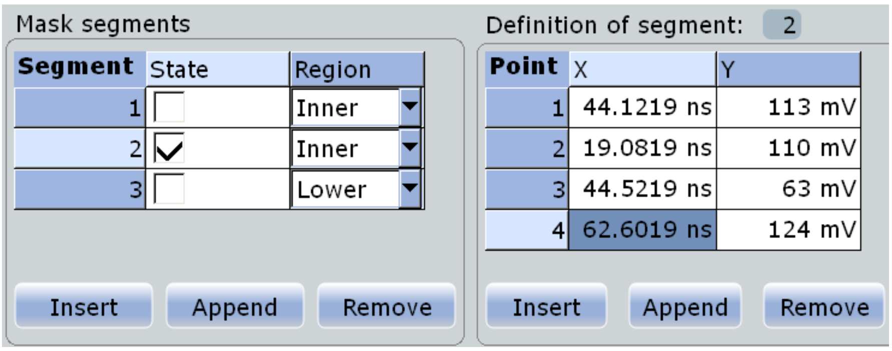
To change the mask definition numerically

The settings mentioned here are described in detail in chapter 7.3.2, "Mask Definition", on page 206.

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 7.3.2, "Mask Definition", on page 206.

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.

7.2.3 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". All channel, math, and reference waveforms can 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"

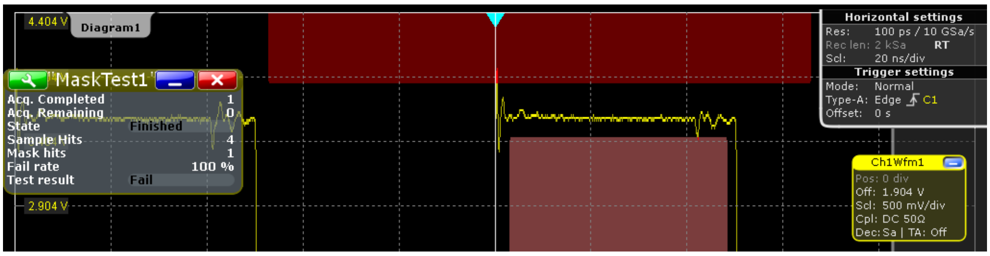
7.2.4 Configuring the Mask and Hit Display

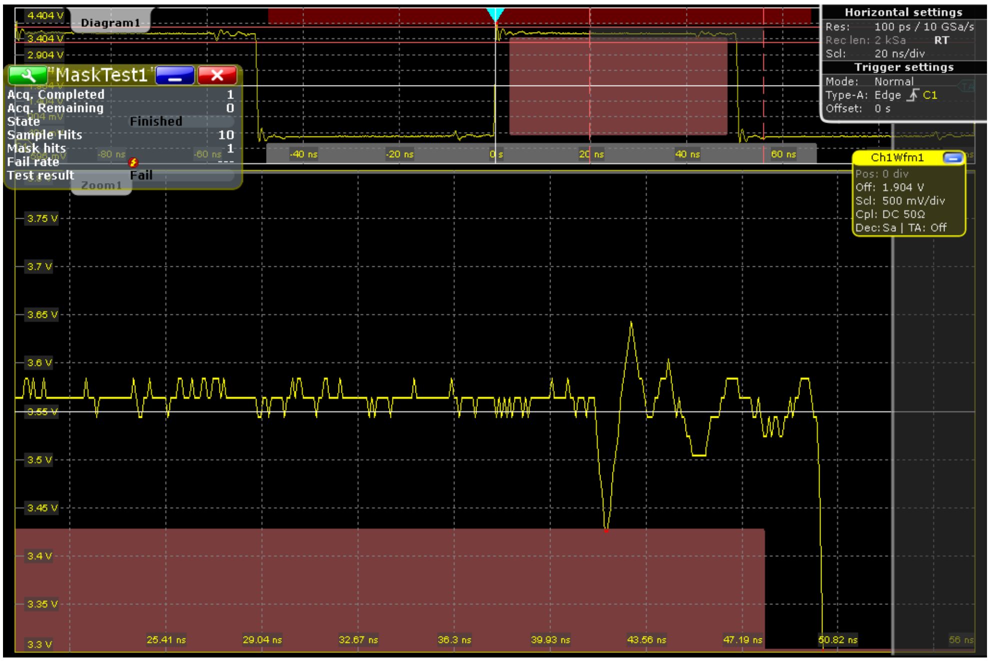
The display of masks and mask violation is the same for all mask tests.

The settings mentioned here are described in detail in chapter 7.3.4, "Mask Display", on page 210.

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.





7.2.5 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 7.2.1, "Creating New Masks", on page 198 and chapter 7.2.2, "Modifying Masks", on page 199.
- The mask test is defined, see chapter 7.2.3, "Setting Up a Mask Test", on page 202
- The mask display is configured, see chapter 7.2.4, "Configuring the Mask and Hit Display", on page 202.

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:"Average count" on page 34
   c) Press RUN N× SINGLE.

7.2.6 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 "To define the automatic file name pattern" on page 264.
4. To select the directory and enter the file name, tap "Save As".

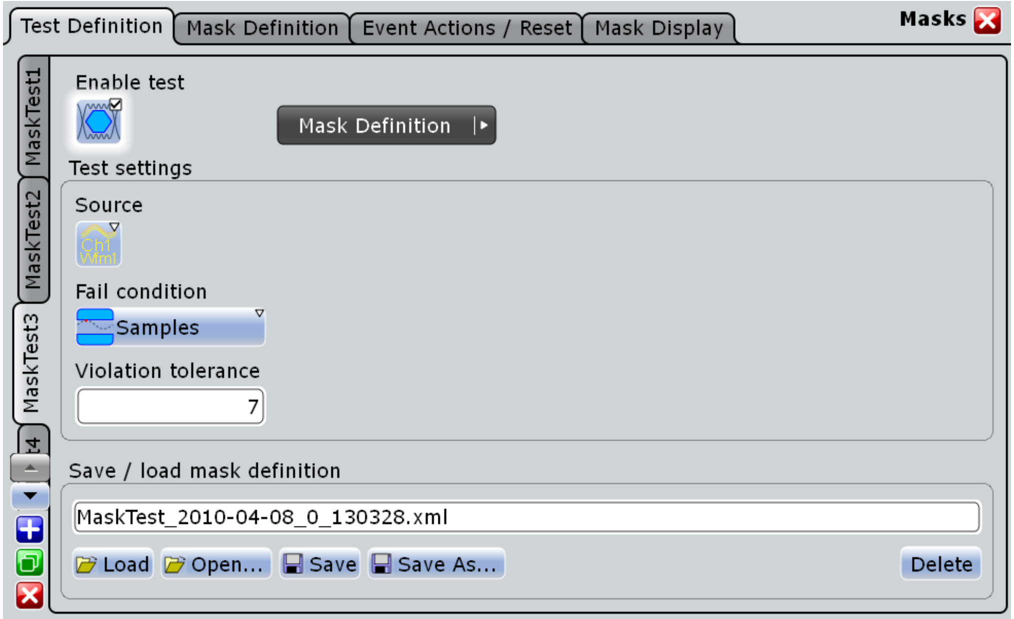
To load a mask

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.

7.3 Reference for Masks

7.3.1 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.



Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

SCPI commands:

MTESt:ADD on page 492

MTESt:REMove on page 492

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.

SCPI command:

MTESt[:STATe] on page 492

Source

Selects the waveform to be tested against the mask. All channel, math, and reference waveforms can be tested.

SCPI command:

MTESt:SOURce on page 493

Fail condition

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 of Violation tolerance hits.

"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 second criteria for a failed test, the number of tolerable sample hits or acquisition hits. Use Fail condition to define which hits are considered for test evaluation.

Save / load mask definition

Provides all functions to store and recall a mask test. The mask definition, defined actions and fail conditions are stored in an R&S RTO-specific xml file.

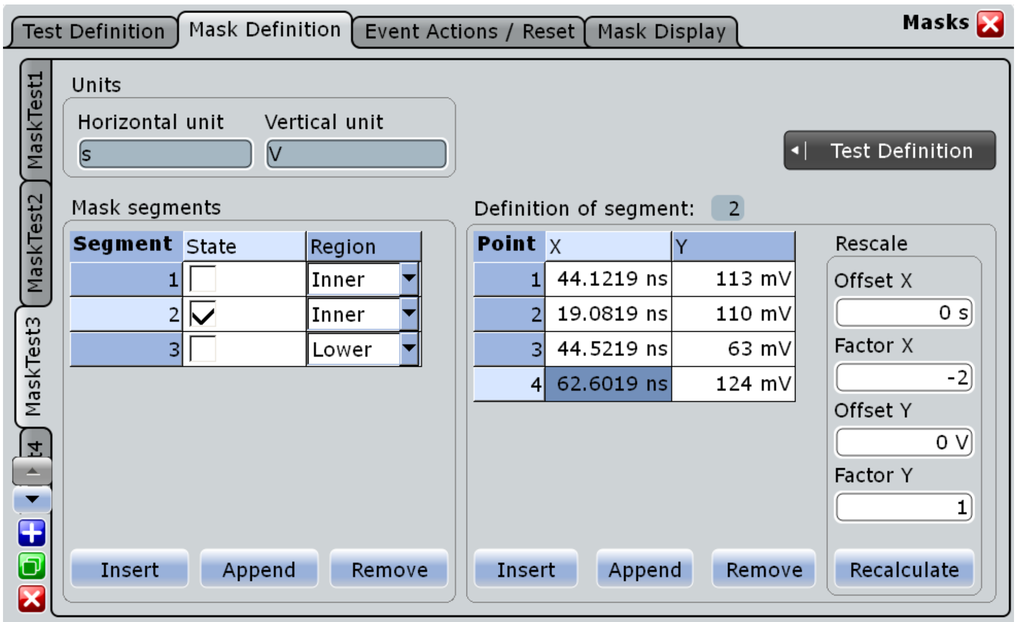
"Load, Save" Recalls or stores the specified file.

"Open, Save As" Opens a dialog box where you can select the directory the file name.

"Delete" Opens a dialog box where you can select the file to be deleted.

7.3.2 Mask Definition

In the "Mask Definition" tab, you define your own masks by entering the time and voltage values for all corner points of the mask segments. To save the mask, select the "Test Definition" tab.



Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

Horizontal unit

Unit for the x-values of the mask points.

Vertical unit
Unit for the y-values of the mask points.

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.

SCPI command:
`MTESt:SEGMent:STATe` on page 494
`MTESt:SEGMent:ADD` on page 495
`MTESt:SEGMent:REMove` on page 495
`MTESt:SEGMent:INSert` on page 495
`MTESt:SEGMent:REGion` on page 495
`MTESt:SEGMent:COUNt` on page 495

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.

SCPI command:
`MTESt:SEGMent:POINt:ADD` on page 496
`MTESt:SEGMent:POINt:REMove` on page 496
`MTESt:SEGMent:POINt:INSert` on page 496
`MTESt:SEGMent:POINt:X` on page 497
`MTESt:SEGMent:POINt:Y` on page 497
`MTESt:SEGMent:POINt:COUNt` on page 497

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".

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".

SCPI command:
`MTESt:SEGMent:RESCale:XFACtor` on page 498

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".

SCPI command:
`MTESt:SEGMent:RESCale:YOFFset` on page 499

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".

SCPI command:
`MTESt:SEGMent:RESCale:YFACtor` on page 499

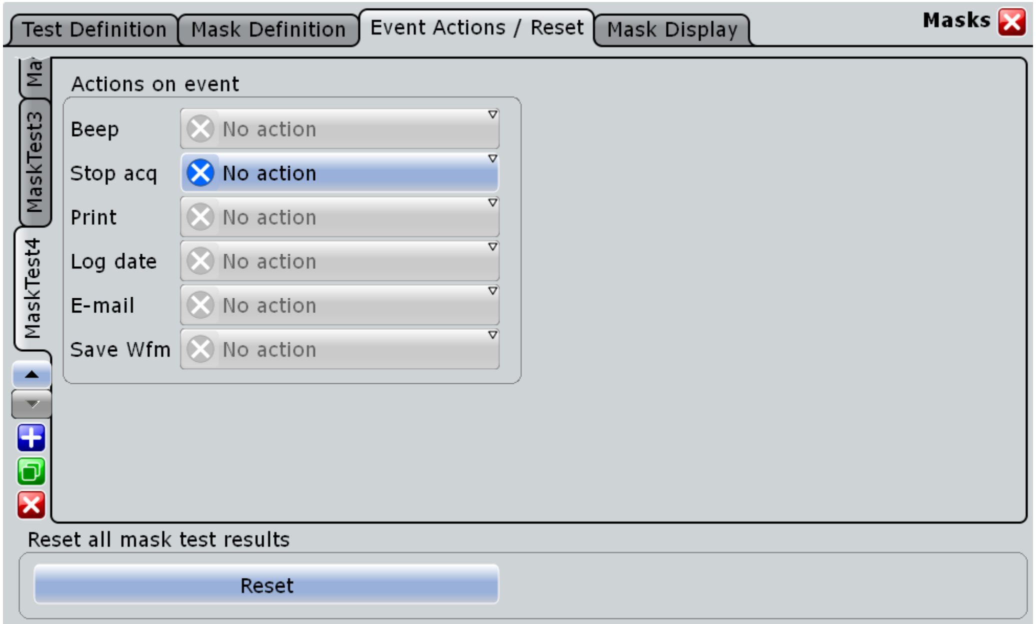
Recalculate ← Rescale
Multiplies and adds the given x- and y-factors and offsets to the coordinates of all points of the selected mask segment.

SCPI command:
`MTESt:SEGMent:RESCale:RECalculate` on page 498

7.3.3 Event Actions /Reset

The settings in this tab define what happens when the mask test has failed or when it has passed successfully. Each action can be initiated either on failure or on success.

Furthermore, you can reset all totals and results in the "Mask Test" result boxes.



Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

Beep
Generates a beep sound.

SCPI command:
`MTESt:ONViolation:BEEP` on page 500

Stop acq.
Stops the waveform acquisition.

SCPI command:
`MTESt:ONViolation:STOP` on page 500

Print
Prints a screenshot including the mask test results to the printer defined in the "Print" dialog box (see chapter 10.1.1, "Configuring Printer Output and Printing", on page 260).

SCPI command:
`MTESt:ONViolation:PRINt` on page 500

Log date, E-mail,
Not yet available

Save Wfm
Saves the failed waveform as a reference waveform to the file specified in FILE > "Save/ Recall" > "Waveform".

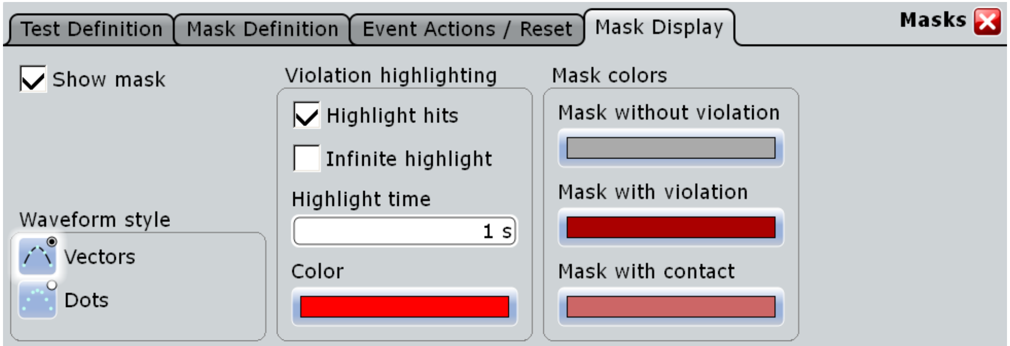
SCPI command:
`MTESt:ONViolation:SAVewaveform` on page 500

Reset
Clears all totals and results in all "Mask Test" result boxes.

SCPI command:
`MTESt:RESet` on page 492

7.3.4 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.

Waveform style
See: "Style" on page 87.

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.

8 Search Functions

Search functions allow you to detect and analyze specific conditions in the acquired data quickly and simply. This is possible both for running acquisitions or for waveforms stored in the sample memory, or for an extract of either. Various search conditions are available, including trigger parameters such as edges, windows or states. Search results can then be qualified further by other waveform conditions.

Simple searches can be performed very quickly and easily; with some additional configuration, even complex searches are possible.

The results are displayed in a table and optionally in a zoom window.

8.1 Search Conditions and Results

To make the search functions suit your requirements, both the search conditions and the result display are configurable.

8.1.1 Search Conditions

Search scope

Searches can be performed for any input signal, math or reference waveform. Either the entire waveform can be searched, or only a defined (gate) area. Previously stored waveform data can also be included in the search.

Search control

Searches can be performed online, that is repeatedly for each new data acquisition, or only once on stored data.

Search conditions

Various different search conditions are available, depending on the source waveform. For trigger searches, most parameters available for trigger event definition can also be configured as search conditions. However, unlike triggering, you can configure several trigger event types to be searched for simultaneously, and search in any signal, math or reference waveform. For details on trigger search conditions see "Search conditions" on page 220.

Frequency marker searches detect peaks in a spectrum. For this search type you can define the peak excursion.

8.1.2 Search Results

The results are displayed in a table and optionally in a zoom window.

Search Results box

Search results are displayed in a "Search Results" box with a tab for each search condition and one for the combined results. Each tab contains a table with the position and, if available, further parameters for each result. The tables can be sorted by x-position or value. You can define a maximum number of table entries.

Search zoom windows

The search results can be displayed in a zoom window, which allows you to analyze the search results in more detail. In this case, a zoom window is displayed for the currently selected search result. You can switch between results in the result table to move the zoom window to each one. The zoom area is indicated in the diagram that displays the source waveform of the search.

8.2 Configuring and Performing Searches

Besides the basic search settings such as the source and conditions, the scope and result presentation can also be configured. Searches can be performed only once or for one or more stored waveforms.

Simple searches can be performed very quickly and easily; with some additional configuration, even complex searches are possible.

8.2.1 Configuring a Trigger Search

Trigger searches look for conditions in the signal that can lead to a trigger event during data acquisition, by using the same parameters.

To perform a simple edge search

1. Select the "Search" icon on the toolbar.

2. Select an active time-based waveform you want to perform the search on.

   The default edge search is configured as "Search<x>" and performed for the selected time-based waveform. The "Search Results" box is displayed.

To configure a more complex trigger search

1. Press the SEARCH key to open the "Search" dialog box.
2. Tap the "Add" icon to create a new tab for the new search configuration, or the "Copy" icon to copy an existing search configuration.

3. Enter a name for the search configuration using the displayed on-screen keyboard.
4. Select the "Source" waveform on which you want to perform the search. To perform a trigger search you must select a time-based waveform.
5. To perform the search only on a part of the waveform or to include previously stored waveforms in the search, configure the scope as described in chapter 8.2.3, "Defining the Search Scope", on page 216.
6. Define the search conditions for the search:
   a) Select the tab for the search condition you want to configure.
   b) Define the search condition settings as described for the trigger parameters in chapter 3.3.1, "Events", on page 53.
   c) Tap "Select" in the "Setup" tab to include the search condition in the search.
   d) Repeat these steps to define further search conditions for the same search.
7. To filter out noise from the search results, configure noise rejection as described in chapter 8.2.6, "Defining Noise Rejection for Searches", on page 218.
8. Define when and how often the search is to be performed.
   To perform the search repeatedly for the current acquisition, select "Search online" in the "Setup" tab.
   To perform the search only once on the stored waveform data, select "Search once" in the "Setup" tab.
9. Configure the results display.
   a) To clear the results automatically before each new search, select "Auto clear" in the "Setup" tab.
   b) Configure which results are displayed as described in chapter 8.2.4, "Configuring the Search Results Presentation", on page 216.

To enter an expression in the Qualification Editor

In order to define a "Pattern" search condition for a trigger search, you must enter the state conditions as an expression using the "Qualification Editor".

1. Double-tap the expression field to open the "Qualification Editor".
   For details on the available keys in the editor, see chapter 8.3.2, "Qualification Editor", on page 221.
2. Select the first waveform by tapping the the "Ch" key for signal channels, the "Math" key for math waveforms, or the "Ref" key for reference waveforms and then selecting one of the available waveforms.
3. Select an operator to combine the results of other waveforms.
4. Select the next waveform to be included in the expression as described in step 2.
5. Add further waveforms and operators as necessary.
6. If necessary, group waveforms using the bracket symbols "(", ")".
   To move the cursor within the expression, use the cursor keys.

7. Finish the expression by selecting the "Enter" key.

8.2.2 Configuring a Frequency Marker Search

A frequency marker search detects peaks in a spectrum, considering a peak excursion if defined.

To perform a simple frequency marker search

1. Select the "Search" icon on the toolbar.

2. Select an active frequency-based waveform you want to perform the search on.

   A frequency marker search is configured as "Search<x>" and performed for the selected frequency-based waveform. The "Search Results" box is displayed.

To configure the frequency marker search manually

1. Press the SEARCH key to open the "Search" dialog box.
2. Tap the "Add" icon to create a new tab for the new search configuration, or the "Copy" icon to copy an existing search configuration.

3. Enter a name for the search configuration using the displayed on-screen keyboard.
4. Select the "Source" waveform on which you want to perform the search. To perform a frequency marker search you must select a frequency-based waveform.
5. To perform the search only on a part of the waveform or to include previously stored waveforms in the search, configure the scope as described in chapter 8.2.3, "Defining the Search Scope", on page 216.
6. If necessary, adapt the "Peak excursion" to be considered for the search.
   Note that the peak excursion is a global setting and is valid for both cursor measurements and search functions.
7. To filter out noise from the search results, configure noise rejection as described in chapter 8.2.6, "Defining Noise Rejection for Searches", on page 218.
8. Define when and how often the search is to be performed.
   To perform the search repeatedly for the current acquisition, select "Search online" in the "Setup" tab.
   To perform the search only once on the stored waveform data, select "Search once" in the "Setup" tab.
9. Configure the results display.

a) To clear the results automatically before each new search, select "Auto clear" in the "Setup" tab.
b) Configure which results are displayed as described in chapter 8.2.4, "Configuring the Search Results Presentation", on page 216.

The search is performed and the results are displayed as configured. For details on the results see chapter 8.1, "Search Conditions and Results", on page 212.

8.2.3 Defining the Search Scope

The scope of a search can be either a single acquisition, a part of an acquisition (defined by a gate area), or the current and previously stored acquisitions from the history (see chapter 4.4, "History", on page 106). The scope is defined on the "Scope" tab of the "Search" dialog box.

Defining a gate for a search is identical to defining a gate area for a measurement, see chapter 5.2.2.7, "Using Gate Areas", on page 132.

To include the history in the search scope

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 "Scope" tab.
4. Select the "Include history" option.

   By default, all history elements previously stored are included in the search scope.
5. To include only a range of stored waveforms, disable the "All history elements" option and enter a start and stop index to define which waveforms are to be searched.

   The results from all included waveforms are displayed in the result table.

8.2.4 Configuring the Search Results Presentation

Search results are displayed in a table in the "Search Results" box. The result tables can be sorted by x-position or value. You can define a maximum number of table entries.

In addition, a zoom window for each search result can be displayed automatically in the source diagram so that you can analyze the result in more detail.

To move the position of the search results display

By default, the "Search Results" box is displayed in front of the other diagrams. Alternatively, you can display it in its own area on the screen, like another diagram. For details see "Working with Waveforms" in the "Getting Started" manual.

1. Minimize the initial result box.
2. Drag the result icon from the signal bar to the diagram area and drop it in its dedicated target area, as you would a waveform.

The search results are displayed in a table in the specified area of the screen.

3. To minimize the result box again, select the label of the result area and drag it towards the signal bar. The result box is replaced by a result icon.
4. To delete the result box, tap the "Delete" icon and then the result box or result icon.

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" dialog box, in the "Result Presentation" tab, select "Show search zoom windows".
2. Configure the zoom area for all search results as described in "To define the zoom area numerically using position and range values" on page 97.
3. Perform a search.

   A zoom window is displayed for the currently selected search result. Directly after a search this is the last result that was found. You can switch between results in the result table by selecting the result index to move the zoom window to each one. The zoom area is indicated in the diagram that displays the source waveform of the search. It can also be moved manually, as with other zoom areas, thus changing the settings of the zoom window. Be aware, however, that the zoom window settings are valid for all search zoom windows, so if you change the settings drastically for one result, they may not be correct for the next search result you switch to.

8.2.5 Clearing Search Results

You can clear the search results manually or automatically before each new search.

1. Press the SEARCH key to open the "Search" dialog box.
2. Select the tab for the search whose results you want to delete.

3. Select the "Setup" tab.
4. To clear the current search results tap "Clear results".
   To have the results cleared automatically before a new search is performed, tap "Auto clear".

8.2.6 Defining Noise Rejection for Searches

Noise rejection for searches is very similar to noise rejection for triggers.

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 "Noise reject" tab.
4. For each waveform for which noise rejection is to be considered:
   a) Select the "Enable" option.
   b) Select the mode for the noise values: absolute or relative to the vertical scaling values.
   c) Define the absolute or relative hysteresis. If you change one value, the other is automatically calculated.

   If the signal jitters inside this range and crosses the trigger level, no search result is detected.

8.3 Reference for Search Settings

Search settings include basic configuration of the source and conditions, as well as the search scope and result presentation. Finally, noise rejection can be configured.

Each search definition is configured on a separate tab. For details on defining a search, see chapter 8.2, "Configuring and Performing Searches", on page 213.

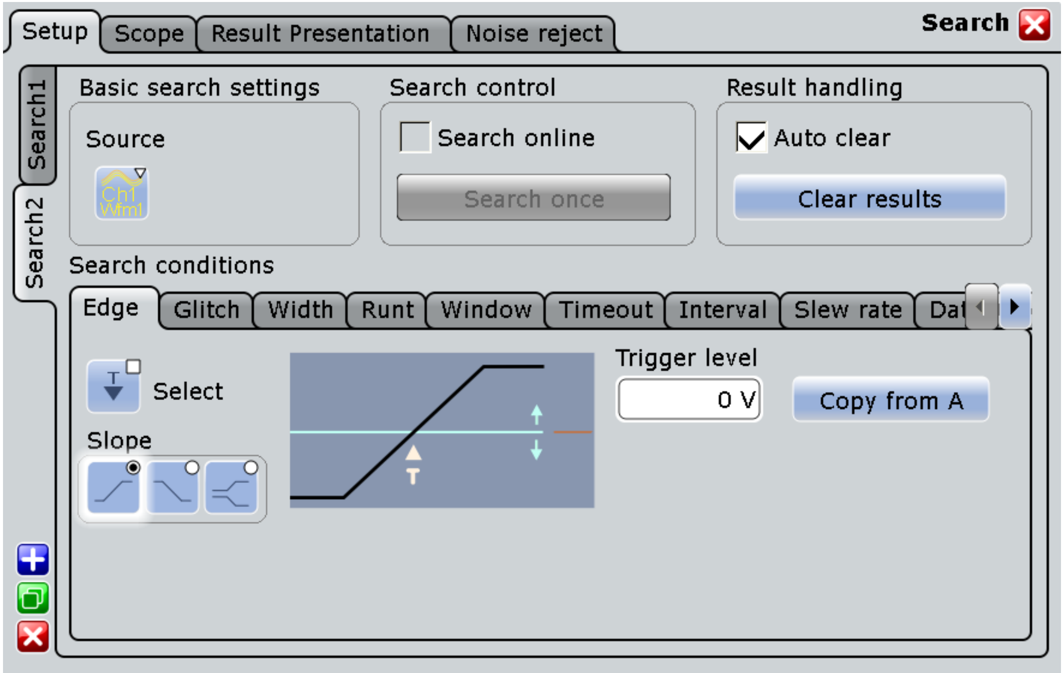
SCPI commands:

`SEARch:ADD` on page 504

`SEARch:REMove` on page 504

8.3.1 Setup Tab

The "Setup" tab contains the basic search settings, including the source, search conditions and search control.



Source

Defines the source of the search. The source can be any input signal, math or reference waveform. Depending on the selected source, not all search conditions are available.

SCPI command:

`SEARch:SOURce` on page 505

Search online

Repeatedly performs a search for each new data acquisition.

SCPI command:

`SEARch:ONLine` on page 505

Search once

Performs a single search on the existing data from the selected source.

SCPI command:

`SEARch:NEXT` on page 504

`SEARch:ALL` on page 504

Auto clear

Automatically clears the results before each new search.

Clear results

Clears the search results once to start a new search.

SCPI command:

`SEARch:CLEar` on page 504

Search conditions
Defines the search conditions, depending on the search type (spectrum or trigger). For trigger searches, most parameters available for trigger event definition can also be configured as search conditions. However, not only signal channels, but also math and reference waveforms can be selected as the search source.

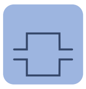
For details on trigger event definition, see chapter 3.3.1, "Events", on page 53.

For frequency marker searches, only the peak excursion can be defined as a parameter for the search.

The following search conditions are available for trigger searches:

- Edge, see page 56
- Glitch, see page 57
- Width, see page 58
- Runt, see page 59
- Window, see page 61
- Timeout, see page 62
- Interval, see page 63
- Slew Rate, see page 65
- Data2Clock, see page 66
- Pattern, see page 68

Note: Serial patterns are currently not supported as search conditions.
While the interval and width triggers can only analyze **either** positive **or** negative polarity, searching for an interval or width is also possible for both polarities at the same time ("Either").



The following general functions are available in addition to the trigger-related settings, or alternatively for frequency-related searches.

SCPI command:
The remote control commands are described in chapter 14.2.11.2, "Search Conditions", on page 506.

Select ← Search conditions
Includes the search conditions for the selected trigger event type in the next search.

SCPI command:
`SEARch:TRIGger:EDGE[:STATe]` on page 507
`SEARch:TRIGger:GLITch[:STATe]` on page 507
`SEARch:TRIGger:WIDTh[:STATe]` on page 507
`SEARch:TRIGger:RUNT[:STATe]` on page 507
`SEARch:TRIGger:WINDow[:STATe]` on page 507
`SEARch:TRIGger:TIMeout[:STATe]` on page 507
`SEARch:TRIGger:INTerval[:STATe]` on page 507
`SEARch:TRIGger:SLEWrate[:STATe]` on page 507
`SEARch:TRIGger:DATatoclock[:STATe]` on page 507

Copy from A ← Search conditions
Copies the trigger event configuration from Trigger A for the selected channel source to the search condition settings (see chapter 3.3.1, "Events", on page 53).

SCPI command:
`SEARch:TRIGger:EDGE:ACOPy` on page 507

Trigger level ← Search conditions
Sets the voltage level for the trigger level that is used to determine other parameters.

SCPI command:
`SEARch:TRIGger:LEVel[:VALue]` on page 525

(Pattern) Condition ← Search conditions
The Pattern condition defines a logic search. It provides logical combinations of the input channels, math or reference waveforms, and supports you in verifying the operation of digital logic.

Double-tapping the condition field opens the "QualificationEditor", see chapter 8.3.2, "Qualification Editor", on page 221.

SCPI command:
`SEARch:TRIGger:CONDitions` on page 506

Peak excursion ← Search conditions
Defines 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.

This setting is only available for sources in the frequency domain.

Note that the peak excursion is a global setting and is valid for both cursor measurements and search functions.

SCPI command:
`CURSor<m>:PEXCursion` on page 422

8.3.2 Qualification Editor

The qualification editor provides an interface to enter state conditions for a Pattern search. As opposed to the trigger event, you can define state conditions for various different waveforms, not only active signal channels.

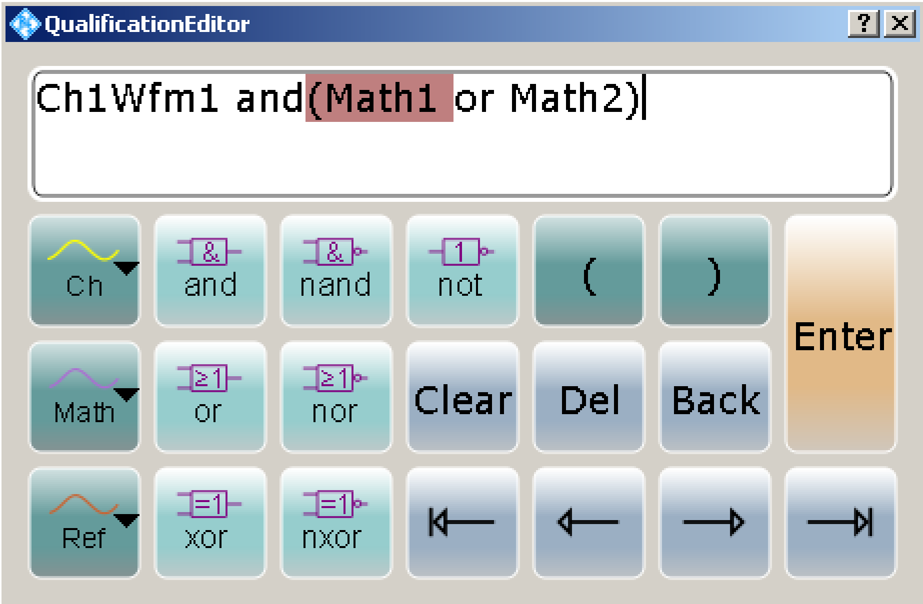


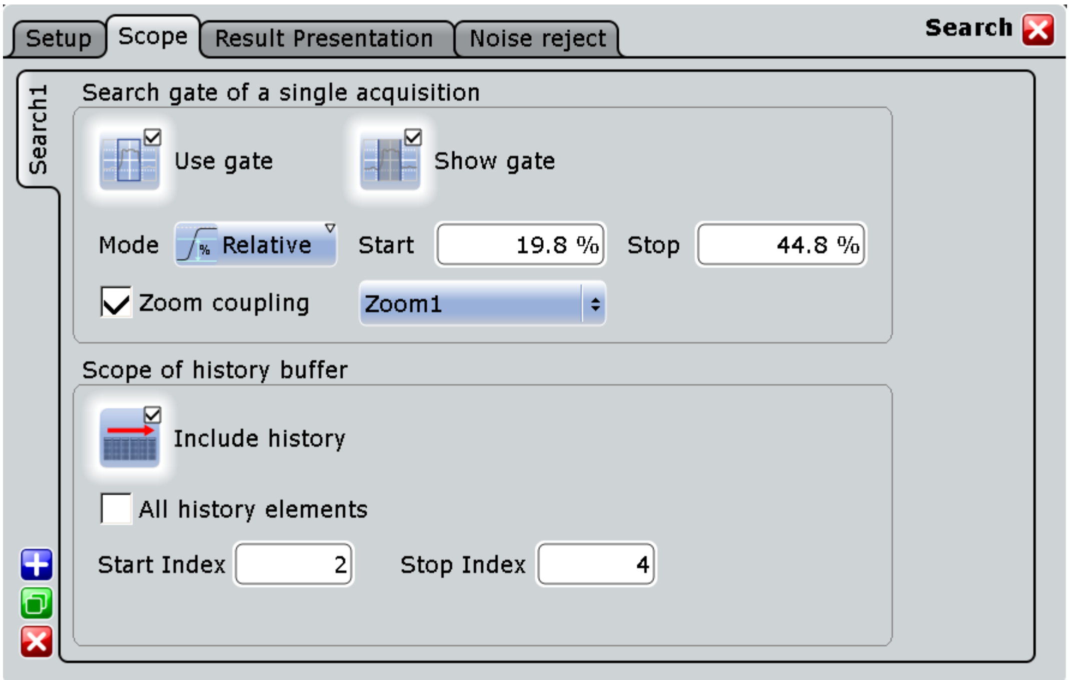
Table 8-1: Qualification Editor keys and resulting expressions

Icon	Description	Usage/ Comment *FormulaEditor expression*
Basic keys		
(	left bracket	enclose operands
)	right bracket	enclose operands
Enter	expression complete	insert expression in Setup dialog
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
Signal sources		
Ch	signal channel	*Ch<1...4>Wfm<1...3>*
Math	math channel	*Math<1...4>*
Ref	reference channel	*Ref<1...4>*
Cursor keys		
|←	move cursor to beginning	
←	move cursor 1 step to the left	
→	move cursor 1 step to the right	
→|	move cursor to end	
Operators		
and		*and*

Icon	Description	Usage/ Comment ***FormulaEditor expression***
nand	negation of and	*nand*
not	negation	*not(x)*
or		*or*
nor	negation of or	*nor*
xor	exclusive or	*xor*
nxor	negation of exclusive or	*nxor*

8.3.3 Scope Tab

The scope defines the search area within the source waveform. The settings are identical to those for gate areas for measurements or FFT analysis.



Use Gate

Performs the search only on the defined gate area of the source waveform.

SCPI command:

`SEARch:GATE[:STATe]` on page 526

Show Gate

Indicates the gate area in the source diagram.

SCPI command:

`CALCulate:MATH<m>:FFT:GATE:SHOW` on page 480
`MEASurement<m>:GATE:SHOW` on page 456
`SEARch:GATE:SHOW` on page 527

Gate Mode

Defines whether the gate settings are configured using absolute or relative values.

"Absolute" Gating is performed between the defined absolute start and stop values.

"Relative" Gating is performed for a percentage of the value range, defined by start and stop values.

SCPI command:

`CALCulate:MATH<m>:FFT:GATE:MODE` on page 479
`MEASurement<m>:GATE:MODE` on page 455
`SEARch:GATE:MODE` on page 526

(Relative) Start

Defines the starting value for the gate.

SCPI command:

`CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt` on page 479
`CALCulate:MATH<m>:FFT:GATE:RELative:STARt` on page 480
`MEASurement<m>:GATE:ABSolute:STARt` on page 455
`MEASurement<m>:GATE:RELative:STARt` on page 455
`SEARch:GATE:ABSolute:STARt` on page 527
`SEARch:GATE:RELative:STARt` on page 527

(Relative) Stop

Defines the end value for the gate.

SCPI command:

`CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP` on page 479
`CALCulate:MATH<m>:FFT:GATE:RELative:STOP` on page 480
`MEASurement<m>:GATE:ABSolute:STOP` on page 455
`MEASurement<m>:GATE:RELative:STOP` on page 455
`SEARch:GATE:ABSolute:STOP` on page 527
`SEARch:GATE:RELative:STOP` on page 528

Zoom Coupling
If enabled, the gate area is defined identically to the zoom area for the selected active zoom diagram.

SCPI command:
CALCulate:MATH<m>:FFT:GATE:ZCOupling on page 480
CALCulate:MATH<m>:FFT:GATE:ZDIagram on page 481
MEASurement<m>:GATE:ZCOupling on page 456
MEASurement<m>:GATE:ZDIagram on page 457
SEARch:GATE:ZCOupling on page 528
SEARch:GATE:ZDIagram on page 528

Include history
Search source includes previously stored waveforms.

For details on the history function, see chapter 4.4, "History", on page 106.

SCPI command:
SEARch:HISTory[:STATe] on page 530

Start Index ← Include history
Defines the index of the most recently stored waveform to be considered in the search.

SCPI command:
SEARch:HISTory:STARt on page 529

Stop Index ← Include history
Defines the index of the oldest stored waveform to be considered in the search.

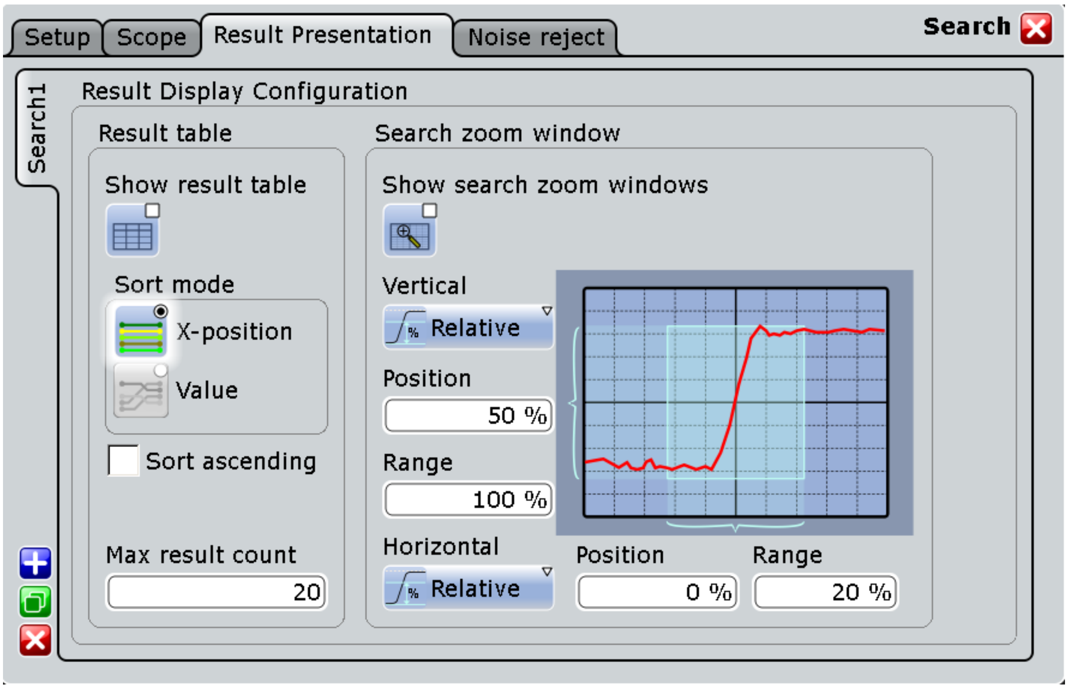
SCPI command:
SEARch:HISTory:STOP on page 529

All history elements ← Include history
Includes all available stored waveforms in the search.

SCPI command:
SEARch:HISTory:ALL on page 529

8.3.4 Result Presentation

The following settings configure the presentation of the search results.



Result table

These settings refer to the search result table.

Show result table ← Result table

Displays or hides the search result table.

SCPI command:

`SEARch:RESult:SHOW` on page 534

Sort mode ← Result table

Sorts the search result table by x-value position or value of the result.

SCPI command:

`SEARch:RESult:SORT[:MODE]` on page 535

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".

SCPI command:

`SEARch:RESult:SORT:ASCending` on page 535

Max result count ← Result table

Defines the maximum number of entries in the search result table.

SCPI command:

`SEARch:RESult:LIMit` on page 534

Search zoom window

The search results can be displayed in a zoom window, which allows you to analyze the search results in more detail.

The zoom window settings are identical to those for other waveforms. Note that the settings for the search zoom window are also changed when you move the search zoom area manually, and that they remain valid for **all** search result zoom windows.

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.

SCPI command:
`SEARch:RESDiagram:SHOW` on page 532

Vertical mode ← Search zoom window
Defines whether absolute or relative values are used to specify the y-axis values.

SCPI command:
`LAYout:ZOOM:VERTical:MODE` on page 412
`SEARch:RESDiagram:VERT:MODE` on page 533

Position / Relative position ← Search zoom window
Defines the y-value of the centerpoint of the zoom area.

SCPI command:
`LAYout:ZOOM:VERTical:ABSolute:POSition` on page 412
`LAYout:ZOOM:VERTical:RELative:POSition` on page 414
`SEARch:RESDiagram:VERT:ABSolute:POSition` on page 532
`SEARch:RESDiagram:VERT:RELative:POSition` on page 533

Range / Relative Range ← Search zoom window
Defines the height of the zoom area.

SCPI command:
`LAYout:ZOOM:VERTical:RELative:SPAN` on page 414
`LAYout:ZOOM:VERTical:ABSolute:SPAN` on page 413
`SEARch:RESDiagram:VERT:ABSolute:SPAN` on page 533
`SEARch:RESDiagram:VERT:RELative:SPAN` on page 534

Horizontal mode ← Search zoom window
Defines whether absolute or relative values are used to specify the x-axis values.

SCPI command:
`LAYout:ZOOM:HORZ:MODE` on page 409
`SEARch:RESDiagram:HORZ:MODE` on page 531

Position / Relative position ← Search zoom window
Defines the x-value of the centerpoint of the zoom area.

SCPI command:
`LAYout:ZOOM:HORZ:ABSolute:POSition` on page 409
`LAYout:ZOOM:HORZ:RELative:POSition` on page 410

Range / Relative Range ← Search zoom window
Defines the width of the zoom area.

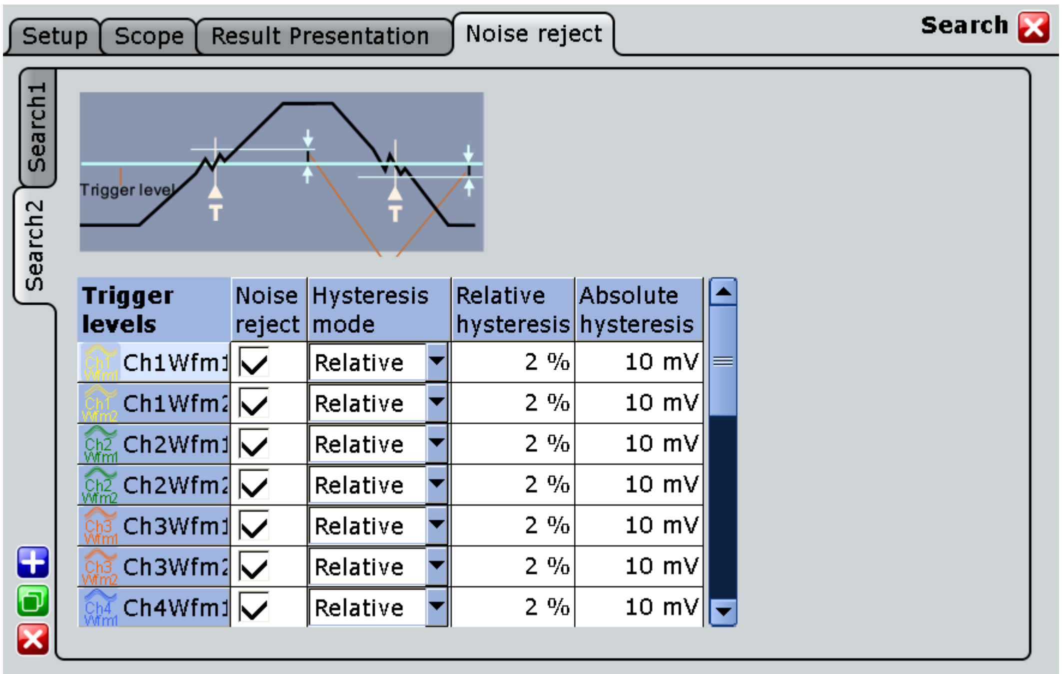
SCPI command:
LAYout:ZOOM:HORZ:ABSolute:SPAN on page 409
LAYout:ZOOM:HORZ:RELative:SPAN on page 411
SEARch:RESDiagram:HORZ:ABSolute:SPAN on page 531
SEARch:RESDiagram:HORZ:RELative:SPAN on page 532

8.3.5 Noise Reject

You can reject noise by setting a hysteresis in order to avoid finding trigger events caused by noise oscillation around the trigger level.

You can select the hysteresis mode and value for each input channel, math and reference waveform.

The noise reject settings are similar to those for triggers, see also chapter 3.3.3, "Noise Reject", on page 73.



Enable
If enabled, the noise reject settings for the waveform are considered for the search.

SCPI command:
SEARch:TRIGger:LEVel:NOISe[:STATe] on page 537

Absolute/Relative
Defines whether values absolute or relative to the vertical scaling are used.

SCPI command:
SEARch:TRIGger:LEVel:NOISe:MODE on page 536

Hysteresis
Defines a range in absolute or relative values around the trigger level. If the signal jitters inside this range and crosses the trigger level, no trigger event is detected.

For hysteresis values relative to the vertical scaling, the absolute values are adapted when either the hysteresis percentage or the vertical scaling values are changed.

For absolute hystersis values, the percentage is adapted if the absolute or vertical scaling values are changed.

SCPI command:

`SEARch:TRIGger:LEVel:NOISe:ABSolute` on page 536
`SEARch:TRIGger:LEVel:NOISe:RELative` on page 537

9 Protocol Analysis

With the R&S RTO and some additional options, you can analyze the following serial protocols:

- SPI (Serial Peripheral Interface) - decoding requires option R&S RTO-K1
- I²C (Inter-Integrated circuit bus) - decoding requires option R&S RTO-K1
- UART/RS232 (EIA-232 serial interface) - decoding requires option R&S RTO-K2

Triggering on SPI, I²C and UART is available with the main R&S RTO without any options.

9.1 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 two ways:

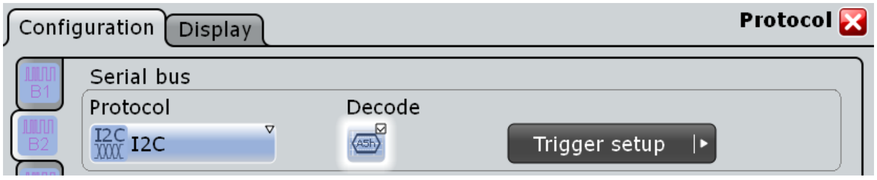
- Triggering: You can trigger on various events that are typical for the selected protocol type, for example, on start and stop of messages, on specific addresses, or on specified data patterns in the message.
- Protocol decoding: The digitized signal data is displayed on the screen together with the decoded content of the messages in readable form, and the decoding results are listed in a table.
  For all serial protocols, decoding requires an option.

9.1.1 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 9.2.3.1, "I²C Configuration", on page 236
- SPI: chapter 9.3.3.1, "SPI Configuration", on page 246
- UART: chapter 9.4.2.1, "UART Configuration", on page 253



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.

SCPI command:

BUS<m>:TYPE on page 538

Decode
Enables the decoding of the selected bus. The signal icon appears on the signal bar.

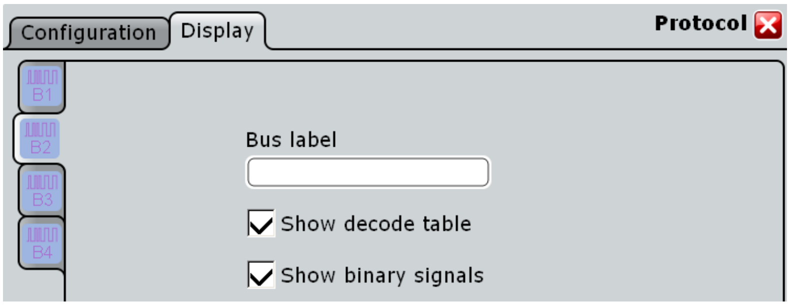
This function is only available if at least one protocol option is installed. For triggering on I²C, SPI, and UART signals, the bus can be used as trigger source without any option, provided that the bus is configured correctly.

SCPI command:

BUS<m>[:STATe] on page 538

9.1.2 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.

SCPI command:

BUS<m>:LABel on page 538

Show decode table
Opens a table with decoded data of the serial signal. The function requires the option for the analyzed protocol.

The decoding results are protocol-specific. They are described in the related chapters:

- I²C: chapter 9.2.3.3, "I²C Decode Results (Option R&S RTO-K1)", on page 241
- SPI: chapter 9.3.3.3, "SPI Decode Results (Option R&S RTO-K1)", on page 250
- UART: chapter 9.4.2.3, "UART Decode Results (Option R&S RTO-K2)", on page 257

SCPI command:

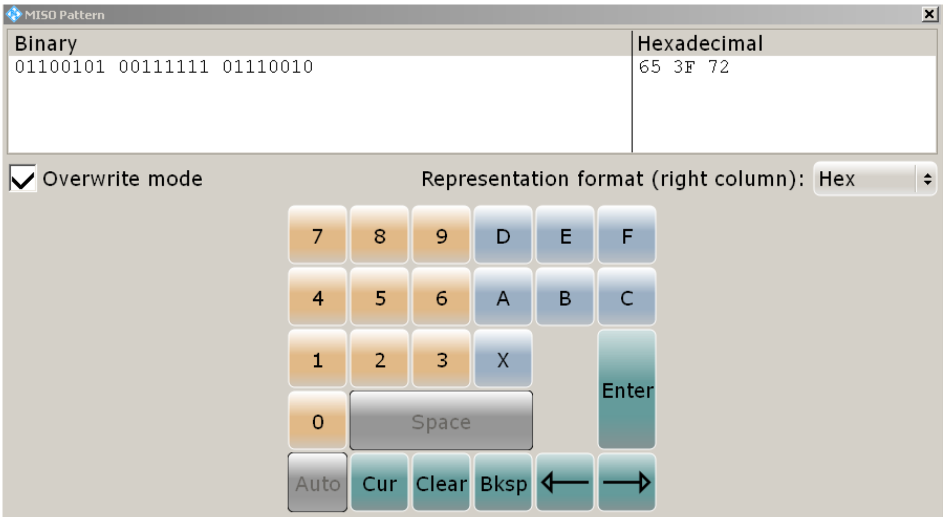
`BUS<m>:RESult` on page 538

Show binary signals

For each configured line, the binary signal is displayed additionally.

9.1.3 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:

- Decimal: 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.
- Hex: most common format in the right column.

- Octal: Each digit represents 3 bit.
- ASCII: X (don't care) is not allowed.

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.

9.2 I²C

The Inter-Integrated Circuit is a simple, low-bandwidth, low-speed protocol used for communication between on-board devices.

9.2.1 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.
- Adressing 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 RTO 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

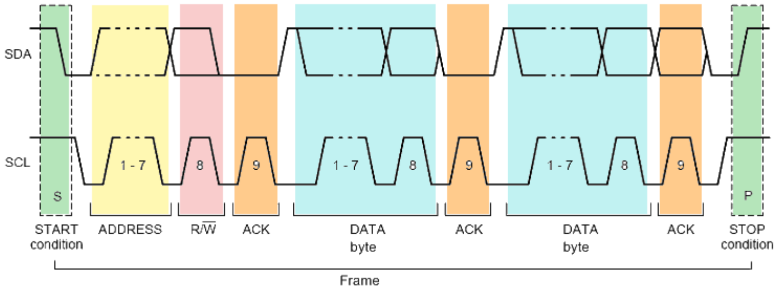


Fig. 9-1: I2C write access with 7-bit address

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.

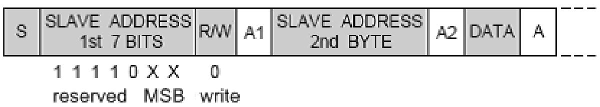


Fig. 9-2: 10-bit address, write access

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.

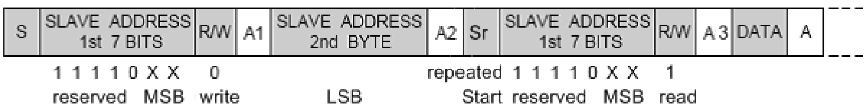


Fig. 9-3: 10-bit address, read access

Trigger

The R&S RTO 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

9.2.2 Analyzing I²C Signals

The analysis of I²C consists of two main steps:

- Configuring I²C Protocol
- Triggering on I²C

To display the decoded signal, option R&S RTO-K1 is required.

9.2.2.1 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 9.2.3.1, "I²C Configuration", on page 236.

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.

9.2.2.2 Triggering on I²C

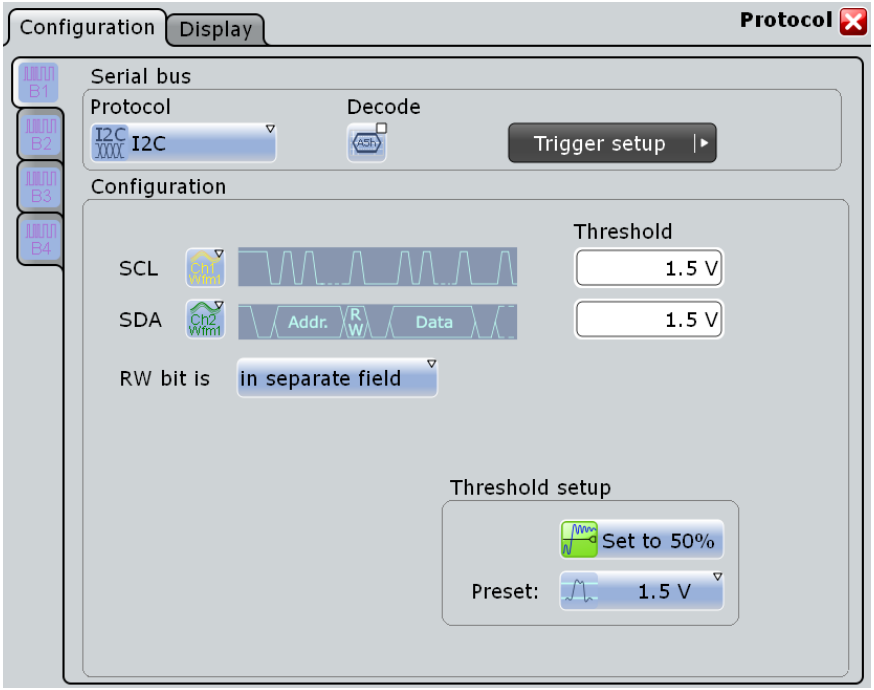
Prerequesites: A I²C-bus is configured, see chapter 9.2.2.1, "Configuring I²C Protocol", on page 235. SDA and SCL lines are set to channel waveforms.

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" 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 9.2.3.2, "I²C Trigger", on page 237

9.2.3 Reference for I²C

9.2.3.1 I²C Configuration

Make sure that the tab of the correct serial bus is selected on the left side.



See also: chapter 9.1.1, "Configuration - General Settings", on page 230.

SDA, SCL

Set the waveforms of the data line (SDA) and clock line (SCL). Waveform 1 of channel signals, math waveforms, and reference waveforms can be used.

For triggering, both lines require channel waveforms. Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

SCPI command:

`BUS<m>:I2C:SDA:SOURce` on page 539

`BUS<m>:I2C:SCL:SOURce` on page 539

Threshold

Threshold value for digitization of analog signals. If the signal value is higher than the threshold, the signal state is high (logic 1). Otherwise, the signal state is considered low (logic 0).

You can enter a value directly, or Set to 50%, or select a Preset value.

SCPI command:

BUS<m>:I2C:SCL:THReshold on page 540

BUS<m>:I2C:SDA:THReshold on page 540

Set to 50%

Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Preset

Selects the 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 entered directly.

SCPI command:

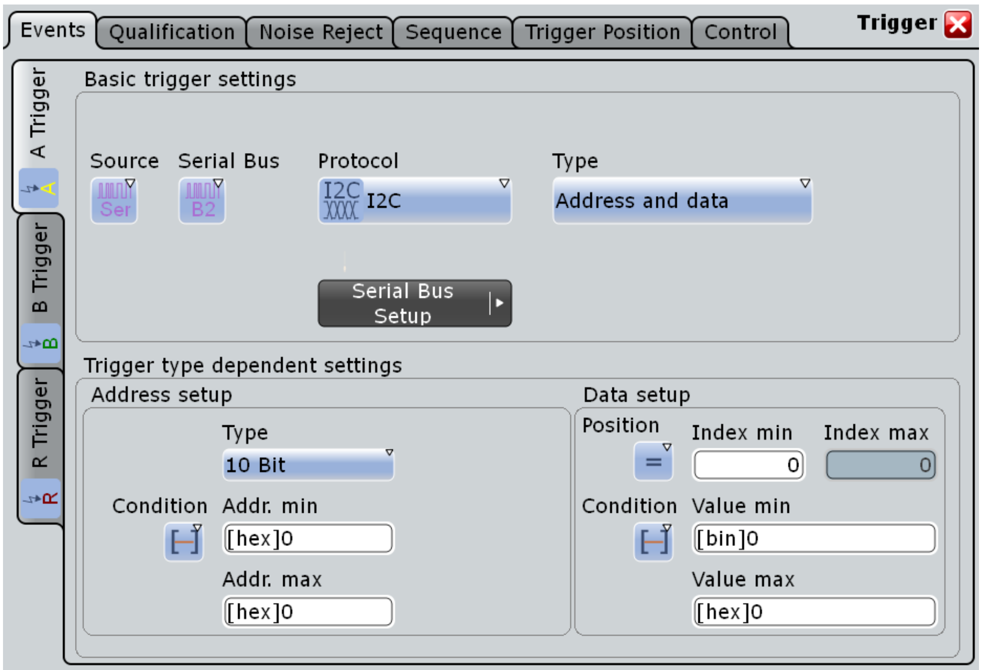
BUS<m>:I2C:TECHnologie on page 540

RW bit is

Defines if the R/W bit is considered separately or as part of the address. The setting affects the "Address setup" on page 239 of the trigger conditions.

9.2.3.2 I²C Trigger

The "Events" tab of the "Trigger" dialog box provides the trigger settings for the configured serial buses.



Make sure that the trigger source is "Serial bus", and the correct serial bus is selected.

Protocol

Defines protocol type of the bus for bus configuration and trigger settings.

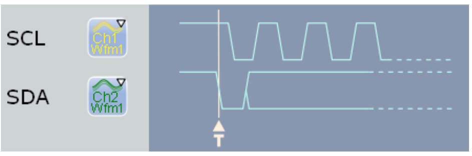
SCPI command:

`BUS<m>:TYPE` on page 538

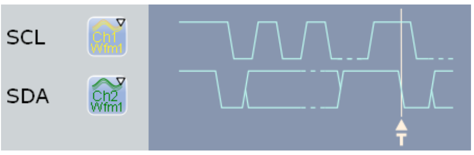
Trigger type

Selects the trigger type for I²C analysis.

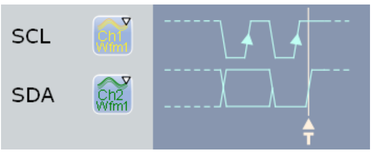
"Start" Sets the trigger to the start of the message. The start condition is a falling edge on SDA while SCL is high. The trigger instant is the falling edge of the SDA line.
You can change the SDA and SCL lines here if necessary.



"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 239.

"Address OR" Triggers on one to four address conditions.
Description of trigger type specific settings: "Address OR conditions" on page 240.

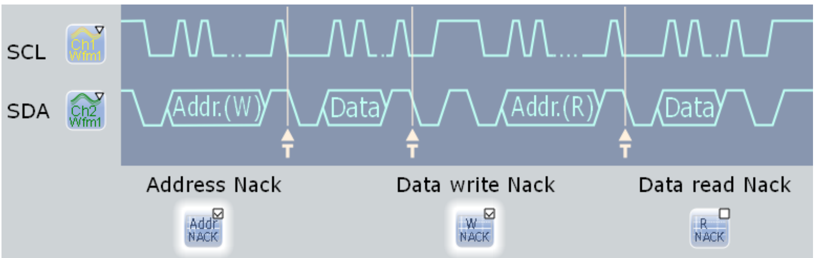
"Address and data" Sets the trigger to a combination of address and data condition. The address conditions are the same as for the "Address" trigger type, see "Address setup" on page 239 and "Data setup" on page 240.

SCPI command:

`TRIGger<m>:I2C:MODE` on page 541

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.

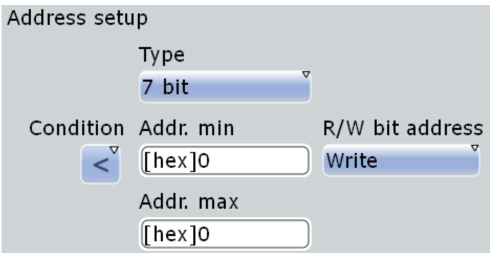
"Data read Nack" Marks the end of the read process when the master reads data from the slave. This Nack is sent according to the protocol definition, it is not an error.

SCPI command:

`TRIGger<m>:I2C:ADNack` on page 542
`TRIGger<m>:I2C:DWNack` on page 543
`TRIGger<m>:I2C:DRNack` on page 543

Address setup

Specifies the address conditions:



Type ← Address setup

Triggers on the address length: 7 bit, 7 bit + R/W bit, or 10 bit. Available settings depend on the RW bit is 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 Address setup field to select the transfer direction.

For "7 bit + R/W bit", enter the seven address bits and the R/W bit in the "Address" field. The Address setup changes to a read-only setting and displays the R/W bit from the address.

SCPI command:
`TRIGger<m>:I2C:AMODe` on page 543

Addr. min / Addr. max ← Address setup
Defines the bit pattern of the slave device address. The length of the entry is restricted 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 9.1.3, "Bit Pattern Editor", on page 232.

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.

SCPI command:
`TRIGger<m>:I2C:ADDRess` on page 543
`TRIGger<m>:I2C:ADDTo` on page 544

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.

R/W bit address ← 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.

SCPI command:
`TRIGger<m>:I2C:ACCess` on page 542

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. In the address pattern, X is not allowed.

The R/W bit can be either "Read" or "Write".

Example: To trigger on read and write access of the same address, configure two OR-lines with the same address, but different "R/W bit". Alternatively, use the trigger type "Address" with "R/W bit" = *Either*.

Data setup
Specifies the address 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.

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.

Condition ← Data setup
Selects the operator for the "Data" pattern: "Equal", "Not equal", or a range definition.

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 bit pattern editor helps you to enter the pattern, see chapter 9.1.3, "Bit Pattern Editor", on page 232.

9.2.3.3 I²C Decode Results (Option R&S RTO-K1)

If the option is installed, the "Decode" function in the "Configuration" tab is available. Enable "Decode" to display the decoded signal below the waveforms.

Additionally, you can display the binary signal and the detailed decoding results, see chapter 9.1.2, "Display", on page 231.

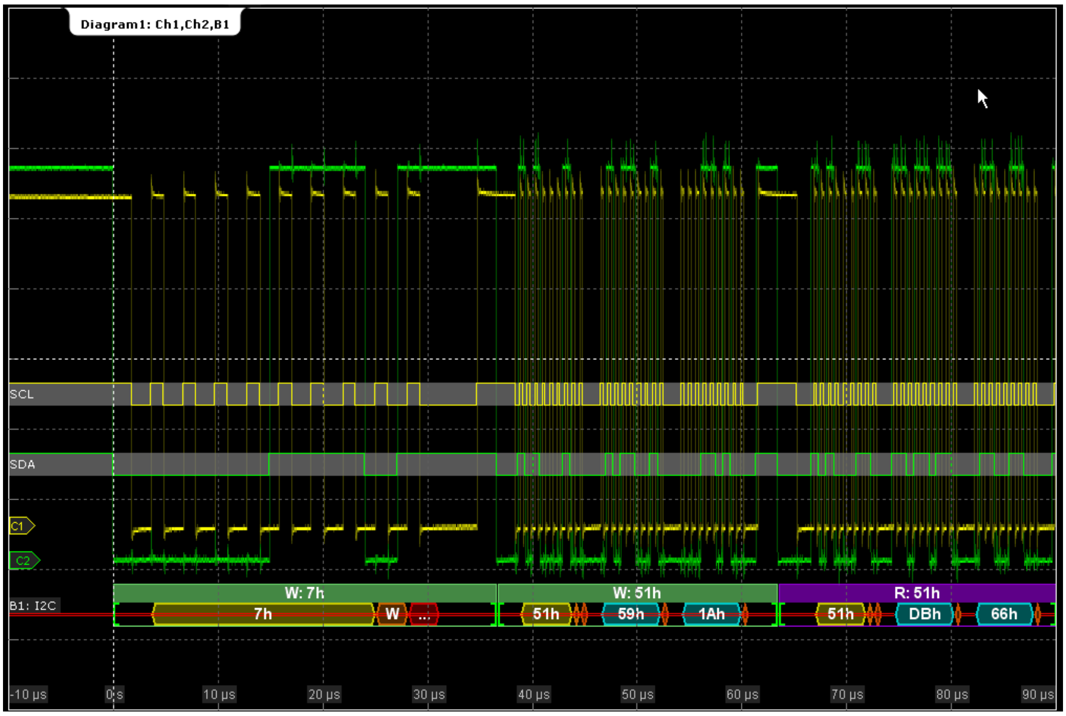


Fig. 9-4: Decoded and binary I2C signal

green brackets [...]	= start and end of frame
yellow	= address
blue	= correct data
red	= No ack (missing acknowledge bit) or incomplete frame
light orange	= R/W bit
orange	= acknowledge bits
green block	= frame ok, with transfer direction and address value
violet block	= frame is incomplete (end of acquisition before end of frame), with transfer direction and address value

The "Decode results" box shows the detailed decoded data for each data frame. Decode results consist of two tables: The left table lists the frames, while the right table lists the data bytes for the frame that is selected in the left table.

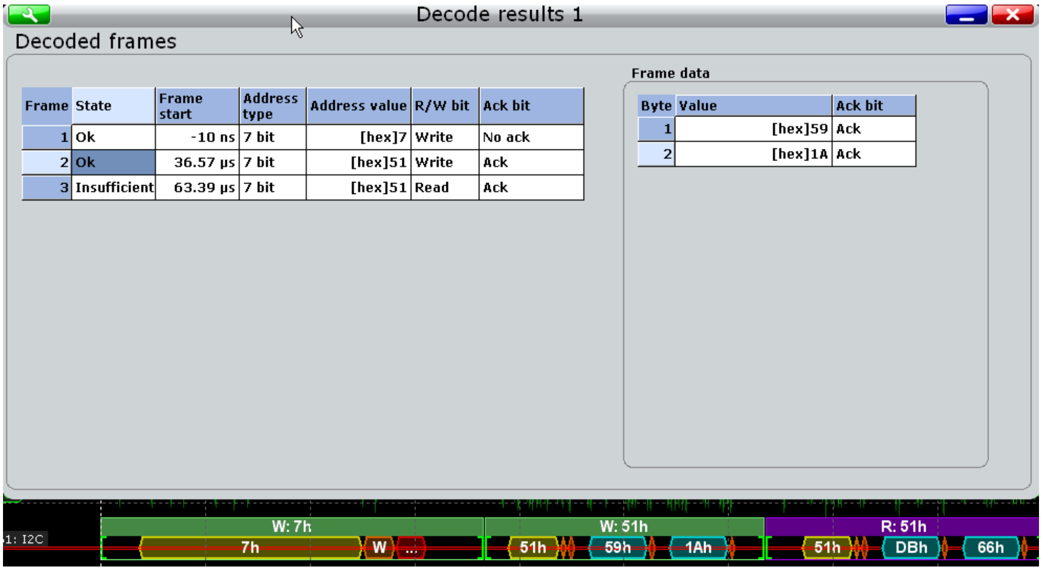


Fig. 9-5: Decode results showing data bytes of the second frame selected in the left table

Table 9-1: Content of "Frames" table

Column	Description
State	Overall state of the frame. "Insuffcient" 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	Hexadecimal value of the address
R/W bit	Value of the R/W bit
Ack bit	Value of the address acknowledge bit

Table 9-2: Content of "Frame data" table

Column	Description
Value	Hexadecimal value of the data byte
Ack Bit	Value of the data acknowledge bit

SCPI commands:

- BUS<m>:I2C:FRAMe<n>:STATus on page 544
- BUS<m>:I2C:FRAMe<n>:STARt on page 545
- BUS<m>:I2C:FRAMe<n>:STOP on page 545
- BUS<m>:I2C:FRAMe<n>:AMODe on page 541
- BUS<m>:I2C:FRAMe<n>:ADDRess on page 547
- BUS<m>:I2C:FRAMe<n>:ADEVice on page 547

- BUS<m>:I2C:FRAMe<n>:ACCess on page 546
- BUS<m>:I2C:FRAMe<n>:RWBStart on page 546
- BUS<m>:I2C:FRAMe<n>:AACCess on page 547
- BUS<m>:I2C:FRAMe<n>:ASTart on page 548
- BUS<m>:I2C:FRAMe<n>:ADBStart on page 548
- BUS<m>:I2C:FRAMe<n>:ACOMplete on page 548
- BUS<m>:I2C:FRAMe<n>:BYTE<o>:VALue on page 549
- BUS<m>:I2C:FRAMe<n>:BYTE<o>:STARt on page 550
- BUS<m>:I2C:FRAMe<n>:BYTE<o>:ACKStart on page 550
- BUS<m>:I2C:FRAMe<n>:BYTE<o>:ACCess on page 550
- BUS<m>:I2C:FRAMe<n>:BYTE<o>:COMPlete on page 551

9.3 SPI Bus

9.3.1 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.

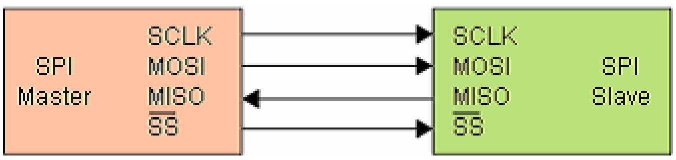


Fig. 9-6: Simple configuration of SPI bus

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 RTO provides the following trigger possiblities:

- On frame start
- On a serial pattern
- On a serial pattern at a specified position

9.3.2 Analyzing SPI Signals

9.3.2.1 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 9.3.3.1, "SPI Configuration", on page 246.

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.

9.3.2.2 Triggering on SPI

Prerequesites: A bus is configured for the SPI signal to be analyzed.

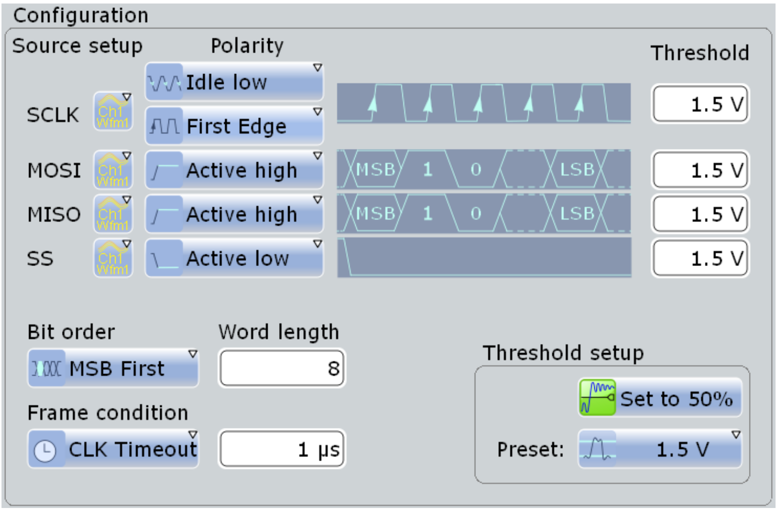
1. Press the TRIGGER key.
2. Tap the "Source" button and select the "Serial" trigger source.

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 9.3.3.2, "SPI Trigger", on page 248

9.3.3 Reference for SPI

9.3.3.1 SPI Configuration

Make sure that the tab of the correct serial bus is selected on the left side.



See also: chapter 9.1.1, "Configuration - General Settings", on page 230.

SCLK
Defines the settings for the clock line.

SCLK source ← SCLK
Sets the input channel of the clock line. Waveform 1 of channel signals, math waveforms, and reference waveforms can be used.

SCPI command:
`BUS<m>:SPI:SCLK:SOURce` on page 552

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. Waveform 1 of channel signals, math waveforms, and reference waveforms can be used.

SCPI command:
`BUS<m>:SPI:SSELect:SOURce` on page 552
`BUS<m>:SPI:MISO:SOURce` on page 553
`BUS<m>:SPI:MOSI:SOURce` on page 554

Polarity ← SS, MISO, MOSI
Selects whether transmitted data or the slave select signal is high active (high = 1) or low active (low = 1).

SCPI command:
`BUS<m>:SPI:SSELect:POLarity` on page 553
`BUS<m>:SPI:MISO:POLarity` on page 553
`BUS<m>:SPI:MOSI:POLarity` on page 554

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.

You can enter a value directly, or Set to 50%, or select a Preset value.

SCPI command:
`BUS<m>:SPI:SCLK:THReshold` on page 555
`BUS<m>:SPI:MISO:THReshold` on page 555
`BUS<m>:SPI:MOSI:THReshold` on page 555
`BUS<m>:SPI:SSELect:THReshold` on page 555

Set to 50%
Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Preset
Selects the 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 entered directly.

SCPI command:
`BUS<m>:SPI:TECHnologie` on page 554

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.

SCPI command:
`BUS<m>:SPI:BORDer` on page 552

Word length
Sets the number of bits in a word.

SCPI command:
`BUS<m>:SPI:WSIZe` on page 552

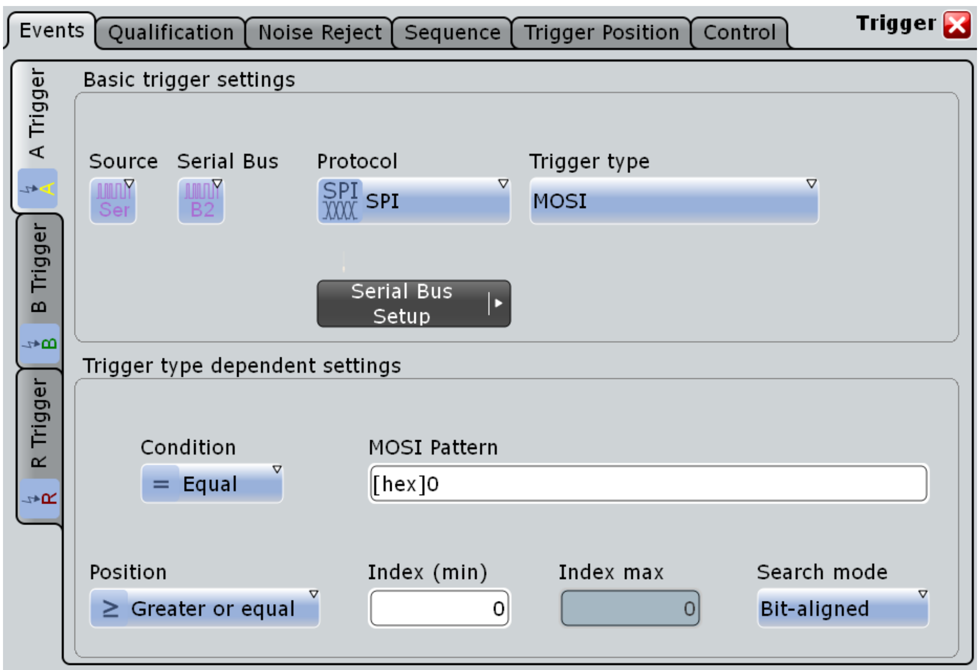
Frame condition
Defines the start of a frame. A frame contains a number of successive words, at least one word.

"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.

9.3.3.2 SPI Trigger

The "Events" tab of the "Trigger" dialog box provides the trigger settings for the configured serial buses.



Make sure that the trigger source is "Serial bus", and the correct serial bus is selected.

Protocol

Defines protocol type of the bus for bus configuration and trigger settings.

SCPI command:

BUS<m>:TYPE on page 538

Trigger type

Selects the trigger type for SPI analysis.

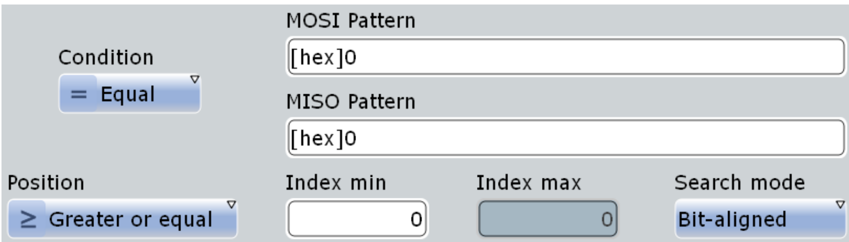
"Frame start (SS)"	Sets the trigger to the start of the frame when the slave select signal SS changes to the active state.
"Frame start (Timeout)"	Sets the trigger to the start of the frame when the clock idle time exceeds the "Timeout" time.
"MOSI"	Sets the trigger to a specified data pattern expected on the MOSI line. See: "MOSI and MISO data conditions" on page 249.
"MISO"	Sets the trigger to a specified data pattern expected on the MISO line. See: "MOSI and MISO data conditions" on page 249.
"MOSI/MISO"	Sets the trigger to specified data patterns expected on the MOSI and MISO lines.

SCPI command:

TRIGger<m>:SPI:MODE on page 555

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".

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. 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 9.1.3, "Bit Pattern Editor", on page 232.

SCPI command:

TRIGger<m>:SPI:MOSipattern on page 557

TRIGger<m>:SPI:MISopattern on page 557

Position ← MOSI and MISO data conditions
Operator for the data position. You can defined an exact position, or a position range.

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.

SCPI command:

`TRIGger<m>:SPI:POFFset` on page 556

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 be at any position in the message.

SCPI command:

`TRIGger<m>:SPI:PALignment` on page 556

9.3.3.3 SPI Decode Results (Option R&S RTO-K1)

If the option is installed, the "Decode" function in the "Configuration" tab is available. Enable "Decode" to display the decoded signal below the waveforms.

Additionally, you can display the binary signal and the detailed decoding results, see chapter 9.1.2, "Display", on page 231.

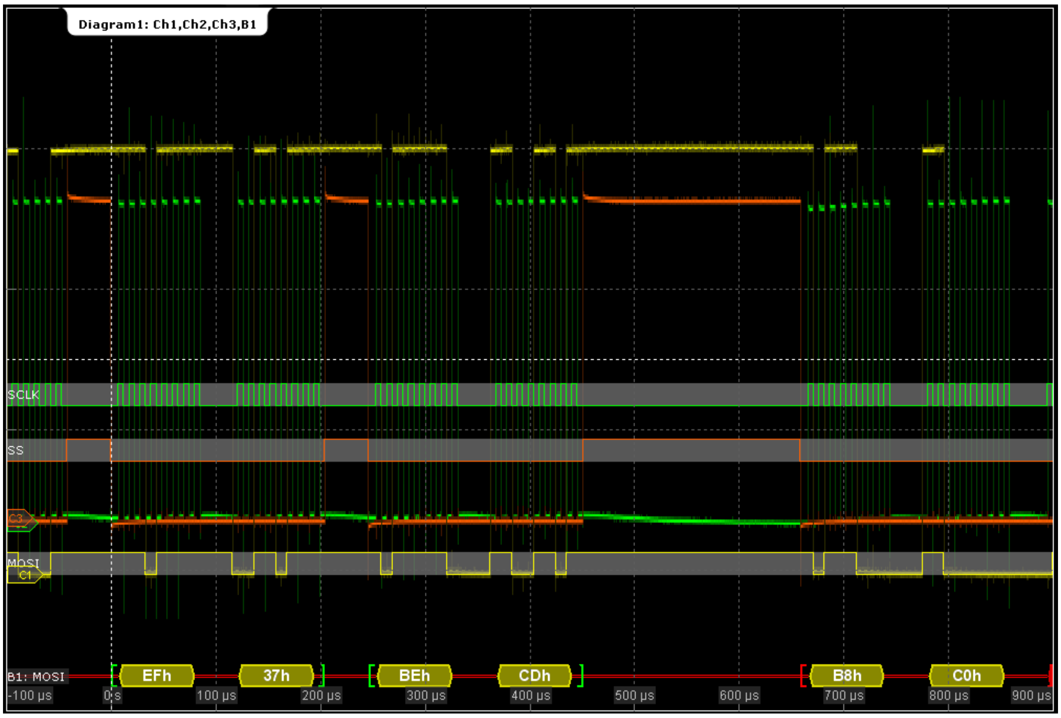


Fig. 9-7: Decoded and binary SPI signal with SCLK, MOSI, and SS line

green brackets [...] = start and end of complete frame
red brackets [...] = start and end of insufficient frame
yellow = word
red = error

The "Decode results" box shows the detailed decoded data for each data frame. It consist of two tables: The upper table lists the frames, while the lower table lists the data words for the frame that is selected in the frame table.

In the figure below, the first two frames contain two words each. The third frame is incomplete, two words of the frame are recognized, the third word is incomplete because it contains only one bit.

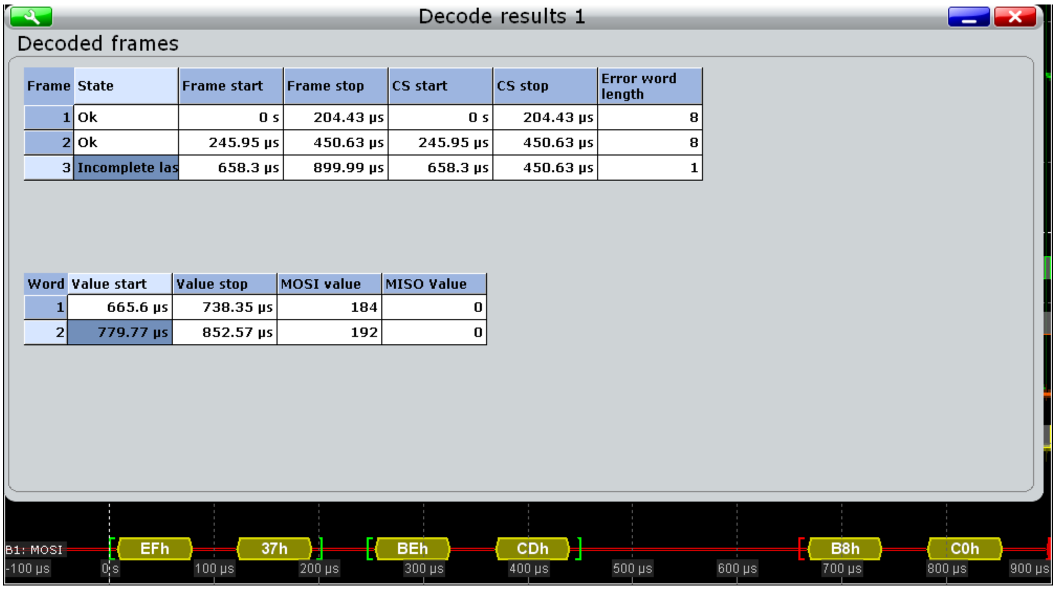


Fig. 9-8: Decode results showing word values of the third frame selected in the lower table

Table 9-3: Content of "Frames" table

Column	Description
State	Overall state of the frame
Frame start , Frame stop	Times of frame start and frame end
SS start	Start time of slave select signal
SS stop	Stop time of slave select signal
Word length	Number of recognized bits of the last word of a frame

Table 9-4: Content of "Words" table

Column	Description
Value start	Start time of the data word
Value stop	Stop time of the data word
MOSI value	Value of the data word
MOSI value	Value of the data word

SCPI commands:

BUS<m>:SPI:FRAMe<n>:STATus on page 558

BUS<m>:SPI:FRAMe<n>:COUNt on page 559

BUS<m>:SPI:FRAMe<n>:DATA on page 559

BUS<m>:SPI:FRAMe<n>:STARt on page 558

BUS<m>:SPI:FRAMe<n>:STOP on page 558

BUS<m>:SPI:FRAMe<n>:SSSTart on page 559

BUS<m>:SPI:FRAMe<n>:SSENd on page 560

BUS<m>:SPI:FRAMe<n>:ERRLength on page 559

BUS<m>:SPI:FRAMe<n>:WORD<o>:STARt on page 560

BUS<m>:SPI:FRAMe<n>:WORD<o>:STOP on page 561

BUS<m>:SPI:FRAMe<n>:WORD<o>:MISO on page 561

BUS<m>:SPI:FRAMe<n>:WORD<o>:MOSI on page 561

9.4 UART / RS232

9.4.1 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, it has no clock.

The data is transmitted in words. 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. 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

Fig. 9-9: Bit order on UART

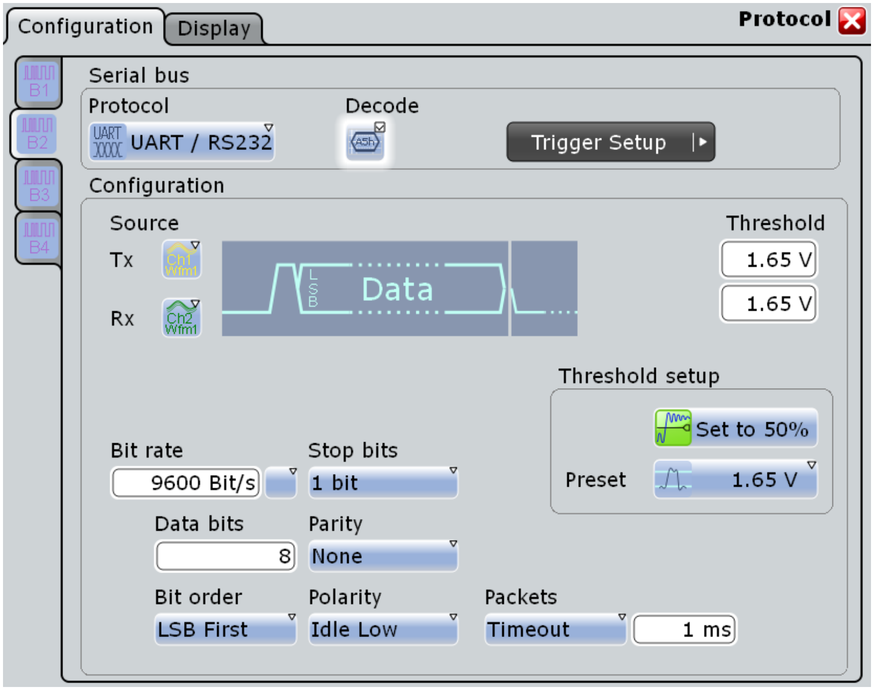
The R&S RTO can trigger on specified parts of UART serial signals:

- Start bit
- Package start
- Parity errors, and breaks
- Stop errors
- A serial pattern at any or a specified position

9.4.2 Reference for UART/RS-232 Interface

9.4.2.1 UART Configuration

Make sure that the tab of the correct serial bus is selected on the left side.



See also: chapter 9.1.1, "Configuration - General Settings", on page 230.

Source: Tx, Rx

Select the input channels for the transmitter and receiver signals. Waveform 1 of channel signals, math waveforms, and reference waveforms can be used.

SCPI command:

`BUS<m>:UART:TX:SOURce` on page 562

`BUS<m>:UART:RX:SOURce` on page 562

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.

You can enter individual values, or set the thresholds to 50% of the amplitude, or select default values for various signal technologies with "Preset" on page 254.

SCPI command:

`BUS<m>:UART:RX:THReshold` on page 563

`BUS<m>:UART:TX:THReshold` on page 563

Set to 50%

Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Preset

Selects the 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 entered directly.

SCPI command:

`BUS<m>:UART:TECHnologie` on page 563

Bit rate

Sets the number of transmitted bits per second. To select a common bit rate from list, 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.

SCPI command:

`BUS<m>:UART:BAUDrate` on page 564

Data bits

Sets the number of data bits of a word in a range from 5 to 8 bits.

SCPI command:

`BUS<m>:UART:SSIZe` on page 565

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.

SCPI command:

`BUS<m>:UART:SBIT` on page 565

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.

SCPI command:
BUS<m>:UART:PARity on page 564

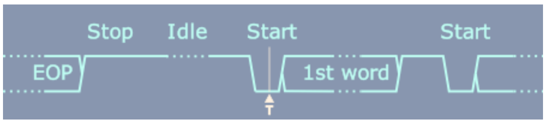
Polarity
Defines the idle state of the bus. The idle state corresponds to a logic 1. The transmitted data on the bus is high (high = 1) or low (low = 1) active.

SCPI command:
BUS<m>:UART:POLarity on page 565

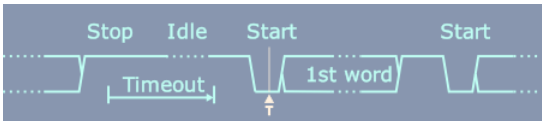
Packets
Allows to define packets of several words in the data stream.

"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.



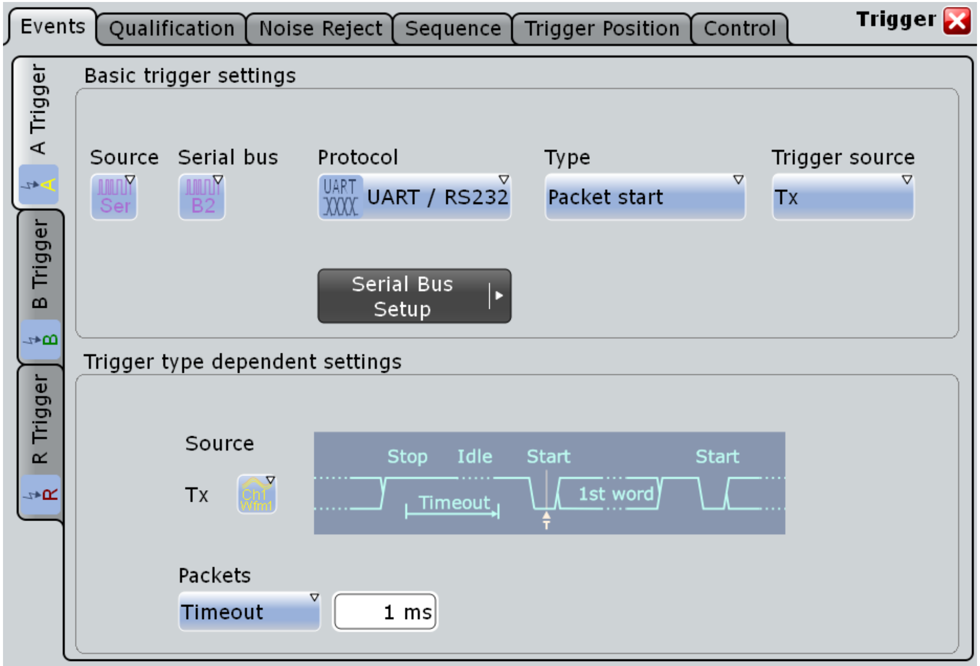
"Timeout" Defines a timeout between a stop bit and the next start bit. Enter the minimum time that marks the end of a packet.
A new packet starts with the first start bit after the timeout.



SCPI command:
BUS<m>:UART:BITime on page 565

9.4.2.2 UART Trigger

The "Events" tab of the "Trigger" dialog box provides the trigger settings for the configured serial buses.



Make sure that the trigger source is "Serial bus", and the correct serial bus is selected.

Protocol

Defines protocol type of the bus for bus configuration and trigger settings.

SCPI command:

`BUS<m>:TYPE` on page 538

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 255.

"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 257.

"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.

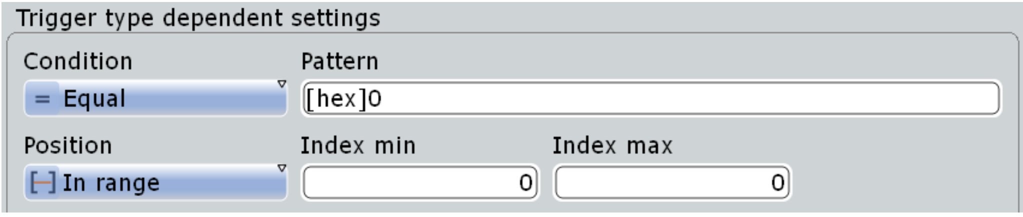
SCPI command:

`TRIGger<m>:UART:TYPE` on page 566

Trigger source
Selects the transmitter or receiver line as trigger source.

SCPI command:
`TRIGger<m>:UART:SOURce` on page 566

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".

SCPI command:
`TRIGger<m>:UART:OPERator` on page 568

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 9.1.3, "Bit Pattern Editor", on page 232.

SCPI command:
`TRIGger<m>:UART:DATA` on page 567

Position ← Data conditions
Operator for the data position. You can defined an exact position, or a position range.

SCPI command:
`TRIGger<m>:UART:DPOPerator` on page 567

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.

SCPI command:
`TRIGger<m>:UART:DPOSition` on page 567
`TRIGger<m>:UART:DPTO` on page 567

9.4.2.3 UART Decode Results (Option R&S RTO-K2)

If the option is installed, the "Decode" function in the "Configuration" tab is available. Enable "Decode" to display the decoded signal below the waveforms.

Additionally, you can display the binary signal and the detailed decoding results, see chapter 9.1.2, "Display", on page 231.

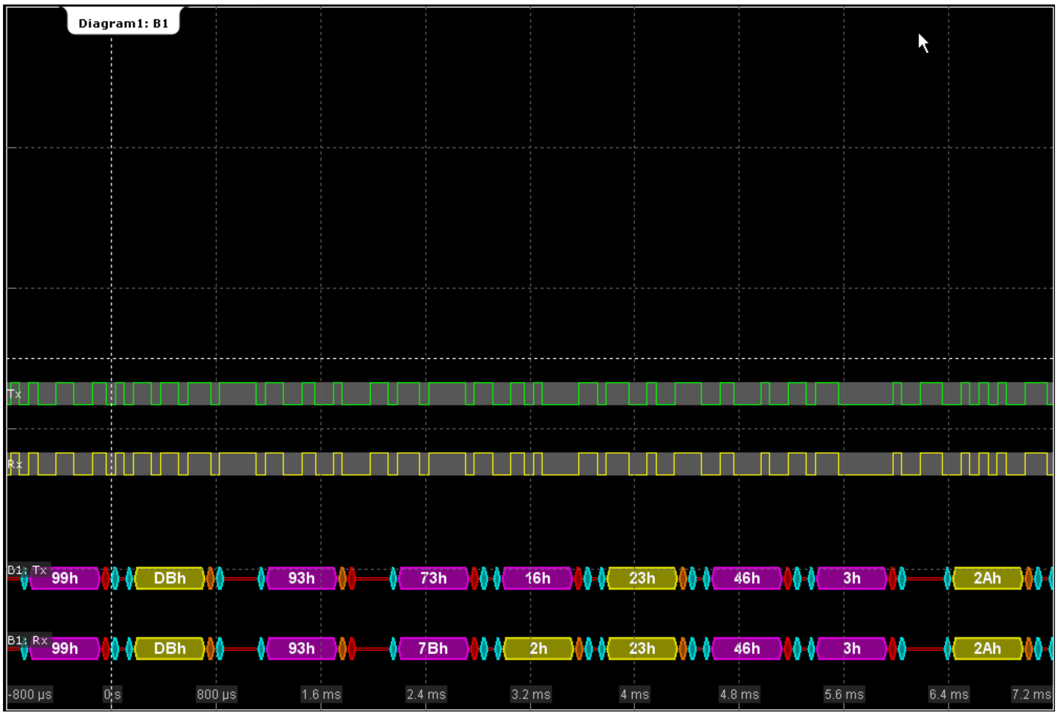


Fig. 9-10: Decoded and binary UART signal

blue = start and stop bits if ok
red = start error, stop error, parity error
orange = parity bit if ok
yellow = word ok
violet = word contains error

The "Decode results" box shows the detailed decoded data for each word.

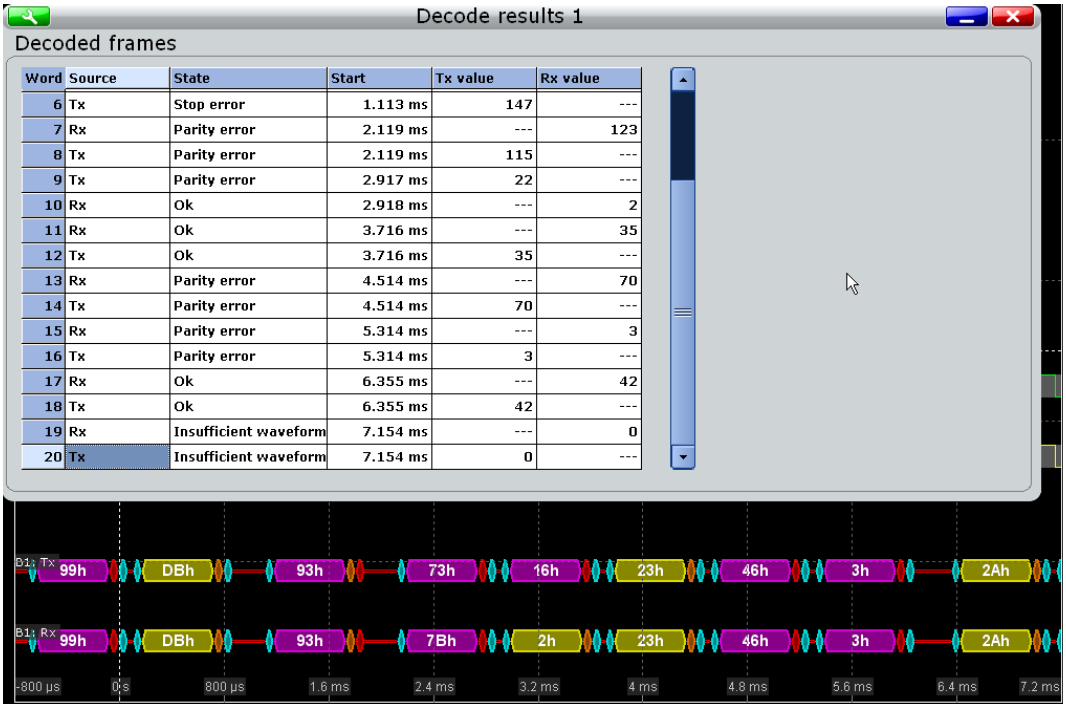


Fig. 9-11: Decode results of the UART signal

Table 9-5: Content of "Decoded words" table

Column	Description
Source	Line, Tx or Rx
State	Decoding state of the word. "Insuffcient waveform" 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	Decimal value of the Tx word
Rx value	Decimal value of the Rx word

SCPI commands:

`BUS<m>:UART:WORD<n>:COUNt` on page 569

`BUS<m>:UART:WORD<n>:SOURce` on page 570

`BUS<m>:UART:WORD<n>:STATe` on page 569

`BUS<m>:UART:WORD<n>:STARt` on page 569

`BUS<m>:UART:WORD<n>:TXValue` on page 568

`BUS<m>:UART:WORD<n>:RXValue` on page 568

10 Data and Results Management

This chapter describes how to manage measurement settings and results and other data.

10.1 Saving, Loading and Printing Data

After a measurement with the R&S RTO you would usually like to save the results for further evaluation or comparison. You can save the results of a measurement as a data file containing the waveform data, or print or save the current measurement display to a printer or a file. 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. These tasks are described here.

10.1.1 Configuring Printer Output and Printing

If you want to store the graphical results of the measurement, you can either print the current display on a printer or an image to a file.

You can configure the format and colors used for printing and select a printer, or save the print file on the instrument. A preview of the current print image is shown for reference.

1. Press the PRINT key to display the "Print" dialog box.
2. Tap the printer selection box to select the printer to use for printing.
3. Tap the "Color" selection box to configure black and white or color images.
4. To enhance waveform printouts on white paper, enable the "Inverse color" option.
5. Tap the "Orientation" selection box to select the paper format.
6. If the current display is likely to have changed since you opened the "Print" dialog box (e.g. due to a running measurement), tap the "Update image" button.

   The current print image is updated.
7. In order to zoom into the image preview, enable the "Zoom" option beneath the preview area.

   The image is enlarged and scrollbars are displayed to scroll through the print image.

8. To edit the image in an external application and process it further from there, tap the "Edit image" button.

   The print image is opened in the Paint application. Edit the image as necessary, and store or print the file from there. Alternatively, save the file and close the Paint application to return to the "Print" dialog. Then print or save the (edited) image as described below.

9. To print the image to the selected printer, tap the "Print" button.

10. To save the print image to the specified file, tap the "Save" button.
    To save it to a different file, tap the "Save As" button and select the file in the file selection dialog box.

10.1.2 Saving and Loading Waveform Data

You can save the waveform data resulting from a measurement to an `.xml`, `.csv`, or `.bin` file. Files in `.bin` format can be reloaded to the R&S RTO as reference waveforms.

Saving waveform data to a file

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. Tap "Save" to save the waveform data to the specified file. By default, the prefix for reference waveforms is "RefCurves_".
   Tap "Save As" to save the waveform data to a different file or file type. Select the file from the file selection dialog box.

   The waveform data is saved to the selected file.

Loading 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.

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "Waveform" tab.
4. Select the tab for the reference waveform you want to define ("Ref1"/2/3/4).
5. Tap "Load" to load the waveform from the specified file.
   Tap "Open" to load the waveform from a different file. Select the file from the file selection dialog box.

   The selected waveform is displayed as the specified reference waveform.

For details on configuring reference waveforms, see chapter 6.2.1, "Working with Reference Waveforms", on page 188.

10.1.3 Saving and Loading 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, functions are provided so you can easily save the instrument settings of a measurement. In addition to the measurement-related settings, user-specific settings concerning the display and data management can also be saved and loaded.

Settings can be stored permanently in a file, or temporarily in a SaveSet. The settings in a SaveSet can be retrieved quickly after presetting the instrument, whereas the settings in a file can be loaded again at any time, even after the instrument has been shut down.

To save instrument settings in a SaveSet

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.
4. Tap one of the three available "SaveSet" buttons in the "Quick Save to RAM" area.

   The current instrument settings are saved in the selected SaveSet.

To load instrument settings from a SaveSet

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab.
4. Tap the required "SaveSet" button in the "Quick Load from RAM" area.

   The saved settings are loaded to the R&S RTO.

Restoring Default Settings

After loading saved instrument settings, you can restore the default settings by pressing the PRESET key or the "Factory Reset" button in the dialog box. For details see chapter 10.1.4, "Restoring Settings", on page 263.

To save settings to a file

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab to save instrument settings, or the "User Preferences" tab to save user-specific settings.

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 from the file selection dialog box.

   The current settings are saved to the selected file.

To load settings from a file

1. Press the FILE key.
2. Select the "Save/Recall" tab.
3. Select the "Settings" tab to load instrument settings, or the "User Preferences" tab to load user-specific settings.
4. Tap "Load" to load the settings from the specified file.
   Tap "Open" to load the settings from a different file. Select the file from the file selection dialog box.

   The saved settings are loaded to the R&S RTO.

10.1.4 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. Depending on the situation and which data is to be restored, the following methods are available:

- Restoring the instrument settings to their default values
- Restoring settings from a file (see "To load settings from a file" on page 263)
- Restoring the default instrument settings and user-specific settings to a saved state in one step during one measurement session
- Restoring all settings on the R&S RTO to the factory-defined values

To restore the instrument settings to their default values

► Press the PRESET key.

The instrument settings are restored to their default values.

To restore the default instrument settings and user-specific settings to a saved state in one step

This method is only available during one measurement session.

1. Press the FILE key.
2. Select the "User-defined Preset" tab.
3. Tap the "Create SaveSet" button to save the current user-specific settings temporarily in a SaveSet. The SaveSet remains available until you switch off the instrument, then it is deleted.
4. Enable the "Enable user-defined preset" option.

5. At any time during the same measurement session, press the PRESET key.

   The instrument settings are reset to their default values, the user-specific settings are reset to the values saved in the SaveSet.

To restore all settings on the R&S RTO to the factory-defined values

► Tap the "Factory Reset" button.

   All settings on the R&S RTO are reset to their factory-defined values.

10.1.5 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 "Save/Recall" tab.
3. Select the "Settings" tab.
4. Double-tap the "Default path for all file operations" field.

   The directory selection dialog box is opened.
5. Select the folder in which the data is to be stored by default.
6. 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.
4. To insert the current date, time or an index (serial number), enable the corresponding option.

   The specified elements are used to generate the default file name for the next storage operation.

10.2 Reference for FILE Settings

The FILE key provides functions for saving and restoring data on the instrument. The following types of data can be saved and loaded:

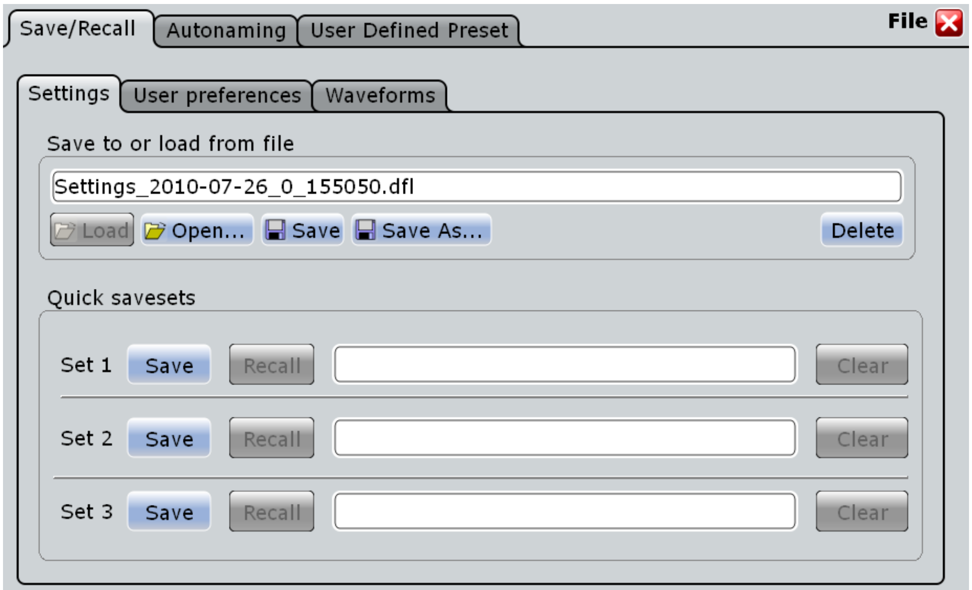
- (Instrument) Settings
- User-specific display settings
- Waveform (measurement) data

10.2.1 Save/Recall

In this tab you define the storage settings for each type of data to be saved.

10.2.1.1 Settings

In this tab, the storage configuration for instrument settings is defined. By default, settings file names have the prefix "Settings_".



Save to or load from file
Specifies the file name to load or to save the data to.

Double-tap the file name to open the file selection dialog box. See also: chapter 10.2.4, "File Selection Dialog", on page 270.

Load ← Save to or load from file
Loads the specified file.

Open ← Save to or load from file
Opens a file selection dialog box and loads the selected file (`.dfl` or `.xml` format).

Save ← Save to or load from file
Saves the data to the selected file.

Save As... ← Save to or load from file
Opens the file selection dialog box and saves the data to the selected file.

Delete ← Save to or load from file
Deletes the selected file.

Quick savesets
A saveset stores the current measurement and instrument settings to the instrument temporarily, i.e. when the R&S RTO is switched off, the savesets are deleted. However, after a "Preset" function, the savesets are still available. This function is useful, for example, to try out different settings and repeat the original measurement later.

Three savesets, i.e. temporary storage sets, are available.

You can define a comment for each saveset before saving.

Save ← Quick savesets
Saves the current measurement and instrument settings to one of the three temporary savesets.

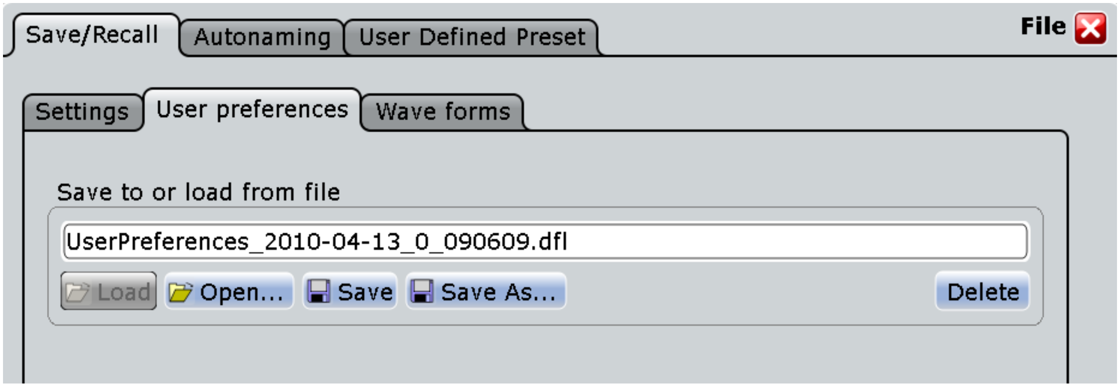
Recall ← Quick savesets
Loads the instrument settings from one of the three temporary savesets.

Comment ← Quick savesets
Double-tap the edit field to insert a comment for the selected saveset.

Clear ← Quick savesets
Deletes the selected saveset.

10.2.1.2 User Preferences

In this tab, the storage settings for user-specific display settings are defined. By default, these file names have the prefix "UserPreferences_".

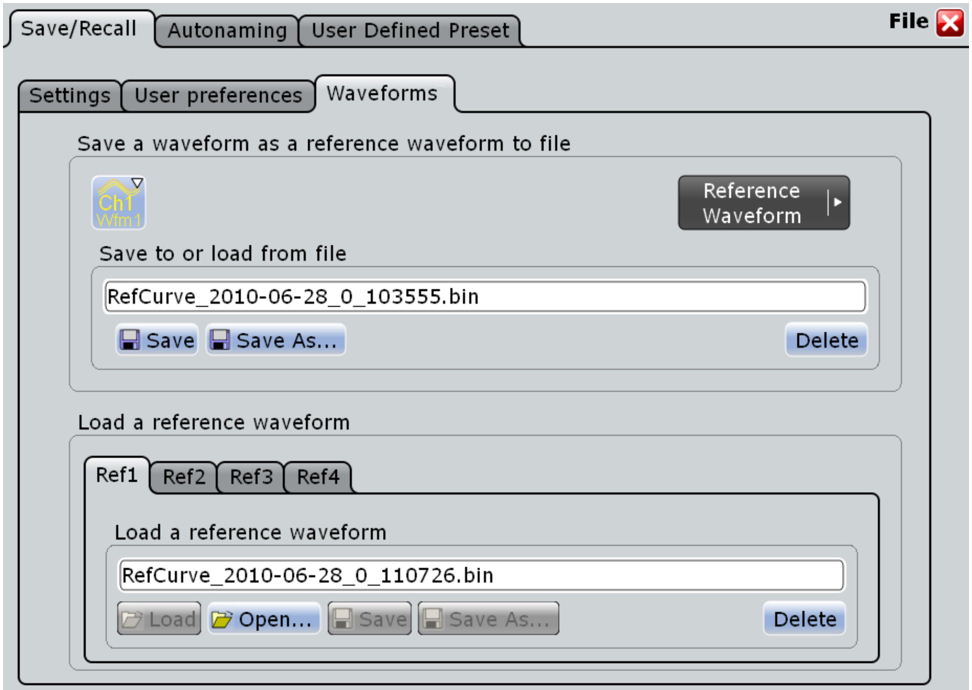


Save to or load from file
The file name to load or to save the data to.

For details see the Save to or load from file function in the "Settings" tab.

10.2.1.3 Waveforms

In this tab, the storage settings for measurement data (results) are defined.



Source
Selects the source waveform from the active waveforms of input channels, math signals and other reference waveforms.

SCPI command:
`REFCurve<m>:SOURce` on page 485

Save to file
Enter the file name to save the waveform to.

By default, the file name has the prefix "RefCurves_". You can define a pattern for automatic naming in the "Autonaming" tab.

Double-tap the file name to open the file selection dialog box.

For details see chapter 10.2.4, "File Selection Dialog", on page 270.

Save ← Save to file
Saves the waveform as a reference waveform in the selected file.

Save As... ← Save to file
Opens the file selection dialog box and saves the waveform to the selected file.

Ref 1/2/3/4
Each tab contains the settings for one of the four available reference waveforms.

Save and load a reference waveform
Select the file name of the stored reference waveform. Double-tap the file name to open the file selection dialog box.

Note that reference waveforms can be loaded from `.bin` files only.

For details see chapter 10.2.4, "File Selection Dialog", on page 270.

Load ← Save and load a reference waveform
Loads the specified reference waveform.

Open ← Save and load a reference waveform
Opens a file selection dialog box and loads the selected reference waveform file

SCPI command:
`REFCurve<m>:OPEN` on page 486

Save / Save As ← Save and load a reference waveform
Saves the selected reference waveform with its current "Scaling" settings to the file.

"Save As" opens the file selection dialog box to select the target directory and the file format.

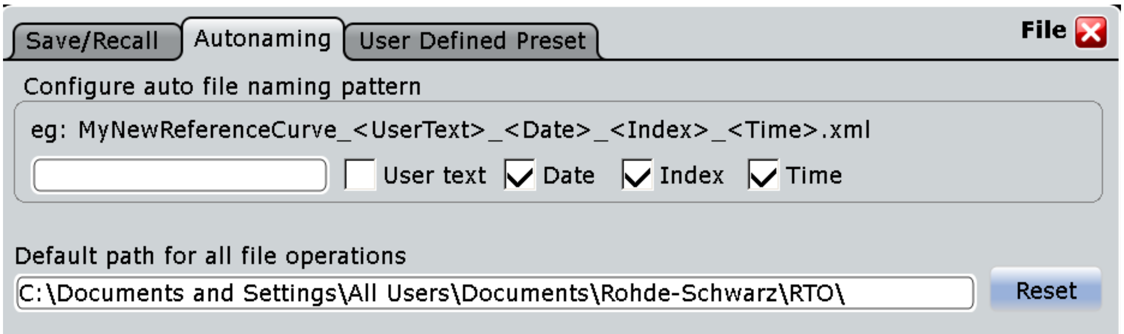
By default, the file name has the prefix "RefCurve_".

Note: XML and CSV formats are meant for further processing in other applications. If you want to load the reference waveform on the R&S RTO again, use the `.bin` format.

SCPI command:
`REFCurve<m>:SAVE` on page 486
`REFCurve<m>:DELete` on page 486

10.2.2 Autonaming

In this tab you can define the pattern for automatic file name generation. This name is used as the default file name in the file selection dialog box when data is saved to a new file ("Save As").



User text
User-defined text to be inserted after the prefix.

User text (enable)
If enabled, inserts the specified user text after the prefix.

Date
If enabled, inserts the current date.

Index
If enabled, inserts an index.

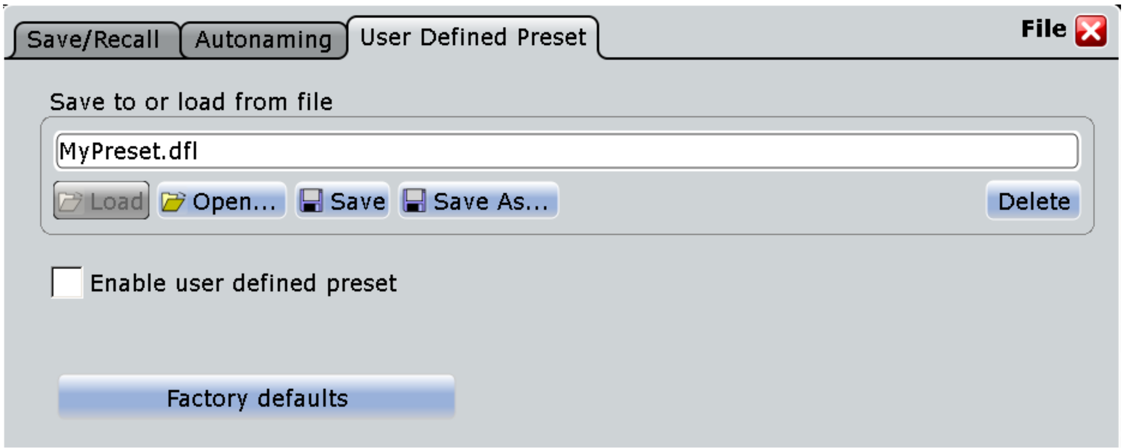
Time
If enabled, inserts the current time.

Default path for all file operations
Defines the default path displayed in the file selection dialog box for loading and storing operations.

Reset
Resets the default file path.

10.2.3 User-defined Preset

The "User-defined Preset" tab allows you to save the current user-specific display settings to a file. Alternatively, you can load an existing user preferences file. You can then specify that these settings are to be restored, in addition to the standard instrument settings, after using the "Preset" function.



Save to or load from file
The file name to load or to save the settings to.

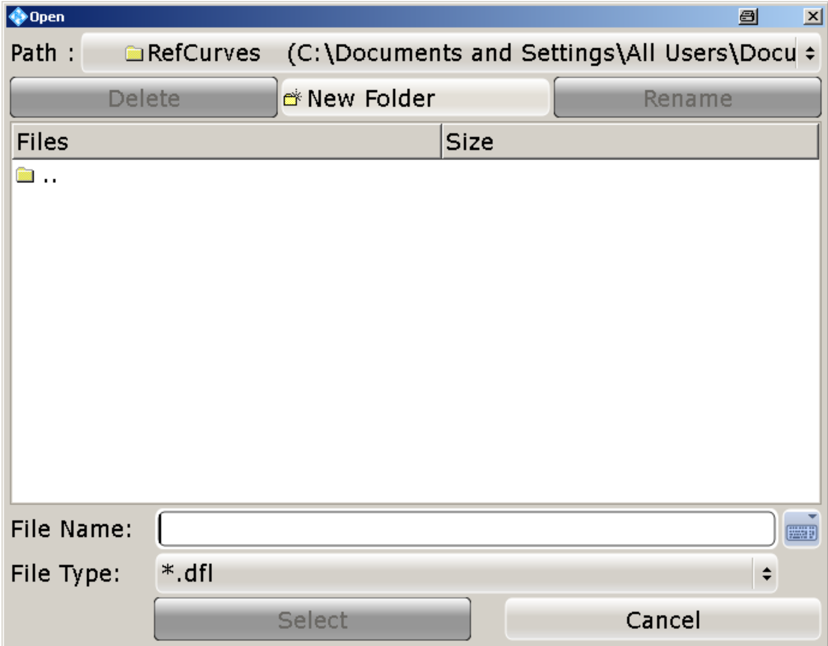
For details see the Save to or load from file function in the "Settings" tab.

Enable user-defined preset
If enabled, the user-specific display settings stored in the specified user preferences file are restored when the "Preset" function is selected.

Factory defaults
Resets the instrument's preset values to the factory defaults, so that after the "Preset" function is selected, the factory settings are restored.

10.2.4 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 269.

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.

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 10.2.2, "Autonaming", on page 269.

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.

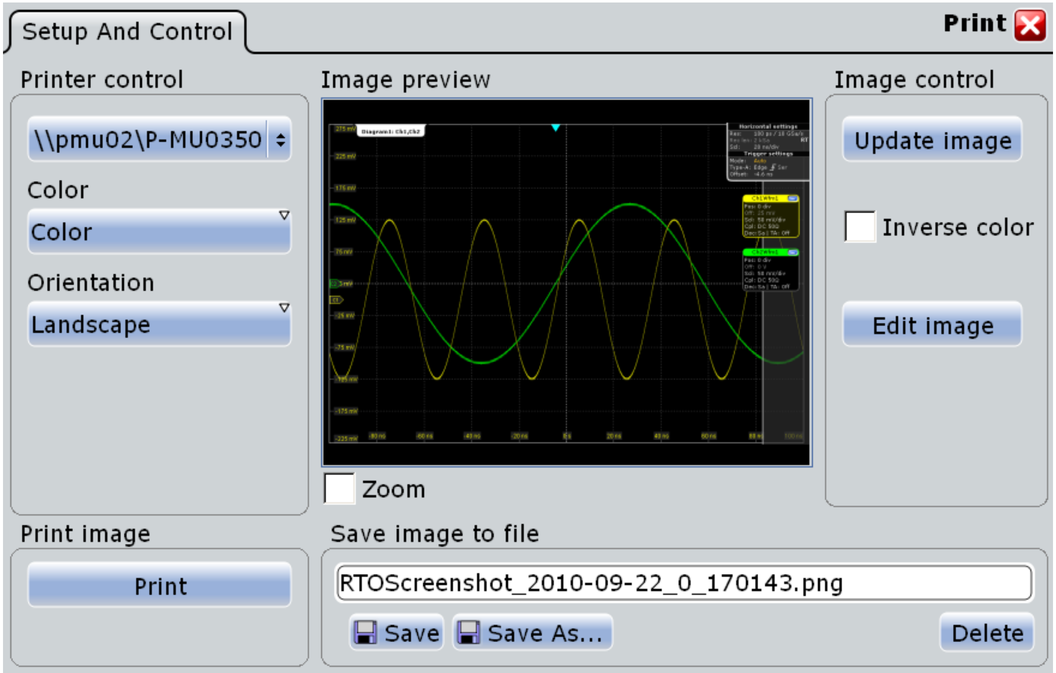
Select
Selects the specified file for the open or save operation and closes the dialog box.

Cancel

Closes the dialog box without selecting a file.

10.3 Reference for PRINT Settings

The PRINT key provides functions for printing data to a printer or a file on the instrument. The data to be printed is a screenshot of the graphic area, without any dialog boxes that may be open.



Printer

Selects a configured printer.

SCPI command:

`SYSTem:COMMunicate:PRINter:SELect<1..2>` on page 579

Color

Defines the color mode for printing.

"Black and white"	Black and white output
"Color"	Color output

SCPI command:
HCOPy:DEVice<m>:COLor on page 577

Orientation

Toggles the page orientation between "Landscape" and "Portrait."

SCPI command:
HCOPy:PAGE:ORIentation<1..2> on page 578

Image preview

Shows a preview of the current print image.

Zoom ← Image 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 image

Updates the preview of the current print image, e.g. after changes to the settings have been made or an additional channel has been activated.

Inverse color

Inverts the colors of the output, i.e. a dark waveform is printed on a white background.

Edit image

Opens a temporary file with the current print image in a graphic editor. There you can edit the image and then print it.

Print

Prints the current print image on the selected printer.

SCPI command:
HCOPy:DESTination<1..2> on page 576
HCOPy:IMMediate on page 578

Save image to file

Defines the file name if the print image is saved. By default, the file name has the prefix "RTOSCreenshot_".

Double-tap the file name to open the file selection dialog box.

SCPI command:
HCOPy:DEVice<m>:LANGuage on page 577
HCOPy:DESTination<1..2> on page 576
MMEMory:NAME on page 573
HCOPy:IMMediate on page 578

Save ← Save image to file
Saves the current print image to the specified file name.

Save As... ← Save image to file
Opens the file selection dialog box and saves the current print image to the selected file name.

Delete ← Save image to file
Opens the file selection dialog box and deletes the selected file.

SCPI command:
`MMEMory:DELete` on page 574

11 General Instrument Setup

Some basic instrument settings concerning the user interface and general system are configurable and may need to be adapted to your specific requirements. Furthermore, the input channels may need to be aligned.

11.1 Setting Up the Instrument

The following procedures for the general instrument setup are described in the "Getting Started" manual:

- Adjusting the Instrument (Self-alignment)
- Aligning the Touch Screen

The following setup procedures are described in this manual:

- chapter 12.2, "Firmware Update", on page 286
- chapter 12.3, "Software Options", on page 287
- chapter 12.4.2, "LXI Configuration", on page 292

11.2 Reference for General Instrument Settings

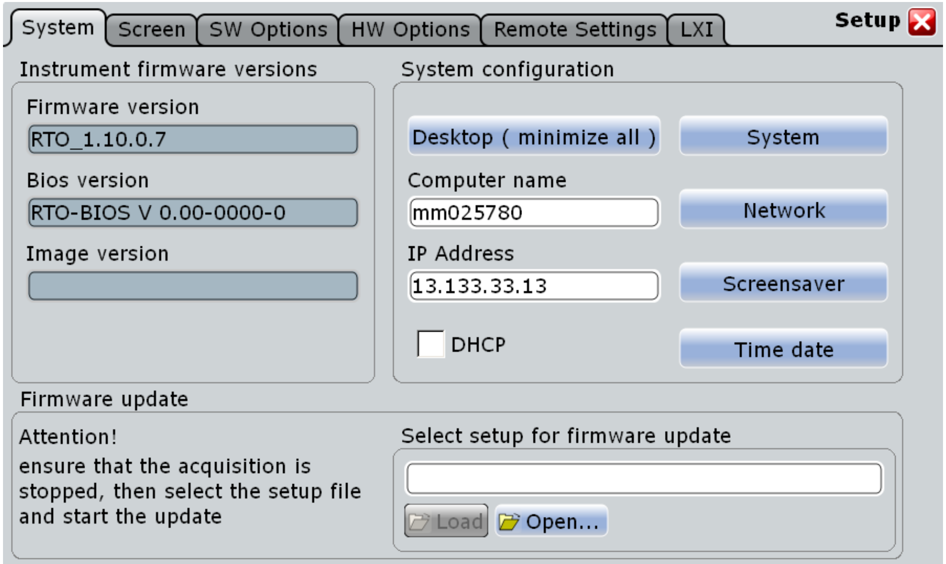
The SETUP key provides functions for basic instrument settings.

"Self-alignment" is available from the "File" menu.

11.2.1 Setup

11.2.1.1 System

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.

SCPI command:

DIAGnostic:SERVice:FWVersion on page 579

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 12.4.1, "Setting Up a Network (LAN) Connection", on page 289.

SCPI command:

DIAGnostic:SERVice:COMPutername on page 579

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 screensaver.

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

Select Setup for firmware update
Performs the firmware update.

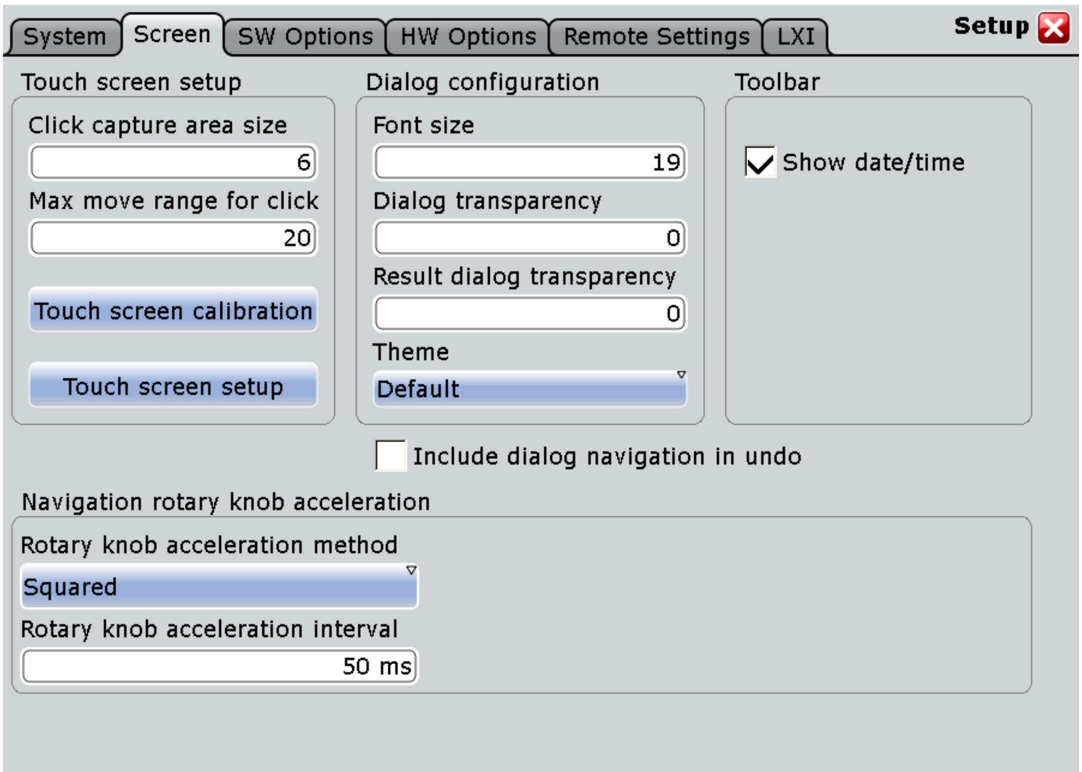
See also: chapter 12.2, "Firmware Update", on page 286.

Load ← Select Setup for firmware update
Loads the specified file.

Open ← Select Setup for firmware update
Opens a file selection dialog box and loads the selected file (`Setup_*.exe`).

11.2.1.2 Screen

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



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 your finger or click the mouse pointer on 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 touch screen calibration application, see "Setting Up the Instrument" in the Quick Start Guide.

Touchscreen setup
Opens the touch screen configuration application for advanced touch screen 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 transparency
Defines the transparency of the measurement result boxes in the same way as Dialog transparency.

Theme
Defines the color scheme and contrast of the dialog boxes. Different themes are provided to optimize the display for the most frequent operating situations.

"Default"	The default setting for standard operation according to user preferences
"Contrast"	Special setting for optimized contrast when using high transparency values for the dialog box background; dialog text is white, the background is dark-colored
"Printing"	Special setting for optimized printing; dialog text is black, background is light-colored

Include dialog navigation in undo
If enabled, navigation steps in dialogs are included and displayed when the undo function is used. Thus, you can see the changes to settings in dialogs as they are undone step by step.

If disabled, changes are also undone; however, the dialog is not displayed and you do not see which settings are restored.

Show date/time
Displays the current date and time on the toolbar.

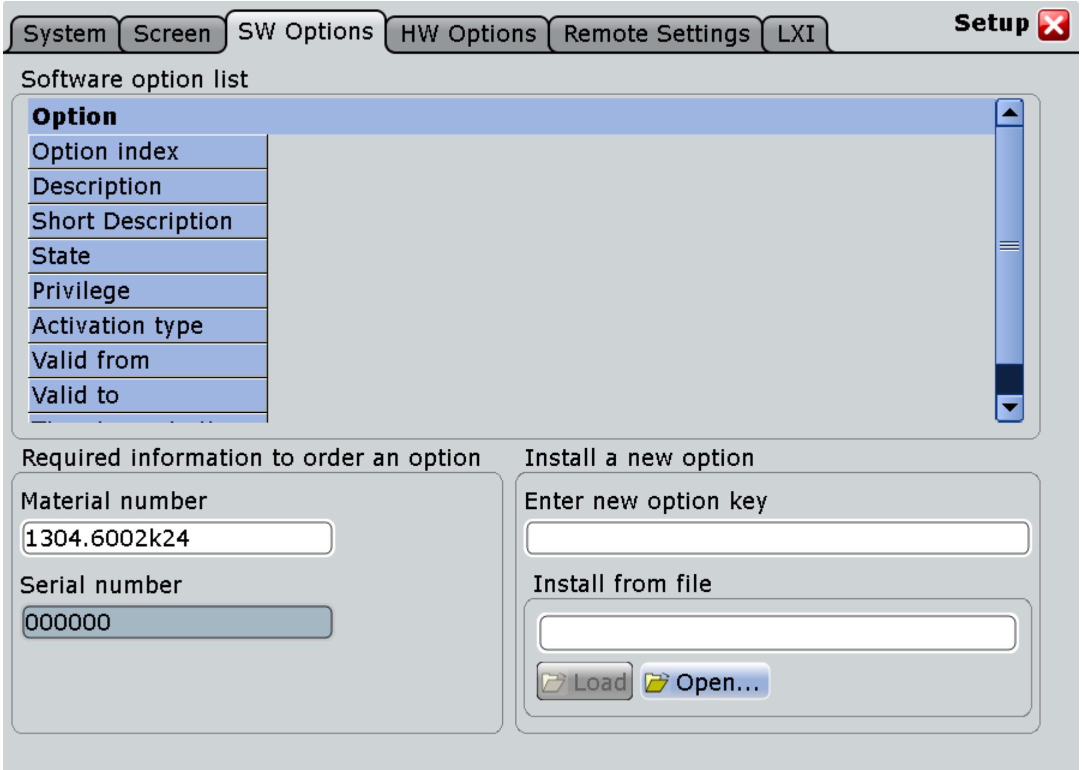
Rotary knob acceleration method
Selects a method to accelerate the movement of the element on the screen compared to the actual movement of the rotary knob. Acceleration is useful if you need to move from one end of the screen to the other, for example. Without acceleration, you might have to turn the knob quite a while. 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 the delay time before a reaction occurs is longer. Furthermore, when you turn the knob slowly during finetuning, subsequent movements that occur during the same interval are accelerated, making precise selection difficult.

11.2.1.3 SW Options

This tab provides information on installed software options and functions to install new options via license keys.



The "State" of the option indicates whether the installed option is an official or merely a beta-release version. Beta-release versions must be activated explicitely in the "Mode" dialog box (see chapter 12.3.1, "Mode", on page 288).

Option list

Indicates the installed options. The information provided in the "Option list" is for administration and troubleshooting purposes only. Should you require support for the option, provide this information to the service representative.

Material number, Serial number

Indicates the material number and serial number of your instrument. These numbers are required to order a new option.

SCPI command:

`DIAGnostic:SERVice:PARTnumber` on page 580

`DIAGnostic:SERVice:SERialnumber` on page 580

Enter new option key

For each option you order an option key is provided. Enter the option key here to activate the option.

Install from file

Alternatively to entering the option key manually, it can be read from a special option file provided with the option.

Load ← Install from file

Loads the specified file.

Open ← Install from file

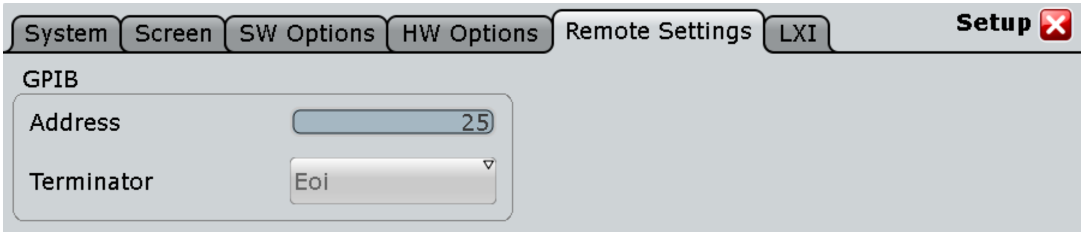
Opens a file selection dialog box and loads the selected file.

11.2.1.4 HW Options

This tab provides information on the availability of hardware options.

11.2.1.5 Remote Settings

The settings on this tab are required for remote control of the instrument via a connected computer, see chapter 14.1, "Basics", on page 301.



Address

Indicates the GPIB address of the instrument if an optional GPIB bus card is installed.

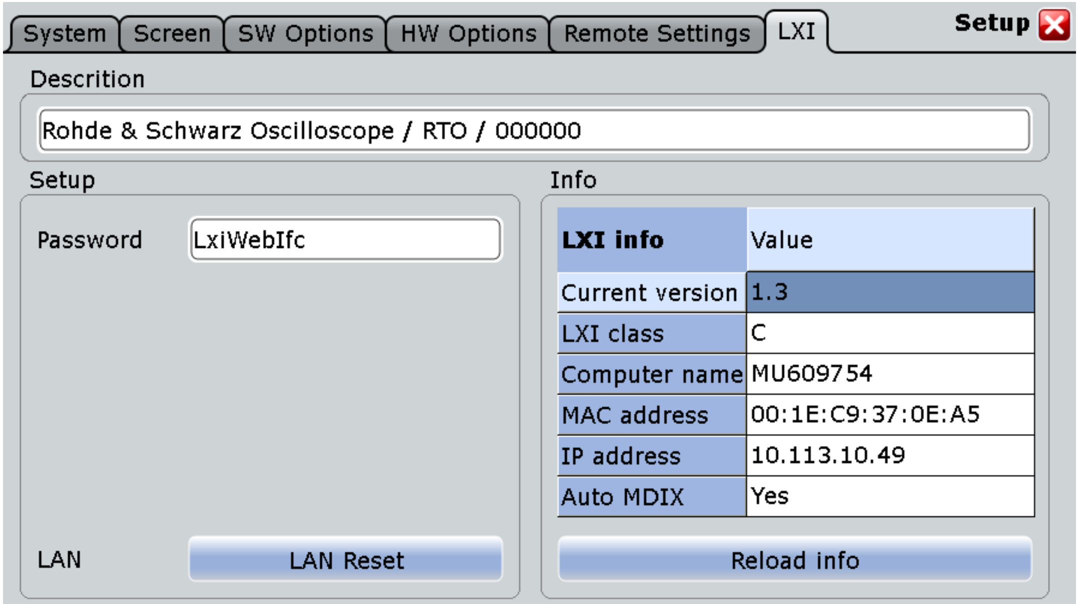
The address can be edited here; however, beware that changing the address has major effects on the communication to the remote computer. For details see chapter 14.1, "Basics", on page 301.

Terminator

Specifies which symbol is used as a terminator in GPIB communication.

11.2.1.6 LXI

This tab provides settings for LXI, which allows you to connect your R&S RTO to other devices in a network. For details, see chapter 12.4.2, "LXI Configuration", on page 292.



Description

Instrument description of the R&S RTO (read-only)

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 RTO.

"Current version"	Current LXI version
"LXI Class"	LXI device class
"Computer name"	Name of the R&S RTO 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 RTO
"IP address"	IP address of the R&S RTO as defined in the operating system.
"Auto MDIX"	Enables the use of the built-in Auto-MDI(X) Ethernet functionality.

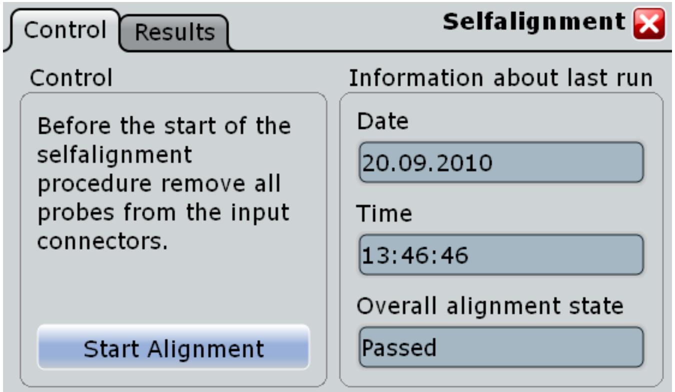
Reload Info

Reloads LXI configuration

11.2.2 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°).

11.2.2.1 Control

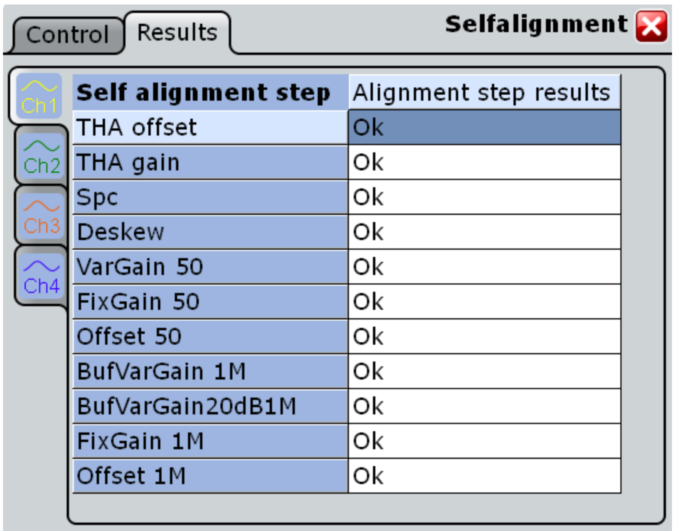


Start Alignment
Starts the self-alignment procedure for all channels.

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.

11.2.2.2 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.



12 Software and Network Operation

12.1 Operating System

The R&S RTO contains the Windows XP operating system which 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 the Windows XP 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 XP 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 12.4.1.1, "Connecting the Instrument to the Network", on page 290).

12.1.1 Virus Protection

Users must take appropriate steps to protect their instruments from infection. Beside the use of strong firewall settings and regularly scanning any removable storage device used with a R&S instrument, it is also recommended that anti-virus software be installed on the instrument. While 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, it does recommend running it during non-critical hours.

For details and recommendations, see the R&S White Paper "Malware Protection" available at http://www2.rohde-schwarz.com/en/service_and_support/Downloads/Application_Notes/?type=20&downid=5699.

12.1.2 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 more details and information on configuring automatic updates see the R&S White Paper "Malware Protection" (available at http://www2.rohde-schwarz.com/en/service_and_support/Downloads/Application_Notes/?type=20&downid=5699).

Changes in the system setup are only required when peripherals like keyboard or a printer are installed or if the network configuration does not comply with the default settings (see chapter 12.4.1.1, "Connecting the Instrument to the Network", on page 290). After the R&S RTO is started, the operating system boots and the instrument firmware is started automatically.

12.1.3 Login

Windows XP requires that users identify themselves by entering a user name and password in a login 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. The instrument provides an auto-login function for the administrator account, i.e. login with unrestricted access is carried out automatically in the background.

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 XP and on the network.

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 in Windows XP for the standard user at any time via "Settings > Control Panel > User Accounts". Some administrative tasks require administrator rights, e.g. the configuration of a LAN network.

If you want to use the standard user account, the auto-login must be deactivated. Proceed as follows:

1. On the "Start" menu, select "Run".
2. Enter the command: `C:\R_S\INSTR\USER\NO_AUTOLOGIN.REG`
3. Tap "Enter" to confirm.

   The next time you switch on the instrument, you are prompted to enter your user name and password before the firmware is started.

   Note: To reactivate the auto-login function, enter the command `C:\R_S\INSTR\USER\AUTOLOGIN.REG`.

12.1.4 Accessing Windows XP functionality

All required Windows XP settings can be changed using the touch screen 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 XP

► On the "File" menu, select "Minimize application".

The application is minimized to the task bar and the "Start" menu becomes available.

To access Windows XP using an external keyboard

► To open the "Start" menu, press the Windows key or the CTRL + ESC key combination on your keyboard.
To access the desktop, press the Windows key + D on your keyboard.

To access Windows XP settings directly

Important Windows XP settings can be accessed directly from the R&S RTO 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.

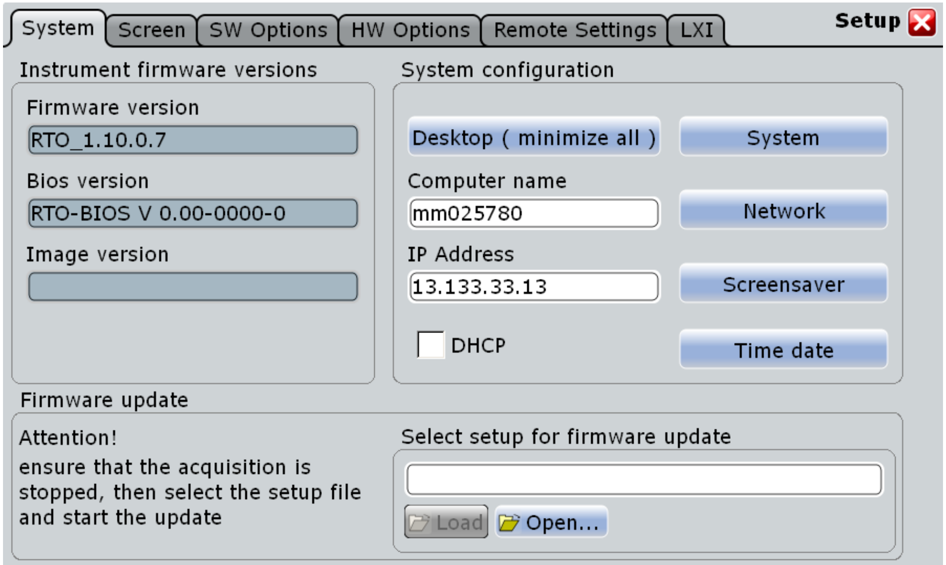
12.2 Firmware Update

The firmware on your R&S RTO may need to be updated in order to enable additional new features or if reasons for improvement come up. Ask your sales representative or check the Rohde&Schwarz website for availability of firmware updates. A firmware update package includes at least a setup file and release notes.

Before updating the firmware on your instrument, read the release notes delivered with the firmware version.

1. Download the update package from the Rohde&Schwarz website and store it on a memory stick, on the instrument, or on a server network drive that can be accessed by the instrument.
2. **NOTICE!** Stop acquisition. The firmware update must not be performed during running acquisition.

   If an acquisition is running, stop it by pressing RUN CONT or RUN N× SINGLE.
3. Press the SETUP key, or tap "Setup" on the "File" menu.
4. Select the "System" tab.



5. If the name of the file that contains the update is already displayed in the "Select Setup for firmware update" field, tap "Load".
Otherwise tap "Open" to open the file selection dialog box and select the `Setup*.exe` file.

6. Select "Next" in the installation dialog box and select the firmware packages. By default, all packages are installed.

7. Tap "Install" to start the update.

8. After the firmware update, the R&S RTO reboots automatically.

9. Depending on the previous firmware version, a reconfiguration of the hardware might be required during the first startup of the firmware. The reconfiguration starts automatically, and a message box informs you about the process. When the reconfiguration has finished, the instrument again reboots automatically.

   Note: Do not switch off the instrument during the reconfiguration process!

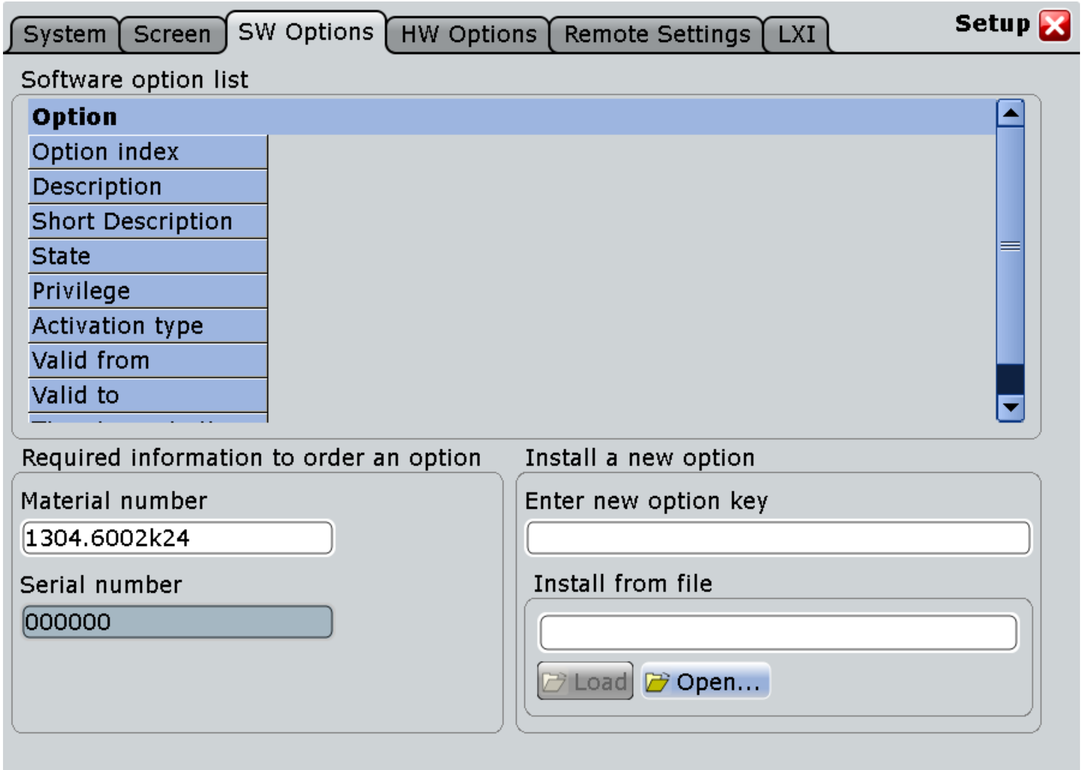
   Now the firmware update is complete. It is recommended that you perform a self-alignment after the update ("File > Selfalignment").
   The self-alignment procedure is described in the "Getting Started" manual, chapter "Setting Up the Instrument".

12.3 Software Options

Additional options for the R&S RTO can be enabled using a license key. To obtain the license key, consult your sales representative. You need the material number and serial number of your instrument to get a license key. No additional installation is required.

To install an option using a license key

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, enter the path and file name in the "Install from file" field and tap "Load". Alternatively, tap "Open" to open the file selection dialog box and select the option key file.
3. If you want to enable several options, repeat step 2 for each option.
4. Restart the instrument or restart the firmware.

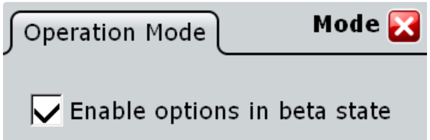
   The functions of the additional option are available for use in your instrument.

The information provided in the "Option list" is for administration and troubleshooting purposes only. Should you require support for the option, provide this information to the service representative.

See also: chapter 11.2.1.3, "SW Options", on page 279

12.3.1 Mode

The MODE key opens a dialog box to activate options with beta-release state. These options are deactivated by default. If you want to use a beta-released option, you must activate it. The activation is effective until the next shut-down of the firmware.



12.4 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

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

The Remote Desktop Connection of the Windows operating system is not supported for instrument control. It can be used for file transfer from and to the instrument.

12.4.1 Setting Up a Network (LAN) Connection

The R&S RTO is equipped with a network interface and can be connected to an Ethernet LAN (local area network). Provided the appropriate rights have been assigned by the network administrator and the Window XP firewall configuration is adapted accordingly, the interface can be used, for example:

- To transfer data between a controller and the tester, e.g. in order 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 12.4.1.1, "Connecting the Instrument to the Network", on page 290
- chapter 12.4.1.2, "Assigning the IP Address", on page 290

LXI

The R&S RTO complies with LXI Class C. LXI gives you direct access to the LAN settings described below.

12.4.1.1 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 12.4.1.2, "Assigning the IP Address", on page 290.

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 XP 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.

12.4.1.2 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. Select "Network".
3. Touch and hold (or right-click) "Local Area Connection" and select "Properties" from the context-sensitive menu.
4. On the "General" tab, select "Internet Protocol (TCP/IP)" 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.

12.4.1.3 Using computer names

Alternatively to the IP address, each PC or instrument connected in a LAN can be accessed via an unambiguous computer name. Each instrument is delivered with an assigned computer name, but this name can be changed.

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.

12.4.1.4 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. R&S 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 R&S White Paper "Malware Protection" (available at http://www2.rohde-schwarz.com/en/service_and_support/Downloads/Application_Notes/?type=20&downid=5699) and the Windows XP help system.

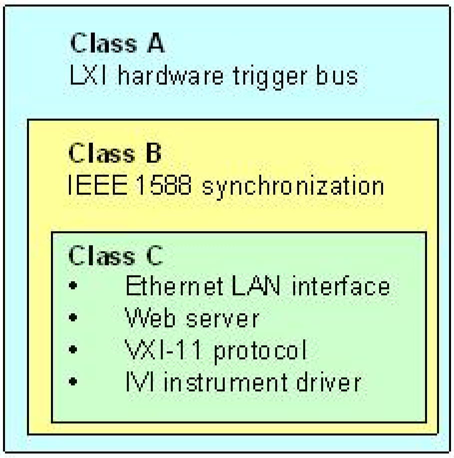
Note that changing firewall settings requires administrator rights.

12.4.2 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.

12.4.2.1 LXI Classes and LXI Functionality

LXI-compliant instruments are divided into three classes, A, B and C, with the functionality of the classes hierarchically based one upon the other:



- **Class C** instruments are characterized by a common LAN implementation, including an ICMP ping responder for diagnostics. The instruments can be configured via a web browser; a LAN Configuration Initialize (LCI) mechanism resets the LAN configuration. The LXI Class C instruments shall also support automatic detection in a LAN via the VXI-11 discovery protocol and programming by means of IVI drivers.
- **Class B** adds IEEE 1588 Precision Time Protocol (PTP) and peer-to-peer communication to the base class. IEEE 1588 allows all instruments on the same network to automatically synchronize to the most accurate clock available and then provide time stamps or time-based synchronization signals to all instruments with exceptional accuracy.
- **Class A** instruments are additionally equipped with the eight-channel hardware trigger bus (LVDS interface) defined in the LXI standard.

For information about the LXI standard refer to the LXI website at http://www.lxistandard.org. See also the article at the Rohde&Schwarz website: http://www2.rohde-schwarz.com/en/technologies/connectivity/LXI/information/.

Instruments of classes A and B can generate and receive software triggers via LAN messages and communicate with each other without involving the controller.

The R&S RTO complies with LXI Class C. In addition to the general class C features described above, it provides the following LXI-related functionality:

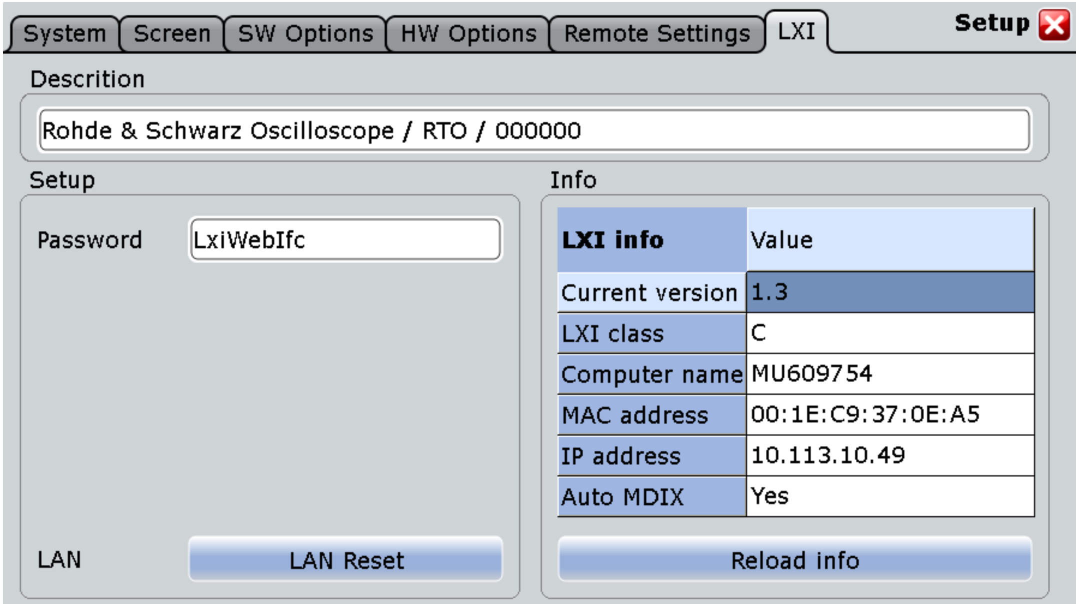
- Integrated "LXI Configuration" dialog box for LXI activation and reset of the LAN configuration (LAN Configuration Initialize, LCI).

Firmware update

After a firmware update, shut-down and re-start the instrument in order to enable the full LXI functionality.

12.4.2.2 LXI Configuration

The "LXI" tab of the "Setup" dialog box provides basic LXI functions and information for the R&S RTO.



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 LCI for the R&S RTO also resets the following parameters:

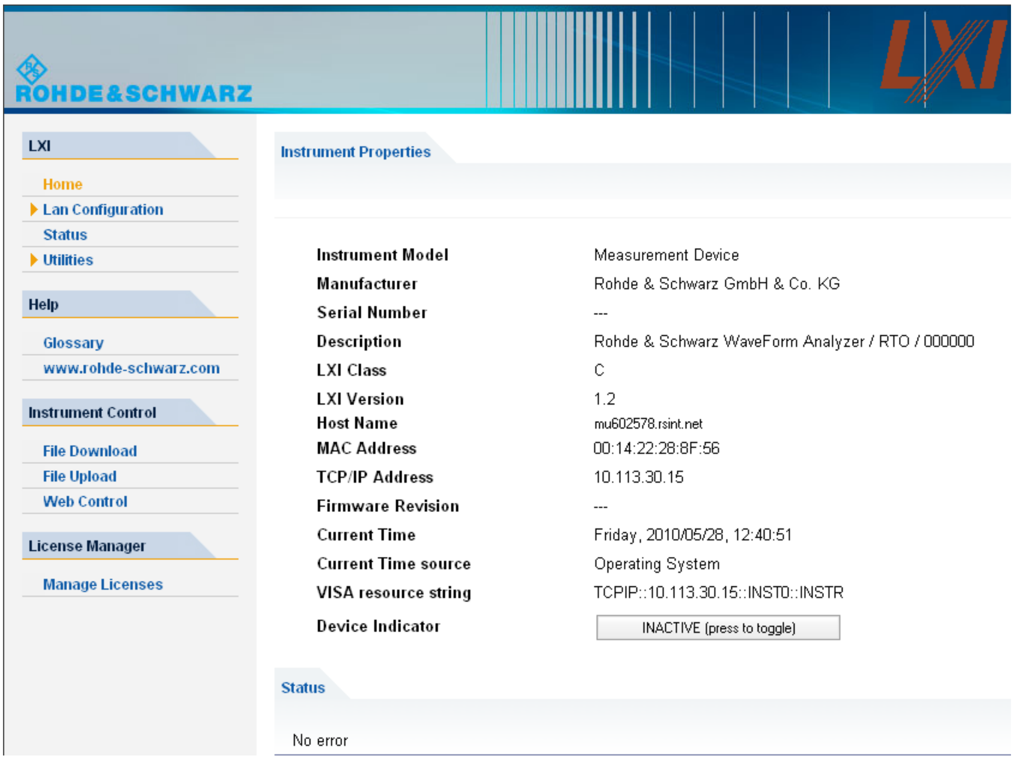
The LAN settings are configured using the instrument's LXI Browser Interface.

12.4.2.3 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 RTO. 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. When a device is connecting to the instrument, the LXI logo is blinking. The "Device Indicator" setting is not password-protected. mit Gerät testen. Zulassungstest 11.6.-->

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.

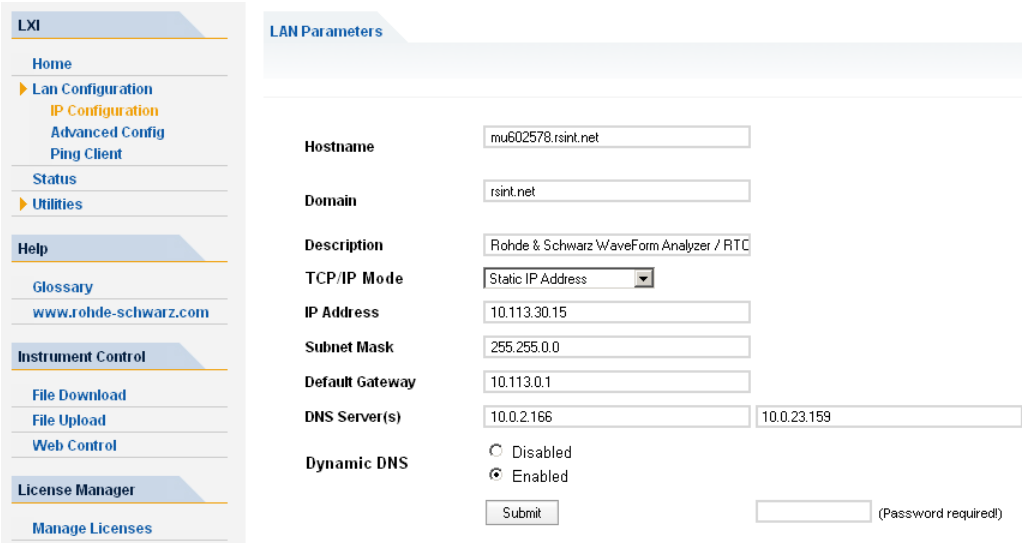
12.4.2.4 LAN Configuration

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

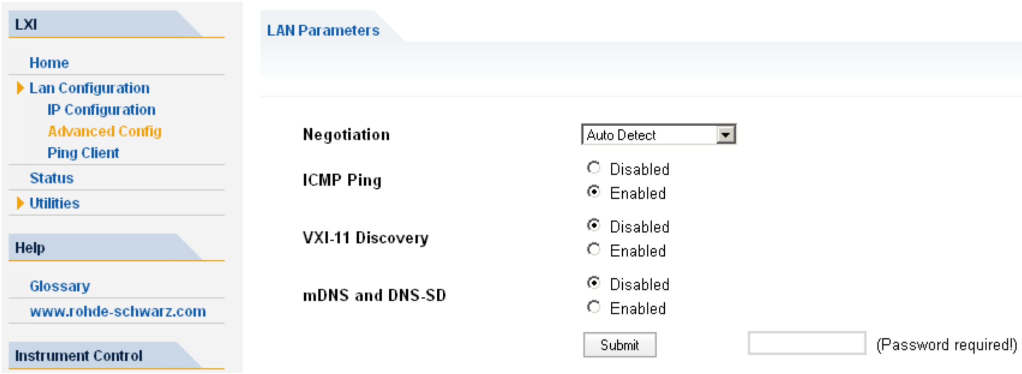
The "LAN Configuration > IP configuration" web page displays all mandatory LAN parameters and allows their modification.



The "TCP/IP Mode" configuration field controls how the IP address for the instrument gets assigned (see also chapter 12.4.1.2, "Assigning the IP Address", on page 290). 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

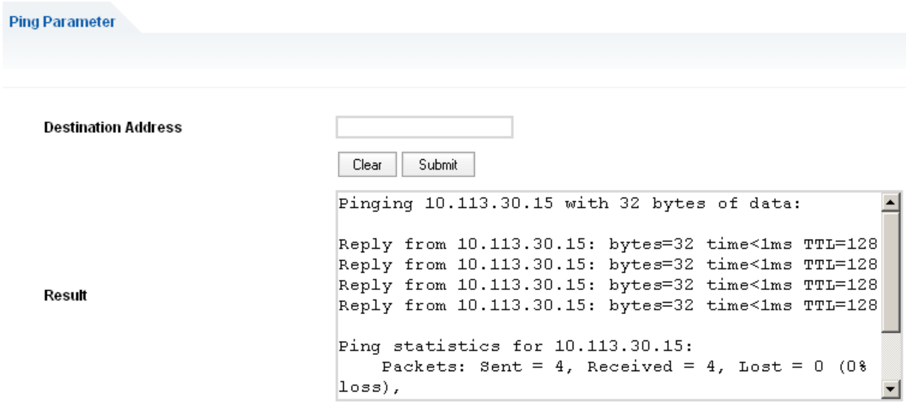
Ping Client

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. 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".



13 Maintenance

The instrument does not need a periodic maintenance. Only the cleaning of the instrument is essential.

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 (including adjustment of the OCXO oscillator) 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 address of our support center and a list of all Rohde & Schwarz service centers can be found at the beginning of this manual.

13.1 Cleaning

The outside of the instrument can be cleaned sufficiently using a soft, lint-free dust cloth. Make sure that the air vents 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, e.g. cleaning agents that contain a solvent may damage the front panel labeling or plastic parts.

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.

13.2 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.

13.3 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.

13.4 Reference for Maintenance Settings

13.4.1 Board Detection/Maintenance

The "Board Detection/Maintenance" dialog box in the "File" menu provides service information for your R&S RTO. In case you require support, you may be asked to provide this information.

13.4.1.1 System Info

This tab provides general information on the hardware configuration, and indicates where system information can be found on the instrument.

13.4.1.2 Mainboard

This tab provides information on the mainboard configuration in your instrument.

13.4.1.3 Frontend

This tab provides information on the frontend configuration in your instrument.

13.4.1.4 Frontpanel

This tab provides information on the frontpanel module installed in your instrument.

13.4.1.5 Service

This tab allows the service personnel to enter a password that activates further service functions.

SCPI command: `DIAGnostic:SERVice:PWD` on page 581

13.4.2 Selftest

The instrument selftest checks the hardware for correct operation. Perform the selftest if you suspect problems in hardware operation.

Selftest
Starts the selftest.

SCPI command:
`*TST` on page 337

State
Shows the summary result of the selftest: Pass or Fail.

SCPI command:
`DIAGnostic:SERVice:STST:STATe` on page 580

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.

SCPI command:
`DIAGnostic:SERVice:STST:RESult` on page 581

14 Remote Control

14.1 Basics

This chapter provides basic information on operating an instrument via remote control.

14.1.1 Starting and Stopping Remote Control

14.1.1.1 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".

14.1.1.2 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.

14.1.1.3 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.

14.1.2 Remote Control Interfaces and Protocols

The instrument supports different interfaces for remote control. The following table gives an overview.

Table 14-1: Remote control interfaces and protocols

Interface	Protocols, VISA*) address string	Remarks
Local Area Network (LAN)	Protocols: ● VXI-11 VISA*) address string: TCPIP::host address[::LAN device name][::INSTR]	A LAN connector is located on the front or rear panel of the instrument, or both. The interface is based on TCP/IP and supports various protocols. For a description of the protocols refer to: ● "VXI-11 Protocol", on page 305
USB	VISA*) address string: USB::<vendor ID>::<product ID>::<serial number>[::INSTR]	USB connectors are located on the front or the rear panel of the instrument, or both. For a description of the interface refer to chapter 14.1.2.4, "USB Interface", on page 305.
GPIB (IEC/IEEE Bus Interface)	VISA*) address string: GPIB::primary address[::INSTR] (no secondary address)	Optional GPIB bus interfaces according to standard IEC 625.1/IEEE 488.1 are located on the rear panel of the instrument. For a description of the interface refer to chapter 14.1.2.5, "GPIB Interface (IEC/IEEE Bus Interface)", on page 306.
*) VISA is a standardized software interface library providing input and output functions to communicate with instruments. A VISA installation on the controller is a prerequisite for remote control using the indicated interfaces (see also chapter 14.1.2.1, "VISA Libraries", on page 303).		

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.

14.1.2.1 VISA Libraries

VISA is a standardized software interface library providing input and output functions to communicate with instruments. 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 14-1, or by an appropriately defined VISA alias (short name). A VISA installation is a prerequisite for remote control using the following interfaces:

- chapter 14.1.2.3, "LAN Interface", on page 304 (using VXI-11)
- chapter 14.1.2.4, "USB Interface", on page 305
- chapter 14.1.2.5, "GPIB Interface (IEC/IEEE Bus Interface)", on page 306

For more information about VISA refer to the user documentation.

14.1.2.2 Messages

The messages transferred on the data lines are divided into the following categories:

- Interface messages
  Interface messages are transmitted to the instrument on the data lines, with the attention line being active (LOW). They are used to communicate between the controller and the instrument. Interface messages can only be sent by instruments that have GPIB bus functionality. For details see the sections for the required interface.
- Instrument messages
  Instrument messages are employed in the same way for all interfaces, if not indicated otherwise in the description. Structure and syntax of the instrument messages are described in chapter 14.1.3, "SCPI Command Structure", on page 307. A detailed description of all messages available for the instrument is provided in the chapter "Remote Control Commands".
  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.

14.1.2.3 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 (for specified protocols only) the VISA program library must be installed on the controller.

VISA library

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. See chapter 14.1.2.1, "VISA Libraries", on page 303 for details.

IP address

Only the IP address or the computer name (LAN device name) is required to set up the connection. The IP address/computer name is part of the "visa resource string" used by the programs to identify and control the instrument. The visa resource string has the form:

TCPIP::host address[::LAN device name][::INSTR]

where:

- **TCPIP** designates the network protocol used
- **host address** is the IP address
- **LAN device name** is the computer name of the control device (alternative to IP address)
- **INSTR** indicates that the VXI-11 protocol is used

Example:

If the instrument has the IP address *192.1.2.3*; the valid resource string is:

`TCPIP::192.1.2.3::INSTR`

If the computer name is *RSSM1*; the valid resource string is:

`TCPIP::RSSM1::INSTR`

Identifying instruments in a network

If several instruments are connected to the network, each instrument has its own IP address and associated resource string. The controller identifies these instruments by means of the resource string.

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.

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).
&GTR	Go to Remote	Transition to the "remote" state (remote control).
&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 switchover from remote control to manual control by means of the front panel keys.
&NREN	Not Remote Enable	Enables switchover from remote control to manual operation by means of the front panel keys
&POL	Serial Poll	Starts a serial poll.

14.1.2.4 USB Interface

For remote control via the USB connection, the PC and the instrument must be connected via the USB type B interface. A USB connection requires the VISA library to be installed.

VISA detects and configures the R&S instrument automatically when the USB connection is established. You do not have to enter an address string or install a separate driver.

USB address

The used USB address string is:

`USB::<vendor ID>::<product ID>::<serial number>[::INSTR]`

where:

- <vendor ID> is the vendor ID for Rohde&Schwarz
- <product ID> is the product ID for the R&S instrument
- <serial number> is the individual serial number on the rear of the instrument

Example:

`USB::0x0AAD::0x0054::100001::INSTR`

0x0AAD is the vendor ID for Rohde&Schwarz

0x54 is the product ID for the R&S SMB

100001 is the serial number of the particular instrument

14.1.2.5 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 (see "GPIB Instrument Address", on page 307).

Characteristics

The GPIB interface is described by the following 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.

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.

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 281.

14.1.3 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.

14.1.3.1 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.

14.1.3.2 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>]`
- `HardCOPy:DEVice:COLor <Boolean>`
- `HardCOPy:DEVice:CMAP:COLor:RGB <red>,<green>,<blue>`
- `HardCOPy[:IMMediate]`
- `HardCOPy:ITEM:ALL`
- `HardCOPy:ITEM:LABel <string>`
- `HardCOPy:PAGE:DIMensions:QUADrant[<N>]`
- `HardCOPy:PAGE:ORIentation LANDscape | PORTrait`
- `HardCOPy: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:

`HardCOPy: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: `HardCOPy: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. With GSM, for instance, slots are counted from 0 to 7. In remote control, the slots are selected using the suffixes 1 to 8. 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: `HardCOPy[: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 14.1.3.3, "SCPI Parameters", on page 311.

Example:

Definition:`HardCOPy: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:`HardCOPy: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**: `HardCOPy[: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`

14.1.3.3 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: `SENSe:FREQ:STOP 1.5GHz` = `SENSe: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: `HardCOPy: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.

14.1.3.4 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.
#	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.

14.1.3.5 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 is represented in its full length and contains two commands separated from each other by the semicolon. 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`

However, a new command line always begins with the complete path.

Example:

`HCOP:ITEM ALL`

`HCOP:IMM`

14.1.3.6 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: `HardCOPy:PAGE:ORIentation LANDscape`
  Query: `HCOP:PAGE:ORI?`
  Response: `LAND`

14.1.4 Command Sequence and Synchronization

IEEE 488.2 defines a distinction between overlapped and sequential commands:

- A sequential command is one which finishes executing before the next command starts executing. Commands that are processed quickly are usually implemented as sequential commands.
- An overlapping command is one which 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 do have to be executed in a defined order, e.g. in order to avoid wrong measurement results, they must be serviced sequentially. This is called synchronization between the controller and the instrument.

Setting commands within one command line, even though they may be implemented as sequential commands, are not necessarily serviced in the order in which they have been received. In order to make sure that commands are actually carried out in a certain order, each command must be sent in a separate command line.

Example: Commands and queries in one message

The response to a query combined in a program message with commands that affect the queried value is not predictable.

The following commands always return the specified result:

`:FREQ:STAR 1GHZ;SPAN 100 :FREQ:STAR?`

Result:

`1000000000` (1 GHz)

Whereas the result for the following commands is not specified by SCPI:

`:FREQ:STAR 1GHz;STAR?;SPAN 1000000`

The result could be the value of `STARt` before the command was sent since the instrument might defer executing the individual commands until a program message terminator is received. The result could also be 1 GHz if the instrument executes commands as they are received.

As a general rule, send commands and queries in different program messages.

Example: Overlapping command with *OPC

The instrument implements `INITiate[:IMMediate]` as an overlapped command. Assuming that `INITiate[:IMMediate]` takes longer to execute than `*OPC`, sending the following command sequence results in initiating a sweep and, after some time, setting the `OPC` bit in the `ESR`:

`INIT; *OPC.`

Sending the following commands still initiates a sweep:

`INIT; *OPC; *CLS`

However, since the operation is still pending when the instrument executes `*CLS`, forcing it into the "Operation Complete Command Idle" State (OCIS), `*OPC` is effectively skipped. The `OPC` bit is not set until the instrument executes another `*OPC` command.

14.1.4.1 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 14-2: 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? appended to an overlapped command is a good choice if the overlapped command takes only little time to process. The two synchronization techniques simply block overlapped execution of the command.

For time consuming overlapped commands it is usually desirable to 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.

***OPC? with short timeout**

1. Send the overlapped command without *OPC, *OPC? or *WAI
2. Poll the operation complete state periodically (by means of a timer) using the sequence: <short timeout>; *OPC?
3. A return value (LSB) of 1 indicates that the overlapped command has finished. In case of a timeout, the operation is ongoing.
4. Reset timeout to former value
5. Clear the error queue with `SYStem:ERRor?` to remove the "-410, Query interrupted" entries.

Using several threads in the controller application

As an alternative, provided the programming environment of the controller application supports threads, separate threads can be used for the application GUI and for controlling the instrument(s) via SCPI.

A thread waiting for a *OPC? thus will not block the GUI or the communication with other instruments.

14.1.5 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).

14.1.5.1 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.

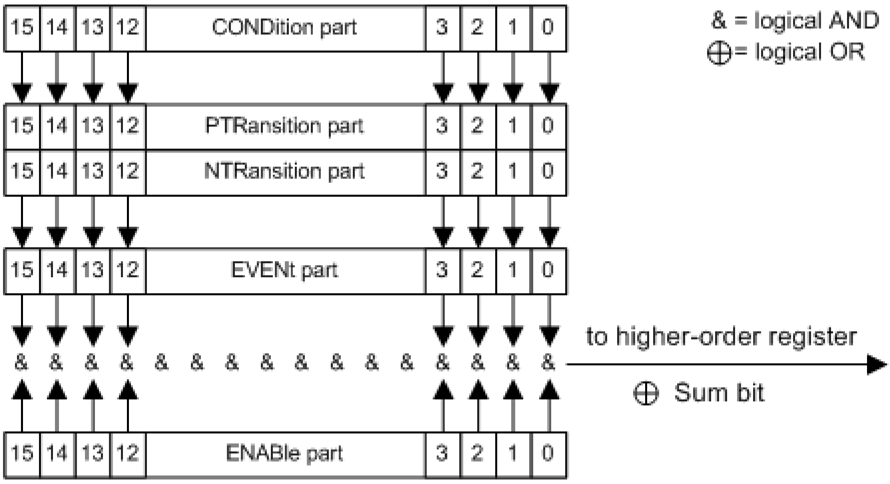


Fig. 14-1: The status-register model

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**
  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.
- **NTRansition**
  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.

14.1.5.2 Hierarchy of status registers

As shown in the following figure, the status information is of hierarchical structure.

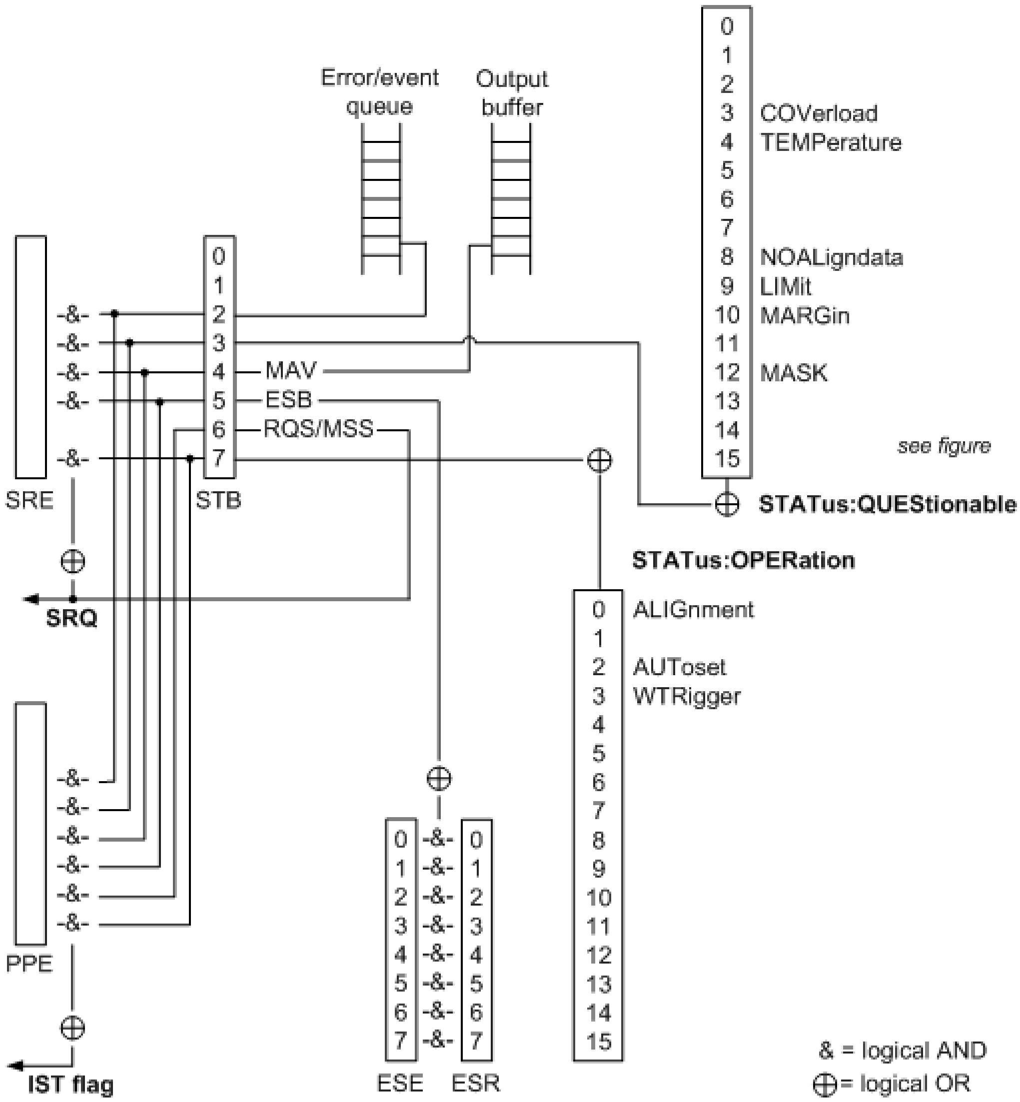


Fig. 14-2: Overview of the status registers hierarchy

- **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.

14.1.5.3 Contents of the Status Registers

In the following sections, the contents of the status registers are described in more detail.

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 14-3: 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.
3	QUEStionable status sum 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 polling the QUEStionable status register.

Bit No.	Meaning
4	MAV bit (message available) The bit is set if a message is available in the output buffer 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	`OPERation` status register sum 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 polling the `OPERation` status register.

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 "Parallel Poll", on page 328) 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?.

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 14-4: 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.

Bit No.	Meaning
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.

STATus:OPERation Register

In the `CONDition` part, this register contains information on which actions the instrument is being 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]?`.

The remote commands for the STATus:OPERation register are described in chapter 14.2.16, "Status Reporting", on page 581.

Table 14-5: 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	`SELFtest` This bit is set while the selftest is running.
2	`AUToset` This bit is set while the instrument is performing an auto setup.
3	`WTRIgger` This bit is set while the instrument is waiting for the trigger.
4 to 14	Not used
15	This bit is always 0.

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 14.2.16, "Status Reporting", on page 581 .

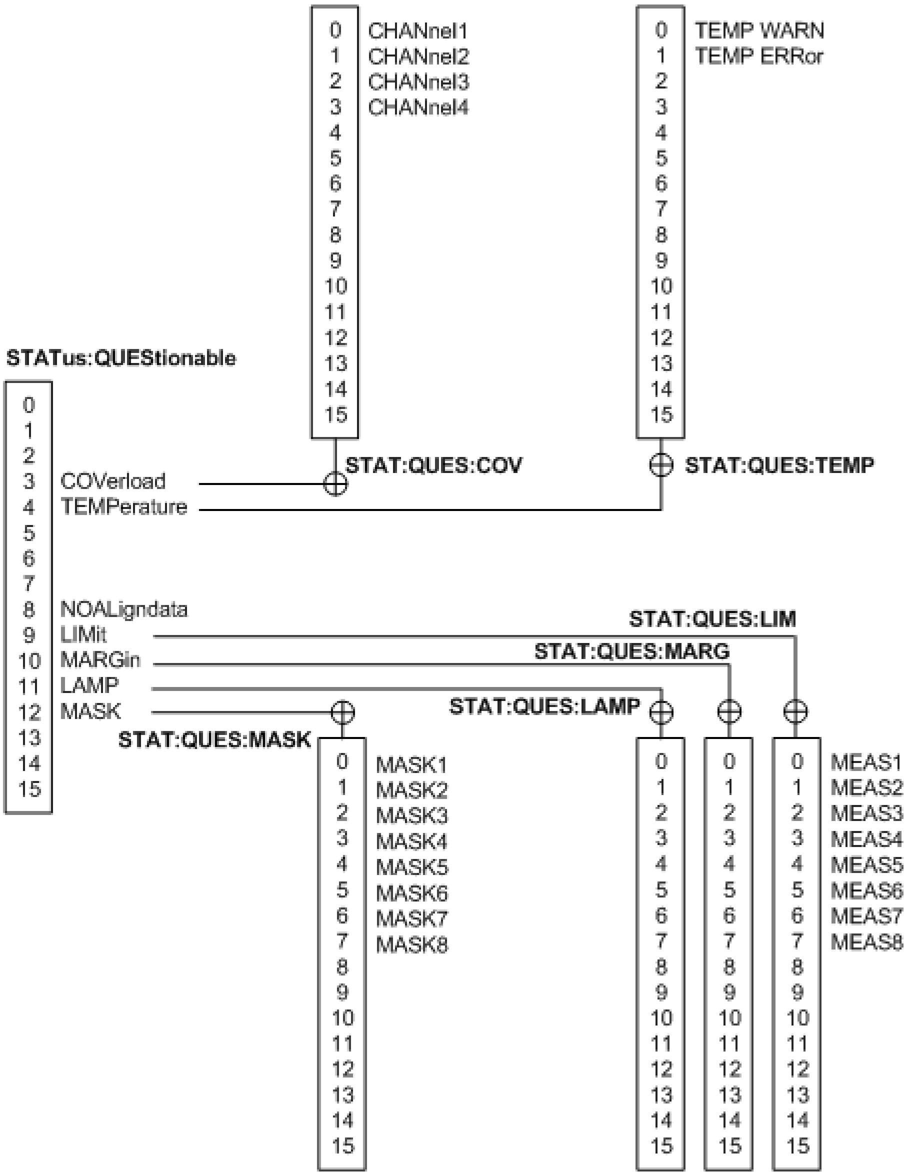


Fig. 14-3: Overview of the STATus:QUEStionable register

Table 14-6: 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 "STATus:QUEStionable:COVerload register", on page 326).
4	`TEMPerature` This bit is set if a questionable temperature occurs (see "STATus:QUEStionable:TEMPerature register", on page 326).

Bit No.	Meaning
5 to 7	Not used
8	NOALigndata This bit is set if no alignment data is available - the instrument is uncalibrated.
9	LIMit This bit is set if a limit value is violated (see "STATus:QUEStionable:LIMit, STATus:QUEStionable:MARGin, STATus:QUEStionable:LAMP registers", on page 327).
10	MARGin This bit is set if a margin value is violated (see "STATus:QUEStionable:LIMit, STATus:QUEStionable:MARGin, STATus:QUEStionable:LAMP registers", on page 327).
11	LAMP (Low AMPlitude) This bit is set if the magnitude of the signal is too low to get reliable measurement results.
12	MASK This bit is set if a mask value is violated (see "STATus:QUEStionable:MASK register", on page 327
13 to 14	Not used
15	This bit is always 0.

STATus:QUEStionable:COVerload register

This register contains all information about overload of the channels. The bit is set if the assigned channel is overloaded.

Table 14-7: Bits in the STATus:QUEStionable:COVerload register

Bit No.	Meaning
0	CHANnel1
1	CHANnel2
2	CHANnel3
3	CHANnel4

STATus:QUEStionable:TEMPerature register

This register contains information about the instrument's temperature.

Table 14-8: 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.

STATus:QUEStionable:LIMit, STATus:QUEStionable:MARGin, STATus:QUEStionable:LAMP registers

These registers contain information about the observance of the limits or margins of measurements. For LIMit and MARGin, this bit is set if the limits or margins of the main or additional measurement of assigned measurement are violated. The LAMP (Low AMPlitude) bit is set if the magnitude of the signal is too low to get reliable measurement results.

Table 14-9: Bits in the STATus:QUEStionable:LIMit, STATus:QUEStionable.MARGin, and STATus:QUEStionable:AMP registers

Bit No.	Meaning
0	MEAS1
1	MEAS2
2	MEAS3
3	MEAS4
4	MEAS5
5	MEAS6
6	MEAS7
7	MEAS8

STATus:QUEStionable:MASK register

This register contains information about the violation of masks. This bit is set if the assigned mask is violated.

Table 14-10: 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

14.1.5.4 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**

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 14-2, 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.

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.

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.

Query of an instrument status

Each part of any status register can be read using queries. There are two types of commands:

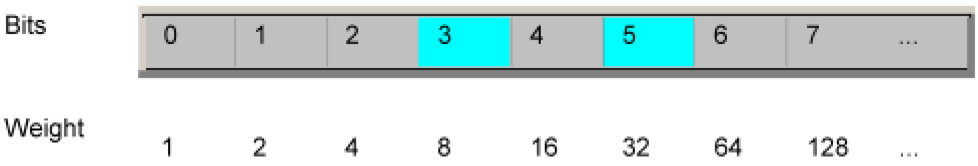
- The common commands `*ESR?`, `*IDN?`, `*IST?`, `*STB?` query the higher-level registers.
- The commands of the `STATus` system query the SCPI registers (`STATus:QUEStionable`...)

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.

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.



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.

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]?` or `SYSTem:ERRor:ALL?`. 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.

14.1.5.5 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 14-11: 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	-
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.						

14.1.6 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.

14.2 Command Reference

This chapter provides the description of all remote commands available for R&S RTO. The commands are sorted according to the menu and dialog structure of the instrument. A list of commands in alphabetical order ist given in the "List of Commands" at the end of this documentation.

14.2.1 Frequently Used Parameters and Suffixes

This chapter describes in general those parameters and suffixes that are used in several subsystems.

14.2.1.1 Waveform Suffix

Numeric suffix with values 1...37

Waveform number	Description
1	None
2...4	Channel 1 waveforms: C1W1, C1W2, C1W3
5...7	Channel 2waveforms: C2W1, C2W2, C2W3
8...10	Channel 3 waveforms: C3W1, C3W2, C3W3
11...13	Channel 4 waveforms: C4W1, C4W2, C4W3
14...17	Math waveforms: M1, M2, M3, M4
18...21	Reference waveforms: R1, R2, R3, R4

Waveform number	**Description**
22...25	XY-waveforms: XY1, XY2, XY3, XY4
26...33	Measurement results: MRESult1, MRESult2, MRESult3, MRESult4, MRESult5, MRESult6, MRESult7, MRESult8
34...37	Serial buses: SBUS1, SBUS2, SBUS3, SBUS4

14.2.1.2 Waveform Parameter

In many commands, one of the waveforms has to be specified as source. The table lists all waveforms. For each command using a waveform parameter, the available waveforms are specified.

Waveform	**Description**
C1W1 | C1W2 | C1W3	Channel 1 waveforms
C2W1 | C2W2 | C2W3	Channel 2waveforms
C2W3 | C3W1 | C3W2	Channel 3 waveforms
C4W1 | C4W2 | C4W3	Channel 4 waveforms
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

14.2.1.3 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.

14.2.1.4 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.

14.2.1.5 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

14.2.2 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**

Calibration Query

Initiates a calibration of the instrument and subsequently queries the calibration status. Responses > 0 indicate errors.

***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>"

Example: `Rohde&Schwarz,ZVA8-4Port,12345,0.10.1.23`

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 CD-ROM.

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.

***RST**

ReSeT

Sets the instrument to a defined default status. It is equivalent to `SYSTem:PRESet`. The default settings are indicated in the description of commands.

Usage: Setting only

***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 (Manual Trigger). This common command complements the commands of the `TRIGger` subsystem.

Usage: Event

***TST?**

self TeST query

Triggers selftests of the instrument and returns an error code in decimal form (see Service Manual supplied with the instrument). "0" indicates no errors occured.

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

14.2.3 Acquisition and Setup

14.2.3.1 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

14.2.3.2 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) and the setting for resolution enhancement:

- In interpolated time mode if sample rate > ADC sample rate:
  Any value for the horizontal scale can be set due to the interpolation factor.
- In real time mode and equivalent time mode for all sample rates; and in interpolated time mode if sample rate < ADC sample rate:
  The resolution is an integer multiple of the ADC sample rate.

Parameters:
<TimeScale>

Range:	25E-12 to 50
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 500
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:POSition <Offset>

Defines the trigger offset - the time interval between trigger point and reference point to analize the signal some time before or after the trigger event.

See also: `TIMebase:REFerence` on page 340

Parameters:
<Offset>

Range:	-500 to 500
Increment:	0.01
*RST:	0
Default unit:	s

TIMebase:REFerence <ReferencePoint>

Sets the reference point of the time scale in % of the display. The reference point defines which part of the waveform is shown. If the "Trigger offset" is zero, the trigger point matches the reference point.

See also: `TIMebase:POSition` on page 339

Parameters:

<ReferencePoint> The reference point is the zero point of the time scale.

Range: 10 to 90
Increment: 1
*RST: 50
Default unit: %

TIMebase:ROLL:ENABle <Mode>

Activates the automatic roll mode.

Parameters:

<Mode> AUTO | OFF

AUTO: the instrument activates the roll mode under specific conditions.
See: "Mode" on page 28

*RST: AUTO

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

14.2.3.3 Acquisition

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 change either the resolution or the record length. The other value remains constant and cannot be changed.

Parameters:
<RecLengthManual> RESolution | RECLength

*RST: RESolution

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: 10 to 20E+9
Increment: 1
*RST: 10E+9
Default unit: Hz

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 29.

Parameters:
<SampleRate>

Range: 2 to 20E+12
Increment: 1
*RST: 20E+3
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: 500E-6
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

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 31.

Parameters:

<EnhancementMode> RTIMe | ITIMe | ETIMe

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 343.

ETIMe
Equivalent time: The waveform points are taken from several acquisitions of a repetive signal at a different time in relation to the trigger point.

*RST: ITIMe

ACQuire:INTerpolate <IntpolMode>

Selects the interpolation method if ACQUire:MODE ITIMe (interpolated time) is set for enhancement.

See also: "Interpolation mode" on page 32.

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
Selects the waveform. For each channel, up to three waveforms can be analized. If `WAVeform<n>` is omitted, waveform 1 is adressed.

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 33.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
Selects the waveform. For each channel, up to three waveforms can be analized. If WAVeform<n> is omitted, waveform 1 is adressed.

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

CHANnel<m>[:WAVeform<n>]:ARIThmetics <TrArith>

Selects the method to build the resulting waveform from several consecutive acquisitions of the signal.

See also: "Wfm Arithmetic" on page 33.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
Selects the waveform. For each channel, up to three waveforms can be analized. If WAVeform<n> is omitted, waveform 1 is adressed.

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. To define the number of acquisitions, use `ACQuire:COUNt`.

*RST: OFF

ACQuire:COUNt <MaxAcqCount>

Defines the "Average count" that has a double effect:

- it defines the number of waveforms used to calculate the average waveform, and
- it sets the number of waveforms acquired with `RUNSingle`.

Parameters:
<MaxAcqCount>

Range: 1 to 16777215
Increment: 10
*RST: 1

ACQuire:SEGMented:STATe <State>

Switches the Ultra Segmentation mode on and off.

See also: chapter 2.3.1.4, "Ultra Segmentation", on page 34.

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: ON

14.2.3.4 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: DC

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: 1E-3 to 1
Increment: 10E-6
*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: 0.01 to 10
Increment: 100E-6
*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: 0.02
*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 36

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Offset> Negative values move the waveform up, positive values move it down.

Range: -1 to 1
Increment: 0.01
*RST: 0
Default unit: V

CHANnel<m>:BANDwidth <BandwidthLimit>

Selects the bandwidth limit for the indicated channel.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<BandwidthLimit> FULL | B800 | B200 | B20

FULL
Use full bandwidth.

B800
Limit to 800 MHz.

B200
Limit to 200 MHz.

B20
Limit to 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.

14.2.3.5 Waveform Data

CHANnel<m>[:WAVeform<n>]:DATA:HEADer?

Returns the header of channel waveform data. The header contains setup and acquisition settings.

Suffix:
<m> 1..4
Selects the input channel.
<n> 1..3
Selects the waveform. If [WAVeform<n>] is omitted, waveform 1 is adressed.

Example:
```
CHAN1:WAV1:DATA:HEAD?
1e-008,50,0,0.05,0,Auto,Ch1Tr1,Interpolated
time,sin(x)/x,0,1000,1,0,0,9.91E+37,10,10,
Source,1e-010,-5e-008,5e-008,1000,-5e-008,
5e-008,1000,0,Completely finite and defined,
Sample,Original,50,0,
```

Usage:
Query only
SCPI conform

Table 14-12: Header data

Position	Meaning	Example
01	Time scale in s	1e-008
02	Reference point in %	50
03	Vertical position in divisions	0
04	Vertical scale in V/div	0.05
05	Vertical offset in V	0
06	Use inter-sample trigger offset	Auto

Position	Meaning	Example
07	Waveform type: channel, math, reference or meas waveform	CH1Tr1 = waveform 1 of channel 1 M2 = math waveform 2
08	Enhancement mode	Interpolated time
09	Interpolation mode	sin(x)/x
10	Center frequency of the FFT spectrum in Hz	0
11	Frequency span of the FFT spectrum in Hz	1000
12	Resolution bandwidth of the FFT spectrum in Hz	1
13	Start frequency of the FFT spectrum in Hz	0
14	Stop frequency of the FFT spectrum in Hz	0
15	FFT gate coupling if signal type = Spectrum Otherwise: 9.91E+37	9.91E+37
16	Number of horizontal divisions	10
17	Number of vertical divisions	10
18	Signal type: ● Source = normal signal ● Spectrum = FFT spectrum, specific math signal ● Correlation = correlated signal, specific math signal	Source
19	Resolution in s	1e-010
20	XStart in s	-5e-008
21	XStop in s	5e-008
22	Record length of the waveform in Samples	1000
23	HardwareXStart, can differ from XStart if signal type is Spectrum	-5e-008
24	HardwareXStop, can differ from XStop if signal type is Spectrum	5e-008
25	Hardware record length, can differ from Record length if signal type is Spectrum	1000
26	Trigger offset in s	0
27	Value type	Completely finite and defined
28	Decimation mode	Sample
29	Waveform arithmetics	Original = off
30	Impedance in Ω	50
31	AdjustedResolutionBW	0

CHANNel<m>[:WAVeform<n>]:DATA[:VALues]?

Returns the data of the channel waveform points. The waveforms data can be used in MATLAB, for example.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [WAVeform<n>] is omitted, waveform 1 is adressed.

Return values:

<Data>	Comma-separated value list. The first value is the length: the number of waveform data values. The second value indicates the data format: int8, int16, int24, int32, float, double or none. The actual waveform data starts with the third value. These are the vertical values - voltages of recorded waveform samples, or magnitudes of a spectrum.

Example:

```
CHAN1:WAV1:DATA?
1000,float,-0.125000,-0.123016,-0.123016,
-0.123016,-0.123016,-0.123016,...
```

Usage: Query only

14.2.3.6 Probes

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

PROBe<m>:SETup:OFFSet:AZERo

Performs an automatic correction of the zero error. If the DUT is ground-referenced, the Auto Zero function can improve the measurement results.

See also: "Auto Zero" on page 40

Suffix:

<m> 1..4
Selects the input channel.

Usage: Event

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

PROBe<m>:SETup:MODE <Mode>

Select the action that is started with the micro button on the probe head.

See also: "Action on micro button" on page 40.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Mode> RCONtinuous | RSINgle | AUToset | AZERo | SEToffsettomean | NOACtion

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
Auto zero: 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.

NOACtion
Nothing is started on pressing the micro button.

*RST: RCONtinuous

PROBe<m>:SETup:ATTenuation?

Queries the attenuation of the probe.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<ProbeAtt>

*RST: 1:1

Usage: Query only

PROBe<m>:SETup:TYPE?

Queries the type of the probe.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<Type> **NONE**
not detected

ACTive
active probe

PASSive
passive probe

*RST: not detected

Usage: Query only

PROBe<m>:SETup:NAME?

Queries the name of the probe.

Suffix:
<m> 1..4
Selects the input channel.

Return values:
<Name>
*RST: Not detected

Usage: Query only

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
Increment: 1E-12
*RST: 50
Default unit: Ohm

Usage: Query only

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
Increment: 1E-12
*RST: 10E-12
Default unit: F

Usage: Query only

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
Increment: 10
*RST: 1E+9
Default unit: Hz

Usage: Query only

PROBe<m>:ID:SWVersion?

Queries the version of the probe firmware.

Suffix:
<m> 1..4
Selects the input channel.

Return values:
<Softwareversion> Returns the version number in a string.
*RST: Empty

Usage: Query only

PROBe<m>:ID:PRDate?

Queries the production date of the probe.

Suffix:
<m> 1..4
Selects the input channel.

Return values:
<ProductionDate> Returns the date in a string.
*RST: Empty

Usage: Query only

PROBe<m>:ID:PARTnumber?

Queries the R&S part number of the probe.

Suffix:
<m> 1..4
Selects the input channel.

Return values:
<PartNumber> Returns the part number in a string.
*RST: Empty

Usage: Query only

PROBe<m>:ID:SRNumber?

Queries the serial number of the probe.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<SerialNo> Returns the serial number in a string.

*RST: Empty

Usage: Query only

PROBe<m>:SERVice:STESt:RUN

Starts the selftest of the probe connected to the specified channel input.

Suffix:

<m> 1..4
Selects the input channel.

Usage: Event

PROBe<m>:SERVice:STESt:STATus?

Queries the status of a probe selftest for the specified channel input.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<SelfTestStatus> PSSD | FAILed | UNDefined

When the selftest has finished, the status is passed or failed, otherwise it is undefined.

*RST: UNDefined

Usage: Query only

PROBe<m>:SERVice:STESt[:RESult]?

Queries the result of a probe selftest for the specified channel input.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<SelftestResult> The string contains the pass/fail results of all steps of the probe selftest.

*RST: Empty

Usage: Query only

PROBe<m>:SERVice:FW:PATH <FlashPath>

Indicates the location of the firmware update package.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<FlashPath>	String with the path and file name of the update package.

PROBe<m>:SERVice:FW:FLASh

Starts the update of the probe firmware.

Suffix:

<m>	1..4 Selects the input channel.
Usage:	Event

PROBe<m>:SERVice:STATe?

Queries the update status of the probe firmware.

See also: "Probe FW update" on page 42.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<ServiceState>	MEASuring | UPDate | FAILed | UNKNown *RST: UNKNown
Usage:	Query only

14.2.3.7 Skew

CALibration:SOURce:FREQuency <Frequency>

Frequency value of the internal calibration source.

Parameters:

<Frequency>	MHZ10 | GHZ1 1 GHz sine wave or 10 MHz square wave *RST: GHZ1

CALibration:SOURce:MODE <Mode>

Sets the calibration operating mode. To determine the skew offset, use the "Skew" operating mode. It uses the internal channel alignment for best results.

Parameters:

<Mode> SKEW | GAIN

*RST: SKEW

CALibration:SOURce:SKEW:DESTination <DeskewDest>

Sets the output for the calbration signal.

Parameters:

<DeskewDest> DINTernal | DEXTernal

DEXTernal
routes the signal to the AUX OUT 50Ω OUTPUT.

*RST: DINTernal

14.2.4 Trigger

14.2.4.1 Trigger Events and Trigger Types

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 <Source>

Selects the source of the trigger signal.

Suffix:

<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:

<Source> CHANnel1 | CHANnel2 | CHANnel3 | CHANnel4 | EXTernanalog | SBUS

CHANnel1...4
Input channels

EXTernanalog
External analog signal connected to the External Trigger Input on the rear panel. For this source, only the analog edge trigger is available.

SBUS
Serial bus

*RST: CHANnel1

TRIGger<m>:TYPE <Type>

Selects the trigger type for the trigger event.

See also: chapter 3.3.1, "Events", on page 53.

Suffix:

<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:

<Type> EDGE | GLITch | WIDTh | RUNT | WINDow | TIMeout | INTerval | SLEWrate | DATatoclock | PATTern | ANEDge | SERPattern

Most of the type values are self-explanatory.

DATatoclock
Data2Clock: analyzes the relative timimg between a data signal and the synchronous clock signal.

ANEDge
Analog Edge trigger which uses the analog trigger signal while the Edge trigger uses the digitized trigger signal.

SERPattern
Serial Pattern for signals with serial data patterns in relation to a clock signal.

*RST: EDGE

TRIGger<m>:LEVel<n>[:VALue] <Level>

Sets the trigger level for the specified event and source.

Suffix:

<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

<n> 1..6
Indicates the trigger source: 1...4 = channel 1...4;
5 = External Trigger Input on the rear panel for analog signals;
6 = Not used. For serial bus, the trigger level is set by the thresholds in the protocol configuration.

Parameters:

<Level> Voltage for the trigger level.

Range: -10 to 10
Increment: 1E-3
*RST: 0
Default unit: V

TRIGger<m>:FINDlevel

Sets the trigger level automatically. The command is not available for an external trigger source.

Suffix:

<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Usage: Event
Asynchronous command

TRIGger<m>:ECOupling <TrigLevEvtCoup>

Sets the trigger levels of the channels to the values of the indicated event.

Suffix:

<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event (reset event).

Parameters:

<TrigLevEvtCoup> ON | OFF

*RST: ON

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
Indicates the trigger event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event (reset event).

Parameters:

<TrigLevSrcCoup> ON | OFF

*RST: OFF

Edge Trigger

TRIGger<m>:EDGE:SLOPe <Slope>

Defines the edge for the edge trigger event.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:

<Slope> POSitive | NEGative | EITHer

See chapter 14.2.1.3, "Slope Parameter", on page 332.

*RST: POSitive

TRIGger<m>:EXTanalog:LEVel <Value>

Sets the trigger level for the analog external trigger input.

Suffix:

<m> 1..3
Only suffix 1 = A-event is allowed, the external trigger source is not available for B- and R-events.

Parameters:

<Value> Voltage for the trigger level.

TRIGger<m>:ANEDge:COUPling <Coupling>

Sets the coupling for the analog trigger signal.

Suffix:

<m> 1..3
Only suffix 1 = A-event is allowed, the analog edge trigger is not available for B- and R-events.

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: DC

TRIGger<m>:ANEDge:CUToff:HIGHpass <AnalogCutOffHP>

Frequencies below the "Cut-off" frequency are rejected, higher frequencies pass the filter.

Suffix:

<m> 1..3
Only suffix 1 = A-event is allowed, the analog edge trigger is not available for B- and R-events.

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 suffix 1 = A-event is allowed, the analog edge trigger is not available for B- and R-events.

Parameters:

<AnalogCutOffLP> KHZ5 | KHZ50 | MHZ50

KHZ5
5 kHz

KHZ50
50 kHz

MHZ50
50 MHz

*RST: KHZ50

TRIGger<m>:ANEDge:FILTer <Filter>

The analog trigger signal is used for triggering; you can directly select an additional filter to reject high or low frequencies.

Suffix:

<m> 1..3
Only suffix 1 = A-event is allowed, the analog edge trigger is not available for B- and R-events.

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:GND <Ground>

Connects the analog signal to the ground.

Suffix:

<m> 1..3
Only suffix 1 = A-event is allowed, the analog edge trigger is not available for B- and R-events.

Parameters:

<Ground> ON | OFF

*RST: OFF

TRIGger<m>:ANEDge:SLOPe <Slope>

Sets the edge for the trigger event.

Suffix:

<m> 1..3
Only suffix 1 = A-event is allowed, the analog edge trigger is not available for B- and R-events.

Parameters:

<Slope> POSitive | NEGative

See chapter 14.2.1.3, "Slope Parameter", on page 332.

*RST: POSitive

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
Event in a trigger sequence: 1 = A-event, 3 = R-event.

Parameters:

<Polarity> POSitive | NEGative | EITHer

See chapter 14.2.1.4, "Polarity Parameter", on page 332.

*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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:

<Width>

Range: 100E-12 to 10000
Increment: 100E-6
*RST: 1E-9
Default unit: s

Width Trigger

The width trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:WIDTh:POLarity <Polarity>

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event.

Parameters:

<Polarity> POSitive | NEGative

See chapter 14.2.1.4, "Polarity Parameter", on page 332.

*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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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 367).

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Suffix:

<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:

<WidthDelta>

Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

Runt Trigger

The runt trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:RUNT:POLarity <Polarity>

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event.

Parameters:

<Polarity> POSitive | NEGative | EITHer

See chapter 14.2.1.4, "Polarity Parameter", on page 332.

*RST: POSitive

TRIGger<m>:LEVel<n>:RUNT:UPPer <Level>

Sets the upper voltage threshold.

Suffix:

<m>	1..3 Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.
<n>	1..6 Indicates the trigger source: 1...4 = channel 1...4; 5 = External Trigger Input on the rear panel for analog signals; 6 = Serial bus

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 Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.
<n>	1..6 Indicates the trigger source: 1...4 = channel 1...4; 5 = External Trigger Input on the rear panel for analog signals; 6 = Serial bus

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 Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:
<WidthDelta>

Range: 100E-12 to 864
Increment: 100E-9
*RST: 100E-12
Default unit: s

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.
<n> 1..6
Indicates the trigger source: 1...4 = channel 1...4;
5 = External Trigger Input on the rear panel for analog signals;
6 = Serial bus

Parameters:
<Level>

Range: 0 to 1000
Increment: 1E-6
*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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.
<n> 1..6
Indicates the trigger source: 1...4 = channel 1...4;
5 = External Trigger Input on the rear panel for analog signals;
6 = Serial bus

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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 372).

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

Suffix:

<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:
<WidthDelta>

Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:
<Time>

Range: 100E-12 to 10000
Increment: 100E-9
*RST: 100E-9
Default unit: s

Interval Trigger

The interval trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:INTerval:POLarity <Polarity>

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event.

Parameters:

<Polarity> POSitive | NEGative | EITHer

See chapter 14.2.1.4, "Polarity Parameter", on page 332.

*RST: POSitive

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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 374.

Suffix:

<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:

<WidthDelta>

Range: 0 to 10
Increment: 100E-9
*RST: 0
Default unit: s

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
Event in a trigger sequence: 1 = A-event, 3 = R-event.

Parameters:

<Slope> POSitive | NEGative | EITHer

See chapter 14.2.1.3, "Slope Parameter", on page 332.

*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 Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.
<n>	1..6 Indicates the trigger source: 1...4 = channel 1...4; 5 = External Trigger Input on the rear panel for analog signals; 6 = Serial bus

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 Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.
<n>	1..6 Indicates the trigger source: 1...4 = channel 1...4; 5 = External Trigger Input on the rear panel for analog signals; 6 = Serial bus

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 377 and `TRIGger<m>:SLEW:DELTa` on page 377). 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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:
<RangeMode> INSRange | OUTRange | LTHan | GTHan

WITHin
Triggers on pulses inside a given range. The range is defined by the slew rate ±delta.

OUTSide
Triggers on pulses outside a given range. The range is defined by the slew rate ±delta.

SHORter
Triggers on pulses shorter than the given slew rate.

LONGer
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 375).

Suffix:
<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:
<TimeDelta>

Range: 0 to 10
Increment: 100E-9
*RST: 0
Default unit: s

Data2Clock Trigger

The Data2Clock trigger is only available for the A-event (Suffix = 1).

TRIGger<m>:DATatoclock:CSOurce[:VALue] <ClockSource>

Selects the input channel of the clock signal.

Suffix:
<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:
<ClockSource> CHANnel1 | CHANnel2 | CHANnel3 | CHANnel4 | EXTernanalog | SBUS

CHANnel1 | CHANnel2 | CHANnel3 | CHANnel4
Input channel

EXTernanalog
External trigger (analog)

SBUS
Serial bus

*RST: CHANnel1

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..3
1 = A-event only

Parameters:
<ClockEdge> POSitive | NEGative | EITHer

See chapter 14.2.1.3, "Slope Parameter", on page 332.

*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..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:

<ClockLevel>

Range: -10 to 10
Increment: 1E-3
*RST: 0
Default unit: V

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..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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 intrument.

Suffix:

<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:
<SetupTime>

Range: -99.999E-9 to 100E-9
Increment: 1E-9
*RST: 0
Default unit: s

Pattern Trigger

The pattern trigger is only available for the A-event (Suffix = 1).

TRIGger<m>:PATTern:MODE <Mode>

Adds additional time limitation to the pattern definition.

Suffix:
<m> 1..3
1 = A-event only

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
1 = A-event only

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

HIGH
The result stays high.

LOW
The result stays low.

EITHer
The result stays either high or 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
1 = A-event only

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
1 = A-event only

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 382).

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Suffix:

<m> 1..3
1 = A-event only

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
1 = A-event only

Parameters:

<WidthDelta>

Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

Serial Pattern Trigger

The slew serial pattern trigger is only available for the A-event (Suffix = 1).

TRIGger<m>:SPATtern:CSOurce[:VALue] <ClockSource>

Defines the input channel of the clock signal.

Suffix:

<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:

<ClockSource>	CHANnel1 | CHANnel2 | CHANnel3 | CHANnel4 | EXTernanalog | SBUS
	CHANnel1 | CHANnel2 | CHANnel3 | CHANnel4 Input channel
	EXTernanalog External trigger (analog)
	SBUS Serial bus
	*RST: CHANnel1

TRIGger<m>:SPATtern:CSOurce:EDGE <ClockEdge>

Together with the clock level (see `TRIGger<m>:SPATtern:CSOurce:LEVel` on page 383), the clock edge defines the point in time when the state of the data signal is checked.

Suffix:

<m>	1..3 1 = A-event only

Parameters:

<ClockEdge>	POSitive | NEGative | EITHer
	See chapter 14.2.1.3, "Slope Parameter", on page 332.
	*RST: POSitive

TRIGger<m>:SPATtern:CSOurce:LEVel <ClockLevel>

Defines the voltage level for the clock signal.

Suffix:

<m>	1..3 Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

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. You can enter the pattern in binary or hexadecimal format.

Suffix:
<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

Parameters:
<Pattern>
*RST: 0

14.2.4.2 Trigger Qualification

The A-event and B-event in a trigger sequence can have their own trigger qualification. Qualification is not available for R-events (Suffix m = 3).

The trigger type to which the qualification belongs is defined by a suffix.

Table 14-13: Trigger type suffixes

Suffix	Trigger type
1	EDGE
2	GLITch
3	WIDTh
4	RUNT
5	WINDow
6	TIMeout
7	INTerval
8	not supported (SLEWrate)
9	not supported (DATatoclock)
10	PATTern
11	ANEDge
12	currently not used
13	currently not used
14	not supported (SERPattern)

TRIGger<m>:QUALify<n>:STATe <AddTrigLogic>

Enables the use of the qualification definition for the selected trigger event.

Suffix:

<m>	1..3 Event in a trigger sequence: 1 = A-event, 2 = B-event.
<n>	1..14 Defines the trigger type, see table 14-13.

Parameters:

<AddTrigLogic> ON | OFF

ON
The qualification expression is considered for the trigger event.

OFF
The qualification expression is ignored for the trigger event.

*RST: OFF

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>

Selects one of the channels and the specified trigger event to be considered for qualification:

- A[:ENABle]: CH1
- B[:ENABle]: CH2
- C[:ENABle]: CH3
- D[:ENABle]: CH4

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.

Suffix:

<m>	1..3 Event in a trigger sequence: 1 = A-event, 2 = B-event.
<n>	1..14 Defines the trigger type, see table 14-13.

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: CH2
- C: CH3
- D: CH4

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 2 = B-event.

<n> 1..14
Defines the trigger type, see table 14-13.

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 CH2
- CD: CH3 and CH4
- ABCD: all four channels

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 2 = B-event.

<n> 1..14
Defines the trigger type, see table 14-13.

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

14.2.4.3 Noise Reject

TRIGger<m>:LEVel<n>:NOISe[:STATe] <HysteresisMode>

Selects how the hysteresis is set.

Suffix:

<m> 1..3
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

<n> 1..6
Indicates the trigger source: 1...4 = channel 1...4;
5 = External Trigger Input on the rear panel for analog signals;
6 = Serial bus

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: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
Indicates the event in a trigger sequence: 1 = A-event, 2 = B-event, 3 = R-event.

<n> 1..6
Indicates the trigger source: 1...4 = channel 1...4;
5 = External Trigger Input on the rear panel for analog signals;
6 = Serial bus

Parameters:

<HystAbs>

Range: 0 to 10
Increment: 1E-3
*RST: 0
Default unit: V

14.2.4.4 Trigger Sequence

TRIGger<m>:SEQuence:MODE <Type>

Selects the type of the sequence.

See also: chapter 3.3.4, "Sequence", on page 74.

Suffix:

<m> 1..3
The suffix is irrelevant.

Parameters:

<Type> AONLy | ABR

AONLy
Triggers only on A-events. Additionally, a holdoff condition can be set.

ABR
Triggers if all conditions of A- and B-events, as well as additional delay and reset timeout or R-event (reset) conditions are fulfilled.

*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 The suffix is irrelevant.

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 The suffix is irrelevant.

Parameters:

<Events>

Range: 1 to 2147483647
Increment: 10
*RST: 1

TRIGger<m>:SEQuence:RESet:EVENt <EnabRstEvt>

If set to ON, the trigger sequence is restarted by the R-event if the specified number of B-event does not occur.

Suffix:

<m>	1..3 The suffix is irrelevant.

Parameters:

<EnabRstEvt>	ON | OFF *RST: OFF

TRIGger<m>:SEQuence:RESet:TIMeout[:ENABle] <State>

If set to ON, the instrument waits for the time defined using `TRIGger<m>:SEQuence:RESet:TIMeout:TIME` for the specified number of B-events. If no trigger occurs during that time, the sequence is restarted with the A-event.

Suffix:

<m>	1..3 The suffix is irrelevant.

Parameters:
<State> ON | OFF

*RST: OFF

TRIGger<m>:SEQuence:RESet:TIMeout:TIME <ResetTimeout>

The time the instrument waits for the number of B-events specified using `TRIGger<m>:SEQuence:COUNt` before the sequence is restarted with the A-event.

Suffix:
<m> 1..3
The suffix is irrelevant.

Parameters:
<ResetTimeout>
Range: 0 to 50
Increment: 1E-12
*RST: 0
Default unit: s

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
For holdoff settings, only suffix 1 (A-event) is available.

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 392 and `TRIGger<m>:HOLDoff:MAX` on page 392. 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
For holdoff settings, only suffix 1 (A-event) is available.

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
For holdoff settings, only suffix 1 (A-event) is available.

Parameters:

<Events>
Range: 1 to 2147483647
Increment: 10
*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
For holdoff settings, only suffix 1 (A-event) is available.

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 For holdoff settings, only suffix 1 (A-event) is available.

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 For holdoff settings, only suffix 1 (A-event) is available.

Return values:

<AutoTime> Holdoff time

Range:	100E-9 to 10
Increment:	200E-6
*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 393

Suffix:

<m> 1..3

For holdoff settings, only suffix 1 (A-event) is available.

Parameters:

<AutoTimeScaling>

Range: 1E-3 to 1000
Increment: 1
*RST: 0.5

14.2.4.5 Trigger Position

TIMebase:REFerence <ReferencePoint>

Sets the reference point of the time scale in % of the display. The reference point defines which part of the waveform is shown. If the "Trigger offset" is zero, the trigger point matches the reference point.

See also: `TIMebase:POSition` on page 339

Parameters:

<ReferencePoint> The reference point is the zero point of the time scale.

Range: 10 to 90
Increment: 1
*RST: 50
Default unit: %

TIMebase:POSition <Offset>

Defines the trigger offset - the time interval between trigger point and reference point to analize the signal some time before or after the trigger event.

See also: `TIMebase:REFerence` on page 340

Parameters:

<Offset>

Range: -500 to 500
Increment: 0.01
*RST: 0
Default unit: s

TRIGger<m>:OFFSet:LIMited <State>

Ensures that the trigger occurs within within one acquisition cycle.

Suffix:

<m> 1..3
The numeric suffix is irrelevant.

Parameters:

<State> ON | OFF

If ON, the range of the trigger offset is limited considering the acquisition time and the reference point. Thus the trigger cannot be set outside the waveform diagram.

*RST: ON

14.2.4.6 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 78

Suffix:

<m> 1..3
The numeric suffix is irrelevant.

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

Usage: Event

14.2.5 Display

14.2.5.1 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 4.1.2.1, "Editing Signal Colors ", on page 81.

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 <SignColorTableRef>

Assigns the color table to the specified signal.

Suffix:

<m>	1..37 Waveform number, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:

<SignColorTableRef>	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..37 Waveform number, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:

<UseColorTable>	ON | OFF *RST: OFF

14.2.5.2 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

<ColorTableColorPointIdx> 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

14.2.5.3 Diagram Layout

DISPlay:DIAGram:GRID <Show>

If enabled, a grid is displayed in the diagram area.

Parameters:

<Show>	ON | OFF	
	*RST:	ON

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	
	*RST:	ON

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	
	*RST:	ON

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	
	*RST:	ON

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	
	*RST:	ON

DISPlay:SIGBar[:STATe] <State>

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

Parameters:

<State> ON | OFF

*RST: ON

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

*RST: 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:OPACity`, 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

*RST: 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
*RST: 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

*RST: ON

DISPlay:SIGBar:HIDE:OPACity <HidingOpacity>

Sets the opacity, or transparency, of the signal bar. The minimum value is 30% for the least visibility of the signal bar, the maximum value is 80%.

Parameters:

<HidingOpacity>

Range: 30 to 80
Increment: 5
*RST: 50
Default unit: %

DISPlay:SIGBar:COLor:BORDer <BorderColor>

Defines the color of the signal bar border.

See also: "To change the colors" on page 84.

Parameters:

<BorderColor> ARGB color value

Range: 0 to 4294967295
Increment: 1
*RST: 0

DISPlay:SIGBar:COLor:FILL <FillColor>

Define the fill color of the signal bar.

See also: "To change the colors" on page 84.

Parameters:

<FillColor> ARGB color value

Range: 0 to 4294967295
Increment: 1
*RST: 0

LAYout:ADD <sNodeName>, <eParentType>, <eInsertBefore>, <eFirstSource>, <sDiagramName>

Adds a new diagram with a waveform on the screen, in relation to an existing diagram.

Setting parameters:

<sNodeName> Name of the existing diagram

<eParentType>	NONE | 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
<eInsertBefore>	ON | OFF If on, the new diagram is inserted to the left (for HORizontal), above (for VERTical) or in a tab before the existing one.
<eFirstSource>	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 | SBUS1 | SBUS2 | SBUS3 | SBUS4 Waveform to be diplayed in the new diagram, see chapter 14.2.1.2, "Waveform Parameter", on page 332.
<sDiagramName>	Name of the new diagram.
Usage:	Setting only SCPI conform

LAYout:REMove <sNodeName>

Setting parameters:
<sNodeName>

Usage: Setting only
SCPI conform

LAYout:SHOW <sNodeName>

Setting parameters:
<sNodeName>

Usage: Setting only
SCPI conform

LAYout:SIGNal:ASSign <sDiagramName>, <eSource>

Shows the specified waveform in the selected diagram.

Setting parameters:
<sDiagramName> Name of the diagram

<eSource> 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 | SBUS1 | SBUS2 | SBUS3 | SBUS4

Waveform to be assigned, see chapter 14.2.1.2, "Waveform Parameter", on page 332

Usage: Setting only

LAYout:SIGNal:AXIS <sDiagramName>, <eSource>, <eXSource>

Creates an XY-diagram by adding a second waveform to a diagram with a channel, math or reference waveform.

Setting parameters:

<sDiagramName> Name of the diagram where the waveform is added.

<eSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Waveform to be addes, see chapter 14.2.1.2, "Waveform Parameter", on page 332

<eXSource> 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

LAYout:SIGNal:UNASsign <eSource>

Removes the specified waveform from the diagram.

Setting parameters:

<eSource> 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 | SBUS1 | SBUS2 | SBUS3 | SBUS4

See chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: Setting only

14.2.5.4 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

Usage: SCPI conform

WAVeform<m>:XYCurve:STATe <State>

Activates an XY-waveform.

Suffix:

<m> 1...4
XY-diagram

Parameters:

<State> ON | OFF

*RST: OFF

Usage: SCPI conform

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
SCPI conform

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> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of x-values, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

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> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of y-values, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

14.2.5.5 Zoom

LAYout:ZOOM:ADD <sNodeName>, <eParentType>, <eInsertBefore>, <fXStart>, <fXStop>, <fYStart>, <fYStop>, <ZoomDiagName>

Adds a new zoom diagram based on the specified waveform.

Setting parameters:

<sNodeName> Name of diagram to be zoomed

<eParentType> NONE | HORizontal | VERTical | TAB

Position of the zoom diagram in relation to the original one.

HORizontal
Besides the existing diagram

VERTical
Above or below the existing diagram

TAB
In a new tab in the existing diagram

<eInsertBefore> ON | OFF

If on, the zoom diagram is inserted to the left (for HORizontal), above (for VERTical) or in a tab before the original diagram.

<fXStart> Defines the x-value at the beginning of the zoom area.

<fXStop> Defines the x-value at the end of the zoom area.

<fYStart> Defines the y-value at the beginning of the zoom area.

<fYStop> Defines the y-value at the end of the zoom area.

<ZoomDiagName> Defines the name of the new zoom diagram.

Usage: Setting only
SCPI conform

LAYout:ZOOM:ADDCoupled <ZoomDiagName>, <fXOffset>, <fYOffset>, <NewZoomDiagName>

Creates a new zoom diagram based on the settings of an existing zoom area for the same source.

Parameters:

<NewZoomDiagName> Defines the name of the new zoom diagram.

Setting parameters:

<ZoomDiagName> Defines the name of the zoom diagram to be copied.

<fXOffset> Defines an offset to the existing zoom area in x direction.

<fYOffset> Defines an offset to the existing zoom area in y direction.

Usage: SCPI conform

LAYout:ZOOM:HORZ:MODE <DiagGroupName>, <ZoomDiagramName>,<Mode>

LAYout:ZOOM:HORZ:MODE? <DiagGroupName>, <ZoomDiagramName>

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:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:POSition <DiagGroupName>, <ZoomDiagramName>,<Position>

LAYout:ZOOM:HORZ:ABSolute:POSition? <DiagGroupName>, <ZoomDiagramName>

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:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:SPAN <DiagGroupName>, <ZoomDiagramName>,<Span>

LAYout:ZOOM:HORZ:ABSolute:SPAN? <DiagGroupName>, <ZoomDiagramName>

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:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:STARt <DiagGroupName>, <ZoomDiagramName>,<Start>

LAYout:ZOOM:HORZ:ABSolute:STARt? <DiagGroupName>, <ZoomDiagramName>

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:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:STOP <DiagGroupName>, <ZoomDiagramName>,<Stop>

LAYout:ZOOM:HORZ:ABSolute:STOP? <DiagGroupName>, <ZoomDiagramName>

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:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:HORZ:RELative:POSition <DiagGroupName>, <ZoomDiagramName>,<RelPosi>

LAYout:ZOOM:HORZ:RELative:POSition? <DiagGroupName>, <ZoomDiagramName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<RelPosi> Relative position of the centerpoint (x-value)

Range: -100E+24 to 100E+24
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:HORZ:RELative:SPAN <DiagGroupName>, <ZoomDiagramName>,<RelativeSpan>

LAYout:ZOOM:HORZ:RELative:SPAN? <DiagGroupName>, <ZoomDiagramName>

Defines the width of the zoom area.

Parameters:

<RelativeSpan>

Range: -100E+24 to 100E+24
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:HORZ:RELative:STARt <DiagGroupName>, <ZoomDiagramName>,<RelativeStart>

LAYout:ZOOM:HORZ:RELative:STARt? <DiagGroupName>, <ZoomDiagramName>

Defines the lower limit of the zoom area on the x-axis.

Parameters:

<RelativeStart>

Range: -100E+24 to 100E+24
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:HORZ:RELative:STOP <DiagGroupName>, <ZoomDiagramName>,<RelativeStop>

LAYout:ZOOM:HORZ:RELative:STOP? <DiagGroupName>, <ZoomDiagramName>

Defines the upper limit of the zoom area on the x-axis.

Parameters:

<RelativeStop>

Range: -100E+24 to 100E+24
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:VERTical:MODE <DiagGroupName>, <ZoomDiagramName>,<Mode>

LAYout:ZOOM:VERTical:MODE? <DiagGroupName>, <ZoomDiagramName>

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:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:POSition <DiagGroupName>, <ZoomDiagramName>,<Position>

LAYout:ZOOM:VERTical:ABSolute:POSition? <DiagGroupName>, <ZoomDiagramName>

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:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:SPAN <DiagGroupName>, <ZoomDiagramName>,<Span>

LAYout:ZOOM:VERTical:ABSolute:SPAN? <DiagGroupName>, <ZoomDiagramName>

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:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:STARt <DiagGroupName>, <ZoomDiagramName>,<Start>

LAYout:ZOOM:VERTical:ABSolute:STARt? <DiagGroupName>, <ZoomDiagramName>

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:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:STOP <DiagGroupName>, <ZoomDiagramName>,<Stop>

LAYout:ZOOM:VERTical:ABSolute:STOP? <DiagGroupName>, <ZoomDiagramName>

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:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:POSition <DiagGroupName>, <ZoomDiagramName>,<RelPosi>

LAYout:ZOOM:VERTical:RELative:POSition? <DiagGroupName>, <ZoomDiagramName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:
<RelPosi> Relative position of the centerpoint (y-value)

Range: -100E+24 to 100E+24
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:SPAN <DiagGroupName>, <ZoomDiagramName>,<RelativeSpan>

LAYout:ZOOM:VERTical:RELative:SPAN? <DiagGroupName>, <ZoomDiagramName>

Defines the height of the zoom area.

Parameters:
<RelativeSpan>

Range: -100E+24 to 100E+24
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:

<DiagGroupName> Name of the diagram on which the zoom area is based.

<ZoomDiagramName> Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:STARt <DiagGroupName>, <ZoomDiagramName>,<RelativeStart>

LAYout:ZOOM:VERTical:RELative:STARt? <DiagGroupName>, <ZoomDiagramName>

Defines the lower limit of the zoom area on the y-axis.

Parameters:

<RelativeStart>

Range:	-100E+24 to 100E+24
Increment:	0.1
*RST:	0
Default unit:	%

Parameters for setting and query:

<DiagGroupName>	Name of the diagram on which the zoom area is based.
<ZoomDiagramName>	Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:STOP <DiagGroupName>, <ZoomDiagramName>,<RelativeStop>

LAYout:ZOOM:VERTical:RELative:STOP? <DiagGroupName>, <ZoomDiagramName>

Defines the upper limit of the zoom area on the y-axis.

Parameters:

<RelativeStop>

Range:	-100E+24 to 100E+24
Increment:	0.1
*RST:	100
Default unit:	%

Parameters for setting and query:

<DiagGroupName>	Name of the diagram on which the zoom area is based.
<ZoomDiagramName>	Name of the zoom diagram

LAYout:ZOOM:REMove <Diagram>, <Zoom>

Removes the specified zoom diagram.

Setting parameters:

<Diagram>	Name of the diagram on which the zoom area is based.
<Zoom>	Name of the zoom diagram

Usage: Setting only
SCPI conform

14.2.6 Cursor Measurements

CURSor<m>:AOFF

This command switches all cursors off.

Suffix:

<m>	1..4 The numeric suffix is ignored.
Usage:	Event

CURSor<m>:STATe <State>

Switches the indicated cursor on or off.

Suffix:

<m>	1..4 Selects the cursor.

Parameters:

<State>	ON | OFF *RST: OFF

CURSor<m>:FUNCtion <Type>

Defines the type of the indicated cursor.

Suffix:

<m> 1..4
Selects the cursor.

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..4
Selects the cursor.

Parameters:

<TrackCurve> ON | OFF

*RST: OFF

CURSor<m>:SOURce <CursorSource>

Defines the source of the cursor measurement.

Suffix:

<m> 1..4
Selects the cursor.

Parameters:

<CursorSource> 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 | SBUS1 | SBUS2 | SBUS3 | SBUS4

Source of the cursor measurement, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

CURSor<m>:X1Position <XPosition1>

Defines the position of the left vertical cursor line.

Suffix:
<m> 1..4
Selects the cursor.

Parameters:
<XPosition1>

Range: 0 to 500
Increment: 0.1
*RST: 0

CURSor<m>:X2Position <XPosition2>

Defines the position of the right vertical cursor line.

Suffix:
<m> 1..4
Selects the cursor.

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..4
Selects the cursor.

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.

Suffix:
<m> 1..4
Cursor measurement

Parameters:
<YPosition1>

Range: -50 to 50
Increment: 0.01
*RST: 0

CURSor<m>:Y2Position <YPosition2>

Defines the position of the upper horizontal cursor line.

Suffix:
<m> 1..4
Cursor measurement

Parameters:
<YPosition2>

Range: -50 to 50
Increment: 0.01
*RST: 0

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..4
Selects the cursor.

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 344) and `CURSor<m>:TRACking[:STATe]` is set to "ON", this setting defines whether the first horizontal cursor is positioned to the maximum or to the minimum envelope values.

Suffix:
<m> 1...4
math waveform

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 344) and `CURSor<m>:TRACking[:STATe]` is set to "ON", this setting defines whether the second horizontal cursor is positioned to the maximum or to the minimum envelope values.

Suffix:

<m> 1...4
math waveform

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..4
Selects the cursor.

Return values:

<Delta>

Range: -100E+24 to 100E+24
Increment: 0.1
*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..4
Selects the cursor.

Return values:
<DeltaInverse>
Range: -100E+24 to 100E+24
Increment: 0.1
*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..4
Selects the cursor.

Return values:
<Delta>
Range: -100E+24 to 100E+24
Increment: 0
*RST: 0

Usage: Query only

CURSor<m>:YDELta:SLOPe <DeltaSlope>

Queries the inverse value of the delta value (distance) of two horizontal cursor lines.

Suffix:
<m> 1..4
Selects the cursor.

Parameters:
<DeltaSlope>
Range: -100E+24 to 100E+24
Increment: 0
*RST: 0

CURSor<m>:MAXimum[:PEAK]

Sets both cursors to the absolute peak value.

Suffix:
<m> 1..4
Selects the cursor (set).

Usage: Event

CURSor<m>:MAXimum:LEFT

Sets cursor 2 to the next maximum to the left of the current position.

Suffix:

<m> 1..4
Selects the cursor.

Usage: Event

CURSor<m>:MAXimum:RIGHt

Sets cursor 2 to the next peak to the right (from the current position).

Suffix:

<m> 1..4
Selects the cursor (set).

Usage: Event

CURSor<m>:MAXimum:NEXT

Sets cursor 2 to the next smaller peak (from the current position).

Suffix:

<m> 1..4
Selects the cursor (set).

Usage: Event

CURSor<m>:PEXCursion <PeakExcursion>

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..4
irrelevant

Parameters:

<PeakExcursion>

Range: 0 to 100
Increment: 1
*RST: 5
Default unit: dB

14.2.7 Automatic Measurements

14.2.7.1 General Settings

MEASurement<m>[:ENABle] <State>

Switches the indicated measurement on or off.

Suffix:

<m>	1..8 Selects the measurement.

Parameters:

<State>	ON | OFF *RST: OFF

MEASurement<m>:SOURce <SignalSource>, [<SignalSource2>]

Defines the source 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.

Suffix:

<m>	1..8 Selects the measurement.

Parameters:

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the measurement, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

<SignalSource2> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

MEASurement<m>:MULTiple <MultiMeas>

The measurement is performed repeatedly if the measured parameter occurs several times inside the defined gate.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<MultiMeas> ON | OFF

*RST: OFF

MEASurement<m>:CATegory <Category>

Defines the measurement category.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<Category> AMPTime | EYEJitter | SPECtrum | HIST

AMPTime
Amplitude and time measurements

EYEJitter
Eye and jitter mesurements

SPECtrum
Spectrum measurements

HIST
Histogram measurements

*RST: AMPTime

MEASurement<m>:MAIN <MeasType>

Defines or queries the main measurement. This measurement is the one referred to if the measurement waveform is used as a source for math calculations. The main measurement type must belong to the same category as the other types assigned to the same measurement waveform, if there are any.

For details on the measurement types and categories, see chapter 5.1, "Measurement Types and Results", on page 110.

Suffix:

<m>	1..8 Selects the measurement.

Parameters:

<MeasType>

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 | PROBemeter | ERATio | ERPercent | ERDB | EHEight | EWIDth | ETOP | EBASe | CPOints | CPPercent | QFACtor | SDNoise | BER | PPNoise | RMSNoise | SNRatio | DCDistortion | ERTime | EFTime | EBRate | EAMPlitude | EOFactor | EPWidth | EDCYcle | ECRatio | PJITter | CJITter | TIERror | PPJitter | STDJitter | RMSJitter | CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | PLISt | WCOunt | WSAMples | HSAMples | HPEak | PEAK | UPEakvalue | LPEakvalue | HMAXimum | HMINimum | MEDian | MAXMin | HMEan | HSTDdev | M1STddev | M2STddev | M3STddev | MKPositive | MKNegative

In the parameter description, the corresponding measurement category for each measurement type is indicated in brackets.

HIGH: High (amplitude vs. time)
LOW: Low (amplitude vs. time)
AMPLitude: Amplitude (amplitude vs. time)
MAXimum: Maximum (amplitude vs. time)
MINimum: Minimum (amplitude vs. time)
PDELta: Peak to peak (amplitude vs. time)
MEAN: Mean value (amplitude vs. time)
RMS: Root mean square (amplitude vs. time)
STDDev: Standard deviation (amplitude vs. time)
POVershoot: Positive overshoot (amplitude vs. time)
NOVershoot: Negative overshoot (amplitude vs. time)
AREA: Area (amplitude vs. time)
RTIMe: Rise time (amplitude vs. time)
FTIMe: FAll time (amplitude vs. time)
PPULse: Positive pulse (amplitude vs. time)
NPULse: Negative pulse (amplitude vs. time)
PERiod: Period (amplitude vs. time)
FREQuency: Frequency (amplitude vs. time)
PDCYcle: Positive duty cycle (amplitude vs. time)
NDCYcle: Negative duty cycle (amplitude vs. time)
CYCarea: Cycle area (amplitude vs. time)
CYCMean: Cycle mean (amplitude vs. time)
CYCRms: Cycle RMS (amplitude vs. time)
CYCStddev: Standard deviation of the cycle (amplitude vs. time)
PULCnt: Pulse count (amplitude vs. time)
DELay: Delay (amplitude vs. time)
PHASe: Phase (amplitude vs. time)
BWIDth: Burst width (amplitude vs. time)
PSWitching: Positive switching (amplitude vs. time)
NSWitching: Negative switching (amplitude vs. time)

PROBemeter: Probemeter (amplitude vs. time)
ERPercent: Extinction ratio in % (eye/jitter
ERDB: Extinction ratio in dB (eye/jitter)
EHEight: Eye height (eye/jitter)
EWIDth: Eye width (eye/jitter)
ETOP: Eye top (eye/jitter)
EBASe: Eye base (eye/jitter)
QFACtor: Q factor (eye/jitter)
RMSNoise: Noise in RMS values (eye/jitter)
SNRatio: S/N ratio (eye/jitter)
DCDistortion: Duty cycle distortion (eye/jitter)
ERTime: Eye rise time (eye/jitter)
EFTime: Eye fall time (eye/jitter)
EBRate: Eye bit rate (eye/jitter)
EAMPlitude: Eye amplitude (eye/jitter)
PPJitter: Peak to peak jitter (eye/jitter)
STDJitter: Standard deviation of the jitter (eye/jitter)
RMSJitter: RMS jitter(eye/jitter)
CPOWer: Channel power (spectrum)
OBWidth: Occupied bandwidth (spectrum)
SBWidth: n dB down Bandwidth (spectrum)
THD: Total harmonic distortion (spectrum)
WCOunt: Waveform count (histogram)
WSAMples: Waveform samples (histogram)
HSAMples: Histogram samples (histogram)
HPEak: Histogram peak (histogram)
PEAK: Peak value (histogram)
UPEakvalue: Upper peak value (histogram)
LPEakvalue: Lower peak value (histogram)
HMAXimum: Histogram maximum (histogram)
HMINimum: Histogram minimum (histogram)
MEDian: Median (histogram)
MAXMin: Maximum - Minumum (histogram)
HMEan: Histogram mean (histogram)
HSTDdev: Histogram standard deviation (histogram)
M1STddev: Mean ±σ (histogram)
M2STddev: Mean ±2*σ (histogram)
M3STddev: Mean ±3*σ (histogram)
MKPositive: Positive marker probability in percent (histogram)
MKNegative: Negative marker probability in percent (histogram)

The *RST value depends on the measurement category, which is defined by the first measurement type assigned to the measurement waveform:

Amplitude vs. time: `AMPLitude`

Eye/jitter: `ERPercent`

Histogram: `WCOunt`

Spectrum: `CPOWer`

MEASurement<m>:ADDitional <MeasType>, [<State>]

MEASurement<m>:ADDitional? <MeasType>

Enables or disables an additional measurement. Only one measurement type can be enabled or disabled per command. The query returns the state of the specified measurement type.

Note that each measurement waveform can only perform measurements from the same category. For example, if you enable an amplitude measurement for measurement waveform 1, then you cannot enable an eye width measurement for the same waveform.

For details on the measurement types and categories, see chapter 5.1, "Measurement Types and Results", on page 110.

Suffix:

<m>	1..8 Selects the measurement.

Parameters:

<State>	ON | OFF Enables or disables the measurement type.

Parameters for setting and query:

<MeasType>	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 | PROBemeter | ERATio | ERPercent | ERDB | EHEight | EWIDth | ETOP | EBASe | CPOints | CPPercent | QFACtor | SDNoise | BER | PPNoise | RMSNoise | SNRatio | DCDistortion | ERTime | EFTime | EBRate | EAMPlitude | EOFactor | EPWidth | EDCYcle | ECRatio | PJITter | CJITter | TIERror | PPJitter | STDJitter | RMSJitter | CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | PLISt | WCOunt | WSAMples | HSAMples | HPEak | PEAK | UPEakvalue | LPEakvalue | HMAXimum | HMINimum | MEDian | MAXMin | HMEan | HSTDdev | M1STddev | M2STddev | M3STddev | MKPositive | MKNegative See `MEASurement<m>:MAIN` on page 425 for a description of the <MeasType> parameter.

MEASurement<m>:AON

Enables all additional measurements in all categories of the indicated measurement. The additional measurements are defined with `MEASurement<m>:ADDitional` on page 428.

Suffix:

<m>	1..8 Selects the measurement.
Usage:	Event

MEASurement<m>:AOFF

Disables all additional measurements in all categories of the indicated measurement. The additional measurements are defined with `MEASurement<m>:ADDitional` on page 428.

Suffix:

<m>	1..8 Selects the measurement.
Usage:	Event

MEASurement<m>:ARES?

Returns the results of all selected measurements in all categories.

Suffix:

<m>	1..8 Selects the measurement.

Return values:

<sData>	Result string
Usage:	Query only

MEASurement<m>:CLEar

Deletes the statistic results of the indicated mesurement.

Suffix:

<m>	1..8 Selects the measurement.
Usage:	Event

14.2.7.2 Amplitude/Time Measurement

Table 14-14: Amplitude vs. time measurement types

	Meas. type	Description/Result
1	High	The high signal level
2	Low	The low signal level
3	Amplitude	The amplitude of the signal
4	Max	The maximum value of the waveform
5	Min	The minimum value of the waveform
6	Peak to peak	The peak-to-peak value of the waveform
7	Mean	The mean value of the waveform
8	RMS	The RMS (Root Mean Square) value of the voltage
9	σ (S-dev)	The standard deviation of the waveform
10	Pos. overshoot	The positive overshoot of a square wave
11	Neg. overshoot	The negative overshoot of a square wave
12	Area	The area beneath the waveform (integral)
13	Rise time	The rise time of the left-most rising edge of the waveform. The rise time is determined as the time it takes the signal to rise from 10% to 90% of its amplitude.
14	Fall time	The falling time of the left-most falling edge of the waveform. The falling time is determined as the time it takes the signal to fall from 90% to 10% of its amplitude.
15	Pos. pulse	The width of a positive pulse. A positive pulse consists of a rising edge followed by a falling edge. The measurement requires at least one complete period of a triggered signal.
16	Neg. pulse	The width of a negative pulse. A negative pulse consists of a falling edge followed by a rising edge. The measurement requires at least one complete period of a triggered signal.
17	Period	The length of the left-most signal period of the waveform
18	Frequency	The frequency of the signal. The result is based on the length of the left-most signal period of the waveform.
19	Pos. duty cycle	The positive duty cycle. To do so, the share of the positive alternation within a period is measured and is placed in relation to the signal period. The measurement requires at least one complete period of a triggered signal.
20	Neg. duty cycle	The negative duty cycle. To do so, the share of the negative alternation within a period is measured and is placed in relation to the signal period. The measurement requires at least one complete period of a triggered signal.
21	Cycle area	The area (integral) beneath one cycle
22	Cycle mean	The mean value of one cycle
23	Cycle RMS	The RMS (Root Mean Square) value of one cycle
24	Cycle σ (S-dev)	The standard deviation of one cycle

	Meas. type	Description/Result
25	Pulse count	The number of impulses of the waveform. The mean value of the signal is determined. If the signal passes the mean value, an edge is counted. The impulse is counted if a rising edge and a falling edge are detected.
26	Delay	The difference between the trigger times of two waveforms
27	Phase	The phase difference between two waveforms (delay/period * 360)
28	Burst width	The duration of one burst, measured from the first edge to the last
29	Pos. switching	The number of transitions of the signal from low level to high level in the waveform (rising edge). To do so, the mean value of the signal is determined. If the signal passes the mean value, a rising edge is counted.
30	Neg. switching	The number of transitions of the signal from high level to low level in the waveform (falling edge). To do so, the mean value of the signal is determined. If the signal passes the mean value, a falling edge is counted.
31	ProbeMeter	The DC voltage from the connected probe

MEASurement<m>:AMPTime:ALEVel <AreaLevel>

Defines the reference level used to integrate the waveform.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<AreaLevel>

Range: -100E+24 to 100E+24
Increment: 0
*RST: 0
Default unit: V

MEASurement<m>:DETThreshold <SignDetectThres>

Defines the value above which measurement results are displayed. Values beneath the threshold are considered to be noise and are ignored.

Suffix:

<m> 1..8
irrelevant

Parameters:
<SignDetectThres>

Range: 0 to 50
Increment: 1
*RST: 5
Default unit: %

MEASurement<m>:AMPTime:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for amplitude vs. time measurements in the specified measurement channel.

Suffix:
<m> 1..8
Selects the measurement.
<n> 1..31
Number of the amplitude/time measurement type, see table 14-14.

Parameters:
<ValidRange> ILIMit | ULIMit | LLIMit | OLIMit

ILIMit
Inside (within) limit; between the upper and lower limit values

ULIMit
Upper limit; above the upper limit value

LLIMit
Lower limit; below the lower limit value

OLIMit
Outside limit; above the upper limit or below the lower limit values

*RST: ILIMit

MEASurement<m>:AMPTime:LCHeck<n>:LOWer:LIMit <LowerLimit>
MEASurement<m>:AMPTime:LCHeck<n>:UPPer:LIMit <UpperLimit>

Define the lower and upper limit for limit checking, respectiveley. The valid range is defined using the `MEASurement<m>:AMPTime:LCHeck<n>:VALid` command.

Suffix:
<m> 1..8
Selects the measurement.
<n> 1..31
Number of the amplitude/time measurement type, see table 14-14.

Parameters:
<UpperLimit>

Range: -100 to 100
Increment: 10E-6
*RST: 0

MEASurement<m>:AMPTime:LCHeck<n>:LOWer:MARGin <LowerMargin>
MEASurement<m>:AMPTime:LCHeck<n>:UPPer:MARGin <UpperMargin>

Define the lower and upper margins for the limit check, respectively. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:AMPTime:LCHeck<n>:VALid` command.

Suffix:

<m> 1..8
Selects the measurement.

<n> 1..31
Number of the amplitude/time measurement type, see table 14-14.

Parameters:

<UpperMargin>

Range: -100 to 100
Increment: 10E-6
*RST: 0

14.2.7.3 Eye/Jitter Measurement

Table 14-15: Eye/jitter measurement types

	Meas. type	Description/Result
2	Extinction ratio (%)	Top level / Base level in percent ($V_{top}/V_{tobasep}$*100)
3	Extinction ratio (dB)	Top level / Base level in dB 10*log (V_{top}/V_{base})
4	Eye height	Vertical eye size (V_{top} – 3 * σ_top) – (V_{base} + 3 * σ_base)
5	Eye width	Horizontal eye size
6	Eye top	Upper reference level (V_{top}, high level)
7	Eye base	Lower reference level (V_{base}, low level)
10	Q factor	(V_{top} – V_{base})/(σ_top + σ_base)
14	Noise (RMS)	Average of top and base deviation
15	S/N ratio	Signal-to-Noise Ratio 20 * log (Eye height / NoiseRMS)
16	Duty cycle distortion	Eye Rise Time / Eye Fall Time
17	Eye rise time	Duration for signal to rise from 10% to 90%
18	Eye fall time	Duration for signal to fall from 90% to 10%
19	Eye bit rate	Frequency between two crossings
20	Eye amplitude	V_{top}-V_{base}

	Meas. type	Description/Result
28	Jitter (peak to peak)	Average of the jitter for both crossing points.
29	Jitter (6*σ)	Jitter *6
30	Jitter (RMS)	Average deviation of the time from the virtual crossing point.

MEASurement<m>:EYEJitter:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for eye/jitter measurements in the specified measurement channel.

Suffix:

<m> 1..8
Selects the measurement.

<n> 1..30
Number of eye/jitter measurement type, see table 14-15.

Parameters:

<ValidRange> ILIMit | ULIMit | LLIMit | OLIMit

ILIMit
Inside (within) limit; between the upper and lower limit values

ULIMit
Upper limit; above the upper limit value

LLIMit
Lower limit; below the lower limit value

OLIMit
Outside limit; above the upper limit or below the lower limit values

*RST: ILIMit

MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:LIMit <LowerLimit>
MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:LIMit <UpperLimit>

Define the lower and upper limit for the limit check, respectively. The valid range is defined using the `MEASurement<m>:EYEJitter:LCHeck<n>:VALid` command.

Suffix:

<m> 1..8
Selects the measurement.

<n> 1..30
Number of eye/jitter measurement type, see table 14-15.

Parameters:
<UpperLimit>

Range: -100 to 100
Increment: 10E-6
*RST: 0

MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:MARGin <LowerMargin>
MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:MARGin <UpperMargin>

Defines the upper margin for the limit check. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:EYEJitter:LCHeck<n>:VALid` command.

Suffix:
<m> 1..8
Selects the measurement.
<n> 1..30
Number of eye/jitter measurement type, see table 14-15.

Parameters:
<UpperMargin>

Range: -100 to 100
Increment: 10E-6
*RST: 0

14.2.7.4 Spectrum

Table 14-16: Spectrum measurement types

	Meas. type	Description/Result
1	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
2	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
3	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	Total harmonic distortion	Power sum of the harmonic waves divided by the power of the fundamental wave.
5... 8		not supported

MEASurement<m>:SPECtrum:CPOWer:BANDwidth <ChPowBandwidth>

Defines the bandwidth over which the channel power is calculated.

Suffix:

<m> 1..8
Selects the measurement.

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..8
Selects the measurement.

Parameters:

<OccupiedBW>
Range: 0.1 to 99.9
Increment: 1
*RST: 20
Default unit: %

MEASurement<m>:SPECtrum:CPOWer:CFRequency <ChPowCenterFreq>

Defines the center frequency from which the channel power is calculated over the specified bandwidth.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<ChPowCenterFreq>
Range: 0 to 4E+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..8 Selects the measurement.

Parameters:

<NDbDown>

Range: 0 to 100
Increment: 1
*RST: 20
Default unit: dB

MEASurement<m>:SPECtrum:NREJect <NoiseReject>

Defines the threshold beneath which values are rejected as noise.

Suffix:

<m>	1..8 Selects the measurement.

Parameters:

<NoiseReject>

Range: 0 to 100
Increment: 1
*RST: 0
Default unit: dB

MEASurement<m>:SPECtrum:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for spectrum measurements in the specified measurement channel.

Suffix:

<m>	1..8 Selects the measurement.
<n>	1..8 Number of spectrum measurement type, see table 14-16.

Parameters:

<ValidRange> ILIMit | ULIMit | LLIMit | OLIMit

ILIMit
Inside (within) limit; between the upper and lower limit values

ULIMit
Upper limit; above the upper limit value

LLIMit
Lower limit; below the lower limit value

OLIMit
Outside limit; above the upper limit or below the lower limit values

*RST: ILIMit

MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:LIMit <LowerLimit>
MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:LIMit <UpperLimit>

Define the lower and upper limits for the limit check, respectively. The valid range is defined using the `MEASurement<m>:SPECtrum:LCHeck<n>:VALid` command.

Suffix:

<m> 1..8
Selects the measurement.

<n> 1..8
Number of spectrum measurement type, see table 14-16.

Parameters:

<UpperLimit>

Range: -100 to 100
Increment: 10E-6
*RST: 0

MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:MARGin <LowerMargin>
MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:MARGin <UpperMargin>

Define the lower and upper margins for the limit check, respectively. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:SPECtrum:LCHeck<n>:VALid` command.

Suffix:

<m> 1..8
Selects the measurement.

<n> 1..8
Number of spectrum measurement type, see table 14-16.

Parameters:

<UpperMargin>

Range: -100 to 100
Increment: 10E-6
*RST: 0

14.2.7.5 Histograms

Histogram Display

LAYout:HISTogram:ADD <sHistogramName>, <eSource>, <fXStart>, <fXStop>, <fYStart>, <fYStop>, <eRelative>

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:

<sHistogramName> Defines the histogram name which is displayed in the Histogram dialog box and used to refer to the histogram by other functions.

<eSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Data source of the histogram, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

<fXStart> Defines the start value of the x-value range.

<fXStop> Defines the stop value of the x-value range.

<fYStart> Defines the start value of the y-value range.

<fYStop> Defines the stop value of the y-value range.

<eRelative> ON | OFF

Defines whether relative or absolute values are used for the value range definition.

Usage: Setting only
SCPI conform

LAYout:HISTogram:SOURce <HistogramName>,<HistogramSource>

LAYout:HISTogram:SOURce? <HistogramName>

Defines the source of the histogram. Any input signal, math or reference waveform can be selected.

Parameters:

<HistogramSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Waveform source of the histogram, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Parameters for setting and query:

<HistogramName>

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 439.

Usage: SCPI conform

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:	-100E+24 to 100E+24
Increment:	0.1
*RST:	0
Default unit:	%

Parameters for setting and query:
<HistogramName>

Usage: SCPI conform

LAYout:HISTogram:HORZ:RELative:STOP <HistogramName>,<RelativeStop>

LAYout:HISTogram:HORZ:RELative:STOP? <HistogramName>

Defines the horizontal stop value of the histogram.

Parameters:
<RelativeStop>

Range: -100E+24 to 100E+24
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:
<HistogramName>

Usage: SCPI conform

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: -100E+24 to 100E+24
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:

<HistogramName>

Usage: SCPI conform

LAYout:HISTogram:VERTical:RELative:STOP <HistogramName>,<RelativeStop>

LAYout:HISTogram:VERTical:RELative:STOP? <HistogramName>

Defines the vertical stop value of the histogram.

Parameters:

<RelativeStop>

Range: -100E+24 to 100E+24
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<HistogramName>

Usage: SCPI conform

LAYout:HISTogram:RESet <HistogramName>

Resets the values to begin a new histogram.

Setting parameters:

<HistogramName>

Usage: Setting only
SCPI conform

LAYout:HISTogram:REMove <Name>

Removes the specified histogram.

Setting parameters:

<Name>

Usage: Setting only
SCPI conform

Histogram Measurement

Table 14-17: Histogram measurement types

	Meas. type	Description/Result
1	Waveform count	The number of acquisitions (waveforms) the histogram is based on
2	Waveform samples	The number of samples from the most recent acquisition included in the current histogram
3	Histogram samples	The number of samples from all acquisitions included in the current histogram
4	Histogram peak	The maximum sample value in the histogram
5	Peak value	The signal value at the histogram peak
6	Upper peak value	The signal value at the maximum sample value in the upper half of the histogram
7	Lower peak value	The signal value at the maximum sample value in the lower half of the histogram
8	Maximum	The highest signal value with a probability > 0
9	Minimum	The lowest signal value with a probability > 0
10	Median	The signal value for which half the samples lie above, the other half below in the histogram The sample numbers 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.
11	Max - Min	The range of signal values with a probability > 0
12	Mean	The weighted arithmetic average of the histogram
13	σ (S-dev)	Standard deviation of the sample numbers
14	Mean ±σ	The range between (mean value + standard deviation) and (mean value - standard deviation)
15	Mean ±2*σ	The range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)
16	Mean ±3*σ	The range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)
17	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.
18	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.

MEASurement<m>:HISTogram:SELect <MeasHistgRef>

Selects the histogram on which the measurement is based.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<MeasHistgRef> Name of the histogram

MEASurement<m>:HISTogram:PROBability:TYPE <HistgProbDomMark>

Defines the marker reference in the probability domain.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<HistgProbDomMark>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 <HistgProbDomLim>

Defines a range around the probability marker.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:
<HistgProbDomLim>

Range: 0 to 100
Increment: 10
*RST: 10
Default unit: %

MEASurement<m>:HISTogram:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for histogram measurements in the specified measurement channel.

Suffix:

<m> 1..8
Selects the measurement.

<n> 1..18
Number of histogram measurement type, see table 14-17.

Parameters:

<ValidRange> ILIMit | ULIMit | LLIMit | OLIMit

ILIMit
Inside (within) limit; between the upper and lower limit values

ULIMit
Upper limit; above the upper limit value

LLIMit
Lower limit; below the lower limit value

OLIMit
Outside limit; above the upper limit or below the lower limit values

*RST: ILIMit

MEASurement<m>:HISTogram:LCHeck<n>:LOWer:LIMit <LowerLimit>
MEASurement<m>:HISTogram:LCHeck<n>:UPPer:LIMit <UpperLimit>

Define the lower and upper limits for the limit check, respectively. The valid range is defined using the `MEASurement<m>:HISTogram:LCHeck<n>:VALid` command.

Suffix:

<m> 1..8
Selects the measurement.

<n> 1..18
Number of histogram measurement type, see table 14-17.

Parameters:
<UpperLimit>

Range: -100 to 100
Increment: 10E-6
*RST: 0

MEASurement<m>:HISTogram:LCHeck<n>:LOWer:MARGin <LowerMargin>

MEASurement<m>:HISTogram:LCHeck<n>:UPPer:MARGin <UpperMargin>

Define the lower and upper margins for the limit check, respectively. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:HISTogram:LCHeck<n>:VALid` command.

Suffix:

<m>	1..8 Selects the measurement.
<n>	1..18 Number of histogram measurement type, see table 14-17.

Parameters:

<UpperMargin>

Range:	-100 to 100
Increment:	10E-6
*RST:	0

14.2.7.6 Display

MEASurement<m>:DISPlay:LEVels <DisplayLevels>

If enabled, the reference levels used for the measurement are displayed in the diagram.

Suffix:

<m>	1..8 Selects the measurement.

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..8 Selects the measurement.

Parameters:

<DisplayResult>	ON | OFF
	*RST: OFF

MEASurement<m>:DISPlay:STYLe <DisplayStyle>

Selects the style in which the measurement waveform is displayed.

Suffix:

<m>	1..8 Selects the measurement.

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..8 Selects the measurement.

Parameters:

<DispHistg>	ON | OFF *RST: OFF

14.2.7.7 Limit check

MEASurement<m>:LCHeck <LimitCheckState>

Defines the type of the limit check that can run together with the measurement.

Suffix:

<m>	1..8 Selects the measurement.

Parameters:

<LimitCheckState>	OFF | LIMit | LMARgin **OFF** No limit check. **LIMit** Only limits are checked. **LMARgin** Limits and margins are checked. *RST: OFF

14.2.7.8 Statistics and Long-term Measurements

MEASurement<m>:STATistics[:ENABle] <StatisticsState>

Enables statistics calculation for the measurement.

For details on the statistics results, see chapter 5.1, "Measurement Types and Results", on page 110.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<StatisticsState> ON | OFF

*RST: OFF

MEASurement<m>:STATistics:MODE <ResetMode>

Defines when the statistics for long term measurements are reset.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<ResetMode> NONE | TIME | WFMS

NONE
No reset, the number of measurements considered by the statistics is not limited.

Time
Resets the statistics after the time defined using `MEASurement<m>:STATistics:RTIMe`.

Waveforms
Resets the statistics after a number of measurements defined using `MEASurement<m>:STATistics:RCOunt`.

*RST: NONE

MEASurement<m>:STATistics:RCOunt <RstWfmCount>

Defines the number of measurements after which the statistics are reset.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<RstWfmCount>

Range: 2 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..8
Selects the measurement.

Parameters:

<ResetTime>

Range: 0.1 to 2.14748E+9
Increment: 1E-3
*RST: 0.2
Default unit: s

MEASurement<m>:STATistics:RESet

Resets the statistics.

Suffix:

<m> 1..8
Selects the measurement.

Usage: Event

MEASurement<m>:VERTical:OFFSet <VerticalOffset>

Defines a vertical offset for the long term measurement.

Suffix:
<m> 1..8
Selects the measurement.

Parameters:
<VerticalOffset>
Range: -100E+24 to 100E+24
Increment: 1E-6
*RST: 0
Default unit: div

Usage: SCPI conform

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..8
Selects the measurement.

Parameters:
<VerticalScale>
Range: 1E-15 to 10E+24
Increment: 10E-6
*RST: 0.5
Default unit: V/div

Usage: SCPI conform

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..8
Selects the measurement.

Usage: Event
SCPI conform

MEASurement<m>:STATistics:WEIGht <Weight>

Suffix:
<m> 1..8
Selects the measurement.

Parameters:
<Weight>

Range: 2 to 2147483647
Increment: 10
*RST: 10000

MEASurement<m>:LTMeas[:STATe] <ShowDiagram>

Enables long term measurement for a defined number of measurement points (see MEASurement<m>:LTMeas:COUNt on page 452) or a specified time (seeMEASurement<m>:LTMeas:TIME on page 452).

Suffix:
<m> 1..8
Selects the measurement.

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..8

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..8
Selects the measurement.

Parameters:
<MeasurementTime>

Range: 0.01 to 2.14748E+9
Increment: 1
*RST: 200
Default unit: s

MEASurement<m>:LTMeas:ENVSensor:STATe <EnvState>

Enables the evaluation of a connected environment sensor.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<EnvState> ON | OFF

*RST: OFF

Usage: SCPI conform

MEASurement<m>:LTMeas:ENVSensor:SELect <LongTermMeasEnvSensRef>, <LongTermMeasEnvSensRef>

MEASurement<m>:LTMeas:ENVSensor:SELect? <LongTermMeasEnvSensRef>

Suffix:

<m> 1..8

Parameters:

<LongTermMeasEnvSensRef>

Parameters for setting and query:

<LongTermMeasEnvSensRef>

14.2.7.9 Results

MEASurement<m>:RESult[:ACTual]? [<MeasType>]
MEASurement<m>:RESult:AVG? [<MeasType>]
MEASurement<m>:RESult:EVTCount? [<MeasType>]
MEASurement<m>:RESult:WFMCount? [<MeasType>]
MEASurement<m>:RESult:NPEak? [<MeasType>]
MEASurement<m>:RESult:PPEak? [<MeasType>]
MEASurement<m>:RESult:RMS? [<MeasType>]

MEASurement<m>:RESult:STDDev? [<MeasType>]

Returns the specified statistic result of the specified measurement type or the main measurement, if no parameter is specified. Which of the measurement types is the main one is defined using `MEASurement<m>:MAIN`.

- [: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 measurement types see chapter 5.1.3, "Histograms", on page 115.

Suffix:

<m> 1..8
Selects the measurement.

Query parameters:

<MeasType> 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 | PROBemeter | ERATio | ERPercent | ERDB | EHEight | EWIDth | ETOP | EBASe | CPOints | CPPercent | QFACtor | SDNoise | BER | PPNoise | RMSNoise | SNRatio | DCDistortion | ERTime | EFTime | EBRate | EAMPlitude | EOFactor | EPWidth | EDCYcle | ECRatio | PJITter | CJITter | TIERror | PPJitter | STDJitter | RMSJitter | CPOWer | ACPower | OBWidth | SBWidth | TOI | AMMod | THD | PLISt | WCOunt | WSAMples | HSAMples | HPEak | PEAK | UPEakvalue | LPEakvalue | HMAXimum | HMINimum | MEDian | MAXMin | HMEan | HSTDdev | M1STddev | M2STddev | M3STddev | MKPositive | MKNegative

See `MEASurement<m>:MAIN` on page 425 for a description of the <MeasType> parameter.

Usage: Query only

14.2.7.10 Gating

MEASurement<m>:GATE[:STATe] <State>

Considers the gating settings of the source waveform for the measurement.

Suffix:

<m> 1..8
Selects the measurement.

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..8
Selects the measurement.

Parameters:

<Mode> ABS | REL

*RST: ABS

MEASurement<m>:GATE:ABSolute:STARt <Start>
MEASurement<m>:GATE:ABSolute:STOP <Stop>

Define the absolute start and end values for the gate. respectively.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<Stop>

Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Usage: SCPI conform

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..8
Selects the measurement.

Parameters:
<RelativeStop>
Range: -100E+24 to 100E+24
Increment: 0.1
*RST: 100
Default unit: %

Usage: SCPI conform

MEASurement<m>:GATE:NOISe <NoiseEvalArea>

Suffix:
<m> 1..8
Selects the measurement.

Parameters:
<NoiseEvalArea> UPPer | LOWer
*RST: LOWer

MEASurement<m>:GATE:SHOW <DisplayState>

Indicates the gate area in the source diagram.

Suffix:
<m> 1..8
Selects the measurement.

Parameters:
<DisplayState> 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 selected using `MEASurement<m>:GATE:ZDIagram`.

Suffix:
<m> 1..8
Selects the measurement.

Parameters:
<ZoomCoupling> ON | OFF
*RST: OFF

MEASurement<m>:GATE:ZDIagram <MeasGatingZoomDiag>, <MeasGatingZoomDiag>

MEASurement<m>:GATE:ZDIagram? <MeasGatingZoomDiag>

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..8

Selects the measurement.

Parameters:

<MeasGatingZoomDiag>

Parameters for setting and query:

<MeasGatingZoomDiag>

14.2.7.11 Event Actions

MEASurement<m>:ONViolation:BEEP <Beep>

Generates a beep sound for the specified event.

Suffix:

<m> 1..8

Selects the measurement.

Parameters:

<Beep> NOACtion | SUCCess | VIOLation

See chapter 14.2.1.5, "Event Parameter", on page 333

*RST: NOACtion

Usage: SCPI conform

MEASurement<m>:ONViolation:ACQStop <StopAcq>

Stops data acquisition for the specified event.

Suffix:

<m> 1..8

Selects the measurement.

Parameters:

<StopAcq> NOACtion | SUCCess | VIOLation

See chapter 14.2.1.5, "Event Parameter", on page 333

*RST: NOACtion

Usage: SCPI conform

MEASurement<m>:ONViolation:PRINt <Print>

Prints a screenshot including the measurement results to the printer defined using SYSTem:COMMunicate:PRINter:SELect<1..2> for the specified event.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<Print> NOACtion | SUCCess | VIOLation

See chapter 14.2.1.5, "Event Parameter", on page 333

*RST: NOACtion

Usage: SCPI conform

MEASurement<m>:ONViolation:WFMSave <SaveWfm>

Saves the waveform data.

Suffix:

<m> 1..8
Selects the measurement.

Parameters:

<SaveWfm> NOACtion | SUCCess | VIOLation

See chapter 14.2.1.5, "Event Parameter", on page 333

*RST: NOACtion

Usage: SCPI conform

14.2.7.12 Reference Level

General Reference Level

REFLevel<m>:LDETection <LevelDetection>

Defines whether the reference level is configured manually or automatically.

For automatic configuration, select the signal level to be used (see REFLevel<m>:AUTO:MODE on page 460).

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<LevelDetection> AUTO | MANual

*RST: AUTO

REFLevel<m>:RELative:MODE <RelativeLevels>

The lower, middle and upper reference levels, defined as percentages of the high signal level.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<RelativeLevels> FIVE | TEN | TWENty

FIVE
5/50/95

TEN
10/50/90

TWENty
10/50/90

*RST: TEN

Example: `REFL<1>:REL:MODE FIVE`
lower reference level = 5% of high signal level
middle reference level = 50% of high signal level
upper reference level = 95% of high signal level

Usage: SCPI conform

REFLevel<m>:USRLevel <UserLevel>

Defines whether the user-defined signal levels or user-defined reference levels are used for the measurements.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:

<UserLevel> USIGnal | UREF

USIGnal
The high and low signal levels are defined by the user.

UREF
The reference levels are defined by the user.

*RST: USIGnal

REFLevel<m>:LMODe <LevelMode>

Defines whether the reference is configured using absolute or relative values.

Suffix:

<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:

<LevelMode> ABS | REL

*RST: REL

Automatic Configuration

REFLevel<m>:AUTO:MODE <AutoLevelMode>

Defines which signal level is used as a reference.

This setting is only available for automatic reference level mode (see REFLevel<m>:LDETection on page 458).

Suffix:

<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:

<AutoLevelMode> AUTO | PPRobability | MPRobability | ABSolutepeak

*RST: AUTO

Usage: SCPI conform

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 458).

Suffix:

<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:

<HistgAveraging> ON | OFF

*RST: OFF

Usage: SCPI conform

REFLevel<m>:AUTO:COUNt <Weight>

Defines the number of histograms to calculate the average from if REFLevel<m>:AUTO[:STATe] is set to ON.

This function is only available in automatic reference level mode (see REFLevel<m>:LDETection on page 458).

Suffix:

<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:

<Weight>

Range: 2 to 128
Increment: 2
*RST: 128

Usage: SCPI conform

Manual Configuration

User Signal Level

REFLevel<m>:ABSolute:HIGH <SignalHigh>

The signal value that represents a high level.

Suffix:

<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<SignalHigh>

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: SCPI conform

REFLevel<m>:ABSolute:LOW <SignalLow>

The signal value that represents a low level.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<SignalLow>

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: SCPI conform

REFLevel<m>:ABSolute:TDIStance <TopDistance>

The distance between the high signal level and the upper reference level.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<TopDistance>

Range: 0 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: SCPI conform

REFLevel<m>:ABSolute:BDIStance <BottomDistance>

The distance between the lower reference level and the low signal value.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<BottomDistance>

Range: 0 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: SCPI conform

User Reference Level

REFLevel<m>:ABSolute:ULEVel <UpperLevel>

The upper reference level, required e.g. to determine a rise.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<UpperLevel>

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: SCPI conform

REFLevel<m>:ABSolute:MLEVel <MiddleLevel>

The middle reference level.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<MiddleLevel>

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: SCPI conform

REFLevel<m>:ABSolute:LLEVel <LowerLevel>

The lower reference level, required e.g. to determine a fall.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<LowerLevel>

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: SCPI conform

Hysteresis

REFLevel<m>:RELative:HYSTeresis <Hysteresis>

Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<Hysteresis>

Range: 0 to 50
Increment: 1
*RST: 5
Default unit: %

Tube

REFLevel<m>:RELative:OTUBe <TubeRelOuterDist>

Defines a percentage of the signal level by which the absolute signal level may be larger than the high signal level or lower than the low signal level to be considered high or low, respectively.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<TubeRelOuterDist>

Range: 0 to 100
Increment: 1
*RST: 10
Default unit: %

Usage: SCPI conform

REFLevel<m>:RELative:ITUBe <TubeRelInnDist>

Defines a percentage of the signal level by which the absolute signal level may be higher than the low signal level or lower than the high signal level to be considered low or high, respectively.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<TubeRelInnDist>

Range: 0 to 50
Increment: 1
*RST: 0
Default unit: %

Usage: SCPI conform

REFLevel<m>:ABSolute:TOTube <TubeTopOuterDist>

Defines an area above the high signal level which is still considered to be high level.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<TubeTopOuterDist>

Range: 0 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: SCPI conform

REFLevel<m>:ABSolute:TITube <TubeTopInnDist>

Defines an area beneath the high signal level which is still considered to be high level.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<TubeTopInnDist>
Range: 0 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: SCPI conform

REFLevel<m>:ABSolute:BITube <TubeBottomInnDist>

Defines an area above the low signal level which is still considered to be low level.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<TubeBottomInnDist>
Range: 0 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: SCPI conform

REFLevel<m>:ABSolute:BOTube <TubeBottomOuterDist>

Defines an area beneath the low signal level which is still considered to be low level.

Suffix:
<m> 1..37
Source waveform number from which the reference is taken, see chapter 14.2.1.1, "Waveform Suffix", on page 331.

Parameters:
<TubeBottomOuterDist>
Range: 0 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: SCPI conform

Results

MEASurement<m>:REFLevel:RESult:BINNer?

Returns the area above the low signal level which is still considered to be low level.

Suffix:
<m> 1..8
Selects the measurement.

Return values:
<BottomInner>
Range: -100E+24 to 100E+24
Increment: 0
*RST: 0

Usage: Query only
SCPI conform

MEASurement<m>:REFLevel:RESult:BOUTer?

Returns the area beneath the low signal level which is still considered to be low level.

Suffix:
<m> 1..8
Selects the measurement.

Return values:
<BottomOuter>
Range: -100E+24 to 100E+24
Increment: 0
*RST: 0

Usage: Query only
SCPI conform

MEASurement<m>:REFLevel:RESult:LOWer?

Returns the lower reference level.

Suffix:
<m> 1..8
Selects the measurement.

Return values:
<Lower>

Range:	-100E+24 to 100E+24
Increment:	0
*RST:	0

Usage: Query only
SCPI conform

MEASurement<m>:REFLevel:RESult:MIDDle?

Returns the middle reference level.

Suffix:
<m> 1..8
Selects the measurement.

Return values:
<Middle>

Range:	-100E+24 to 100E+24
Increment:	0
*RST:	0

Usage: Query only
SCPI conform

MEASurement<m>:REFLevel:RESult:UPPer?

Returns the upper reference level.

Suffix:
<m> 1..8
Selects the measurement.

Return values:
<Upper>

Range:	-100E+24 to 100E+24
Increment:	0
*RST:	0

Usage: Query only
SCPI conform

MEASurement<m>:REFLevel:RESult:SIGHigh?

Returns the signal value that represents a high level.

Suffix:
<m> 1..8
Selects the measurement.

Return values:
<SignalHigh>

Range: -100E+24 to 100E+24
Increment: 0
*RST: 0

Usage: Query only
SCPI conform

MEASurement<m>:REFLevel:RESult:SIGLow?

Returns the signal value that represents a low level.

Suffix:
<m> 1..8
Selects the measurement.

Return values:
<SignalLow>

Range: -100E+24 to 100E+24
Increment: 0
*RST: 0

Usage: Query only
SCPI conform

MEASurement<m>:REFLevel:RESult:TINNer?

Returns the area beneath the high signal level which is still considered to be high level.

Suffix:
<m> 1..8
Selects the measurement.

Return values:
<TopInner>

Range: -100E+24 to 100E+24
Increment: 0
*RST: 0

Usage: Query only
SCPI conform

MEASurement<m>:REFLevel:RESult:TOUTer?

Returns the area above the high signal level which is still considered to be high level.

Suffix:
<m> 1..8
Selects the measurement.

Return values:
<TopOuter>

Range: -100E+24 to 100E+24
Increment: 0
*RST: 0

Usage: Query only
SCPI conform

14.2.8 Mathematics

14.2.8.1 General Mathematics

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 math waveforms are used to create envelope and average.

See also: `CHANnel<m>[:WAVeform<n>]:ARIThmetics` on page 344.

Suffix:
<m> 1..4
Selects the math waveform.

Parameters:
<Arithmetics> OFF | ENVelope | AVERage
waveform arithmetic mode
*RST: OFF

CALCulate:MATH<m>:STATe <State>

Enables the math waveform display.

Suffix:
<m> 1..4
math waveform

Parameters:

<State> ON | OFF

*RST: OFF

Usage: SCPI conform

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 table 6-1.

Suffix:

<m> 1..4
math waveform

Parameters:

<RemComplExpr> regular expression for calculation

Usage: SCPI conform

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+24 to 100E+24
Increment: 0.01
*RST: 0
Default unit: div

Usage: SCPI conform

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 100E+24
Increment: 0.01
*RST: 0
Default unit: div

Usage: SCPI conform

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: 100E-12 to 100E+24
Increment: 10E-6
*RST: 0.5
Default unit: V/div

Usage: SCPI conform

14.2.8.2 FFT

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 100E+24 Increment: 1 *RST: 0 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 2E+9 Increment: 1 *RST: 2E+9 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 RTO 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 | 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

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

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: 10000 to 4E+12
Increment: 100
*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: -100E+24 to 100E+24
Increment: 0.1
*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 resolution bandwidth (Hz) / span (Hz).

Suffix:

<m>	1..4 math waveform

Parameters:

<SpanRBWRatio>	ratio resolution bandwidth / span	
	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:	100 to 2E+6
	Increment:	0.1
	*RST:	2E+6
	Default unit:	Hz

CALCulate:MATH<m>:FFT:GATE:COUPling <GateRBWCoupling>

Defines the behaviour of the record length or RBW value in dependancy to the other FFT parameters.

For details see "Record Length/RBW Coupling" on page 187 and chapter 6.1.1, "General Notes and Restrictions for FFT Analysis", on page 163.

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 conform

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 500
Increment: 1E-12
*RST: 0.5
Default unit: s

Usage: Query only

CALCulate:MATH<m>:FFT:FRAMe:ARIThmetics <Arithmetics>

The arithmetic mode defines how the final FFT result is calculated from the individual frame results.

For details on the available modes, see "Frame Arithmetics" on page 182.

Suffix:
<m> 1...4
math waveform

Parameters:
<Arithmetics> OFF | ENVelope | AVERage

*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 478), 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
Increment:	1
*RST:	100
Default unit:	%

Usage: Query only
SCPI conform

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 conform

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 conform

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 conform

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 conform

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 conform

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: -100E+24 to 100E+24
Increment: 0.1
*RST: 0
Default unit: %

Usage: SCPI conform

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: -100E+24 to 100E+24
Increment: 0.1
*RST: 100
Default unit: %

Usage: SCPI conform

CALCulate:MATH<m>:FFT:GATE:SHOW <DisplayState>

Indicates the gate area in the source diagram.

Suffix:

<m> 1...4
math waveform

Parameters:

<DisplayState> ON | OFF

*RST: OFF

Usage: SCPI conform

CALCulate:MATH<m>:FFT:GATE:ZCOupling <ZoomCoupling>

If enabled, the gate area is defined identically to the zoom area for the zoom diagram defined using `CALCulate:MATH<m>:FFT:GATE:ZDIagram`.

Suffix:

<m>	1...4 math waveform

Parameters:

<ZoomCoupling>	ON | OFF *RST: OFF

Usage: SCPI conform

CALCulate:MATH<m>:FFT:GATE:ZDIagram <MathSpectralGatingZoomDiag>, <MathSpectralGatingZoomDiag>

CALCulate:MATH<m>:FFT:GATE:ZDIagram? <MathSpectralGatingZoomDiag>

If `CALCulate:MATH<m>:FFT:GATE:ZCOupling` is set to "ON", the gate area is defined identically to the zoom area for the zoom diagram specified with this command.

Suffix:

<m>	1..4 math waveform

Parameters:

<MathSpectralGatingZoomDiag>

Parameters for setting and query:

<MathSpectralGatingZoomDiag>	<string> The name of the zoom diagram whose zoom area is to be used.

Usage: SCPI conform

CALCulate:MATH<m>:FFT:GATE[:STATe] <State>

Enables FFT gating.

Suffix:

<m>	1...4 math waveform

Parameters:

<State>	ON | OFF *RST: OFF

Usage: SCPI conform

CALCulate:MATH<m>:FFT:MAGNitude:LEVel <ReferenceLevel>

Defines the reference level for dB scaling.

Suffix:

<m>	1...4 math waveform

Parameters:
<ReferenceLevel>

Range: -100 to 50
Increment: 0.1
*RST: 0
Default unit: dBm

Usage: SCPI conform

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 conform

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 183.

Suffix:
<m> 1...4
math waveform

Parameters:
<MagnitudeScale> LINear | DBM | DB | DBUV | DBMV | DBV

LINear
linear scaling; displays the RMS value of the voltage

DB
logarithmic scaling; related to reference level

*RST: DBM

Usage: SCPI conform

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 conform

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 483).

Suffix:

<m> 1...4
math waveform

Parameters:

<Suppression> ON | OFF

*RST: OFF

Usage: SCPI conform

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 conform

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 conform

14.2.8.3 Waveform Data

CALCulate:MATH<m>:DATA:STYPe?

Suffix:

<m>	1..4
Usage:	Query only SCPI conform

CALCulate:MATH<m>:DATA:HEADer?

Returns the header of math waveform data. The header contains attributes of the waveform.

Suffix:

<m>	1..4 Selects the math waveform.
Usage:	Query only SCPI conform

CALCulate:MATH<m>:DATA[:VALues]?

Returns the data of the math waveform points. The waveform data can be used in MATLAB, for example.

Suffix:

<m>	1..4 Selects the math waveform.

Return values:

<Data>	Comma-separated value list. The first value is the length: the number of waveform data values. The second value indicates the data format: int8, int16, int24, int32, float, double or none. The actual waveform data starts with the third value. These are the vertical values - voltages of recorded waveform samples, or magnitudes of a spectrum.
Usage:	Query only

14.2.9 Reference Waveforms

14.2.9.1 Reference

REFCurve<m>:SOURce <Source>

Selects the source waveform to be used as a reference.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<Source> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the reference waveform, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*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> '<string>'

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 486.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

REFCurve<m>:UPDate

Copies the selected source waveform (see `REFCurve<m>:SOURce` on page 485) 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 486.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

REFCurve<m>:DELete

Deletes the reference waveform file selected by `REFCurve<m>:NAME` on page 486.

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

REFCurve<m>:RESTore

Restores the settings of the source waveform, if vertical scaling is set to "Independent" (see `REFCurve<m>:VMODe` on page 487).

Suffix:

<m> 1..4
Reference waveform

Usage: Event
SCPI conform

REFCurve<m>:NEW

Suffix:

<m> 1..4
Reference waveform

Usage: Event

14.2.9.2 Scaling

REFCurve<m>:VMODe <VerticalMode>

Selects the coupling of vertical settings.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<VerticalMode> COUPled | INDependent

COUPled
Vertical position and scale of the source are used.

INDependent
Scaling and position can be set specific to the reference waveform.

*RST: INDependent

REFCurve<m>:SCALe <VerticalScale>

Sets the scale factor for the reference waveform if vertical scaling is set to "Independent" (see `REFCurve<m>:VMODe` on page 487).

Suffix:

<m> 1..4
Reference waveform

Parameters:

<VerticalScale>

Range: 100E-12 to 100E+24
Increment: 10E-6
*RST: 0.5
Default unit: V/div

Usage: SCPI conform

REFCurve<m>:POSition <VertPosi>

Moves the reference waveform and its horizontal axis up or down in the diagram, if vertical scaling is set to "Independent" (see `REFCurve<m>:VMODe` on page 487).

Suffix:

<m> 1..4
Reference waveform

Parameters:

<VertPosi>

Range: -100E+24 to 100E+24
Increment: 0.2
*RST: 0
Default unit: div

Usage: SCPI conform

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:FACTor <ScaleFactor>

Defines the vertical stretching factor. A factor greater than 1 stretches the waveform vertically, a factor lower than 1 compresses the curve.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<ScaleFactor>

Range: -1E+6 to 1E+6
Increment: 0.1
*RST: 1

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>:HMODe <HorizontalMode>

Selects the coupling of horizontal settings.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<HorizontalMode> ORIGinal | COUPled

ORIGinal
Horizontal scaling and reference point of the source waveform are used.

COUPled
The current horizontal settings of the diagram are used.

*RST: ORIGinal

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:FACTor <ScaleFactor>

A factor greater than 1 stretches the waveform horizontally, a factor lower than 1 compresses the curve.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<ScaleFactor>

Range: 1E-6 to 1E+6
Increment: 0.1
*RST: 1

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

14.2.9.3 Waveform Data

REFCurve:DATA:STYPe?

Usage: Query only
SCPI conform

REFCurve:DATA:HEADer?

Returns the header of reference waveform data. The header contains scaling and original attributes of the waveform.

Usage: Query only
SCPI conform

REFCurve:DATA[:VALues]?

Returns the data of the channel waveform points. The waveform data can be used in MATLAB, for example.

Return values:
<Data> Comma-separated value list. The first value is the length: the number of waveform data values. The second value indicates the data format: int8, int16, int24, int32, float, double or none. The actual waveform data starts with the third value. These are the vertical values - voltages of recorded waveform samples, or magnitudes of a spectrum.

Usage: Query only

14.2.10 Masks

14.2.10.1 Mask Test Definition

MTESt:ADD <MaskTestName>

Creates a new mask test definition with the specified name.

Setting parameters:
<MaskTestName>

Usage: Setting only
SCPI conform

MTESt:REMove <MaskTestName>

Deletes the mask test definition with the specified name.

Setting parameters:
<MaskTestName>

Usage: Setting only
SCPI conform

MTESt:RESet

Clears all totals and results in all "Mask Test" result boxes.

Usage: Event

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".

Parameters:
<State> ON | OFF

*RST: OFF

Parameters for setting and query:
<MaskTestName>

Usage: SCPI conform

MTESt:SOURce <MaskTestName>,<MaskTestSource>

MTESt:SOURce? <MaskTestName>

Selects the waveform to be tested against the mask. All channel, math, and reference waveforms can be tested.

Parameters:

<MaskTestSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Waveform to be tested, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Parameters for setting and query:

<MaskTestName>

Usage: SCPI conform

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>

Usage: SCPI conform

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>

Usage: SCPI conform

MTESt:NTES?

Returns the number of mask test definitions.

Usage: Query only

14.2.10.2 Mask Segment Definition

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>
<MaskSegmIdx> Index of the mask segment in the mask definition

Usage: SCPI conform

MTESt:SEGMent:ADD <MaskTestName>

Creates a new segment in the mask definition.

Setting parameters:
<MaskTestName>

Usage: Setting only
SCPI conform

MTESt:SEGMent:COUNt? <MaskTestName>, <MaskSegmIdx>

Returns the number of segments in the mask definition

Query parameters:
<MaskTestName>
<MaskSegmIdx> Index of the mask segment in the mask definition

Usage: Query only
SCPI conform

MTESt:SEGMent:INSert <MaskTestName>, <MaskSegmIdx>

Inserts a new segment before the specified index in the mask definition.

Setting parameters:
<MaskTestName>
<MaskSegmIdx> Index of the mask segment in the mask definition

Usage: Setting only
SCPI conform

MTESt:SEGMent:REMove <MaskTestName>, <MaskSegmIdx>

Removes the specified segment from the mask definition.

Setting parameters:
<MaskTestName>
<MaskSegmIdx> Index of the mask segment in the mask definition

Usage: Setting only
SCPI conform

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>

<MaskSegmIdx> Index of the mask segment in the mask definition

Usage: SCPI conform

MTESt:SEGMent:POINt:ADD <MaskTestName>, <MaskSegmIdx>

Adds a new point to the segment definition.

Setting parameters:

<MaskTestName>

<MaskSegmIdx> Index of the mask segment in the mask definition

Usage: Setting only
SCPI conform

MTESt:SEGMent:POINt:INSert <MaskTestName>, <MaskSegmIdx>, <MaskSegmPointIdx>

Inserts a new point before the specified mask segment point.

Setting parameters:

<MaskTestName>

<MaskSegmIdx> Index of the mask segment in the mask definition

<MaskSegmPointIdx> Index of the mask segment point in the mask definition

Usage: Setting only
SCPI conform

MTESt:SEGMent:POINt:REMove <MaskTestName>, <MaskSegmIdx>, <MaskSegmPointIdx>

Removes the specified point from the mask segment.

Setting parameters:
<MaskTestName>
<MaskSegmIdx> Index of the mask segment in the mask definition

<MaskSegmPointIdx> Index of the mask segment point in the mask definition

Usage: Setting only
SCPI conform

MTESt:SEGMent:POINt:COUNt? <MaskTestName>, <MaskSegmIdx>

Returns the number of defined points for the specified mask segment.

Query parameters:
<MaskTestName>
<MaskSegmIdx> Index of the mask segment in the mask definition

Usage: Query only
SCPI conform

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>
<MaskSegmIdx> Index of the mask segment in the mask definition

<MaskSegmPointIdx> Index of the mask segment point in the mask definition

Usage: SCPI conform

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>
<MaskSegmIdx> Index of the mask segment in the mask definition

<MaskSegmPointIdx> Index of the mask segment point in the mask definition

Usage: SCPI conform

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>
<MaskSegmIdx> Index of the mask segment in the mask definition

Usage: Setting only
SCPI conform

MTESt:SEGMent:RESCale:XFACtor <MaskTestName>, <MaskSegmIdx>,<ExpansionFactorX>

MTESt:SEGMent:RESCale:XFACtor? <MaskTestName>, <MaskSegmIdx>

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.

Only takes effect after the `MTESt:SEGMent:RESCale:RECalculate` command.

Parameters:
<ExpansionFactorX>

Range: -100 to 100
Increment: 1
*RST: 1

Parameters for setting and query:
<MaskTestName>
<MaskSegmIdx> Index of the mask segment in the mask definition

Usage: SCPI conform

MTESt:SEGMent:RESCale:YFACtor <MaskTestName>, <MaskSegmIdx>,<ExpansionFactorY>

MTESt:SEGMent:RESCale:YFACtor? <MaskTestName>, <MaskSegmIdx>

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.

Only takes effect after the `MTESt:SEGMent:RESCale:RECalculate` command.

Parameters:

<ExpansionFactorY>

Range: -100 to 100
Increment: 1
*RST: 1

Parameters for setting and query:

<MaskTestName>

<MaskSegmIdx> Index of the mask segment in the mask definition

Usage: SCPI conform

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>

<MaskSegmIdx> Index of the mask segment in the mask definition

Usage: SCPI conform

14.2.10.3 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 14.2.1.5, "Event Parameter", on page 333

*RST: NOAction

Parameters for setting and query:

<MaskTestName>

MTESt:ONViolation:STOP <MaskTestName>,<StopAcq>

MTESt:ONViolation:STOP? <MaskTestName>

Stops data acquisition for the specified event.

Parameters:

<StopAcq> NOAction | SUCCess | VIOLation

See chapter 14.2.1.5, "Event Parameter", on page 333

*RST: NOAction

Parameters for setting and query:

<MaskTestName>

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 chapter 14.2.1.5, "Event Parameter", on page 333

*RST: NOAction

Parameters for setting and query:

<MaskTestName>

MTESt:ONViolation:SAVewaveform <MaskTestName>,<SaveWfm>

MTESt:ONViolation:SAVewaveform? <MaskTestName>

Saves the waveform data.

Parameters:

<SaveWfm> NOAction | SUCCess | VIOLation

See chapter 14.2.1.5, "Event Parameter", on page 333

*RST: NOAction

Parameters for setting and query:
<MaskTestName>

14.2.10.4 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 502).

Return values:
<State> RUNNing | FINished

*RST: RUNNing

Query parameters:
<MaskTestName>
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 493, `MTESt:RESult:COUNt:FAILures` on page 502 and `MTESt:RESult:COUNt:FWAVeforms` on page 502).

Return values:
<TestResult> PASS | FAIL

*RST: PASS

Query parameters:
<MaskTestName>
Usage: Query only

MTESt:RESult:COUNt:WAVeforms? <MaskTestName>

Returns the number of tested acquisitions.

Return values:
<AcqsCompleted>

Range: 0 to 100E+24
Increment: 1
*RST: 0

Query parameters:
<MaskTestName>

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 7.2.5, "Running a Mask Test", on page 203.

Return values:
<AcqsRemaining>

Range: 0 to 100E+24
Increment: 1
*RST: 0

Query parameters:
<MaskTestName>

Usage: Query only

MTESt:RESult:COUNt:FWAVeforms? <MaskTestName>

Returns the number of acquisitions that contained at least one sample hit.

Return values:
<AcquisitionHits>

Range: 0 to 100E+24
Increment: 1
*RST: 0

Query parameters:
<MaskTestName>

Usage: Query only

MTESt:RESult:COUNt:FAILures? <MaskTestName>

Returns the number of sample hits that violated the mask.

Return values:
<SampleHits>

Range: 0 to 100E+24
Increment: 1
*RST: 0

Query parameters:
<MaskTestName>
Usage: Query only

MTESt:RESult:FRATe? <MaskTestName>

Ratio of acquisition hits to the number of tested acquisitions.

Return values:
<FailRate>
Range: -100E+24 to 100E+24
Increment: 0
*RST: 0
Default unit: %

Query parameters:
<MaskTestName>
Usage: Query only

MTESt:RESult:SUMMary? <MaskTestName>

Return values:
<TestSummary>
Range: 0 to 100E+24
Increment: 1
*RST: 0

Query parameters:
<MaskTestName>
Usage: Query only

14.2.11 Search Commands

14.2.11.1 General Search Settings

SEARch:ADD <Key>

Creates a new search definition with the specified name.

Setting parameters:

<Key> Name of the search definition

Usage: Setting only
SCPI conform

SEARch:CLEar <SearchName>

Clears the search results once to start a new search.

Setting parameters:

<SearchName> Search definition

Usage: Setting only

SEARch:REMove <Key>

Deletes the specified search definition.

Setting parameters:

<Key> Name of the search definition

Usage: Setting only
SCPI conform

SEARch:ALL <SearchName>

Performs a search for all results on the existing data from the selected source.

Setting parameters:

<SearchName> Search definition

Usage: Setting only
Asynchronous command

SEARch:NEXT <SearchName>

Performs a single search for the next result on the existing data from the selected source.

Setting parameters:

<SearchName> Search definition

Usage: Setting only
Asynchronous command

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:SOURce <SearchName>,<SearchConditionSrc>

SEARch:SOURce? <SearchName>

Defines the source on which the search conditions are applied. The source can be any input signal, math or reference waveform.

Parameters:

<SearchConditionSrc> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the search, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Parameters for setting and query:

<SearchName> Search definition

SEARch:CATegory <SearchName>,<Category>

SEARch:CATegory? <SearchName>

Assigns the search definition to a search category.

Parameters:

<Category> TRIGger | FREQuencymarker | MEASurement | LOGic

TRIGger
Trigger condition search on a source waveform in the time domain

FREQuencymarker
Search on a source waveform in the frequency domain

MEASurement
Currently not available

LOGic
Currently not available

*RST: TRIGger

Parameters for setting and query:

<SearchName> Name of the search definition

Usage: SCPI conform

SEARch:TRIGger:CONDitions? <SearchName>

The trigger search condition defines a logic search. It provides logical combinations of the input channels, math or reference waveforms, and supports you in verifying the operation of digital logic.

See also chapter 8.3.2, "Qualification Editor", on page 221.

Return values:

<sData> Regular expression defining the logic search.

Query parameters:

<SearchName> Search definition

Usage: Query only
SCPI conform

14.2.11.2 Search Conditions

Basic

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:RUNT[:STATe] <SearchName>,<State>

SEARch:TRIGger:RUNT[:STATe]? <SearchName>
SEARch:TRIGger:SLEWrate[:STATe] <SearchName>,<State>

SEARch:TRIGger:SLEWrate[: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

Usage: SCPI conform

SEARch:TRIGger:DATatoclock:ACOPy <SearchName>
SEARch:TRIGger:EDGE:ACOPy <SearchName>
SEARch:TRIGger:GLITch:ACOPy <SearchName>
SEARch:TRIGger:INTerval:ACOPy <SearchName>
SEARch:TRIGger:RUNT:ACOPy <SearchName>
SEARch:TRIGger:SLEWrate: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 3.3.1, "Events", on page 53.

Setting parameters:

<SearchName> Search definition

Usage: Setting only
SCPI conform

SEARch:TRIGger:DATatoclock:BCOPy <SearchName>
SEARch:TRIGger:EDGE:BCOPy <SearchName>
SEARch:TRIGger:GLITch:BCOPy <SearchName>
SEARch:TRIGger:INTerval:BCOPy <SearchName>
SEARch:TRIGger:RUNT:BCOPy <SearchName>
SEARch:TRIGger:SLEWrate:BCOPy <SearchName>
SEARch:TRIGger:TIMeout:BCOPy <SearchName>
SEARch:TRIGger:WIDTh:BCOPy <SearchName>
SEARch:TRIGger:WINDow:BCOPy <SearchName>

Copies the trigger event configuration from Trigger B for the selected channel source to the search condition settings.

See also: chapter 3.3.1, "Events", on page 53.

Setting parameters:

<SearchName> Search definition

Usage: Setting only
SCPI conform

Data2Clock

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 14.2.1.3, "Slope Parameter", on page 332.

*RST: POSitive

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

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

Usage: SCPI conform

SEARch:TRIGger:DATatoclock:CSOurce <SearchName>,<ClockSource>

SEARch:TRIGger:DATatoclock:CSOurce? <SearchName>

Selects the waveform used for the clock signal.

Parameters:
<ClockSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the clock signal, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: C1W1

Parameters for setting and query:
<SearchName> Search definition name

Usage: SCPI conform

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

Usage: SCPI conform

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

Usage: SCPI conform

Edge

SEARch:TRIGger:EDGE:SLOPe <SearchName>,<Slope>

SEARch:TRIGger:EDGE:SLOPe? <SearchName>

Selects the edge type.

Parameters:

<Slope> POSitive | NEGative | EITHer

See chapter 14.2.1.3, "Slope Parameter", on page 332.

*RST: POSitive

Parameters for setting and query:

<SearchName> Search definition

Usage: SCPI conform

Glitch

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 14.2.1.4, "Polarity Parameter", on page 332.

*RST: POSitive

Parameters for setting and query:

<SearchName> Search definition

Usage: SCPI conform

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 512).

Parameters:

<RangeMode> SHORter | LONGer

*RST: SHORter

Parameters for setting and query:

<SearchName> Search definition

Usage: SCPI conform

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 511).

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

Usage: SCPI conform

Interval

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 513).

Parameters:
<WidthDelta>

Range: 0 to 10
Increment: 100E-9
*RST: 0
Default unit: s

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

SEARch:TRIGger:INTerval:POLarity <SearchName>,<Polarity>

SEARch:TRIGger:INTerval:POLarity? <SearchName>

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

Parameters:

<Polarity> POSitive | NEGative | EITHer

See chapter 14.2.1.4, "Polarity Parameter", on page 332.

*RST: POSitive

Parameters for setting and query:

<SearchName> Search definition

Usage: SCPI conform

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 513 and `SEARch:TRIGger:INTerval:DELTa` on page 512).

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

Usage: SCPI conform

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

Usage: SCPI conform

Runt

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

Usage: SCPI conform

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 14.2.1.4, "Polarity Parameter", on page 332.
*RST: POSitive

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

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 515 and SEARch:TRIGger:RUNT:DELTa on page 514).

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

Usage: SCPI conform

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 515.

Parameters:

<Width>

Range: 100E-12 to 864
Increment: 100E-9
*RST: 5E-9
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

Usage: SCPI conform

SEARch:TRIGger:LEVel:RUNT:LOWer <Key>, <SignalSource>, <Value>

SEARch:TRIGger:LEVel:RUNT:LOWer? <Key>, <SignalSource>

Sets the lower voltage threshold.

Parameters:

<Value> Voltage value

Parameters for setting and query:

<Key> Search definition

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the search, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

SEARch:TRIGger:LEVel:RUNT:UPPer <Key>, <SignalSource>, <Value>

SEARch:TRIGger:LEVel:RUNT:UPPer? <Key>, <SignalSource>

Sets the upper voltage threshold.

Parameters:

<Value> Voltage value

Parameters for setting and query:

<Key> Search definition

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the search, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

Slew Rate

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> Search definition

Usage: SCPI conform

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> Search definition

Usage: SCPI conform

SEARch:TRIGger:SLEWrate:SLOPe <SearchName>,<Slope>

SEARch:TRIGger:SLEWrate:SLOPe? <SearchName>

Selects the edge type.

Parameters:
<Slope> POSitive | NEGative | EITHer

See chapter 14.2.1.3, "Slope Parameter", on page 332.

*RST: POSitive

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

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> Search definition

Usage: SCPI conform

SEARch:TRIGger:LEVel:TRANsition:LOWer <Key>, <SignalSource>, <Value>

SEARch:TRIGger:LEVel:TRANsition:LOWer? <Key>, <SignalSource>

Sets the lower voltage threshold. 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:
<Key> Search definition

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the search, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

SEARch:TRIGger:LEVel:TRANsition:UPPer <Key>, <SignalSource>, <Value>

SEARch:TRIGger:LEVel:TRANsition:UPPer? <Key>, <SignalSource>

Sets the upper voltage threshold. 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:

<Key> Search definition

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the search, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

Timeout

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

Usage: SCPI conform

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

Usage: SCPI conform

Width

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 521).

Parameters:

<WidthDelta>

Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

Usage: SCPI conform

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 14.2.1.4, "Polarity Parameter", on page 332.

*RST: POSitive

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

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 521 and `SEARch:TRIGger:WIDTh:DELTa` on page 520).

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

Usage: SCPI conform

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

Usage: SCPI conform

Window

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 524).

Parameters:
<WidthDelta>
Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

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

Usage: SCPI conform

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 522).

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

Usage: SCPI conform

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

Usage: SCPI conform

SEARch:TRIGger:LEVel:WINDow:LOWer <Key>, <SignalSource>, <Value>

SEARch:TRIGger:LEVel:WINDow:LOWer? <Key>, <SignalSource>

Sets the lower voltage limit for the window.

Parameters:

<Value> Voltage value

Parameters for setting and query:

<Key> Search definition

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the search, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

SEARch:TRIGger:LEVel:WINDow:UPPer <Key>, <SignalSource>, <Value>

SEARch:TRIGger:LEVel:WINDow:UPPer? <Key>, <SignalSource>

Sets the upper voltage limit for the window.

Parameters:

<Value> Voltage value

Parameters for setting and query:

<Key> Search definition

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the search, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

14.2.11.3 Trigger Level

SEARch:TRIGger:LEVel[:VALue] <Key>, <SignalSource>, <Value>

SEARch:TRIGger:LEVel[:VALue]? <Key>, <SignalSource>

Sets the voltage level for the trigger level that is used to determine other parameters.

Parameters:

<Value> Voltage value

Parameters for setting and query:

<Key> Search definition

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the search, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

SEARch:TRIGger:FINDlevel <SearchName>

Sets the trigger level automatically to 0.5 * (MaxPeak – MinPeak). The function is not available for an external trigger source.

Setting parameters:

<SearchName> Search definition

Usage: Setting only
SCPI conform

14.2.11.4 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

Usage: SCPI conform

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

Usage: SCPI conform

SEARch:GATE:SHOW <SearchName>,<DisplayState>

SEARch:GATE:SHOW? <SearchName>

If enabled, the gate area is indicated in the source diagram.

Parameters:

<DisplayState> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName> Search definition

Usage: SCPI conform

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

Usage: SCPI conform

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

Usage: SCPI conform

SEARch:GATE:RELative:STARt <SearchName>,<RelativeStart>

SEARch:GATE:RELative:STARt? <SearchName>

Defines the starting value for the gate.

Parameters:
<RelativeStart>

Range:	-100E+24 to 100E+24
Increment:	0.1
*RST:	0
Default unit:	%

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

SEARch:GATE:RELative:STOP <SearchName>,<RelativeStop>

SEARch:GATE:RELative:STOP? <SearchName>

Defines the end value for the gate.

Parameters:
<RelativeStop>

Range:	-100E+24 to 100E+24
Increment:	0.1
*RST:	100
Default unit:	%

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

SEARch:GATE:ZCOupling <SearchName>,<ZoomCoupling>

SEARch:GATE:ZCOupling? <SearchName>

If enabled, the gate area is defined identically to the zoom area for the zoom diagram selected using `SEARch:GATE:ZDIagram`.

Parameters:
<ZoomCoupling> ON | OFF

*RST: OFF

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

SEARch:GATE:ZDIagram <SearchName>,<SearchGatingZoomDiag>, <SearchGatingZoomDiag>

SEARch:GATE:ZDIagram? <SearchName>,<SearchGatingZoomDiag>

If `SEARch:GATE:ZCOupling` is set to "ON", the gate area is defined identically to the zoom area for the zoom diagram specified with this command.

Parameters:

<SearchGatingZoomDiag> The name of the zoom diagram whose zoom area is to be used.

Parameters for setting and query:

<SearchName> Search definition

<SearchGatingZoomDiag> The name of the zoom diagram whose zoom area is to be used.

Usage: SCPI conform

SEARch:HISTory:ALL <SearchName>,<AllHistoryElems>

SEARch:HISTory:ALL? <SearchName>

If enabled, all available stored waveforms are included in the search.

Parameters:

<AllHistoryElems> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName> Search definition

Usage: SCPI conform

SEARch:HISTory:STARt <SearchName>,<StartIndex>

SEARch:HISTory:STARt? <SearchName>

Defines the index of the most recently stored waveform to be considered in the search. "0" refers to the current acquisition.

Parameters:

<StartIndex>

Range: 0 to 2147483647
Increment: 1
*RST: 0

Parameters for setting and query:

<SearchName> Search definition

Usage: SCPI conform

SEARch:HISTory:STOP <SearchName>,<StopIndex>

SEARch:HISTory:STOP? <SearchName>

Defines the index of the oldest stored waveform to be considered in the search. "0" refers to the current acquisition.

Parameters:
<StopIndex>

Range: 0 to 2147483647
Increment: 1
*RST: 1

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

SEARch:HISTory[:STATe] <SearchName>,<State>

SEARch:HISTory[:STATe]? <SearchName>

If enabled, the search source includes previously stored waveforms.

See also: chapter 4.4, "History", on page 106.

Parameters:
<State> ON | OFF

*RST: OFF

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

14.2.11.5 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

Usage: SCPI conform

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

Usage: SCPI conform

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

Usage: SCPI conform

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: -100E+24 to 100E+24
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

SEARch:RESDiagram:HORZ:RELative:SPAN <SearchName>,<RelativeSpan>

SEARch:RESDiagram:HORZ:RELative:SPAN? <SearchName>

Defines the width of the zoom area.

Parameters:
<RelativeSpan>

Range: -100E+24 to 100E+24
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

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

Usage: SCPI conform

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

Usage: SCPI conform

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

Usage: SCPI conform

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

Usage: SCPI conform

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: -100E+24 to 100E+24
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

SEARch:RESDiagram:VERT:RELative:SPAN <SearchName>,<RelativeSpan>

SEARch:RESDiagram:VERT:RELative:SPAN? <SearchName>

Defines the height of the zoom area.

Parameters:
<RelativeSpan>

Range: -100E+24 to 100E+24
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

SEARch:RESult:LIMit <SearchName>,<ResultListLimit>

SEARch:RESult:LIMit? <SearchName>

Defines the maximum number of entries in the search result table.

Parameters:
<ResultListLimit>

Range: 0 to 2147483647
Increment: 1
*RST: 20

Parameters for setting and query:
<SearchName> Search definition

Usage: SCPI conform

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

Usage: SCPI conform

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

Usage: SCPI conform

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

Usage: SCPI conform

SEARch:RESult[:ALL]? <SearchName>

Queries all search results.

Return values:
<sData> List of search results, separated by commas

Query parameters:
<SearchName> Search definition

Usage: Query only
SCPI conform

14.2.11.6 Noise Rejection

SEARch:TRIGger:LEVel:NOISe:ABSolute <Key>, <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:
<Key> Search definition

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the search, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

SEARch:TRIGger:LEVel:NOISe:MODE <Key>, <SignalSource>, <Mode>

SEARch:TRIGger:LEVel:NOISe:MODE? <Key>, <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:
<Key> Search definition

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the trigger waveform, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

SEARch:TRIGger:LEVel:NOISe:RELative <Key>, <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:

<Key> Search definition

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the search, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

SEARch:TRIGger:LEVel:NOISe[:STATe] <Key>, <SignalSource>, <State>

SEARch:TRIGger:LEVel:NOISe[:STATe]? <Key>, <SignalSource>

If enabled, the noise reject settings for the waveform are considered for the search.

Parameters:

<State> ON | OFF

Parameters for setting and query:

<Key> Search definition

<SignalSource> NONE | C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the search, see chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: SCPI conform

14.2.12 Protocols

14.2.12.1 General Setup

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 | LIN | FLEXray

*RST: I2C

Usage: Asynchronous command

BUS<m>[:STATe] <State>

Switches the protocol display on or off.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<State> ON | OFF

*RST: OFF

Usage: Asynchronous command

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

14.2.12.2 I²C

Configuration

BUS<m>:I2C:SCL:SOURce <I2CSettingsSCLSrc>

Sets the waveform of the clock line.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<I2CSettingsSCLSrc> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

See chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: Asynchronous command

BUS<m>:I2C:SDA:SOURce <I2CSettingsSDASrc>

Sets the waveform of the data line.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<I2CSettingsSDASrc>NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

See chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

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:TECHnologie`.

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:TECHnologie`.

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:TECHnologie <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 conform

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

Trigger

TRIGger<m>:I2C:MODE <Type>

Selects the trigger type for I²C analysis.

See: "Trigger type" on page 238

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

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 condition or a combination of address conditions.

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.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:

<RWBitAddress> INComplete | 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.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

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.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

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.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:

<DataReadNack> ON | OFF

*RST: ON

Usage: Asynchronous command

TRIGger<m>:I2C:AMODe <AddressType>

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:

<AddressType> BIT7 | BIT7_RW | BIT10 | AUTO | ANY

*RST: BIT7

Usage: Asynchronous command

TRIGger<m>:I2C:ADDRess <Address>

Triggers on the specified slave address, or sets the the start value of an address range.

Suffix:
<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:
<Address> Address string
*RST: 0

Usage: Asynchronous command

TRIGger<m>:I2C:ADDTo <AddressTo>

Sets the the end value of an address range.

Suffix:
<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:
<AddressTo> Address string
*RST: 0

Usage: Asynchronous command

Decoding Results (Option R&S RTO-K1)

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

INSufficient
The frame is not completely contained in the acquisition.

*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
Increment: 100E-12
*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
Increment: 100E-12
*RST: 0
Default unit: s

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>	INComplete | READ | WRITe | EITHer *RST: INComplete

Usage: Query only

BUS<m>:I2C:FRAMe<n>:RWBStart?

Returns ...

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<AddressAckBitStart>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

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>: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>:ADDRess?

Returns the address value of the indicated frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<AddressValue>	String with decimal value of the address Range: 0 to 2047 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ADEVice?

Returns the slave address of the indicated frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<DeviceAddressValue>	Range: 0 to 1023 Increment: 1 *RST: 0

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
Increment: 100E-12
*RST: 0
Default unit: s

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
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ACOMplete?

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>:COUNt?

Returns the number of decoded frames.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* The frame suffix is irrelevant and can be ignored.

Return values:

<Count>	Total number of decoded frames.

Usage: Query only

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.

Parameters:

<Data>	Comma-separated list of decimal values of the data bytes.

Usage: Query only
Asynchronous command

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:

<FrameByteData>	Decimal value Range: 0 to 255 Increment: 1 *RST: 0

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:

<FrameByteStart>

Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

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:

<FrameByteAckBitStart>

Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

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:

<FrameByteAckBit> INComplete | ACK | NACK | EITHer

*RST: INComplete

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:COMPlete?

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte number.

Return values:

<FrameByteComplete> ON | OFF

*RST: OFF

Usage: Query only

14.2.12.3 SPI

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 <SPISettingsSCLKSrc>

Sets the input channel of the clock line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SPISettingsSCLKSrc> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

See chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: Asynchronous command

BUS<m>:SPI:SSELect:SOURce <SPISettingsSlaveSelectSrc>

Sets the input channel of the Slave Select line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SPISettingsSlaveSelectSrc> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

See chapter 14.2.1.2, "Waveform Parameter", on page 332

*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 <SPISettingsMISOSrc>

Sets the input channel of the MISO line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SPISettingsMISOSrc> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

See chapter 14.2.1.2, "Waveform Parameter", on page 332

*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 <SPISettingsMOSISrc>

Sets the input channel of the MOSI line.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<SPISettingsMOSISrc> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

See chapter 14.2.1.2, "Waveform Parameter", on page 332

*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:TECHnologie <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 conform

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:TECHnologie`.

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

Trigger

TRIGger<m>:SPI:MODE <Type>

Selects the trigger type for SPI analysis.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

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.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:

<DataAlignment> BYTE | BIT

BYTE
The pattern is searched backwards from the end of each byte.

BIT
Bit-by bit: the pattern can be at any position in the data word.

*RST: BIT

Usage: Asynchronous command

TRIGger<m>:SPI:POFFset <DataPosition>

Sets the number of bytes before the first byte of interest. These offset bytes are ignored.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:
<DataPosition>

Range: 0 to 32767
Increment: 1
*RST: 0

Usage: Asynchronous command

TRIGger<m>:SPI:MISopattern <MISOPattern>

Specifies the pattern to be triggered on the MOSI line.

Suffix:
<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:
<MISOPattern>

*RST: 0

Usage: Asynchronous command

TRIGger<m>:SPI:MOSipattern <MOSIPattern>

Specifies the pattern to be triggered on the MOSI line.

Suffix:
<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:
<MOSIPattern>

*RST: 0

Usage: Asynchronous command

Decoding Results (Option R&S RTO-K1)

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 | INCFirst | INCLast | INSufficient

*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
Increment: 100E-12
*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
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:COUNt?

Returns the number of decoded frames.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* The frame suffix is irrelevant and can be ignored.

Return values:

<Count>	Total number of decoded frames.

Usage: Query only

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 list of decimal values of the data words.

Usage: Query only
Asynchronous command

BUS<m>:SPI:FRAMe<n>:ERRLength?

Returns the length of the word which contains an error.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameErrorWordLength>	Length in bit Range: 0 to 32 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:SPI:FRAMe<n>:SSSTart?

Returns the start time of slave select signal.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameSSStart>

Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:SSENd?

Returns the end time of slave select signal.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameSSEnd>

Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

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:

<FrameWordStart>

Range: -100E+24 to 100E+24
Increment: 100E-12
*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:

<FrameWordStop>

Range: -100E+24 to 100E+24
Increment: 100E-12
*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:

<FrameWordMOSIValue>

Range: 0 to 4294967295
Increment: 1
*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:
<FrameWordMOSIValue>

Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

14.2.12.4 UART

Configuration

BUS<m>:UART:RX:SOURce <UARTSettingsRxSrc>

Selects the input channel for the receiver signal.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<UARTSettingsRxSrc> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

See chapter 14.2.1.2, "Waveform Parameter", on page 332

*RST: NONE

Usage: Asynchronous command

BUS<m>:UART:TX:SOURce <UARTSettingsTxSrc>

Selects the input channel for the transmitter signal.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:

<UARTSettingsTxSrc> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

See chapter 14.2.1.2, "Waveform Parameter", on page 332

*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:TECHnologie`.

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:TECHnologie`.

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:TECHnologie <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 conform

BUS<m>:UART:BAUDrate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<Bitrate>

Range: 1000 to 10000000
Increment: 1
*RST: 9600
Default unit: Bit/s

Usage: Asynchronous command

BUS<m>:UART:PARity <Parity>

Defines the optional parity bit that is used for error detection.

See also: "Parity" on page 254.

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:BITime <InterframeTime>

Defines a timeout between a stop bit and the next start bit. The frame start is the first start bit after the interframe time.

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

BUS<m>:UART:POLarity <Polarity>

Defines if 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: IDLLow

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 | B1_5 | 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

Trigger

TRIGger<m>:UART:TYPE <Type>

Selects the trigger type for UART analysis.

See also: "Type" on page 256

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:

<Type> STBT | PCKS | DATA | PRER | BRKC | FERRor

STBT: Start bit
PCKS: Packet start
DATA: Serial pattern
PRER: Parity error
BRKC: Break condition
FERR: Stop error

*RST: STBT

Usage: Asynchronous command

TRIGger<m>:UART:SOURce <Source>

Selects the transmitter or receiver line as trigger source.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:

<Source> TX | RX

*RST: TX

Usage: Asynchronous command

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.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:

<Data> Data string
*RST: 0

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.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:

<DataPosiOperator> EQUal | NEQual | GETHan | INRange
*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.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

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.

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:

<DataPositionTo>

Range: 0 to 32767
Increment: 1
*RST: 0

Usage: Asynchronous command

TRIGger<m>:UART:OPERator <DataOperator>

Selects the operator for the data pattern (TRIGger<m>:UART:DATA).

Suffix:

<m> 1..3
Event in a trigger sequence: 1 = A-event, 3 = R-event

Parameters:

<DataOperator> EQUal | NEQual

*RST: EQUal

Usage: Asynchronous command

Decoding Results (Option R&S RTO-K1)

BUS<m>:UART:WORD<n>:RXValue?

Returns the value of the specified word on the Rx line.

Suffix:

<m> 1..4

<n> *
Selects the word.

Return values:

<WordTxValue>

Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:UART:WORD<n>:TXValue?

Returns the value of the specified word on the Tx line.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:
<WordTxValue>

Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:UART:WORD<n>:COUNt?

Suffix:
<m> 1..4
Selects the serial bus.
<n> *
Selects the word.

Return values:
<Count>

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
Increment: 100E-12
*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 | STERror | SPERror | PRERror | INSufficient

*RST: OK

Usage: Query only

BUS<m>:UART:WORD<n>:SOURce?

Returns the line on which the specified word was tranferred.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<WordSource> TX | RX

*RST: TX

Usage: Query only

14.2.13 Data Management

14.2.13.1 MMEMory Commands

The MMEMory system provides mass storage capabilities for the R&S RTO

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:CDIRectory [<directory_name>]

MMEMory:CDIRectory? [<directory_name>]

Changes the default directory for mass memory storage.

Parameters:

<directory_name> String parameter to specify the directory.

Example: `MMEM:BASE:CDIR 'C:\Temp\Setups\Basic_Setups'`

MMEMory:CATalog? <path_name>[, <format>]

Returns the contents of the current or of a specified directory.

Return values:

<used_memory> Total amount of storage currently used in the directory, in bytes.

<free_memory> Total amount of storage available in the directory, in bytes.

<file_entry> All files of the directory are listed with their file name, format and size in bytes.

Query parameters:

<path_name> String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be queried with `MMEMory:CDIRectory`.

<format> ALL | WTIMe

Example: `MMEM:BASE:CAT?`
Response:
`235009,5195137024,"SaveFil e001.xml,BIN,`
`78335","SaveFile002.xml,BIN,78338"`

Usage: Query only

MMEMory:CATalog:LENGth? [<path_name>]

Returns the number of files and subdirectories of the current or of a specified directory. The number includes the parent directory strings "." and ".." so that it corresponds to the number of strings returned by the MMEMory:CATalog? command after the initial numeric parameters.

Return values:
<count> Number of files and subdirectories.

Query parameters:
<path_name> String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be queried with MMEMory:CDIRectory?

Example: `MMEM:BASE:CAT:LENG?`
`Response: 4`

Usage: Query only

MMEMory:DCATalog? [<path_name>]

Returns the subdirectories of the current or of a specified directory.

Return values:
<file_entry> Names of the subdirectories separated by colons. The first two strings are related to the parent directory.

Query parameters:
<path_name> String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be queried with MMEMory:CDIRectory?

Example: `MMEM:BASE:DCAT?`
`Response: ".","..","temp","test","mydirectory"`

Usage: Query only

MMEMory:DCATalog:LENGth? [<path_name>]

Returns the number of subdirectories of the current or of a specified directory. The number includes the parent directory strings "." and ".." so that it corresponds to the number of strings returned by the MMEMory:DCATalog? command.

Return values:
<file_entry_count> Number of parent and subdirectories.

Query parameters:
<path_name> String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be queried with MMEMory:CDIRectory?

Example:
```
MMEM:BASE:DCAT:LENG?
Response: 5
```

Usage: Query only

MMEMory:DRIVes?

Returns a list of the drives of the instrument.

Return values:
<drive> List of strings, for example, `"C:\","D:\"`

Usage: Query only

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` command.

Setting parameters:
<FileName>

Usage: Setting only
SCPI conform

MMEMory:COPY <file_source>[, <file_destination>]

Copies an existing file to a new file.

Setting parameters:
<file_source> String parameter to specify the name of the file to be copied.

<file_destination> String parameter to specify the name of the new file. If no file destination is specified, the source file is written to the current directory, to be queried with MMEMory:CDIRectory? .

Example:
```
MMEM:BASE:COPY 'C:
\USER\DATA\quickstart.pdf','A:'
```
Copies the file `quickstart.pdf` in directory `C:\USER\DATA` to an external storage medium, mapped to drive `A:\`.

Usage: Setting only

MMEMory:MOVE <file_source>, <file_destination>

Moves an existing file to a new location.

Setting parameters:

<file_source>	String parameter to specify the name of the file to be moved.
<file_destination>	String parameters to specify the name of the new file.
Example:	`MMEM:BASE:MOVE 'C:\USER\DATA\SETUP.CFG','A:\'` Moves the file "Setup.cfg" from the directory `C:\USER\DATA` to the external storage medium, mapped to drive `A:\`.
Usage:	Setting only

MMEMory:DELete <file_name>

Removes a file from the specified directory.

Setting parameters:

<file_name>	String parameter to specify the name and directory of the file to be removed.
Example:	`MMEM:BASE:DEL 'C:\TEMP\TEST01.HCP'` Removes the file `TEST01.HCP` from `C:\TEMP\.`.
Usage:	Setting only

MMEMory:DATA <file_name>, <data>[, <append>]

MMEMory:DATA? <file_name>

Loads data into the specified file.

Parameters:

<data>	<block> Data in 488.2 block data format. The delimiter EOI must be selected to achieve correct data transfer.

Setting parameters:

<append>	APPend ???

Parameters for setting and query:

<file_name>	String parameter to specify the name of the file.
Example:	`MMEM:BASE:DATA? 'C:\TEMP\TEST01.HCP` Queries the block data contained in file `TEST01.HCP`.

MMEMory:MDIRectory <directory_name>

Creates a new directory for mass memory storage.

Setting parameters:
<directory_name> String parameter to specify the new directory.

Example: `MMEM:BASE:MDIR 'C:\Temp\NetworkService\Application Data'`

Usage: Setting only

MMEMory:RDIRectory <directory_name>

Removes an existing directory from the mass memory storage system.

Setting parameters:
<directory_name> String parameter to specify the directory to be deleted.

Example: `MMEM:BASE:RDIR 'C:\Temp\NetworkService\Application Data'`

Usage: Setting only

MMEMory:ATTRibute <path_name>, <attributes>

MMEMory:ATTRibute? <path_name>

Return values:
<file_entry>
Setting parameters:
<attributes>
Parameters for setting and query:
<path_name>

MMEMory:LOAD:STATe <sav_rcl_state_number>, <file_name>[, <msus>]

Setting parameters:
<sav_rcl_state_number>
<file_name>
<msus>
Usage: Setting only

MMEMory:STORe:STATe <sav_rcl_state_number>, <file_name>[, <msus>]

Setting parameters:
<sav_rcl_state_number>
<file_name>

<msus>

Usage: Setting only

MMEMory:MSIS [<msus>]

Parameters:
<msus>

SYSTem:DFPRint [<Path>]

Return values:
<XMLDeviceFootprint <dblock>
>

Setting parameters:
<Path>

***RCL** <num>

Setting parameters:
<num>

Usage: Setting only

***SAV** <num>

Setting parameters:
<num>

Usage: Setting only

14.2.13.2 Printer Control Commands

HCOPy:DESTination<1..2> <medium>

This command selects the printer output medium (Disk, Printer or Clipboard).

The type of instrument is selected with `SYSTem:COMMunicate:PRINter:SELect<1..2>`, which automatically selects a default output medium. Therefore the `HCOPy:DESTination` command should always be sent after setting the device type.

Parameters:

<medium> MMEM | SYST:COMM:PRIN | SYST:COMM:CLIP

MMEM
Directs the hardcopy to a file. The `MMEMory:NAME` on page 573 command defines the file name. All formats can be selected for `HCOPy:DEVice<m>:LANGuage`.

SYST:COMM:PRIN
Directs the hardcopy to the printer. The printer is selected with the `SYSTem:COMMunicate:PRINter:SELect<1..2>` command.

SYST:COMM:CLIP
Directs the hardcopy to the clipboard.

*RST: SYST:COMM:CLIP

HCOPy:DEVice<m>:COLor <Color>

Defines the color mode for printing.

Suffix:

<m> 1..2

Parameters:

<Color> ON | OFF

ON
Color output

OFF
Black and white output

*RST: ON

HCOPy:DEVice<m>:LANGuage <FileFormat>

Defines the file format for the image of the display.

Suffix:

<m> 1..2

Parameters:

<FileFormat> PNG | JPG | BMP | TIFF

*RST: PNG

HCOPy:IMMediate

Prints an image of the display to the printer or saves an image to a file or the clipboard, depending on the `HCOPy:DESTination<1..2>` command.

The printer is defined by `SYSTem:COMMunicate:PRINter:SELect<1..2>`. The file name for storage is defined by `MMEMory:NAME`.

Usage: Event
SCPI conform

HCOPy:IMMediate:NEXT<1..2>

Usage: Event

HCOPy:IMMediate[:DUM<1..2>]

Usage: Event

HCOPy:NEXT<1..2>

Usage: Event

HCOPy:PAGE:ORIentation<1..2> <Orientation>

Defines the page orientation.

Parameters:
<Orientation> PORTrait | LANDscape

*RST: LANDscape

SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?

This command queries the name of the first printer (in the list of printers) available under Windows XP.

The names of other installed printers can be queried with the `SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]` command.

If no printer is configured an empty string is output.

Return values:
<PrinterName>
Usage: Query only

SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]?

This command queries the name of the next printer installed under Windows. After all available printer names have been output, an empty string enclosed by quotation marks (") is output for the next query. Further queries are answered by a query error.

The `SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt` command should be sent previously to return to the beginning of the printer list and query the name of the first printer.

Return values:
<PrinterName>

Usage: Query only

SYSTem:COMMunicate:PRINter:SELect<1..2> <PrinterName>

Selects a configured printer. To determine which printers are installed, use the `SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt` and `SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]` commands.

Parameters:
<PrinterName>

14.2.14 General Instrument Setup

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>

Returns the computer name that is currently defined. The computer name is required when configuring a network.

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

SYSTem:EXIT

Starts the shutdown of the firmware.

Usage: Event

14.2.15 Maintenance

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:STST:RESult?

Returns a string with detailed information on the selftest steps and hardware components operation. In case you require support, you may be asked to provide this information.

Return values:
<Result>

Usage: Query only

DIAGnostic:SERVice:PWD <Password>

Sets the password to enter the service mode.

Setting parameters:
<Password> Password string

Usage: Setting only

14.2.16 Status Reporting

14.2.16.1 STATus:QUEStionable Registers

The commands of the `STATus:QUEStionable` subsystem control the status reporting structures of the STATus:QUEStionable registers:

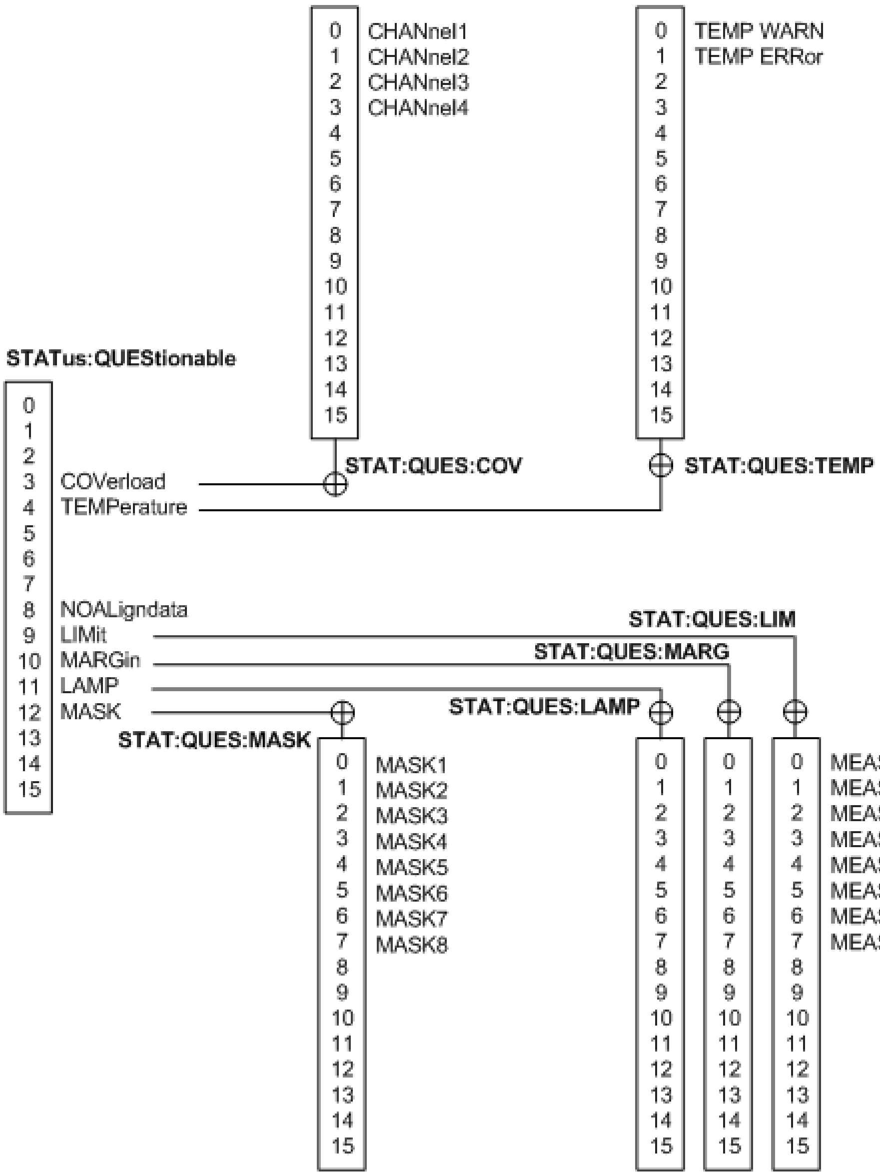


Fig. 14-4: Structure of the STATus:QUEStionable register

See also:

- chapter 14.1.5.1, "Structure of a SCPI Status Register", on page 319
- chapter 14.1.5.3, "Contents of the Status Registers", on page 322

The following commands are available:

STATus:QUEStionable:COVerload:CONDition?
STATus:QUEStionable:TEMPerature:CONDition?
STATus:QUEStionable:LIMit:CONDition?
STATus:QUEStionable:MARGin: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 conform

STATus:QUEStionable:COVerload:ENABle <Value>
STATus:QUEStionable:TEMPerature:ENABle <Value>
STATus:QUEStionable:LIMit:ENABle <Value>
STATus:QUEStionable:MARGin:ENABle <Value>
STATus:QUEStionable:MASK:ENABle <Value>

Sets the enable mask 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 conform

STATus:QUEStionable:COVerload[:EVENt]?
STATus:QUEStionable:TEMPerature[:EVENt]?
STATus:QUEStionable:LIMit[:EVENt]?
STATus:QUEStionable:MARGin[: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 conform

STATus:QUEStionable:COVerload:NTRansition <Value>
STATus:QUEStionable:TEMPerature:NTRansition <Value>
STATus:QUEStionable:LIMit:NTRansition <Value>
STATus:QUEStionable:MARGin: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 conform

STATus:QUEStionable:COVerload:PTRansition <Value>
STATus:QUEStionable:TEMPerature:PTRansition <Value>
STATus:QUEStionable:LIMit:PTRansition <Value>
STATus:QUEStionable:MARGin: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 conform

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
Exit	Shuts down the firmware.	
Minimize Application	Shows the Windows desktop with the application icon of the R&S RTO firmware.	
Board Detection / Maintenance	chapter 13.4.1, "Board Detection/Maintenance", on page 299	
Mode	chapter 12.3.1, "Mode", on page 288	MODE
Help	"Getting Started" manual, chapter "Getting Information and Help"	HELP
Print	chapter 10.3, "Reference for PRINT Settings", on page 272 chapter 10.1.1, "Configuring Printer Output and Printing", on page 260	PRINT
Setup	chapter 11.2.1, "Setup", on page 275	SETUP
Demo board	For internal use only. Opens a setup dialog box for the demo board If a demo board is connected to the instrument.	
Calibration Settings	chapter 2.3.6, "Calibration Settings", on page 45	
File	chapter 10.2, "Reference for FILE Settings", on page 265	FILE
Selfalignment	chapter 11.2.2, "Self-alignment", on page 282	
Selftest	chapter 13.4.2, "Selftest", on page 300	

A.2 Horizontal Menu

Menu item	Description	Corresponding key
Time Base	chapter 2.3.1.1, "Time Base", on page 27	HORIZONTAL
Resolution	chapter 2.3.1.2, "Resolution", on page 28	RES / REC LEN
Acquisition	chapter 2.3.1.3, "Acquisition", on page 30	ACQUISITION
Ultra Segmentation	chapter 2.3.1.4, "Ultra Segmentation", on page 34	
FFT Setup	chapter 6.1.3.3, "FFT Setup", on page 179	
Reference	chapter 2.3.5.1, "Reference (OCXO Option)", on page 44	
Skew	chapter 2.3.5.2, "Skew", on page 45	

A.3 Trigger Menu

Menu item	Description	Corresponding key
Trigger Events Setup	chapter 3.3.1, "Events", on page 53	TRIGGER
Trigger Slope	Opens a dialog box to select the slope or polarity, and the trigger type.	SLOPE
Trigger Mode	Selects the trigger mode in the submenu.	AUTO/NORMAL
Source	Opens a dialog box to select the trigger source. "Source" on page 54	SOURCE
Trigger Type	Selects the trigger type in the submenu.	
Force Trigger	Provokes an immediate single acquisition to confirm that a signal is available. Use the waveform display to determine how to trigger on it.	
Trigger Qualification	chapter 3.3.2, "Trigger Qualification", on page 70	
Trigger Noise Reject	chapter 3.3.3, "Noise Reject", on page 73	
Trigger Sequence	chapter 3.3.4, "Sequence", on page 74	
Trigger Position	chapter 3.3.5, "Trigger Position", on page 77	
Trigger Control	chapter 3.3.6, "Control", on page 78	
Digital Filter	chapter 2.3.4, "Digital Filter Setup", on page 43	

A.4 Vertical Menu

Menu item	Description	Corresponding key
Channels	chapter 2.3.2.1, "Channels", on page 35	CH<N>
Power Calculation	chapter 2.3.2.2, "Power Calculation", on page 37	
Probe Setup	chapter 2.3.3.1, "Setup", on page 38	
Probe Auto Zero	Performs an automatic correction of the zero error. "Auto Zero" on page 40	
Probe Maintenance	Opens a submenu: chapter 2.3.3.2, "Probe Attributes", on page 40 chapter 2.3.3.3, "Calibration Results", on page 41 chapter 2.3.3.4, "Service", on page 42	
Digital Filter	chapter 2.3.4, "Digital Filter Setup", on page 43	

A.5 Math Menu

Menu item	Description	Corresponding key
Math Setup	chapter 6.1.3.1, "Math Setup", on page 171	MATH
FFT Setup	chapter 6.1.3.3, "FFT Setup", on page 179 chapter 6.1.2.3, "Configuring FFT Waveforms", on page 169	
FFT Magnitude/Phase	chapter 6.1.3.4, "FFT Magnitude/Phase", on page 183	
FFT Gating	chapter 6.1.3.5, "FFT Gating", on page 185	
Reference Waveform	Submenu: Setup, Scaling, Original Attributes	

A.6 Cursor Menu

Menu item	Description	Corresponding key
Setup	chapter 5.3.1.1, "Cursor Setup Tab", on page 135	CURSOR
Style and Label	chapter 5.3.1.2, "Cursor Style and Label Tab", on page 137	
Peak Search	chapter 5.3.1.3, "Peak Search Tab", on page 138	

A.7 Meas Menu

Menu item	Description	Corresponding key
Setup	chapter 5.3.2.1, "Setup Tab", on page 139	MEAS Also acitvates the measurement
Gate/Display	chapter 5.3.2.2, "Gate/Display Tab", on page 148	
Long Term/Statistics	chapter 5.3.2.3, "Long Term/Statistics Tab", on page 151	
Event Actions	chapter 5.3.2.4, "Event Actions Tab", on page 154	
Histogram	chapter 5.3.3, "Reference for Histograms", on page 155	
Reference Level	chapter 5.3.4, "Reference for Reference Level Settings", on page 157	

A.8 Masks Menu

Menu item	Description	Corresponding key
Test Definition	chapter 7.3.1, "Test Definition", on page 204	MASKS Opens the last selected tab in the "Masks" dialog box.
Mask Definition	chapter 7.3.2, "Mask Definition", on page 206	
Event Actions / Reset	chapter 7.3.3, "Event Actions /Reset ", on page 208	
Mask Display	chapter 7.3.4, "Mask Display", on page 210	

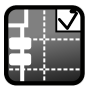
A.9 Search Menu

Menu item	Description	Corresponding key
Search Setup	chapter 8.3.1, "Setup Tab", on page 218	SEARCH Opens the last selected tab in the "Search" dialog box.
Scope	chapter 8.3.3, "Scope Tab", on page 223	
Result Presentation	chapter 8.3.4, "Result Presentation", on page 225	
Noise Reject	chapter 8.3.5, "Noise Reject", on page 228	

A.10 Protocol Menu

Menu item	Description	Corresponding key
Configuration	Depends on the selected protocol: chapter 9.2, "I²C ", on page 233 chapter 9.3, "SPI Bus", on page 244 chapter 9.4, "UART / RS232", on page 252	PROTOCAL Opens the last selected tab in the "Protocol" dialog box.
Display		

A.11 Display Menu

Menu item	Description	Corresponding key
Signal Colors / Persistence	chapter 4.1.3.1, "Signal Colors / Persistence", on page 86	DISPLAY Opens the last selected tab in the "Display" dialog box.
Color Tables	chapter 4.1.3.2, "Color Tables", on page 88 chapter 4.1.2.1, "Editing Signal Colors ", on page 81	
Diagram Layout	chapter 4.1.3.3, "Diagram Layout", on page 89	
XY-Diagram	chapter 4.3, "XY-diagram", on page 103	
Zoom	chapter 4.2, "Zoom", on page 93	ZOOM Also acitvates the zoom
History	chapter 4.4, "History", on page 106	HISTORY
Performance	Displays the current performance values of the instrument.	
Clear screen results	Deletes the current results in the result box together with the measurement and channel waveforms.	
Toolbar	chapter 4.1.3.4, "Toolbar", on page 92	
Signal Bar State	Switches the signal bar on or off. chapter 4.1.2.2, "Using the Signal bar", on page 83	

List of Commands

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