

R&S® RTM

Digital Oscilloscope

User Manual



1305.0595.02 – 02

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

- R&S®RTM1052 (1305.0008K52)
- R&S®RTM1054 (1305.0008K54)

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

- R&S®RTM-K1 (1305.0295.02)
- R&S®RTM-K2 (1305.0308.02)

TAZ: 01.02

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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Muehldorfstr. 15, 81671 Munich, Germany

Phone: +49 89 41 29 - 0

Fax: +49 89 41 29 12 164

E-mail: info@rohde-schwarz.com

Internet: <http://www.rohde-schwarz.com>

Subject to change – Data without tolerance limits is not binding.

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Trade names are trademarks of the owners.

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

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.

	indicates a hazardous situation which, if not avoided, will result in death or serious injury.
	indicates a hazardous situation which, if not avoided, could result in death or serious injury.
	indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
	indicates 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 $\pm 10\%$ shall apply to the nominal voltage and $\pm 5\%$ 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 $V_{\text{rms}} > 30 \text{ V}$, 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.

Basic Safety Instructions

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.







Informaciones elementales de seguridad

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 identifica un peligro inminente con riesgo elevado que provocará muerte o lesiones graves si no se evita.



ADVERTENCIA identifica un posible peligro con riesgo medio de provocar muerte o lesiones (graves) si no se evita.



ATENCIÓN identifica un peligro con riesgo reducido de provocar lesiones leves o moderadas si no se evita.



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 $\pm 10\%$ sobre el voltaje nominal y de $\pm 5\%$ 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 $U_{\text{eff}} > 30 \text{ V}$ 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 señalar 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.

Informaciones elementales de seguridad

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.

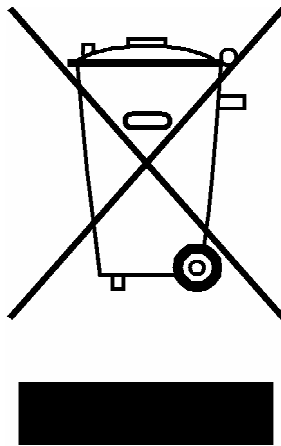
Eliminación

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.



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



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 ISO9001 und ISO14001 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 ISO9001 and ISO14001.

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 ISO9001 et ISO14001.

Engagement écologique

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



ROHDE & SCHWARZ

CE Declaration of Conformity



Certificate No.: 2010-46

This is to certify that:

Equipment type	Stock No.	Designation
RTM	1305.0008.XX	RTM

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
Mühlldorfstr. 15, D-81671 München

Munich, 2010-05-26

Central Quality Management MF-QZ / Radde

1305.0008.XX

CE

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1 Preface

1.1 Documentation Overview

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

- Online Help system on the instrument
- "Getting Started" printed manual
- Documentation CD-ROM with:
 - Getting Started
 - User 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 description of the softkeys and front panel controls.

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.

1.2 Conventions Used in the Documentation

This chapter describes the conventions used throughout this documentation.

1.2.1 Typographical Conventions

The following text markers are used throughout this documentation:

Conventions Used in the 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.
<i>Input</i>	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.

2 Acquisition and Waveform Setup

The chapter describes the horizontal and vertical basic settings including the acquisition and probe settings.

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 M Ω 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.

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.

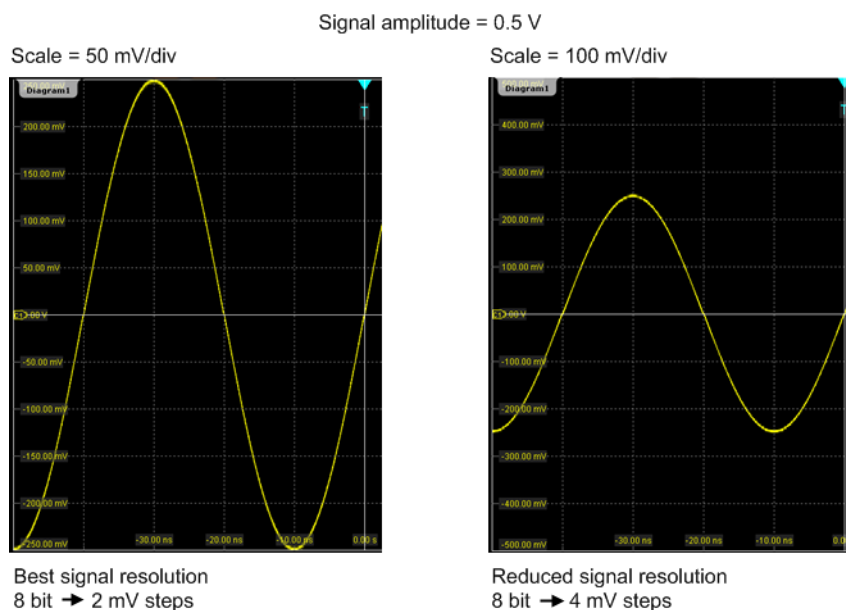


Fig. 2-1: Input range and resolution of the ADC

2.1.1.3 Bandwidth

For analog applications the highest signal frequency determines the required oscilloscope bandwidth. As a rule of thumb, the oscilloscope bandwidth should be 3 times higher than the maximum frequency included in the analog test signal to measure the amplitude with high accuracy.

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.

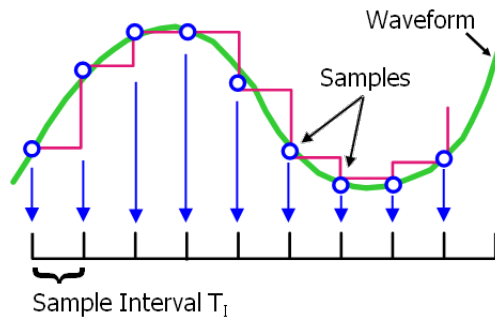
See also: [chapter 2.1.4.1, "Voltage Probes"](#), on page 15

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.

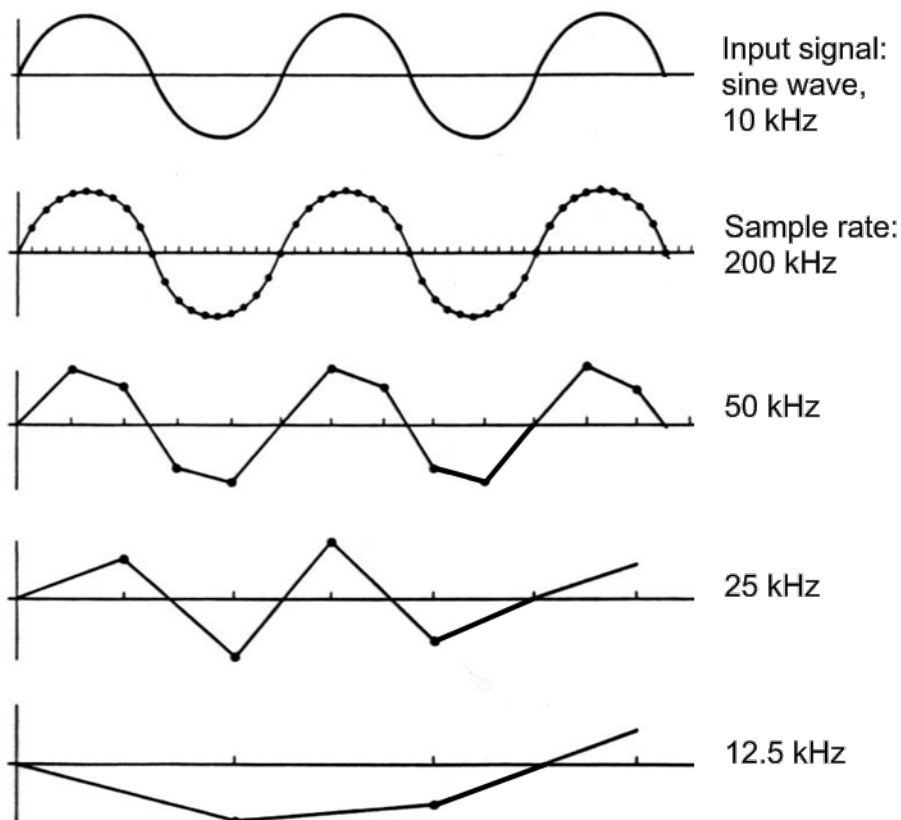


Fig. 2-2: Waveforms acquired with different sample rates

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 resulting sample rate can be the same as the constant ADC sample rate, or higher, or lower.

By default, the **real time sample mode** is used. With fast time base settings, the sample rate becomes higher than the ADC sample rate. The missing waveform samples are added to the ADC samples with $\sin(x)/x$ interpolation automatically.

When measuring high-frequency, repetitive signals whose frequency components are even higher than the ADC sample rate, **equivalent-time sampling** is used to capture the waveform. This sample mode captures ADC samples over a number of subsequent repetitions at different points in time, and creates one waveform with higher sample rate from this data.

At lower time base settings, the required sample rate is lower than the ADC sample rate. To reduce the sample rate, **decimation** methods are used: sample and peak detect.

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 enve-

lope waveforms are resulting waveforms, created from a composite of sample points taken from multiple acquisitions. Another function called **smoothing** calculates a mean value of several adjacent sample points of the same waveform and displays it. The result is a moving average that uses the full data and can be used for non-periodic signals.

2.1.2.3 Acquisition Control

You can run the R&S RTM 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.

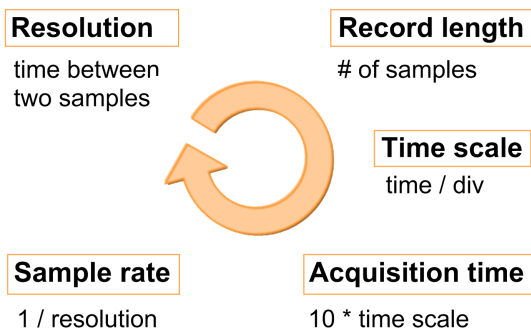
In practice, both trigger modes are useful: The auto mode lets you see the signal with very little adjustment, while the normal mode selects the interesting part of the waveform. If you want to acquire a specified number of waveforms with NxSingle, make sure to select the normal trigger mode. Thus you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

See also: [chapter 3, "Triggers"](#), on page 29

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:

$$\frac{\text{Sample rate}}{1 / \text{Resolution}} \times \text{Time scale} \times \# \text{ of div} = \text{Record length}$$

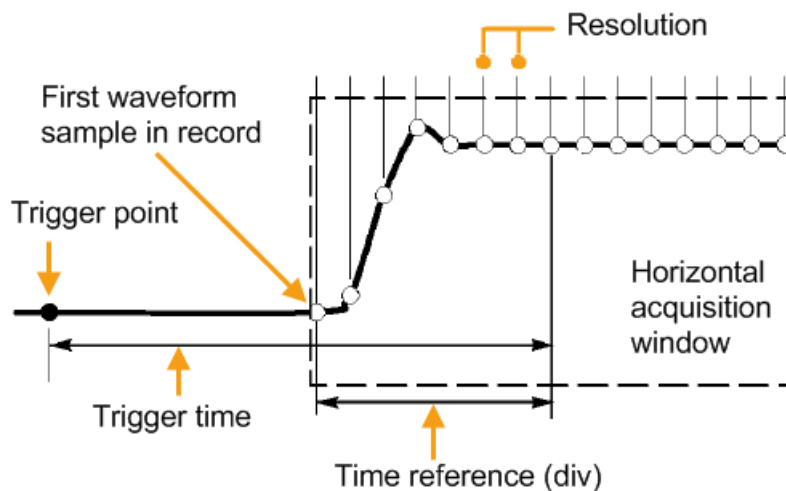
$$\text{Acquisition time} = \text{Time scale} \times \# \text{ of div}$$

The time scale can be changed, all other parameters are adjusted automatically.

2.1.3.2 Horizontal Position

As described before in [chapter 2.1.2.3, "Acquisition Control"](#), on page 13, 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: **time reference** and **trigger time**. 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 impedance	1:1	10 MHz	1 MΩ	Low speed, low level signals
Passive, high impedance	10:1	500 MHz	1 MΩ	General purpose
Passive, low impedance	10:1	up to 10 GHz	50 Ω	High frequency
Active, single-ended	10:1	up to 10 GHz	50 Ω	High speed

For a list of recommended probes refer to the R&S RTM 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:

$$(1/BW_{\text{system}}) = \sqrt{(1/BW_{\text{probe}})^2 + (1/BW_{\text{scope}})^2}$$

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.
High frequency adjustment is an option for higher measurement frequencies in the MHz range.
- 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.

These special features are not available on RT-ZSxxE probes.

2.2 Setting up the Waveform

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



Passive probes

Passive probes require compensation for exact signal display and measurement. The compensation procedure is described in the "Getting Started" manual.

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 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

The settings mentioned here are described in detail in:

- [chapter 2.3.1, "HORIZONTAL Controls"](#), on page 20
- [chapter 2.3.3.2, "Channel Menu"](#), on page 25
- [chapter 2.3.3.1, "VERTICAL Controls"](#), on page 24

1. Connect the probe to the input connector CH N.
The instrument recognizes the probe and turns the channel on.
2. Use the SCALE rotary knob in the HORIZONTAL area of the front panel to set up the time base.

3. Use the POSITION rotary knob to set up the trigger position. Press the knob to reset the trigger time to 50%.
4. Press the channel key corresponding to the input channel. It is lighted with the color of the channel waveform.
5. In the softkey menu, press the "Coupling" softkey repeatedly to select the correct coupling.
6. Select the "Bandwidth" limit.
7. If you use a passive probe, adjust the probe settings:
 - a) Select the "Termination" (input impedance).
 - b) Select "More" to switch the menu page.
 - c) Press the "Probe" softkey and select the attenuation.
8. Use the SCALE rotary knob in the VERTICAL area of the front panel to adjust the vertical scale of the waveform. Press the knob to toggle between fine and rough adjustment.
9. Use the POSITION rotary knob to adjust the vertical position of the waveform. Vertical position is defined by the position of the waveform's zero line and the offset between the zero line and the waveform axis. Pressing the knob toggles between these parameters.

By default, offset is disabled. Press the "Offset" softkey in the "Channel" menu to enable the offset. Use the NAVIGATION knob or the POSITION / OFFSET knob to adjust. Turn clockwise to move the waveform down.
10. Proceed with: [chapter 2.2.3, "Setting the Acquisition"](#), on page 18.

2.2.3 Setting the Acquisition

Prerequisites:

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

For details on acquisition settings, see [chapter 2.3.2, "Acquisition Menu"](#), on page 21.

1. Press the ACQUISITION key in the HORIZONTAL area of the front panel.
2. Select the "Sample Mode" - Real time or Equivalent time.

This defines the behavior of the oscilloscope if the sample rate is higher than the ADC sample rate.

Use Equivalent time to capture fast repetitive signals whose frequency components may be much higher than the sample rate of the ADC.
3. Select the "Decimation Mode" - for example, Peak detect.

This defines the behavior of the instrument if the oscilloscope captures more samples than the waveform memory can save.
4. Select the "Wavef. Arithmetic" - for example, Average or Envelope.

This defines how the resulting waveform is built from several consecutive acquisitions of the signal.

5. If "Average" is selected, enter the "Number of Averages", that is the number of waveforms used for average calculation.
6. Select the "Waveform Rate".

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

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 top information bar.
If not, press the MODE key on the front panel to toggle the setting.
2. Press the RUN CONT key to start acquisition.
The acquisition starts if a trigger occurs.
3. To stop, press the RUN CONT key again.
The acquisition stops immediately.

To acquire a limited number of acquisitions

1. Press the ACQUISITION key in the HORIZONTAL area of the front panel.
2. Select "Nx Single" and enter the number of acquisitions.
3. Press the RUN N× SINGLE key on the front panel.
You can stop the acquisition cycle before it is finished by pressing the key again.

2.3 Reference for Waveform Setup

2.3.1 HORIZONTAL Controls

Time base settings adjust the display in horizontal direction. Use the rotary knobs in the HORIZONTAL functional block for setting.



POSITION.....	20
SCALE.....	20

POSITION

The rotary knob changes the trigger offset. This is the horizontal position of the trigger point in relation to the reference point - the zero point of the grid. Thus, you can set the trigger point even outside the diagram and analyze the signal some time before or after the trigger.

Turn clockwise to move the trigger point to the right. The current trigger position is shown in the top information bar, denoted by "T". Press the knob to reset the trigger time to 0.

Note: If a zoom or FFT window is displayed, the knob can adjust other values depending on the selection of the SCALE rotary knob.

See also: ["Time Reference"](#) on page 145

SCPI command:

[TIMEbase:POSition](#) on page 189

SCALE

The rotary knob adjusts the time scale of the horizontal axis for all signals, also known as time base. The current scale value is shown in the top information bar, denoted by "TB". Turn clockwise to stretch the waveforms - the scale value time/div decreases.

If a Zoom or FFT window is displayed, press the knob to switch between the settings, then turn to adjust the selected value.

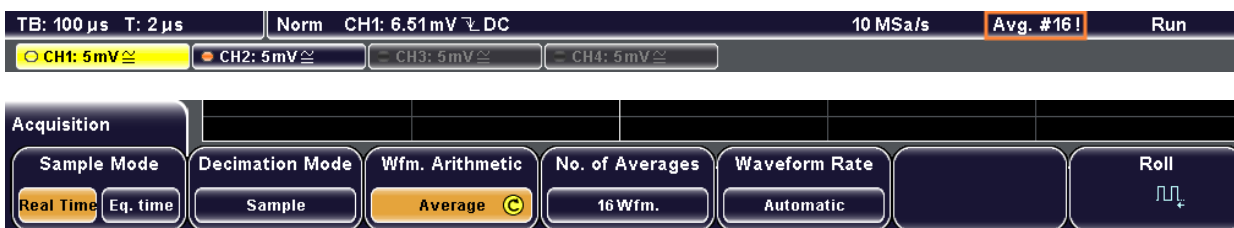
SCPI command:

[TIMEbase:SCALE](#) on page 188

2.3.2 Acquisition Menu

The ACQUISITION key in the Horizontal functional block opens the "Acquisition" softkey menu, where you select the acquisition mode. Acquisition modes control the data processing - how the waveform is built from the captured ADC samples.

The softkeys are placed on two menu pages. The current acquisition mode is shown in the top information bar, the second value from right.



- Sample Mode.....21
- Decimation Mode.....21
- Wavef. Arithmetic.....22
- Nx Single.....22
- Waveform Rate.....23
- Roll.....23

Sample Mode

Defines how the waveform is created from the sample points which are acquired by the ADC.

- "Realtime" At slow time base settings the oscilloscope can acquire enough points to create an accurate waveform, so the sampled points of the input signal are used directly to build the waveform.
With fast time base settings, the sample rate is higher than the ADC sample rate. Waveform samples are added to the ADC samples with sin(x)/x interpolation.
Real-time sampling is used to capture fast, single-shot, transient signals.
- "Eq. time" Random equivalent-time sampling: This mode requires repetitive, stable signals. It is used to capture fast signals whose frequency components may be much higher than the sample rate of the ADC. The waveform points are taken from several acquisitions at a different time in relation to the trigger point. The time difference between the sample and the trigger is random. Then, all the sampled points are put together into one composite waveform.

SCPI command:
[ACQUIRE:MODE](#) on page 190

Decimation Mode

Decimation reduces the data stream of the ADC to a stream of waveform points with lower sample rate and a less precise resolution if the oscilloscope captures more samples than the waveform memory can save.

"Sample"	The oscilloscope acquires the input data with a sample rate which is aligned to the time base (horizontal scale) and the memory depth. Usually, most signals are displayed optimally with this acquisition mode if all trigger conditions are met.
"Peak Detect"	The minimum and the maximum of n samples are recorded as waveform points, the other samples are discarded. Thus the instrument can detect fast signal peaks at slow time scale settings that would be missed with other acquisition modes.
"High Resolution"	The average of n captured sample points is recorded as one waveform sample. Averaging reduces the noise, the result is a more precise waveform with higher vertical resolution.

SCPI command:

[CHANnel<m>:TYPE](#) on page 190

Wavef. Arithmetic

Waveform arithmetic builds the resulting waveform from several consecutive acquisitions of the signal. The arithmetic works with all sample modes and decimated waveforms.

"Off"	No arithmetic is applied.
"Envelope"	The minimum and maximum values are saved in addition to the normal waveform samples. The resulting diagram shows two envelope waveforms below and above the normal waveform: the minimums (floor) and maximums (roof) representing the borders in which the signal occurs. The envelope is refreshed with each acquisition and it is reset each time the waveform parameters are changed.
"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 repetitive signal. The number of acquisitions for average calculation is defined with "No. of Averages".
"Smooth"	Smoothing calculates a mean value of several adjacent sample points and displays it. The result is a smoothed waveform. Thus, smoothing is a moving average that uses the full data and can be used for non-periodic signals. It works like a low pass, and increases the vertical resolution at the expense of bandwidth reduction. The signal must not be triggered.

SCPI command:

[CHANnel<m>:ARITHmetics](#) on page 191

Nx Single

The "Nx Single" key has a double effect:

- It defines the number of waveforms used to calculate the average waveform. The higher the number, the better the noise is reduced.
- 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 "Nx Single" is, the better the noise is reduced.

SCPI command:

[ACQUIRE:COUNT](#) on page 190

Waveform Rate

Defines the mode to set the sample rate (samples per second saved in the memory) and the waveform acquisition rate (waveforms per second).

"Max. Wfm. Rate" The instrument combines sample rate and memory depth to acquire at maximum waveform acquisition rate. In connection with persistence, the mode can display rare signal anomalies.

Note: Due to less memory depth, aliasing effects may occur.

"Max. Sa. Rate" The instrument acquires the signal at maximum sample rate and uses the full memory depth. The result is a waveform with maximum number of waveform samples, high degree of accuracy, and low risk of aliasing. However, the waveform acquisition rate is low.

"Automatic" Default mode: To display the best waveform, the instrument selects the optimum combination of waveform acquisition rate and sample rate using the full memory depth.

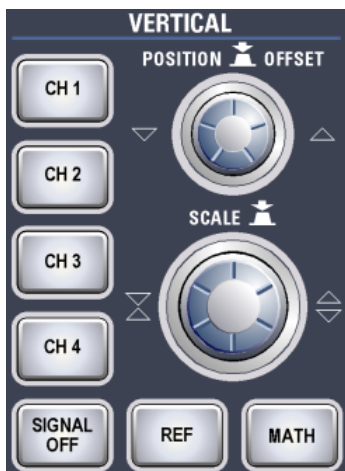
Roll

The roll mode moves the captured input data on the display from the right to the left. The instrument shows the waveform immediately, without waiting for the complete acquisition of the waveform record. The roll mode displays the untriggered signal. Use the roll mode for slow, non-repetitive signals with 200 kHz or slower.

2.3.3 Vertical Settings

To adjust the vertical settings, you use the keys and rotary knobs in the VERTICAL functional block of the front panel and the channel-specific softkey menu.

2.3.3.1 VERTICAL Controls



The REF and MATH functions are described in [chapter 6, "Mathematics and Reference Waveforms"](#), on page 74.

The channel label shows the basic vertical settings. The label of the active channel is highlighted with the channel color.



CH N.....	24
SIGNAL OFF.....	24
POSITION / OFFSET.....	25
L POSITION.....	25
L OFFSET.....	25
SCALE, Y-Scale.....	25

CH N

The channel keys turn on and select analog channels and opens the "Channel" menu for vertical setup. The keys are illuminated in the channel color, if the channel is on.

The effect of the keypress depends on state of the channel:

- If channel is off: Pressing the key turns the channel on and selects it. The rotary knobs alongside light up in the channel color.
- If the channel is on: Pressing the key selects the channel waveform for vertical setup.

SCPI command:

`CHANnel<m>:STATe` on page 192

SIGNAL OFF

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

The key lights up in the color of the selected signal and changes the light according to the new selection.

SCPI command:

`CHANnel<m>:STATe` on page 192

POSITION / OFFSET

The rotary knob adjusts the vertical position or the DC offset. It lights up in the color of the selected waveform. Pressing the key toggles the parameter, the current parameter and its value are shown in a temporary label marked with the channel color.

Note: By default, offset is disabled. Press the "Offset" softkey in the "Channel" menu to enable the offset.

POSITION ← POSITION / OFFSET

Position changes the vertical location of the selected waveform. Turn clockwise to move the waveform up.

SCPI command:

[CHANnel<m>:POSition](#) on page 193

OFFSET ← POSITION / 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.

Offset shifts the vertical center (zero line) of the selected channel by the offset value. Use the offset to measure small AC voltages that are overlaid by higher DC voltages. Unlike AC coupling, the DC part of the signal is not lost with offset setting. The device under test is not affected.

Turn clockwise to move the waveform down.

If an active probe is connected, the offset limit is defined by the probe. Refer to the documentation of the probe for allowed values.

SCPI command:

[CHANnel<m>:OFFSet](#) on page 193

SCALE, Y-Scale

Sets the vertical scale in Volts per division to change the amplitude of the selected waveform. For analog channels, the current value is shown in the waveform label above the grid. The knob lights up in the color of the selected waveform.

Turn SCALE clockwise to stretch the waveform. Doing so, the scale value V/div decreases. Press the knob to toggle between fine and rough adjustment.

For numerical entry, press the "Y-Scale" softkey and then use the NAVIGATION knob.

SCPI command:

[CHANnel<m>:SCALE](#) on page 192

2.3.3.2 Channel Menu

The softkeys of the "Channel" menu are placed on two menu pages.





Coupling.....26
 Termination.....26
 Bandwidth.....26
 Offset.....27
 Invert.....27
 Y-Scale.....27
 Probe.....27
 Deskew.....27
 Threshold.....27

Coupling

Selects the connection of the input signal. The current coupling of each channel is shown in the waveform labels above the grid.

- "AC" A 2 Hz high-pass filter is placed into the signal path that removes the DC offset voltage from the input signal. AC coupling is labeled with ≈.
- "DC" DC coupling passes the input signal unchanged. It is labeled with ≡.

SCPI command:
[CHANnel<m>:COUPling](#) on page 192

Termination

Adjusts the input impedance of the instrument to the impedance of the DUT. By default, the oscilloscope has an input impedance of 1 MΩ || 13 pF. If an active probe is used, the termination is read out from the probe - usually it is 50 Ω.

- "50Ω" In measurement systems that are dimensioned for a characteristic impedance of 50 Ω, reflections along the signal path are minimized by setting the input resistor of the oscilloscope also to 50 Ω. This increases the accuracy of measurement results. 50 Ω termination is identified for each channel by the icon Ω in the waveform label.
- "1 MΩ" The high input resistor minimizes the loading effect on the device under test. This value is set automatically if a passive probe is connected and cannot be changed.

Bandwidth

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 10

- "Full" At full bandwidth, all frequencies in the specified range are acquired and displayed. Full bandwidth is used for most applications.

"400 MHz, 200MHz, 20MHz" Frequencies above the selected limit are removed to reduce noise at different levels. These bandwidth limits are indicated by the icon BW in the waveform label.

SCPI command:

[CHANnel<m>:BANDwidth](#) on page 193

Offset

See ["OFFSET"](#) on page 25.

Invert

Turns the inversion of the signal amplitude on or off. To invert means to reflect the voltage values of all signal components against the ground level. Inversion affects only the display of the signal but not the trigger. For example: if the oscilloscope triggers on the rising edge, the trigger is not changed by inversion, but the actually rising edge is displayed as falling edge.

Inversion is indicated by a line above the channel name in the waveform label.

Y-Scale

See ["SCALE,Y-Scale"](#) on page 25

Probe

Opens the Probe menu. The menu is different for active and passive probes.

- [chapter 2.3.3.3, "Probe Menu \(Passive Probe\)"](#), on page 28
- [chapter 2.3.3.4, "Probe Menu \(Active Probe\)"](#), on page 28

Deskew

Deskew compensates delay differences between channels caused by the different length of cables, probes, and other sources. Correct deskew values are important for accurate triggering.

Signals which are routed over lines with different lengths have a different propagation delay. If high speed signals are measured, this delay may lead to a non-synchronous waveform display. For example, a coax cable with a length of one meter has a propagation delay of typically 5.3 ns.

SCPI command:

[CHANnel<m>:SKEW](#) on page 194

Threshold

Threshold value for digitization of analog signals. If the signal value 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 select the one of the default values for TTL, ECL, or CMOS, or set "User" value individually for each channel.

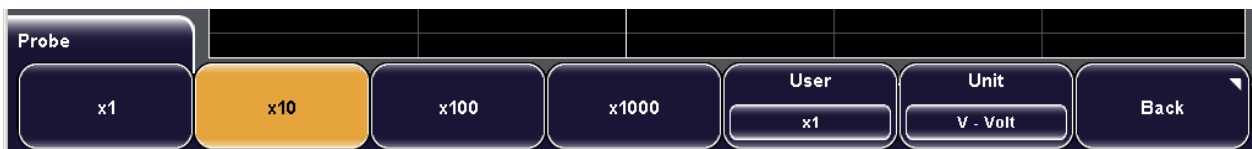
- TTL: 1,4 V
- ECL: -1,3 V
- CMOS: 2,5 V

SCPI command:

[CHANnel<m>:THReshold](#) on page 194

2.3.3.3 Probe Menu (Passive Probe)

In the probe menu for passive probes, the probe attenuation for the selected channel is set. If the probe is known to the instrument, the attenuation factor is set automatically. For unknown probes, you can select a default factor or enter a user-defined value.



x1, x10, x100, x1000: attenuation factor

The keys select a default attenuation factor of the connected probe. The vertical scaling and measured values are multiplied by this factor so that the displayed values are equal to the undivided measured signal values.

To set an arbitrary attenuation factor, press the "User" softkey.

User: user-defined attenuation factor

You can enter an arbitrary attenuation factor in the range between x0.001 and x1000. The vertical scaling and measured values are multiplied by this factor so that the displayed values are equal to the undivided measured signal values.

Unit

Select the unit that the probe can measure:

- V - for voltage measurements
- A - for current measurements

2.3.3.4 Probe Menu (Active Probe)

In the probe menu for active probes, you can also adjust the offset value for the selected channel.

Offset

See "[OFFSET](#)" on page 25.

ProbeMeter

Activates the ProbeMeter of R&S active probes and selects the probe type. If activated, the measurement result is shown in a colored label below the channel label.

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.

Info

Shows general information on the connected probe, for example, type, serial number, and production date, as well as electrical characteristics like bandwidth, attenuation, input capacitance and impedance, and DC offset.

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 simultaneously. It establishes the time-zero point in the waveform record. The instrument acquires continuously and keeps the sample points to fill the pretrigger part of the waveform record. When the trigger occurs, the instrument continues acquisition until the posttrigger part of the waveform record is filled. Then it stops acquiring and displays the waveform. When a trigger is recognized, the instrument will not accept another trigger until the acquisition is complete.

Trigger conditions

A simple set of trigger conditions includes:

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

The R&S RTM provides various trigger types for troubleshooting and signal analysis, for example, edge trigger, width trigger, pattern trigger, and specific triggers like video and bus triggers.

More complex trigger conditions are also available: you can setup a trigger sequence to join two edge triggers with an optional delay time or event count. Similar setups are also known as multi-step trigger or A/B trigger.

Trigger event

In particular for the A/B trigger sequence, 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. The trigger occurs only if the conditions of all events - the A event and the B event - in a trigger sequence and all further trigger conditions are all fulfilled.

Trigger information

Information on the most important trigger settings are shown in the information bar. The label shows:

- Trigger source and level
- Trigger coupling and filters

- Trigger slope or other conditions specific for the selected trigger type

3.2 Setting Up the Trigger

This chapter provides step-by-step procedures for the important stages of trigger setup. The settings mentioned here are described in detail in [chapter 3.3, "Reference for Triggers"](#), on page 31.

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.
1. Press the SETUP key in the TRIGGER functional block.
The "Trigger" menu opens.
 2. Press the "Source" softkey and select the trigger source.
 3. Press "Setup" to return to the "Trigger" menu.
 4. Press the "Type" softkey repeatedly until the required trigger type is selected.
 5. Select "Setup".
 6. Configure the settings for the selected trigger type.
For details, see:
 - [chapter 3.3.2.2, "Edge"](#), on page 35
 - [chapter 3.3.2.3, "Width"](#), on page 37
 - [chapter 3.3.2.4, "Video"](#), on page 38
 - [chapter 3.3.2.5, "Pattern"](#), on page 39
 - [chapter 3.3.2.6, "Protocol"](#), on page 41
 7. Set the "Normal" trigger mode: Press the AUTO/NORMAL key on the front panel until "Norm" is shown in the information bar.

3.2.2 Positioning the Trigger

By positioning the trigger, you define which part of the waveform is displayed: mainly the pretrigger part, or the posttrigger part, or the part around the trigger point. Therefore, you set the time reference (also known as reference point) and the trigger position in relation to the time reference.

1. To set the time reference point:
 - a) Press the SETUP key on the left of the display.
 - b) Select "Time Reference".

- c) Turn the navigation knob to move the reference point.
2. To set the trigger position, turn the POSITION rotary knob in the HORIZONTAL functional block.

3.2.3 Setting Up a Trigger Sequence

An A/B trigger sequence consists of two edge triggers connected by a time delay or event count.

1. Press the SETUP key in the TRIGGER functional block.
2. Press the "Trigger Type" softkey and select "Edge" trigger.
3. Select "Setup", configure the A trigger and select "Back".
4. Press the "B-Trigger" softkey to enable the B-trigger.
The LEVEL knob and SLOPE key on the front panel are automatically assigned to the B-trigger. You can change the assignment with the "Trigger Level" softkey in the "Trigger" menu.
5. Press the "B-Setup" softkey.
6. Configure the B-trigger: Select "B-Source" and "Slope", and turn the LEVEL rotary knob to adjust the B-trigger level.
7. Define the connection between the A and B triggers by doing one of the following:
 - Press "Time" and adjust the delay time with the navigation knob.
 - Press "Events" and enter the number of B-trigger events that have to be fulfilled until the instrument triggers.

3.3 Reference for Triggers

The trigger settings are located in the TRIGGER functional block on the front panel and in the "Trigger" softkey menu.

3.3.1 TRIGGER Controls

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



RUN CONT

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

The status is also shown at the right end of the information bar: "Run" or "Complete".

SCPI command:

[RUN](#) on page 187

[RUNContinuous](#) on page 187

[STOP](#) on page 187

RUN Nx SINGLE

Starts a defined number of acquisition cycles. Press the key again to stop running acquisitions.

To set the number of acquisitions, press the ACQUISITION key and enter "Nx Single".

SCPI command:

[SINGLE](#) on page 187

[RUNSingle](#) on page 187

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.

MODE

Toggles the trigger mode between Auto and Normal. The trigger mode determines the behaviour of the instrument if no trigger occurs. The current setting is shown in the information bar.

"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 is set. The waveform on the screen is not synchronized, and successive waveforms are not triggered at the same point of the waveform.

"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, nothing is displayed.

SCPI command:

[TRIGger:A:MODE](#) on page 203

LEVEL

The rotary knob changes the trigger treshold voltage for all trigger types that require a trigger level.

Turn clockwise to move the trigger level up. Press the knob to set the level to 50% of the signal amplitude.

If a B-trigger is enabled, the knob can set the level for both the A- and B-trigger. To assign the setting, use "Trigger Level" in the "Trigger" menu.

SCPI command:

[TRIGger:A:LEVel<n>\[:VALue\]](#) on page 203

[TRIGger:A:FINDlevel](#) on page 204

SETUP

The key opens the "Trigger" menu.

SOURCE

The key opens the "Trigger Source" menu. Press the key repeatedly until the required source is selected. The key lights up in the color of the selected trigger channel. The selected source is shown in the information bar.

SLOPE

If you have selected "Edge" trigger as trigger type with an analog trigger source, the SLOPE key toggles the trigger slope. The current setting is shown by an icon in the information bar.

If a B-trigger is enabled, the key can set the slope for both the A- and B-trigger. To assign the setting, use "Trigger Level" in the "Trigger" menu.

3.3.2 Trigger Settings

Trigger settings consist of general settings in the "Trigger" menu and the trigger type-specific setup. For B-trigger setup, a separate menu is provided.

- [Trigger Menu and Trigger Source](#).....33
- [Edge](#).....35
- [Width](#).....37
- [Video](#).....38
- [Pattern](#).....39
- [Protocol](#).....41
- [B-Setup](#).....41

3.3.2.1 Trigger Menu and Trigger Source

The "Trigger" menu is general menu for all trigger types and leads to the type-specific menus.



The content of the "Trigger Source" menu depends on the trigger type. The figure below shows the trigger source menu for edge, width, and video triggers.



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L AC Line.....	34
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Trigger Type

Selects the trigger type.

For details, see:

- [chapter 3.3.2.2, "Edge"](#), on page 35
- [chapter 3.3.2.3, "Width"](#), on page 37
- [chapter 3.3.2.4, "Video"](#), on page 38
- [chapter 3.3.2.5, "Pattern"](#), on page 39
- [chapter 3.3.2.6, "Protocol"](#), on page 41

SCPI command:

`TRIGger:A:TYPE` on page 204

Setup

Opens the setup menu for the selected trigger type.

Source

Opens the "Trigger Source" menu for the selected trigger type.

SCPI command:

`TRIGger:A:SOURce` on page 204

Channel N ← Source

Selects one of the input channels as trigger source.

AC Line ← Source

Selects the mains supply of the oscilloscope as trigger input for the edge trigger. The instrument extracts the trigger signal from the power supply.

Extern ← Source

Sets the External Trigger Input on the rear panel as trigger source. Select the signal type that is connected: AC or DC.

Trigger Time

Defines the horizontal position of the trigger point in relation to the reference point - to the zero point of the grid. The value is also known as trigger offset and is indicated by "T" in the information bar above the window.

Note: If a zoom or FFT window is displayed and "Time Control" is selected, the trigger time can be adjusted using the horizontal POSITION rotary knob.

See also:

- "POSITION" on page 20
- "To configure the original Y(t)-diagram" on page 51

SCPI command:

`TIMEbase:POSition` on page 189

B-Trigger

Activates or deactivates the second event in a trigger sequence. The instrument triggers if both trigger event conditions (A and B) are fulfilled.

If the B-trigger is activated, the LEVEL rotary knob and the SLOPE key are automatically assigned to the B-event. You can toggle the assignment of these controls with the "Trigger Level" setting in the "Trigger" menu.

SCPI command:

`TRIGger:B:ENABLE` on page 208

B-Setup

Opens the menu for B-trigger configuration. The B-trigger is a second edge trigger event that can be combined with a preceding edge trigger event. The trigger conditions of this second event are considered when the conditions of the main event (A-trigger) are met.

For a description of the menu, see [chapter 3.3.2.7, "B-Setup"](#), on page 41.

Trigger Level

Assigns the SLOPE key and the LEVEL rotary knob on the front panel to the A- or B-event. The function is only relevant if the B-trigger is enabled. The SOURCE key sets always the A-trigger source.

3.3.2.2 Edge

The edge trigger is the simplest and 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 treshold voltage - the trigger level - in the specified direction (slope).

The edge trigger is also selected with the AUTASET function.



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 Coupling.....36
 LF Reject.....36

HF Reject.....	36
Low-pass.....	36
Hysteresis A / B.....	36

Slope

Sets the edge for the trigger.

- "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.

SCPI command:

[TRIGger:A:EDGE:SLOPe](#) on page 204

Coupling

Sets the coupling for the trigger source.

- "AC" Alternating Current coupling. A 5 Hz high pass filter is connected into the trigger path and removes the DC offset voltage from the trigger signal.
- "DC" Direct Current coupling. The trigger signal remains unchanged.

SCPI command:

[TRIGger:A:EDGE:COUPling](#) on page 205

LF Reject

Sets the trigger coupling to high frequency. A 15 kHz high-pass filter is connected into the trigger path and removes lower frequencies from the trigger signal. Use this mode only with very high frequency signals.

SCPI command:

[TRIGger:A:EDGE:COUPling](#) on page 205

HF Reject

Turns an additional 5 kHz low-pass filter in the trigger path on or off. This filter removes higher frequencies and is available with AC and DC coupling.

SCPI command:

[TRIGger:A:EDGE:FILTer:LPASs](#) on page 205

Low-pass

Turns an additional 100 MHz low-pass filter in the trigger path on or off. This filter removes higher frequencies and is available with AC and DC coupling.

SCPI command:

[TRIGger:A:EDGE:FILTer:NREJect](#) on page 205

Hysteresis A / B

Sets a hysteresis range around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs. Thus, hysteresis avoids unwanted trigger events caused by noise oscillation around the trigger level.

Hysteresis is available for the edge trigger (A-event and B-event) and for the width trigger.

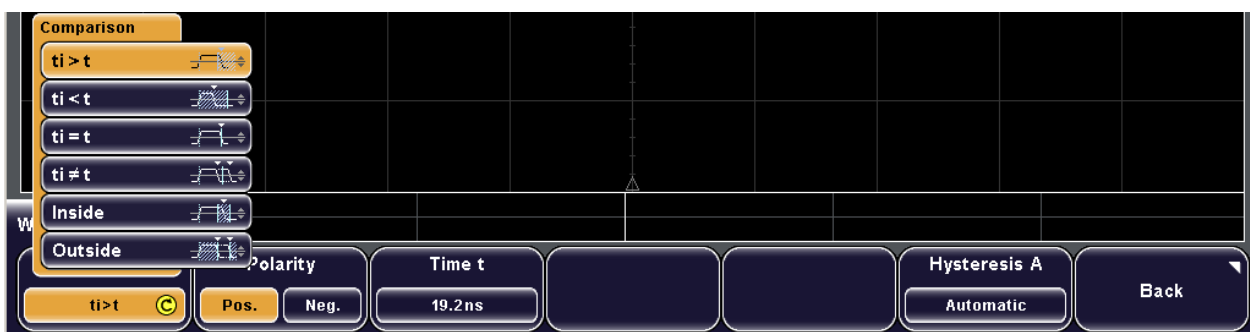
To see the hysteresis on the display, activate "Trigger Hyst." in the "Display > Auxillary Cursors" menu.

The hysteresis value depends on the vertical scale.

3.3.2.3 Width

The width trigger compares the pulse width (duration) with a given time limit. It detects pulses with an exact pulse width, pulses shorter or longer than a given time, as well as pulses inside or outside the allowable time range.

The instrument triggers if the pulse does not cross the specified voltage threshold twice. The pulse width is measured at the trigger level.



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Variation.....	38
Time t1, Time t2.....	38
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Comparison

Sets how the measured pulse width is compared with the given limit(s).

- "ti<t, ti>t" The pulse width is shorter or longer than the reference "Time t".
- "ti=t, ti≠t" The pulse width is equal or unequal to the reference "Time t". You can also set a tolerance interval with "Variation".
- "Inside, Out-
side" Triggers on pulses inside or outside a range specified with "Time t1" and "Time t2".

SCPI command:
[TRIGger:A:WIDTH:RANGE](#) on page 206

Polarity

Sets the polarity of the pulse.

- "Pos." Positive going pulse, the width is defined from the rising to the falling slopes.
- "Neg." Negative going pulse, the width is defined from the falling to the rising slopes.

SCPI command:
[TRIGger:A:WIDTH:POLarity](#) on page 206

Time t

Sets the reference time, the nominal value for comparison.

Variation

Sets a tolerance Δt to the reference "Time", if comparison is set to "ti=t" or "ti≠t". The instrument triggers on pulses inside or outside the range $ti \pm \Delta t$.

Time t1, Time t2

Set the lower and upper time limits defining the time range if "Inside" or "Outside" is set for comparison.

Hysteresis A / B

Sets a hysteresis range around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs. Thus, hysteresis avoids unwanted trigger events caused by noise oscillation around the trigger level.

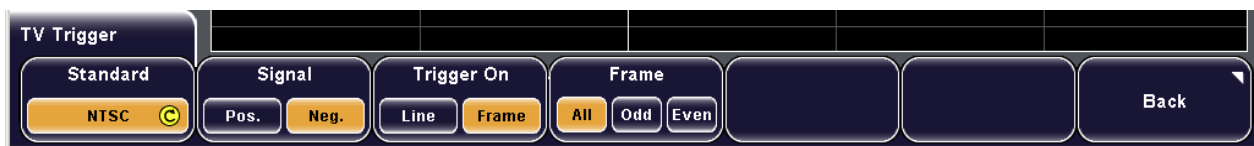
Hysteresis is available for the edge trigger (A-event and B-event) and for the width trigger.

To see the hysteresis on the display, activate "Trigger Hyst." in the "Display > Auxillary Cursors" menu.

The hysteresis value depends on the vertical scale.

3.3.2.4 Video

The video trigger allows you to trigger on standard video signals.



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Standard

Selects the color television standard.

You can trigger on various standard video signals like PAL, SECAM, HDTV, NTSC, and SDTV.

Signal

Selects the polarity of the sync pulses. If the video modulation is positive – the maximum luminance value is represented by the maximum signal voltage – the sync pulses are negative. If the modulation is negative, sync pulses are positive. The edges of the sync pulses are used for triggering, therefore incorrect polarity setting causes a sporadic triggering by the video information.

SCPI command:

[TRIGger:A:VIDeo:POLarity](#) on page 206

Trigger On

Toggles between line or frame (field) related triggering.

Line

Sets an exact line number. If the other trigger conditions are also met, the oscilloscope triggers exactly on the beginning of selected line in any field.

SCPI command:

[TRIGger:A:TV:LINE](#) on page 207

All Lines

The oscilloscope triggers on the beginning of the video signal lines. This key selects all lines, so if the other trigger conditions are also met the oscilloscope triggers on any line.

SCPI command:

[TRIGger:A:TV:FIELD](#) on page 207

Frame

The oscilloscope triggers on the beginning of the video signal fields if the other trigger conditions are fulfilled.

"All" Triggers on all frames.

"Odd" Triggers only on odd half frames.

"Even" Triggers only on even half frames.

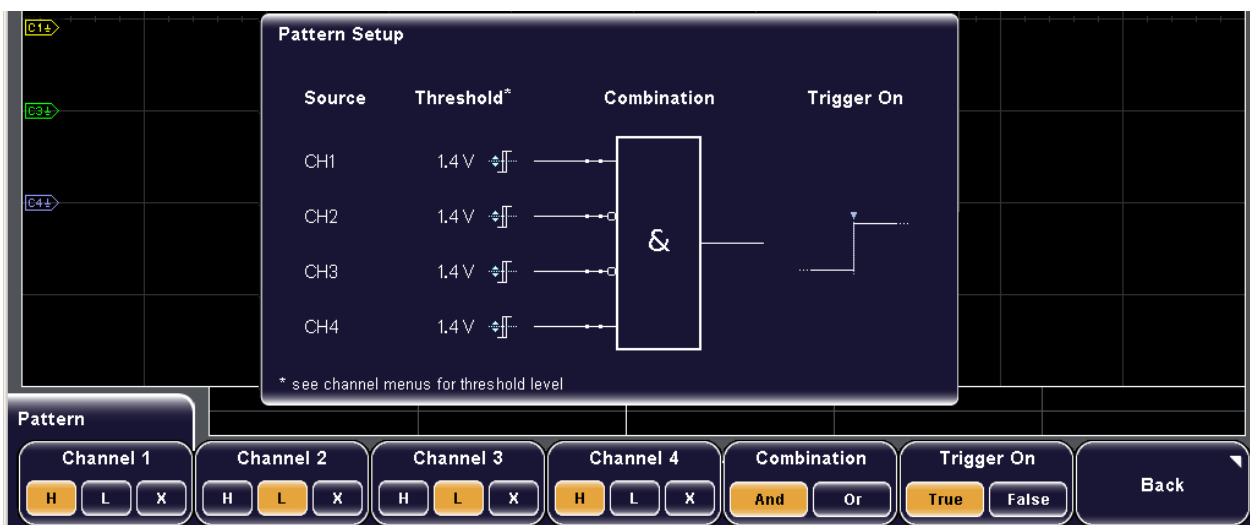
SCPI command:

[TRIGger:A:TV:FIELD](#) on page 207

3.3.2.5 Pattern

The Pattern trigger is a logic trigger. It provides any logical combination of the input channels and supports you in verifying the operation of digital logic.

The "Setup" and the "Source" menus for the pattern trigger are identical.



Channel N.....40
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 Trigger On.....40

Channel N

Select the state for each digital channel. The states are:

- "H" High: the signal voltage is higher than the trigger level.
- "L" Low: the signal voltage is lower than the trigger level.
- "X" Don't care: the channel does not affect the trigger.
 If X is set for all channels, the oscilloscope triggers only in automatic trigger mode.

SCPI command:
[TRIGger:A:PATTern:SOURce](#) on page 207

Combination

Sets the logical combination of the trigger states of the channels.

- "And" The required states of all channels must appear in the input signal at the same time.
- "Or" At least one of the channels must have the required state.

SCPI command:
[TRIGger:A:PATTern:FUNCTion](#) on page 208

Trigger On

Sets the trigger point depending on the result of the logical combination of the channel states.

SCPI command:
[TRIGger:A:PATTern:CONDition](#) on page 208

3.3.2.6 Protocol

The "Protocol" trigger menu contains the trigger settings for the serial bus or interface that is configured with PROTOCOL. Protocol analysis requires additional options.

For protocol setup and trigger settings, see [chapter 7.3, "Protocol Analysis"](#), on page 106.

To trigger on parallel buses, use the pattern trigger. See: [chapter 3.3.2.5, "Pattern"](#), on page 39.

3.3.2.7 B-Setup

The B-trigger is a second edge trigger event that can be combined with a preceding edge trigger event. The conditions of this second event are considered when the conditions of the main event (A-trigger) are met.



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B-Source

Selects one of the input channels as B-trigger source. Press the softkey repeatedly until the required source is selected.

SCPI command:

[TRIGger:B:EDGE:SOURce](#) on page 209

Slope

Sets the edge for the B-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" Selets the rising as well as the falling edge.

SCPI command:

[TRIGger:B:EDGE:SLOPe](#) on page 209

Level

Sets the trigger level for the B-trigger event.

SCPI command:

[TRIGger:B:EDGE:LEVe1](#) on page 209

Trigger On

Sets an additional delay condition for the B-event: time delay or event delay. According to this selection, set also "Time" or "Events" to define the condition completely.

Time

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

SCPI command:

[TRIGger:B:DElay](#) on page 209

Events

Sets a number of B-trigger events that fulfill all B-trigger conditions but do not cause the trigger. The oscilloscope triggers on the n-th event (the last of the specified number of events).

SCPI command:

[TRIGger:B:EVENT:COUNT](#) on page 210

Hysteresis A / B

Sets a hysteresis range around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs. Thus, hysteresis avoids unwanted trigger events caused by noise oscillation around the trigger level.

Hysteresis is available for the edge trigger (A-event and B-event) and for the width trigger.

To see the hysteresis on the display, activate "Trigger Hyst." in the "Display > Auxillary Cursors" menu.

The hysteresis value depends on the vertical scale.

4 Display

This chapter provides information on general display configuration.

4.1 Display Modes and Settings - Overview

Various display modes are available which you can customize according to your needs:

Standard signal vs. time diagrams

The default display is a diagram with a time axis in x-direction and the signal amplitudes displayed in y-direction - the Y(t) or time diagram.

The individual diagram elements can be shown or hidden:

- Basic diagram elements: grid and crosshairs
- Point of the trigger event
- Channel cursors to mark the ground level and the DC offset

For waveforms, you can adjust:

- Waveform style: dots or line
- Intensity: adjusts the optimal contrast of the display
- Persistence: depends on the time elapsed since the value occurred
- Signal colors or brightness: depend on on the cumulative frequency of the values

XY-diagram

XY-diagrams combine the voltage levels of two waveforms in one diagram. They use the amplitude of a second waveform as the x-axis, rather than a time base. This allows you to perform phase shift measurements, for example. With harmonically related signals the resulting XY-diagrams are Lissajous patterns.

It is also possible to define two source signals in y-direction for comparison. You can also define the intensity of the XY-diagram according to a further signal source Z.

Together with the XY-diagram, the time diagrams of the source signals are displayed in separate windows.

Zoom

You can zoom into waveforms to analyze the results in more detail. The zoomed area and its position can be configured numerically or using the rotary knobs.

When you activate zoom display, two windows are displayed: the original signal vs. time at the top, the zoomed area at the bottom.

See also: [chapter 4.2.4, "Zooming for Details"](#), on page 49.

Markers

Markers allow you to mark certain positions on the screen, e.g. a rising or falling edge, or an unexpected signal value. You can then use the markers to identify areas of interest you want to zoom into.

See also: [chapter 4.2.5, "Using Markers"](#), on page 52.

Other display modes

In addition to input channel waveforms, you can display the following:

- Stored reference waveforms, see [chapter 6.2, "Reference Waveforms"](#), on page 86
- Results of mathematical functions, see [chapter 6.1, "Mathematics"](#), on page 74
- Results of an FFT analysis, see [chapter 7.1.2, "Displaying and Configuring FFT Calculations"](#), on page 92
- Signal masks, see [chapter 7.2.1, "Working with Masks"](#), on page 101

4.2 Configuring the Display

This chapter describes how you perform the various display configuration tasks:

- [Configuring the Diagram Display](#).....44
- [Configuring the Waveform Display](#).....45
- [Configuring XY-Diagrams](#).....47
- [Zooming for Details](#).....49
- [Using Markers](#).....52

4.2.1 Configuring the Diagram Display

To display the grid or crosshairs

1. Press "DISPLAY > Grid > Lines" to display a grid.
2. Press "DISPLAY > Grid > Reticle" to display crosshairs.
3. Press "DISPLAY > Grid > Off" to remove both the grid and the crosshairs.

To display the trigger event or the channel cursors

The marker of trigger event and the channel cursors are auxiliary cursors. By default, both auxiliary cursors are displayed. They help to evaluate specific results more easily.

1. Press "DISPLAY > Aux. Cursor > Trigger Event" to display a trigger cursor.
A rhombus marks the point where the trigger event happened.
2. Press "DISPLAY > Aux. Cursor > Channel Cursors" to display a channel cursor.

A dashed line is displayed that marks the ground level of the displayed channel. If a DC offset is defined, a second auxiliary line is displayed. The distance between those two lines is the DC offset.

3. Press "DISPLAY > Aux. Cursor > Defaults" to restore the default setting (both cursors displayed).

4.2.2 Configuring the Waveform Display

The intensity and brightness of the individual screen elements can influence the readability of the results. Depending on which type of result you are interested in, e.g. frequency of occurrence, time of occurrence, or amplitude of a specific value, different settings may be necessary to highlight that aspect in the display. The waveform display depends on the following criteria:

- Intensity: fixed values to adjust the optimal contrast of the display
- Persistency: depends on the time elapsed since the value occurred
- Brightness and signal colors: depend on the cumulative frequency of the value

4.2.2.1 Configuring Intensity

The intensity remains constant for the entire signal throughout the measurement, if not changed by the user. It can be changed to improve the contrast for the relevant display elements.

To configure the intensity of the waveform

The intensity of the waveform determines the strength of the signal in the diagram.

1. Press "DISPLAY > Intensities > Trace".
2. 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.

To configure the intensity of the backlight

The intensity of the background lighting determines the contrast of the signal in the diagram.

1. Press "DISPLAY > Intensities > Backlight".
2. Enter a percentage between 10 and 100%. The default value is 50%.

To configure the intensity of the grid

The intensity of the grid has an influence on the readability of the signal in the diagram.

1. Press "DISPLAY > Intensities > Grid".
2. Enter a percentage between 0 and 100%. The default value is 34%.

4.2.2.2 Configuring Persistence

The persistence defines how long a data point is displayed in the diagram. Each new data point remains on the screen for the defined persistence time, or infinitely until the persistence time is changed or the persistence is cleared.

To eliminate persistence

- ▶ Press "DISPLAY > Intensities > Persistence" until "Off" is highlighted to display only the current signal at any time.

To configure the persistence automatically by the instrument

- ▶ Press "DISPLAY > Intensities > Persistence" until "Automatic" is highlighted to have the instrument define the optimal persistence automatically.

To configure the persistence manually

1. Press "DISPLAY > Intensities > Persistence" until "Manual" is highlighted.
2. Press "DISPLAY > Intensities > Persist. Time" to define the persistence time.
3. Enter a value between 50 ms and 9.6 s or "Infinite".

Each new data point in the diagram area remains on the screen for the defined duration. If "Infinite" is selected, each new data point in the diagram area remains on the screen infinitely until this setting is changed or the persistence is cleared.

To clear displayed persistence

- ▶ Press "DISPLAY > Intensities > Clear Persist."

The waveform is updated.

4.2.2.3 Configuring Brightness

By default, values that occur frequently are displayed brighter than rare values. Alternatively, the brightness level can be converted to a color range, i.e. the color changes gradually with increasing cumulative occurrence.

It is also possible to invert the brightness display so that rare values are brighter than frequent values. This setting is useful in combination with persistence to detect rare values within the waveform.

To convert the brightness level to a color range

- ▶ Press "DISPLAY > Temperature Colors".

By default, rare values are displayed in blue, while more frequent values are red and very frequent values are displayed in yellow or white, with various colors inbetween. The colors change if you invert the brightness display.

To invert the brightness level of the signals

- ▶ Press "DISPLAY > Inverse Brightn."

Rare values are displayed brighter than frequent values.

4.2.2.4 Configuring the Waveform Style

You can configure how the waveform is displayed within the diagram. By default, the individual data points are connected by a line. Alternatively, only the individual data points can be displayed.



You can change the strength of the line using the "INTENSITY" knob on the left side of the screen.

- ▶ Press "DISPLAY > Dots Only" to display the data points only.

4.2.3 Configuring XY-Diagrams

XY-diagrams combine the voltage levels of two waveforms in one diagram. It is also possible to define two source signals in y-direction for comparison. A further signal source can be used to determine the intensity of the XY-waveform.

XY-diagrams can be used to display the IQ representation of a signal.

4.2.3.1 Setting Up the XY-Diagram**To switch the display to XY-diagram and vice versa**

- ▶ Press "DISPLAY > Display Mode" until the required mode is selected.

To configure an XY-diagram

Prerequisite: The "Display Mode" is set to "XY".

1. Select "DISPLAY > XYZ Setup > Source X" to define the signal to be used as the x-axis source. Press "Source X" repeatedly until the required channel is highlighted.
2. Select "DISPLAY > XYZ Setup > Source Y1" to define the signal to be used as the (first) y-axis source. Press "Source Y1" repeatedly until the required channel is highlighted.
3. Optionally, select "DISPLAY > XYZ Setup > Source Y2" to define the signal to be used as a second y-axis source. Press "Source Y2" repeatedly until the required channel is highlighted.

The XY-diagram is displayed in the main window, and additional windows are opened to display the X, Y1, Y2, and Z time diagrams, if the source is defined.

4.2.3.2 Configuring the Intensity of an XY-Waveform

The intensity of the XY-waveform can be set to a defined level, or be modulated dynamically using a further source signal. In the latter case, the amplitudes of the source signal determine the intensity of the displayed waveform.

To configure the intensity of an XY-waveform at a defined level

Prerequisite: The "Display Mode" is set to "XY", and the XY-diagram is configured.

1. Press "DISPLAY > XYZ Setup > Z Setup".
2. Press the left "Source Z" softkey until "OFF" is highlighted to deactivate intensity control by the Z source.
3. Press "DISPLAY > Intensities > Trace" to define the intensity level of the waveform.
4. Enter a percentage between 0 (not visible) and 100% (very strong). The default value is 50%.

The waveform is displayed with a constant intensity.



Regardless of which menu is currently displayed, you can use the "INTENSITY" knob on the left side of the screen to adjust the waveform intensity directly.

To configure the intensity of an XY-waveform modulated by a signal

Prerequisite: The "Display Mode" is set to "XY", and the XY-diagram is configured.

1. Press "DISPLAY > XYZ Setup > Z Setup".
2. Press the left "Source Z" softkey until "ON" is highlighted to activate intensity control by the Z source.
3. Press the second "Source Z" softkey repeatedly until the required channel is selected to select the signal source that is to determine the intensity of the waveform.
4. Press "Z-Intensity" until "Modulation" is highlighted to select intensity control via modulation.

The waveform intensity is modulated dynamically according to the signal source Z. The higher the signal level Z is, the stronger the waveform is displayed.

To configure the intensity of an XY-waveform using a threshold value

Prerequisite: The "Display Mode" is set to "XY", and the XY-diagram is configured.

1. Press "DISPLAY > XYZ Setup > Z Setup".
2. Press the left "Source Z" softkey until "ON" is highlighted to activate intensity control by the Z source.
3. Press the second "Source Z" softkey repeatedly until the required channel is selected to select the signal source that is to determine the intensity of the waveform.

4. Press "Z-Intensity" until "ON | OFF" is highlighted to select intensity control via a threshold value.
5. Press "Threshold" and enter the required value to define the threshold value.

If the Z signal value is below the selected threshold, the corresponding x/y point is not displayed. If the Z signal value is above the threshold, the x/y point is displayed with the defined intensity level.

4.2.4 Zooming for Details

You can zoom into waveforms to analyze the results in more detail. The zoomed area and its position can be configured numerically or using the rotary knobs.

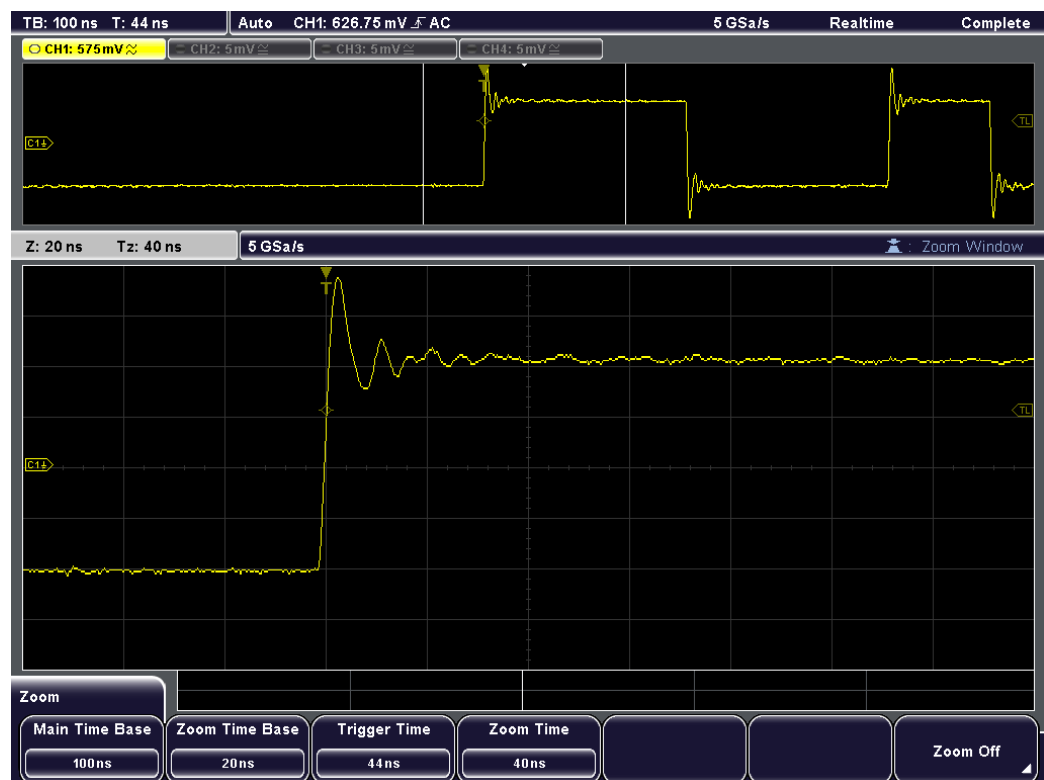


Using Markers

You can use markers to quickly zoom into a place of interest in the display, see ["To zoom into a marker position"](#) on page 53.

Zoom display

When you activate zoom display, two windows are displayed: the original signal vs. time at the top, the zoom window at the bottom. Which area of the original time base is zoomed is defined by the zoom area, which is indicated by white lines in the original Y(t)-diagram.



The usual channel parameters are displayed in the information bar above the original Y(t)-window (see the general display information described in the "Getting Started" manual).

In addition, the zoom area parameters are indicated in the information bar above the zoom window. The following information is given there:

Z	Zoom Time Base, i.e. scaling for the time base in the zoom window in seconds per division; determines the width of the zoom area that is displayed in the zoom window (10 divisions * scaling per division)
Tz	Zoom Time, i.e. the offset of the trigger point to the reference point 0s in the zoom window; determines the position of the zoom area
	Sample rate for zoom window

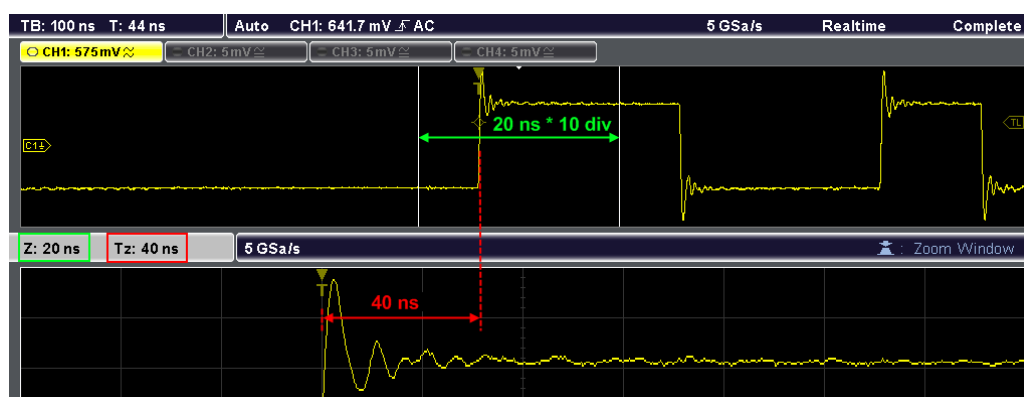


Fig. 4-1: Zoom area width and position

When you deactivate the zoom display, the previous display is restored.

To display a zoom diagram

- ▶ Press the ZOOM key.

The key lights up and two windows are displayed: the original signal vs. time at the top, the zoom at the bottom.

To deactivate the zoom display

- ▶ Press the ZOOM key again, or press the "Zoom Off" softkey in the "Zoom" menu to close the zoom window.

The ZOOM key is no longer illuminated and the previous display is restored.

To configure the zoom area numerically

1. Press the "Zoom Time Base" softkey to define the scaling for the time base in the zoom diagram in seconds per division. The scaling is indicated by "Z" in the information bar above the zoom diagram and determines the width of the zoom area that is displayed in the zoom diagram (10 divisions * scaling per division).

2. Press the "Zoom Time" softkey to define the offset of the trigger point to the reference point 0s in the zoom diagram. The offset is indicated by "Tz" in the information bar above the zoom window and determines the position of the zoom area.

The zoom area is indicated by white lines in the original Y(t)-window. The zoom window displays the data in the defined zoom area from the main time base in greater detail.

To configure the zoom area via the rotary knobs

Press the horizontal SCALE rotary knob to move the focus between the Y(t)-window (Time Control), the zoom area (Zoom Control) and the zoom window. The currently selected screen area is highlighted and displayed in the information bar of the zoom window. Depending on the selection, the functions of the SCALE and POSITION rotary knobs may change.

1. Press the horizontal SCALE rotary knob to select "Zoom Control" or "Zoom Window". The functions for the rotary knobs are the same for both elements; for very high zoom factors, however, it may be faster to scroll through with the "Zoom Window" focus.

2. Turn the horizontal SCALE rotary knob counter-clockwise to enlarge the zoom area, or clockwise to decrease it.

The zoom diagram and the "Z" parameter ([Zoom Time Base](#)) in the information bar above it are adapted.

3. Turn the horizontal POSITION rotary knob counter-clockwise to move the zoom area to the left, or clockwise to move it to the right.

The zoom diagram and the "Tz" parameter ([Zoom Time](#)) in the information bar above it are adapted.

The zoom window displays the data in the defined zoom area from the main time base in greater detail.

To configure the original Y(t)-diagram

1. Press the horizontal SCALE rotary knob to select "Time Control", the original Y(t)-window.
2. Press "Main Time Base" to define the scaling for the time base in the original Y(t)-window in seconds per division. Alternatively, turn the horizontal SCALE rotary knob.
3. Press "Trigger Time" to define the offset of the trigger point to the reference point for 0s in the original Y(t)-window. Alternatively, turn the horizontal POSITION rotary knob.

Note that changing the offset in the original window also changes the offset for the zoom window ([Zoom Time](#)).

4.2.5 Using Markers

Markers allow you to mark certain positions on the screen, e.g. a rising or falling edge, or an unexpected signal value. You can then use the markers to identify areas of interest you want to zoom into, and quickly move through the data. You can set up to 8 markers.

Markers are displayed as colored lines on the screen. If more markers are available but currently not visible on the screen (e.g. in a zoomed display), this is indicated by a small arrow at the right or left edge of the display.

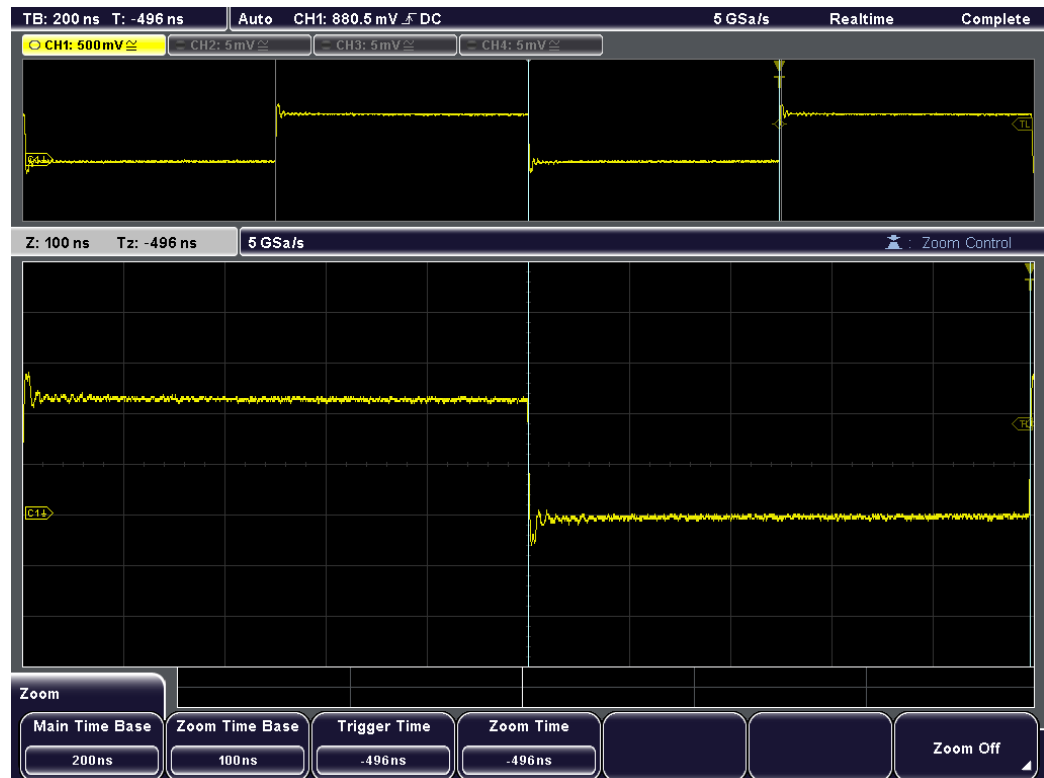


Fig. 4-2: Zoomed display using markers

To set a marker

1. Press the SET key to insert a new marker at the reference position.
2. Move the marker to the required position in the display using the horizontal "Position" rotary knob.

To select a marker

When you select a marker it is automatically moved to the reference point of the display.

1. Press the NEXT key to move the next marker (to the right) to the reference point of the display or zoom area.
2. Press the PREV key to move the previous marker (to the left) to the reference point of the display or zoom area.

To remove a marker

1. Select the marker to be deleted using the NEXT or PREV key.
2. Press the CLEAR key to remove the marker at the reference position.

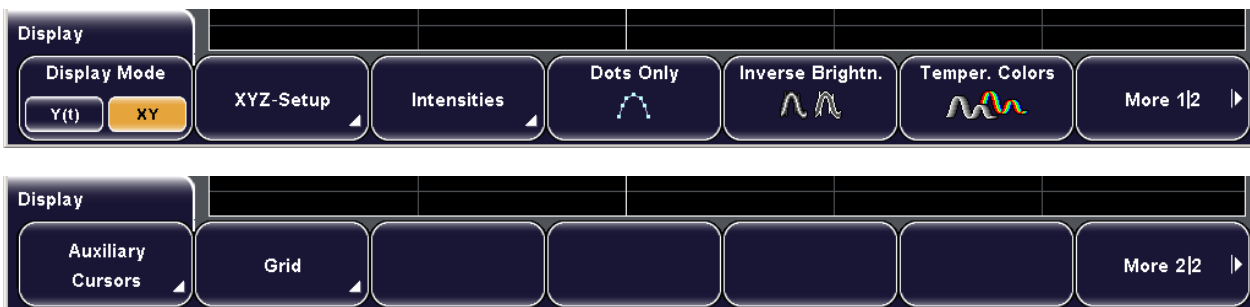
To zoom into a marker position

1. Set a marker in the display as described above.
2. If not yet active, activate the zoom function by pressing the ZOOM key.
The marker lines are displayed both in the original window and in the zoom window.
3. Select the marker that indicates the area you want to zoom into using the NEXT or PREV key.
The center of the zoom area is moved to the marker (see [figure 4-2](#)).
4. If necessary, fine-tune the position of the zoom area around the marker as described in ["To configure the zoom area via the rotary knobs"](#) on page 51.

4.3 Reference for Display Settings

4.3.1 Display Menu

The DISPLAY key provides functions for configuring the display.



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Display Mode

Toggles the diagram mode.

- "Y(t)" Default time diagram with a time axis in x-direction and the signal amplitudes displayed in y-direction.
- "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 than a time base. This allows you to perform phase shift measurements, for example. You can also define the intensity of the XY-diagram according to a further signal source Z. Together with the XY-diagram, the Y(t)-diagrams of the source signals are displayed in separate windows. With R&S RTM1054, it is also possible to define two source signals in y-direction for comparison.

SCPI command:

`DISPlay:MODE` on page 210

XYZ Setup

Provides configuration functions for XY-diagrams.



Source X ← XYZ Setup

Defines the source to be displayed in x direction in an XY-diagram, replacing the usual time base. The source can be selected from any of the analog channels.

The function is available in R&S RTM1054.

SCPI command:

[DISPlay:XY:XSource](#) on page 211

Source Y1 ← XYZ Setup

Defines the (first) source to be displayed in y direction in an XY-diagram. The source can be selected from any of the analog channels.

The function is available in R&S RTM1054.

SCPI command:

[DISPlay:XY:Y1Source](#) on page 211

Source Y2 ← XYZ Setup

Defines an optional second source to be displayed in y direction in an XY-diagram. The source can be selected from any of the analog channels.

The function is available in R&S RTM1054.

SCPI command:

[DISPlay:XY:Y2Source](#) on page 212

X-CH1 Y-CH2 ← XYZ Setup

Defines channel 1 to be displayed in x direction in an XY-diagram, replacing the usual time base, and sets channel 2 to the y-axis.

The function is available in R&S RTM1052.

X-CH2 Y-CH1 ← XYZ Setup

Defines channel 2 to be displayed in x direction in an XY-diagram, replacing the usual time base, and sets channel 1 to the y-axis.

The function is available in R&S RTM1052.

Z Setup ← XYZ Setup

The intensity of the waveform displayed in an XY-diagram can be set to a defined level, or be modulated dynamically using a further source signal Z. In the latter case, the amplitudes of the source signal determine the intensity of the displayed waveform.



Z ← Z Setup ← XYZ Setup

Activates or deactivates the intensity control of the waveform via an additional signal source. If deactivated, the intensity is defined by the general "Intensity" setting for the trace.

SCPI command:

[DISPlay:XY:ZMODE](#) on page 212

Source Z ← Z Setup ← XYZ Setup

Defines the source to be used to determine the intensity of the waveform. The source can be selected from any of the analog channels. Pressing the softkey repeatedly scrolls through the list of available source channels.

SCPI command:

[DISPlay:XY:ZSource](#) on page 212

Z-Intensity ← Z Setup ← XYZ Setup

Toggles between intensity modes.

"Modulation" Modulated intensity; Intensity is modulated continuously according to the selected "Source Z".

"On | Off" Intensity is determined by a "Threshold" value. If the Z signal value is below the selected threshold, the corresponding x/y point is displayed with lowest intensity. If the Z signal value is above the threshold, the x/y point is displayed with the defined intensity level.

SCPI command:

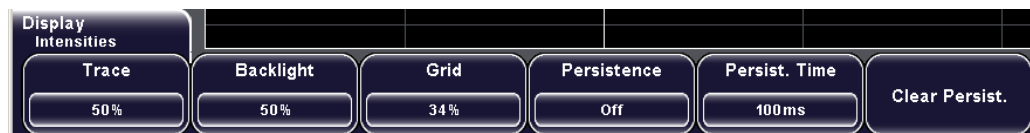
[DISPlay:XY:ZMODE](#) on page 212

Threshold ← Z Setup ← XYZ Setup

Defines the threshold for intensity with a two-state modulation, if "Z-Intensity" is set to "ON | OFF".

Intensities

Provides functions to define the intensity of various display elements.

**Waveform ← Intensities**

This value determines the strength of the waveform line in the diagram. Enter a percentage between 0 (barely 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.

SCPI command:

[DISPlay:INTensity:WAVEform](#) on page 213

Backlight ← Intensities

Defines the intensity of the background lighting of the display in percent. Enter a percentage between 10% and 100%. The default value is 50%.

SCPI command:

[DISPlay:INTensity:BACKlight](#) on page 213

Grid ← Intensities

Defines the intensity of the grid on the screen in percent. Enter a percentage between 0% and 100%. The default value is 34%.

SCPI command:

[DISPlay:INTensity:GRID](#) on page 213

Persistence ← Intensities

Defines the persistence of the waveform on the screen.

- "Off" Deactivates persistence
- "Automatic" The optimal persistence time is determined automatically by the instrument
- "Manual" User-defined persistence according to "Persist. Time" setting.

SCPI command:

[DISPlay:PERSistence:STATE](#) on page 213

[DISPlay:PERSistence:TIME:AUTO](#) on page 214

Persist. Time ← Intensities

User-defined persistence time if "Manual" persistence is selected. Each new data point remains on the screen for the duration defined here. Possible values are from 50 ms to 9.6 s or "Infinite". If "Infinite" is selected, each new data point remains on the screen infinitely until this setting is changed or the persistence is cleared.

SCPI command:

[DISPlay:PERSistence:TIME](#) on page 214

[DISPlay:PERSistence:INFinite](#) on page 214

Clear Persist. ← Intensities

Clears the displayed persistence on the screen.

SCPI command:

[DISPlay:PERSistence:CLEar](#) on page 214

Dots Only

If activated, only the individual data points are displayed. If deactivated, the individual data points are connected by a line. Define the strength of the line using the "INTENSITY" knob on the left side of the screen.

SCPI command:

[DISPlay:STYLE](#) on page 214

Inverse Brightn.

Inverts the brightness level of the signals. Normally, values that occur frequently are brighter than rare values. This setting inverts this behavior: Rare values are brighter than frequent values. Use this setting in combination with persistence to detect rare values within the waveform.

SCPI command:

[DISPlay:PALETTE](#) on page 211 (INVerse, IFColor)

Temper. Colors



Temperature Colors: Converts the brightness level of the displayed signals into a color range, i.e. the color changes gradually in a wide color spectrum with increasing cumulative occurrence.

By default, rare values are displayed in blue, while more frequent values are red and very frequent values are displayed in yellow or white, with various colors inbetween. This results in a higher contrast, which provides a better perception of details in the waveforms.

Note: The colors change if you invert the brightness display.

SCPI command:

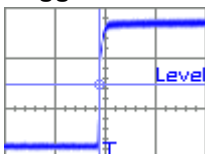
[DISPlay:PALETTE](#) on page 211 (NORMAL, FColor)

Aux. Cursors

Provides functions to display auxiliary cursors. Highlighted functions are active.



Trigger Event ← Aux. Cursors



Show or hides the point of the trigger. A small rhombus marks the intersection of the trigger level and the trigger time T. The time is related to the reference point and is displayed in the header of the display. If you change the trigger level or the trigger position, a line appears temporarily to highlight the changed value.

If the B-trigger is activated, the trigger is the result of an A-event followed by an B-event. The trigger point has the color of the B-trigger source.

Channel Cursors ← Aux. Cursors



Activates or deactivates the channel cursor of the active channel. A channel cursor is a dashed line that marks the ground level of a channel. This line is displayed temporarily if the y-scaling is modified and fades out automatically. If a DC offset is defined, a second auxiliary line is displayed. The distance between those two lines is the DC offset.

Trigger Hyst. ← Aux. Cursors

Shows or hides the hysteresis range around the trigger level when the trigger level or the hysteresis are changed. Hysteresis avoids unwanted trigger events caused by noise oscillation around the trigger level.

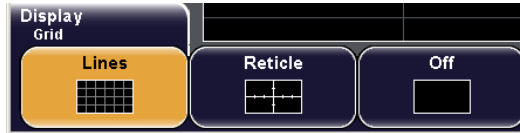
See also: "[Hysteresis A / B](#)" on page 36

Defaults ← Aux. Cursors

Restores the default cursor settings, i.e. both auxiliary cursors are displayed.

Grid

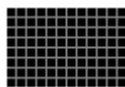
Defines how the grid is displayed.



SCPI command:

[DISPlay:GRID:STYLE](#) on page 215

Lines ← Grid



Displays the grid as horizontal and vertical lines.

Reticle ← Grid



Displays crosshairs instead of a grid.

Off ← Grid

Removes the grid from the display.

4.3.2 Zoom Menu

The ZOOM key provides functions for configuring the zoom display.



Main Time Base	59
Zoom Time Base	60
Trigger Time	60
Zoom Time	60
Zoom Off	60

Main Time Base

Defines the scaling for the time base in the (original) Y(t)-window in seconds per division. The scaling is indicated by "TB" in the information bar above the window.

Note: If "Time Control" is selected, the main time base can be adjusted using the horizontal SCALE rotary knob.

See also ["SCALE"](#) on page 20, ["To configure the original Y\(t\)-diagram"](#) on page 51 and [figure 7-2](#).

SCPI command:

[TIMEbase:SCALE](#) on page 188

Zoom Time Base

Defines the scaling for the time base in the zoom window in seconds per division. The scaling determines the width of the zoom area that is displayed in the zoom window (10 divisions * scaling per division).

The zoom area is indicated by white lines in the original Y(t)-window.

SCPI command:

[TIMEbase:ZOOM:SCALE](#) on page 215

Trigger Time

Defines the horizontal position of the trigger point in relation to the reference point - to the zero point of the grid. The value is also known as trigger offset and is indicated by "T" in the information bar above the window.

Note: If a zoom or FFT window is displayed and "Time Control" is selected, the trigger time can be adjusted using the horizontal POSITION rotary knob.

See also:

- ["POSITION"](#) on page 20
- ["To configure the original Y\(t\)-diagram"](#) on page 51

SCPI command:

[TIMEbase:POSITION](#) on page 189

Zoom Time

Defines the offset of the trigger point to the reference point 0s in the zoom window. The offset determines the position of the zoom area that is displayed in the zoom window.

SCPI command:

[TIMEbase:ZOOM:TIME](#) on page 216

Zoom Off

Closes the zoom window and returns to the previous display.

SCPI command:

[TIMEbase:ZOOM:STATE](#) on page 215

4.3.3 Reference for Markers

You can mark certain positions on the time axis, e.g. a rising or falling edge, or an unexpected signal value. You can then switch from one marker to the next, moving the selected marker to the reference point of the display or zoom area. These markers are also called timestamps.

For details on setting and moving markers see [chapter 4.2.5, "Using Markers"](#), on page 52.

[NEXT](#)61

PREV	61
SET	61
CLEAR	61

NEXT

Moves the next marker (to the right) to the reference point of the display or zoom area.

Note: If another marker is available at the right, but currently not visible on the screen, a small red arrow is displayed at the right edge of the display.

SCPI command:

[TSTamp: NEXT](#) on page 216

PREV

Moves the previous marker (to the left) to the reference point of the display or zoom area.

Note: If another marker is available at the left, but currently not visible on the screen, a small red arrow is displayed at the left edge of the display.

SCPI command:

[TSTamp: PREVIOUS](#) on page 216

SET

Sets a new marker at the reference point of the display, unless an existing marker is already set there.

SCPI command:

[TSTamp: SET](#) on page 216

CLEAR

Deletes the marker at the reference point. Use the NEXT and PREV keys to move the markers to the reference point.

SCPI command:

[TSTemp: CLEAR](#) on page 217

5 Measurements

Using the R&S RTM you can configure and display up to four 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:

- "Quick Meas": basic automatic measurements for the selected channel are performed immediately; the results are displayed directly at the waveform and in a result table.
- "Meas": up to four amplitude and time measurements or pulse counts can be configured and performed simultaneously; the results are displayed in a result table. These measurements can be performed together with the "Quick Meas" measurements.
- "Cursor": determines specific measurement results at the current cursor positions of an active waveform; the results are displayed in a result table.

Use the full height of the screen for waveform display to get best vertical resolution and measurement results.

5.1 Performing Measurements

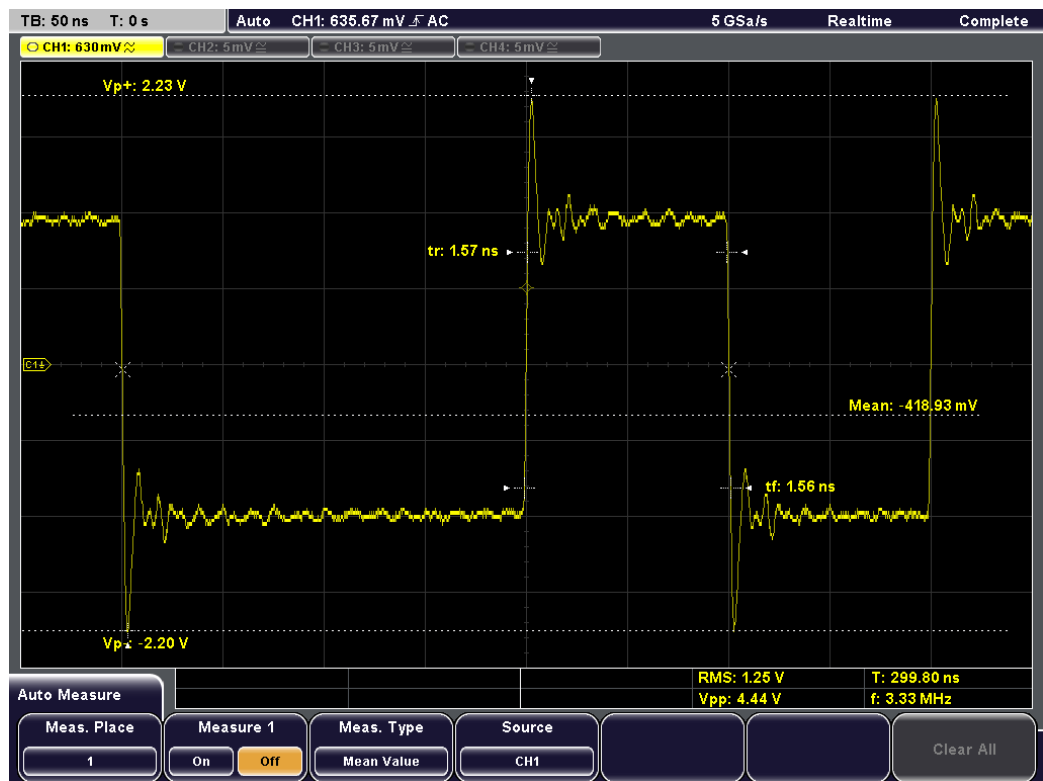
This chapter describes how to configure and perform the different measurement types.

- [Performing Quick Measurements](#).....62
- [Configuring and Performing Automatic Measurements](#).....64
- [Configuring and Performing Cursor Measurements](#).....65

5.1.1 Performing Quick Measurements

Quick measurement performs all currently available automatic measurements for the selected channel. The measurements cannot be configured. The results are displayed either directly at the waveform (WF) or in the right part of the result table (T) and are updated continuously.

- ▶ Press the QUICK MEAS key to activate quick measurement.



The following measurement results are determined for the displayed section of the waveform:

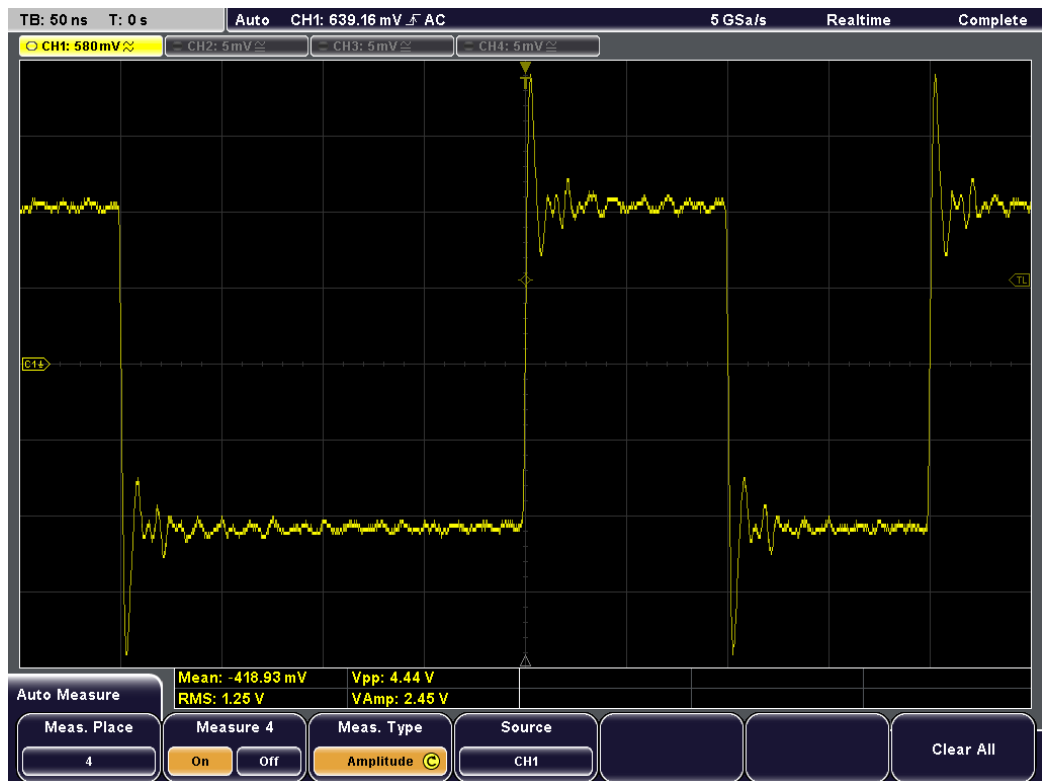
Label	Description	Display
Vp+	Positive peak value	WF
Vp-	Negative peak value	WF
tr	Rising time of the first rising edge	WF
Mean	Mean value	WF
tf	Falling time of the first falling edge	WF
RMS	RMS	T
Vpp	Peak to peak value	T
T	Period length	T
f	Frequency	T

When you activate quick measurements, cursor measurements are automatically deactivated, as well as the reference and math menus. Deactivate quick measurements before selecting these functions. Channels other than the selected one are switched off in quick measurement mode.

- ▶ Press the QUICK MEAS key again to deactivate the quick measurement and remove the results.

5.1.2 Configuring and Performing Automatic Measurements

Using the MEAS key you can configure up to four amplitude and time measurements or pulse counts, based on the active signal or math waveforms. The results are displayed in the result table below the diagram. The color of the results in the left part of the result table corresponds with the source waveform color. If the result for the selected measurement type cannot be determined, e.g. because a complete period of a signal is required but not available, a "?" is displayed.



To configure and activate automatic measurements

1. Press the MEAS key.
2. Press "Meas. Place" to select one of the four measurement positions.
3. Press "Meas. Type" to select the type of measurement to perform. The type determines which results are displayed in the result table.
See also: "[Meas. Type](#)" on page 68.
4. Press "Source" to select the waveform for which the measurement is to be performed. The source can be any active signal or math waveform.
5. Press "Measure 1-4" until "On" is highlighted to activate the measurement.

The selected measurement is activated and the results are displayed in the result table.

To activate configured automatic measurements

1. Press the MEAS key.
2. Press "Meas. Place" to select one of the four measurement positions.
3. Press "Measure 1-4" until "On" is highlighted.

To deactivate automatic measurements

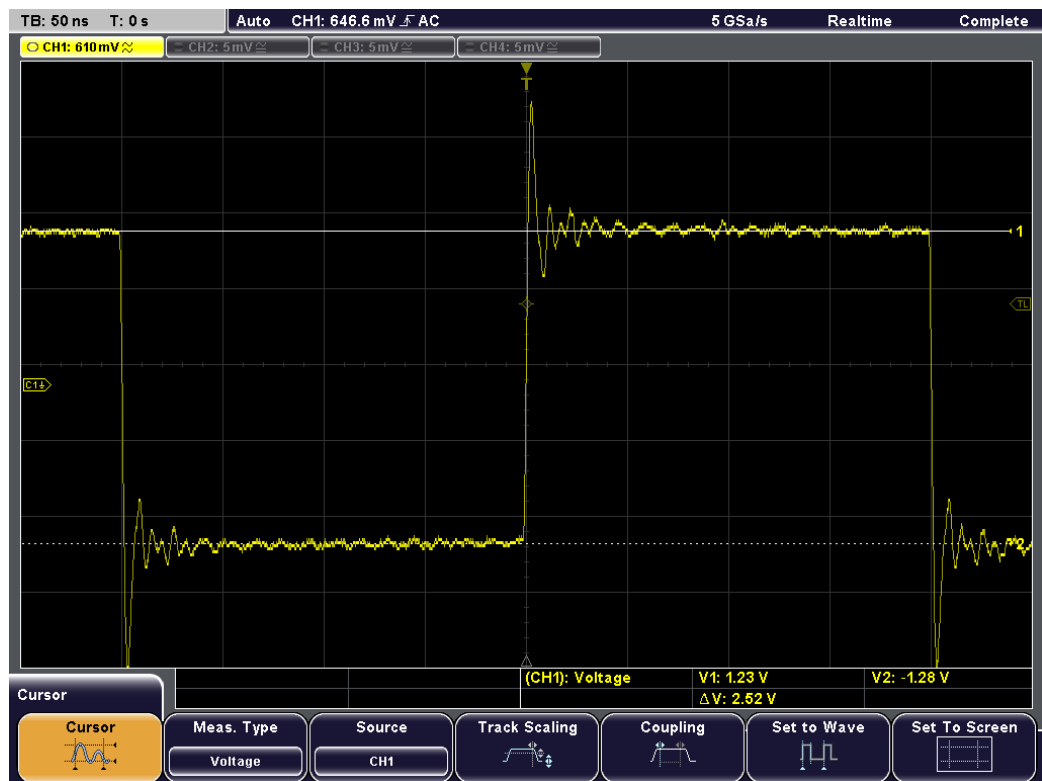
1. Press the MEAS key.
2. Press "Meas. Place" to select the measurement you want to deactivate.
3. Press "Measure 1-4" until "Off" is highlighted.
4. If you want to reset and deactivate all automatic measurements at once, press the "Clear All" softkey in the "Auto measure" menu.

No more measurements are performed, the results are removed from the result table.

5.1.3 Configuring and Performing Cursor Measurements

Using the CURSOR key you can determine specific measurement results at the current cursor positions for an active waveform. The cursors can be set to the required position with the Navigation rotary knob, or set to typical positions on a keypress. The results are displayed in the right part of the result table.

The cursors are activated according to the latest setting as soon as you press the CURSOR key.



To configure cursor measurements

1. Press the CURSOR key.
The cursors are activated according to the latest setting.
2. Press "Meas. Type" to select the type of measurement to perform. The type determines which results are displayed in the result table.
See also: "[Meas.Type](#)" on page 71.
3. Press "Source" to select the waveform for which the measurement is to be performed. The source can be any active signal or math waveform.
4. Move the cursors to obtain the required results.
See also: "[To change the position of the cursors](#)" on page 66.

The cursor measurement is performed and the results are displayed in the result table.

To change the position of the cursors

The cursor measurement displays the results depending on the current position of the cursors. Move the cursors to obtain the results for a specific time range or at specific signal points.

1. Press the NAVIGATION rotary knob to select the first cursor. If a selection menu is open, it is closed.

Tip: If the cursors have disappeared from the screen or must be moved extensively within the screen, press "Set To Screen" in the "Cursor" menu to reset the cursors to their default positions.

2. Turn the NAVIGATION knob to change the position of the selected cursor line.
3. Press the knob again to select the next cursor line, and turn to adjust position.
4. To simplify the cursor positioning, the following functions are helpful:
 - "Track Scaling" to adjust the cursor position when the vertical or horizontal scaling are changed
 - "Coupling" to keep the distance between two cursor lines constant while one of the cursors is moved
 - "Set to Wave" to set the cursor lines to typical points of the waveform based on automatic measurements in the background

See also: [chapter 5.2.2, "Cursor Menu"](#), on page 71.

The results of the cursor measurement in the result table are updated.

To deactivate cursor measurements

1. Press the CURSOR key.
2. Press the "Cursor" softkey.

The "Cursor" softkey is no longer highlighted, no more measurements are performed, the cursor lines disappear and the results are removed from the result table.

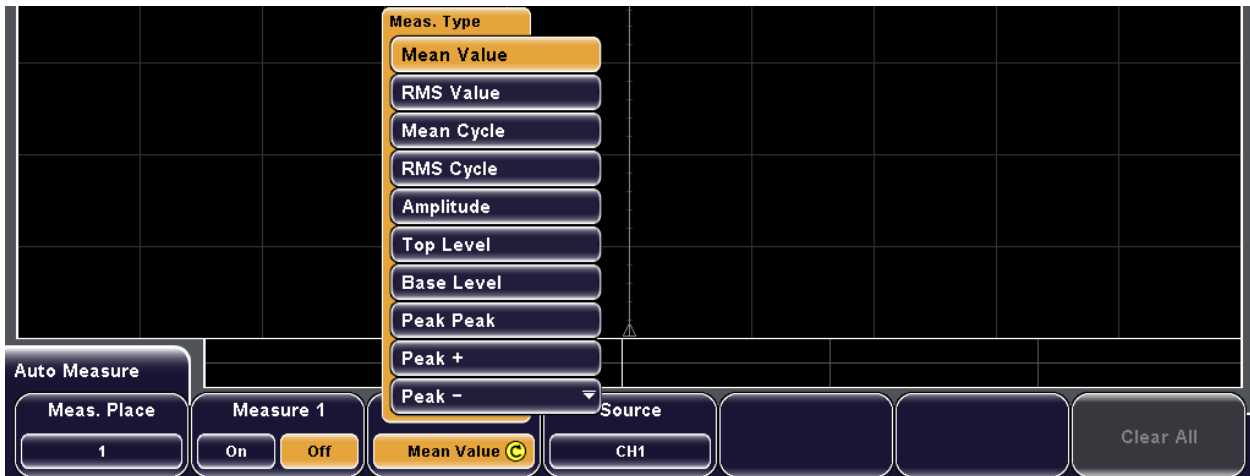
5.2 Reference for Measurements

This chapter describes the functions for automatic and cursor measurements.

5.2.1 Auto Measure Menu (MEAS key)

The MEAS key opens the "Auto Measure" menu to configure automatic measurements.

For details, see [chapter 5.1, "Performing Measurements"](#), on page 62.



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Source.....	70
Clear All.....	71

Meas. Place

Selects one of the four available measurements to be configured or activated.

SCPI command:

Measure 1-4

Activates or deactivates the selected measurement (1-4).

SCPI command:

[MEASurement<m>\[:ENABLE\]](#) on page 224

Meas. Type

Defines the measurement type to be performed on the selected source. Depending on the type, different results are displayed in the result table.

- "Mean Value" Determines the mean value of the complete displayed waveform. The measurement value is displayed as "Mean" in the result table.
- "RMS Value" Measures the RMS (Root Mean Square) value of the voltage of the complete displayed waveform. The measurement value is displayed as "RMS" in the result table.
- "Mean Cycle" Measures the mean value of the left-most signal period. The measurement value is displayed as "MnCy" in the result table.
- "RMS Cycle" Measures the RMS (Root Mean Square) value of the voltage of the left-most signal period. The measurement value is displayed as "RMSCy" in the result table.
- "Amplitude" Measures the amplitude of a square wave. To do so, the potential difference between high and low level ("Vbase" and "Vtop") is calculated. The measurement requires at least one complete period of a triggered signal. The measured value is displayed as "VAmp" in the result table.

"Top Level"	Measures the mean value of the high level of a square wave. To do so, the mean value of the tilt is calculated (without the overshoot). The measurement requires at least one complete period of a triggered signal. The measured value is displayed as "Vtop" in the result table.
"Base Level"	Measures the mean value of the low level of a square wave. To do so, the mean value of the tilt is calculated (without the overshoot). The measurement requires at least one complete period of a triggered signal. The measured value is displayed as "Vbase" in the result table.
"Peak Peak"	Measures the peak-to-peak value within the displayed section of the waveform. The measurement value is displayed as "Vpp" in the result table.
"Peak +"	Measures the maximum value within the displayed section of the waveform. The measured value is displayed as "Vp+" in the result table.
"Peak -"	Measures the minimum value within the displayed section of the waveform. The measured value is displayed as "Vp-" in the result table.
"Period"	Measures the length of the left-most signal period within the displayed section of the waveform. The measurement value is displayed as "T" in the result table.
"Frequency"	Measures the frequency of the signal. The result is based on the length of the left-most signal period within the displayed section of the waveform. The measurement value is displayed as "f" in the result table.
"Count"	<p>⌈ : Counts positive pulses within the displayed section of the waveform. A positive pulse consists of a rising edge followed by a falling edge. The mean value of the signal is determined. If the signal passes the mean value, an edge is counted. The pulse is counted if a rising edge and a falling edge are detected. The number of positive pulses is displayed as "Cnt ⌈" in the result table.</p> <p>⌋ : Counts negative pulses within the displayed section of the waveform. A negative pulse consists of a falling edge followed by a rising edge. The mean value of the signal is determined. If the signal passes the mean value, an edge is counted. The pulse is counted if a falling edge and a rising edge are detected. The number of negative pulses is displayed as "Cnt ⌋" in the result table.</p> <p>⌆ : Counts transitions of the signal from low level to high level within the displayed section of the waveform. To do so, the mean value of the signal is determined. If the signal passes the mean value, a rising edge is counted. The number of rising edges is displayed as "Cnt ⌆" in the result table.</p> <p>⌇ : Counts transitions of the signal from high level to low level within the displayed section of the waveform. To do so, the mean value of the signal is determined. If the signal passes the mean value, a falling edge is counted. The number of falling edges is displayed as "Cnt ⌇" in the result table.</p>

- "Pulse Width" \Uparrow : Measures 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. The measured value is displayed as "t \Uparrow " in the result table.
 \Downarrow : Measures the width of a negative pulse. A negative pulse consists of a falling edge followed by a rising edge. The measurement and requires at least one complete period of a triggered signal. The measured value is displayed as "t \Downarrow " in the result table.
- "Duty Cycle +" Measures 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 and requires at least one complete period of a triggered signal. The result is the measured value as a percentage of the signal period and is displayed as "Dty+" in the result table.
- "Duty Cycle -" Measures 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 and requires at least one complete period of a triggered signal. The result is the measured value as a percentage of the signal period and is displayed as "Dty-" in the result table.
- "Rise Time" Measures the rise time of the left-most rising edge within the displayed section of the waveform. The rise time is determined as the time it takes the signal to rise from 10% to 90% of its amplitude. The measurement value is displayed as "tr" in the result table.
- "Fall Time" Measures the falling time of the left-most falling edge within the displayed section of the waveform. The falling time is determined as the time it takes the signal to fall from 90% to 10% of its amplitude. The measurement value is displayed as "tf" in the result table.
- " σ Std. Deviation" Measures the standard deviation of the waveform.
- "Trigger Freq." Measures the frequency of the trigger signal based on the length of its period. The measurement value is displayed as "f(Tr)" in the result table.
- "Trigger Per." Measures the length of the trigger signal periods (hardware counter). The measurement value is displayed as "T(Tr)" in the result table.

SCPI command:

[MEASurement<m>:MAIN](#) on page 226

[MEASurement<m>:RESult](#) on page 228

Std. Deviation

Measures the standard deviation of the waveform.

Source

Selects one of the active signal or math waveforms as the source of the selected measurement.

SCPI command:

[MEASurement<m>:SOURce](#) on page 224

Clear All

Resets and deactivates all four measurements.

SCPI command:

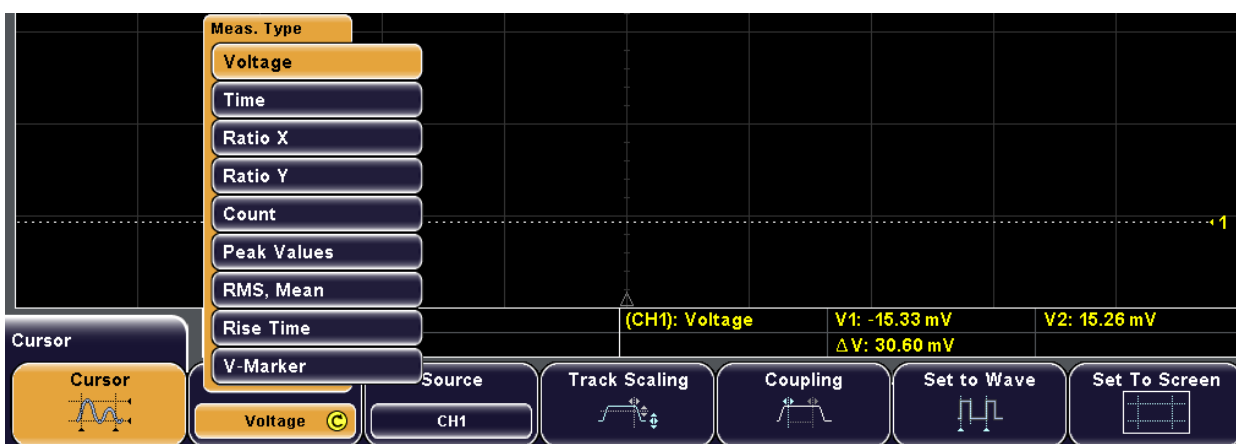
[MEASurement<m>:AOFF](#) on page 224

[MEASurement<m>:CLEar](#) on page 225

5.2.2 Cursor Menu

The CURSOR key opens the "Cursor" menu to configure manual measurements.

See also: [chapter 5.1.3, "Configuring and Performing Cursor Measurements"](#), on page 65.



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Meas.Type	71
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Cursor

Activates or deactivates the selected cursor measurement.

SCPI command:

[CURSor<m>:STATe](#) on page 218

Meas.Type

Selects the cursor measurement type. Depending on the type, different results are displayed in the result table.

For each cursor measurement, two or three cursors are provided which can be set to the required position using the "Navigation" rotary knob.

See also: ["To change the position of the cursors"](#) on page 66.

"Voltage"	Measures the voltages at the two cursor positions and the delta of the two values. Results: V1, V2, ΔV
"Time"	Measures the time from the trigger time to each cursor point, the time between the two cursors and the frequency calculated from that time (1/t) Results: t1, t2, Δt , 1/t
"Ratio X"	Provides three cursors and measures the ratio of the x-values (e.g. a duty cycle) between the first and second cursors and the first and third cursors: $(x2-x1)/(x3-x1)$ The ratio is displayed as a floating value, in percent, in degrees and as a radian. Results: abs, %, °, π
SCPI command: CURSor<m>:XRATio[:VALue] on page 223 CURSor<m>:XRATio:UNIT on page 222	
"Ratio Y"	Provides three cursors and measures the ratio of the y-values (e.g. overshooting) between the first and second cursors and the first and third cursors: $(y2-y1)/(y3-y1)$ The ratio is displayed as a floating value and in percent. Results: abs, %
SCPI command: CURSor<m>:YRATio[:VALue] on page 223 CURSor<m>:YRATio:UNIT on page 223	
"Count"	Provides three cursors to count signal transitions. The time base is defined by the first two cursors, the third cursor defines the threshold value. As a result, the number of rising and falling edges as well as the number of positive and negative impulses is counted. Results: \uparrow , \downarrow , J, L
"Peak Values"	Measures the positive and negative peak values between the two cursors, as well as the absolute difference between the two peak values (peak-to-peak value): $V_{pp} = (V_{p+}) - (V_{p-}) $. Results: Vp+, Vp-, Vpp
"RMS, Mean"	Measures the root mean square (RMS) and mean value between the two cursors. Results: Mean, RMS
"Rise Time"	Measures the rise and fall times of the left-most edge in the display between the two cursors. Results: tr, tf

"V-Marker" Two vertical markers are provided and the values of the waveform at the marker positions are measured. Additionally, the differences of the two values in x- and y-direction are displayed.
Results: V1, V2, Δt , ΔV

SCPI command:

[CURSor<m>:FUNction](#) on page 218

Source

Defines the source of the cursor measurement as one of the active channel or math waveforms.

SCPI command:

[CURSor<m>:SOURce](#) on page 218

Track Scaling

If enabled, "Track Scaling" adjusts the cursor lines if the vertical or horizontal scales are changed. The cursor lines keep their relative position to the waveform.

If disabled, the cursor lines remain on their position on the display if the scaling is changed.

SCPI command:

[CURSor<m>:YCOupling](#) on page 221

Coupling

If enabled, the cursors of a set are coupled so that the distance between the two remains the same if one cursor is moved.

SCPI command:

[CURSor<m>:XCOupling](#) on page 221

Set to Wave

Autoset for cursor lines, sets the cursor lines to typical points of the waveform depending on the selected measurement type. For example, for voltage measurement, the horizontal cursor lines are set to the upper and lower peaks of the waveform. For time measurement, the vertical cursor lines are set to the edges of two positive or two negative pulses.

Set To Screen

Resets the cursors to their initial positions. This is helpful if the cursors have disappeared from the display or need to be moved for a larger distance.

SCPI command:

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.

6.1 Mathematics


Mathematical (math) waveforms are calculated data. You can configure up to five math waveforms.

6.1.1 Configuring and Using Math Waveforms

Math waveforms are configured using the "Equation Set Editor". Each equation for a math waveform is configured and displayed individually, and you can save and load the configuration of all five math waveforms as an "Equation Set".

6.1.1.1 Displaying Mathematical Waveforms

For each of the five available mathematical channels you can define whether it is displayed or not and which equation is performed in each one.

1. Press MATH to display the "Mathematics" menu.
2. Press "Equation" and select the mathematical channel that contains the equation you want to display.
To check which equation is configured for which channel:
 - a) Press "Edit Equations". The "Equation Set Editor" is displayed, where you can see the configuration for each mathematical channel. Currently displayed channels are indicated by the  symbol.
 - b) Press "Back" to exit the editor.
3. Press "Visible" until "On" is highlighted.

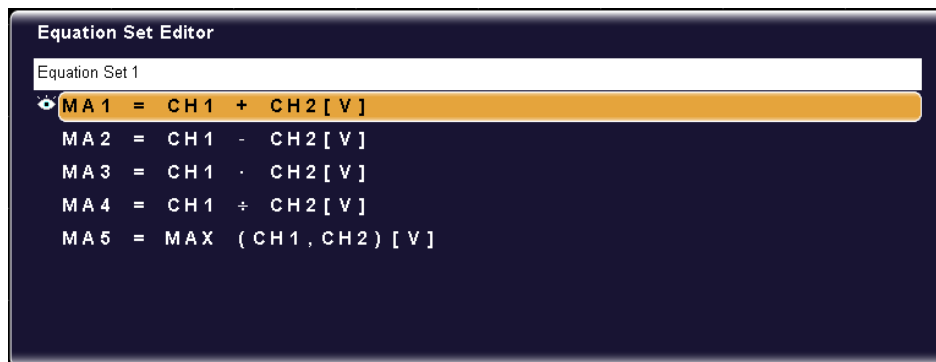
The selected equation is calculated and the results are displayed as an additional (mathematical) waveform on the screen. If necessary, change the vertical scaling of the math waveform to improve the display using the vertical SCALE rotary knob.

If the required equation is not included, edit the current equation set, or load an appropriate equation set that was saved before. See also: "[To configure an equation](#)" on page 75 and "[To load an equation set](#)" on page 77.

6.1.1.2 Editing Equations and Equation Sets

To each math waveform an equation is assigned. The mathematical operation is defined by the operator and is performed on the operands. Operands are one or two of the active channel or math waveforms, or a constant value.

All five math waveforms together build an equation set that can be stored and loaded.



To configure an equation

1. Press "MATH > Edit Equations" to display the "Equation Set Editor" with the current equation set configuration.
2. Press "Equation" and select the equation to be configured.
3. Press "Operator" to select the operator of the equation.
See also: "[Operator](#)" on page 79.
4. Press "Operand1". The operand can be any active channel waveform, a constant value, or any of the other mathematical waveforms
See also: "[Operand 1](#)" on page 83.
5. If the equation requires a second operand, press "Operand2" and define the second operand. Again, this can be any active channel waveform, a constant value, or any of the other mathematical waveforms.
6. If one of the operands is defined as a constant, define its value:
 - a) Press "Operand1" or "Operand2" to select the constant for the corresponding operand.
 - b) Press "Edit Constant" to define its value.
 - c) Press "Constant" and select either a pre-defined constant, or one of 10 available user-defined constants.
 - d) If you selected a user-defined constant, define its value:
 - Press "Value" and enter the numeric value.
 - Press "Decimal Point" to move the decimal point within the numeric value.
 - Press "Prefix" to define an SI-prefix to the unit. See also: "[Prefix](#)" on page 84.
 - Press "Unit" to define the unit of the value. See also: "[Unit](#)" on page 85.
 - e) Press "Save" to store the user-defined constant.

7. Press "Unit" to define the unit of the equation results. See also: "Unit" on page 78.
8. Optionally, press "Equation Label" to define a name for the equation. This label is displayed on the "Equation" softkey and in the "Equation Set Editor".

To edit an equation set

1. Press "MATH > Edit Equations" to display the "Equation Set Editor".
2. Press "Equation" to select the first equation to be configured. This equation is assigned to the first math waveform (MA1).
3. Configure the equation.
See: "To configure an equation" on page 75.
4. Repeat steps 3 and 4 to configure all 5 equations in the equation set.
5. Press "Back" to exit the editor and return to the main "Mathematics" menu.
6. For each equation, define whether it is to be displayed or not:
 - a) Press "Equation" to select the equation.
 - b) Press "Visible" to switch the display of the math waveform on or off.
7. Optionally, press "Eq. Set Label" to define a name for the equation set. This label is displayed in the "Equation Set Editor".

6.1.1.3 Saving and Loading Equation Sets

If you need more than five math waveforms, you can save equations sets on local or external storage. Thus, you can keep math configurations for specific measurement purposes for later use.

You can load equation sets that were saved in a file and possibly imported before. See also: [chapter 8.2.3, "Importing and Exporting Data"](#), on page 133.

To save the current equation set

1. Press MATH to display the "Mathematics" menu.
2. Press "Save".
3. Define the storage location using the "Storage" softkey, and the file name using the "File name" softkey.
See: [chapter 8.1.3, "Configuring Storage Settings"](#), on page 129.
4. Optionally, define a comment to be added to the equation set using the "Comment" softkey.
5. Press "Save".

The equation set is saved as configured.

If necessary, you can copy the equation set to another storage location using the "Export" function. See: [chapter 8.2.3, "Importing and Exporting Data"](#), on page 133.

To load an equation set

1. Press "MATH > Load".
A file explorer is displayed.
2. If necessary, switch to the storage location that contains the file by pressing [Storage \(Internal/Front/Rear\)](#).
3. Select the file that contains the equation sets. Use the "Navigation" knob to scroll through the directories. To change the directory, scroll to the name of the directory and press the knob, or press "Change dir."
4. Press "Load".

The saved equation sets are loaded to the R&S RTM.

6.1.2 Reference for Mathematics

The MATH key provides functions to configure and display calculated data.

For details on working with these functions, see [chapter 6.1.1, "Configuring and Using Math Waveforms"](#), on page 74.



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Equation

Selects one of five possible mathematical channels.

SCPI command:

Visible

Defines whether the selected mathematical channel is displayed on the screen or not.

SCPI command:

[CALCulate:MATH<m>:STATe](#) on page 229

Unit

Defines the unit of the equation results. The selected unit only has an effect on the displayed unit, not on the size of the values.

The following units are available:

- None
- V (Volts)
- A (Amperes)
- Ω (Ohms)
- S (Siemens)
- V/A (Volts per Ampere)
- W (Watts, active power)
- VA (Voltamps, apparent power)
- VAr (Voltamps, reactive power)
- dB (decibels)
- dBm (dB referred to 1 mW)
- dBV (dB referred to 1 V)
- dB μ V (dB referred to 1 μ V)
- s (Second)
- Hz (Hertz)
- F (Farad)
- H (Henry)
- % (Percent)
- $^{\circ}$ (Degree)
- π (Pi)
- Pa (Pascal)
- m (Meter)
- g (Acceleration)
- $^{\circ}$ C (Degrees Celsius)
- K (Kelvin)
- $^{\circ}$ F (Degrees Fahrenheit)
- N (Newton)
- J (Joule)
- C (Coulomb)
- Wb (Weber)
- T (Tesla)
- (dez) (dezimal)
- (bin) (binary)
- (hex) (hexadezimal)
- (oct) (octal)
- DIV (Division, graticule)

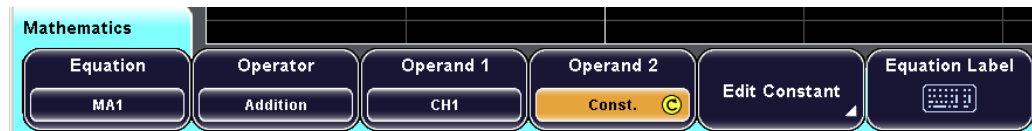
- px (pixel)
- Bit
- Byte
- Bd (Baud)
- Sa (Samples)
- Sa/sec. (Samples per second)
- Trc. (Traces)
- /s
- Sa/X
- \uparrow Rising edge
- \downarrow Falling edge
- \sqcap Positive impulse
- \sqcup Negative impulse
- Ev. (Events)
- Events
- Symb. (symbols)
- Wfm. (waveforms)
- Sy./s (symbols per second)
- Bit/s

Note: The result of a voltage divided by a current is a transient resistance progress [Ω]. The result of a voltage multiplied by a current is a power waveform [W].

SCPI command:

Edit Equations

Provides functions to configure the calculations for the mathematical channels.



SCPI command:

`CALCulate:MATH<m>[:EXPRession] [:DEFine]` on page 229

Equation ← Edit Equations

Selects one of five possible mathematical channels.

SCPI command:

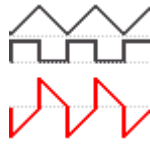
Operator ← Edit Equations

Defines the operation to be performed on the specified operands in the mathematical channel.

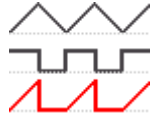
"Addition" $Op1 + Op2$
Adds the two operands.



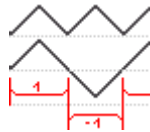
"Subtraction" $Op1 - Op2$
Subtracts the second operand from the first operand.



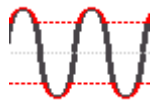
"Multiplication" $Op1 * Op2$
Multiplies the two operands.



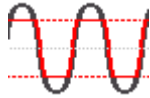
"Division" $Op1 / Op2$
Divides the first operand by the second operand.
For small amplitudes of the second operand, the result increases quickly. If the second operand crosses zero, the result would be a range of $+\infty$ to $-\infty$. In this case, instead of 0V, the calculation function uses the value that the Least Significant Bit (LSB) of the second operand represents. (For an 8-bit value, for example, 1/256).
You can limit the zero-crossings of the operand by using the "Maximum" operator. This limitation results in a smaller result range and a finer resolution.



"Maximum" $\text{Maximum}(Op1, Op2)$
Compares the amplitudes of both operands and displays the maximum amplitude. The sign of the result is taken from Operand1. Use this operation in combination with the "Reciprocal" or "Division" operation to limit the minimal amplitudes of an operand.
Example: Operand1 is a homopolar sine signal with $V_{pp}=3V$. Operand2 is a constant value of 1V. The result is always larger than 1V or smaller than -1V.



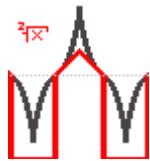
- "Minimum" Minimum (Op1, Op2)
 Compares the amplitudes of both operands and displays the minimum amplitude. The sign of the result is taken from Operand1. Use this operation in combination with the "Reciprocal" or "Division" operation to limit the maximal amplitudes of an operand.
Example: Operand1 is a MATH waveform within the range of +/-10V. Operand2 is a constant value of 1V. The result is always smaller than 1V or larger than -1V.



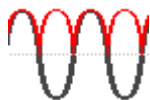
- "Square" $Op1 * Op1$
 Squares the operand. If the operand contains negative values that have been clipped, then the result contains positive clipping.



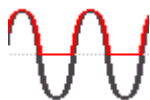
- "Square Root" Square Root (Op1)
 Calculates the square root of the operand. Note that the square root of a negative number is undefined and the result is clipped.



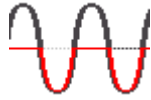
- "Abs. Value" $|Op1|$
 Calculates the absolute value of the operand. All negative values are inverted to positive values. The positive values remain unmodified. If the operand has negative values that have been clipped, the result contains positive clipping.



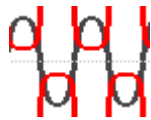
- "Pos. Wave" $Max(Op1, 0)$
 Extracts the positive data points from the operand. For all negative values the result is zero. The positive values remain unmodified.



"Neg. Wave" $\text{Min}(\text{Op1}, 0)$
 Extracts the negative data points from the operand. For all positive values the result is zero. The negative values remain unmodified.



"Reciprocal" $1V / \text{Op1}$
 Divides 1V by the operand values.
 For small operand amplitudes the result increases quickly. If the operand crosses zero, the result would be a range of $+\infty$ to $-\infty$. In this case, instead of 0V, the calculation function uses the value that the Least Significant Bit (LSB) of the operand represents. (For an 8-bit value, for example, 1/256).

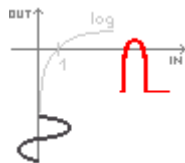


You can limit the zero-crossings of the operand by using the "Maximum" operator. This limitation results in a smaller result range and a finer resolution.

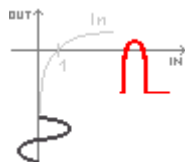
"Inverse"
 Inverts all voltage values of the operand, i.e. all values are mirrored at the ground level. Thus, a positive voltage offset becomes negative. If the amplitude of the operand is clipped, the result is the inverted limitation.



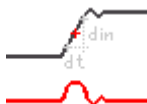
"Common Log." $\log(\text{Op1})$
 Calculates the logarithm to the basis 10 of the operand. Note that the logarithm of a negative number is undefined and the result is clipped.



"Natural Log." $\ln(\text{Op1})$
 Calculates the logarithm to the basis e (Euler number) of the operand. Note that the logarithm of a negative number is undefined and the result is clipped.



- "Derivative" $f'(Op1)$
 The derivative corresponds to the rise of the tangent through a function point and indicates the dimension of the change in quantity of the operand in time. The larger the quantity change of the operand per time becomes, the larger the result of the derivative is.
 The calculation is approximated using the secant based on the current calculated value and a value with a distance of 0.1 DIV. Due to this, the time axis has a finitely small resolution. Therefore, scale the input signal to display the required area appropriately.



- "Integral" Calculates the definite integral of the operand.
 The calculation is displayed in the illustration. The integration starts at point "a" and adds the area beneath the waveform. Point "b" indicates the currently calculated value. At the end of the positive alternation, the integral function reaches its maximum. Due to the homopolar operand used in this example, the waveform of the area reaches zero after the negative alternation.
 Use a V-Marker to measure the area for an extract of the waveform. See also: "[Meas.Type](#)" on page 71.



- "IIR low pass" IIR L (Op1,fg=Op2)
 Calculates a low-pass filtered waveform of "Operand 1". The cut-off frequency is set with constant "Operand 2". Signal components with frequencies higher than the cut-off frequency are attenuated significantly.
- "IIR high pass" IIR J (Op1,fg=Op2)
 Calculates a high-pass filtered waveform of "Operand 1". The cut-off frequency is set with constant "Operand 2". Signal components with frequencies below the cut-off frequency are attenuated significantly.

SCPI command:

[CALCulate:MATH<m>\[:EXPRession\]\[:DEFine\]](#) on page 229

Operand 1 ← Edit Equations

Defines the first operand for the mathematical operation. The source can be any active signal channel, a constant value, or any of the other mathematical channels.

- "CH1 | CH2 | CH3 | CH4" An active signal channel
 "Const." A constant value

"MA1 | MA2 | A mathematical channel
MA3 | MA4"

SCPI command:

Operand 2 ← Edit Equations

Defines the second operand for the mathematical operation, if required. The source can be any active signal channel, a constant value, or any of the other mathematical channels.

"CH1 | CH2 | An active signal channel
CH3 | CH4"

"Const." A constant value

"MA1 | MA2 | A mathematical channel
MA3 | MA4"

SCPI command:

Edit Constant ← Edit Equations

Provides functions to define a constant value to be used in a mathematical operation. In addition to the value, a decimal point, the unit and an SI-prefix can be defined.

This softkey is only available if "Constant" is selected as one of the operands.



Constant ← Edit Constant ← Edit Equations

Specifies a pre-defined constant or a user-defined constant for a mathematical operation. Either one of the following pre-defined constants can be selected, or one of 10 user-defined constants.

- Pi
- 2*Pi
- 1/2*Pi
- e

SCPI command:

Value ← Edit Constant ← Edit Equations

Specifies the value for a user-defined constant. This function is only available if one of the user-defined constants is selected by the "Constant" softkey.

SCPI command:

Decimal Point ← Edit Constant ← Edit Equations

Moves the decimal point within the user-defined constant value.

SCPI command:

Prefix ← Edit Constant ← Edit Equations

Defines an SI-prefix for the unit of a user-defined constant value. The following prefixes are available:

- None

- m (Milli, 10^{-3})
- μ (Mikro, 10^{-6})
- n (Nano, 10^{-9})
- p (Piko, 10^{-12})
- f (Femto, 10^{-15})
- a (Atto, 10^{-18})
- z (Zepto, 10^{-21})
- y (Yokto, 10^{-24})
- K (Kilo, 10^3)
- M (Mega, 10^6)
- G (Giga, 10^9)
- T (Tera, 10^{12})
- P (Peta, 10^{15})
- E (Exa, 10^{18})
- Z (Zetta, 10^{21})
- Y (Yotta, 10^{24})

SCPI command:

Unit ← Edit Constant ← Edit Equations

Defines the unit of the user-defined constant value. The selected unit only has an effect on the displayed unit, not on the size of the values.

For a list of available units, see ["Unit"](#) on page 78.

SCPI command:

Equation Label ← Edit Equations

Defines a label for the current equation.

SCPI command:

Eq. Set Label

Defines a label for the equation set.

SCPI command:

Save

The submenu provides basic functions to configure how the data is saved and to save it. For details, see:

- ["Storage"](#) on page 135
 - ["Storage \(Internal/Front/Rear\)"](#) on page 135
 - ["Change Directory"](#) on page 135
 - ["Create Directory"](#) on page 135
 - ["Remove Directory"](#) on page 136
- ["File name"](#) on page 136
 - ["Default name"](#) on page 136
 - ["Backspace, Cursor ←, Cursor →, Character Set, Accept, Abort"](#) on page 136
- ["Comment"](#) on page 136
- ["Save"](#) on page 136

Load

Displays a file explorer to select an equation set file.

SCPI command:

["Storage \(Internal/Front/Rear\)"](#) on page 135

Storage ← Load

Defines the storage device where the equation set is saved.

See also:

Remove File ← Load

Deletes the selected file.

SCPI command:

[MMEMory:DELeTe](#) on page 256

Load ← Load

Loads the selected file to the instrument.

During an import/export operation, this command confirms the selection of a file and loads it temporarily. In order to actually copy the file to the selected destination, press "Import/Export"

See also ["Import/Export"](#) on page 136.

6.2 Reference Waveforms

Reference waveforms are waveform data stored in the internal reference storages. Four internal temporary reference storages are available. They are cleared when the instrument is switched off.

6.2.1 Using References

You can store any of the active waveforms as reference waveform - channel, math, and other reference waveforms - or load a previously saved reference. A reference waveform is always saved to an internal directory on the R&S RTM. From there, they can be exported to a USB stick.



For each selected reference waveform, you can adjust the vertical position and scale as usual, and, unlike for other waveform types, you can also adjust the horizontal position and scale individually.

The current scale values are shown in the waveform label of the reference waveform.

6.2.1.1 Displaying a Reference Waveform

A reference waveform is displayed as soon as data is stored to its storage, either from an active waveform, or loaded from a reference file. You can hide it and display it again by using the "Visible" key.

1. Press the REF key to display the "Reference" menu.
2. Press "Reference" and select the reference storage position.
If a reference was already loaded to the selected reference position before, the stored reference waveform is displayed.
3. Select the data that will be used as reference by doing one of the following:
 - Press "Source" and select one of the active waveforms, then press "Update".
 - Load a previously saved reference.
See also: [chapter 6.2.1, "Using References"](#), on page 86.The selected data is written to the selected reference storage and displayed.
4. Press "Visible" to hide and show the reference waveform.

6.2.1.2 Saving and Loading References

The reference storage is temporary. If you want to keep a reference for other measurements, you must save it. Together with the waveform data itself, the settings used to obtain the waveform are also saved. This allows you to load the waveform and the settings separately.

The reference data can be saved in the internal directory `/INT/REFERENCE` on the R&S RTM, or on a USB stick. You can copy reference files from the internal reference directory to an USB stick and vice versa using the Import/Export function.

To save references

1. Press REF to display the "Reference" menu
2. Press "Save".
3. Press "Source" and select the waveform whose data you want to save as a reference.
All active waveforms can be saved.
4. Press "Storage" and define the storage settings.
See: [chapter 8.1.3, "Configuring Storage Settings"](#), on page 129.
5. Press "File Name" and enter the name of the target file.
See: ["To define a new file or directory name"](#) on page 130.
6. Press "Save".

The waveform and the device settings are saved in the specified file.

If necessary, you can copy the reference to another storage location using the Import/Export function, see [chapter 8.2.3, "Importing and Exporting Data"](#), on page 133.

To load references and reference settings

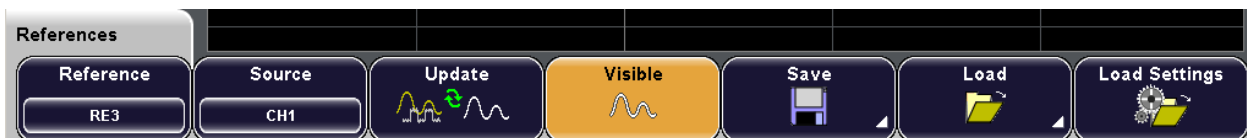
References can only be loaded from the internal storage location `/INT/REFERENCE`, not from a USB stick. If necessary, copy the reference to this directory using the Import/Export function, see [chapter 8.2.3, "Importing and Exporting Data"](#), on page 133.

1. Press REF.

2. Press "Load".
3. Press "Reference" and select the reference number you want to load the reference to.
4. Press "Load".
A file explorer is displayed.
5. Select the file that contains the reference. Use the "Navigation" knob to scroll through the directories. To change the directory, scroll to the name of the directory and press the knob, or press "Change Directory".
6. Press "Load".
The saved reference is loaded to the R&S RTM.
7. If you also want to load the settings that were used to create the reference waveform:
 - a) In the "Reference" or "Load" menu, press "Reference" and select the reference number you want to load the settings to.
 - b) Press "Load Settings".
"Load Settings" is only available if a waveform was loaded to the reference storage before.

6.2.2 Reference for REF key

The REF key provides functions for working with reference waveforms on the instrument. For details on working with these functions, see [chapter 6.2.1, "Using References"](#), on page 86.



Reference.....	88
Source.....	89
Update.....	89
Visible.....	89
Save.....	89
Load.....	89
L Reference.....	89
L Load.....	89
L Load.....	90
L Remove File.....	90
Load Settings.....	90

Reference

Selects one of the four possible internal reference storages. If a reference was loaded to this storage position before, or saved there temporarily, it is displayed.

See also: [chapter 6.2.1, "Using References"](#), on page 86.

Source

Defines the source of the reference waveform. The current waveform from any activated channel or a mathematical waveform can be selected.

SCPI command:

[REFCurve<m>:SOURce](#) on page 230

Update

Replaces the currently selected reference by the waveform defined as the "Source". The replacement is only temporary, however. If a new reference is loaded to the reference storage position or the instrument is switched off, the temporary replacement is lost. To keep the new reference permanently, you must save it.

See also: [chapter 6.2.1.1, "Displaying a Reference Waveform"](#), on page 86.

SCPI command:

[REFCurve<m>:UPDate](#) on page 230

Visible

Displays or hides the selected reference waveform.

Save

The submenu provides basic functions to configure how the data is saved and to save it. For details, see:

- ["Storage"](#) on page 135
 - ["Storage \(Internal/Front/Rear\)"](#) on page 135
 - ["Change Directory"](#) on page 135
 - ["Create Directory"](#) on page 135
 - ["Remove Directory"](#) on page 136
- ["File name"](#) on page 136
 - ["Default name"](#) on page 136
 - ["Backspace, Cursor ←, Cursor→, Character Set, Accept, Abort"](#) on page 136
- ["Comment"](#) on page 136
- ["Save"](#) on page 136

SCPI command:

[REFCurve<m>:SAVE](#) on page 230

Load

Provides functions to load reference data.

SCPI command:

[REFCurve<m>:LOAD](#) on page 231

Reference ← Load

Selects one of the four possible internal reference storages. If a reference was loaded to this storage position before, or saved there temporarily, it is displayed.

See also: [chapter 6.2.1, "Using References"](#), on page 86.

Load ← Load

Opens a file explorer to select the reference waveform file.

Load ← Load ← Load

Loads the data from the selected file to the reference storage.

Remove File ← Load ← Load

Deletes the selected file.

SCPI command:

[MMEMory:DELete](#) on page 256

Load Settings

Loads the device settings that were used to obtain the currently selected reference waveform.

7 Analysis Functions

- [FFT](#).....91
- [Masks](#).....101
- [Protocol Analysis](#).....106

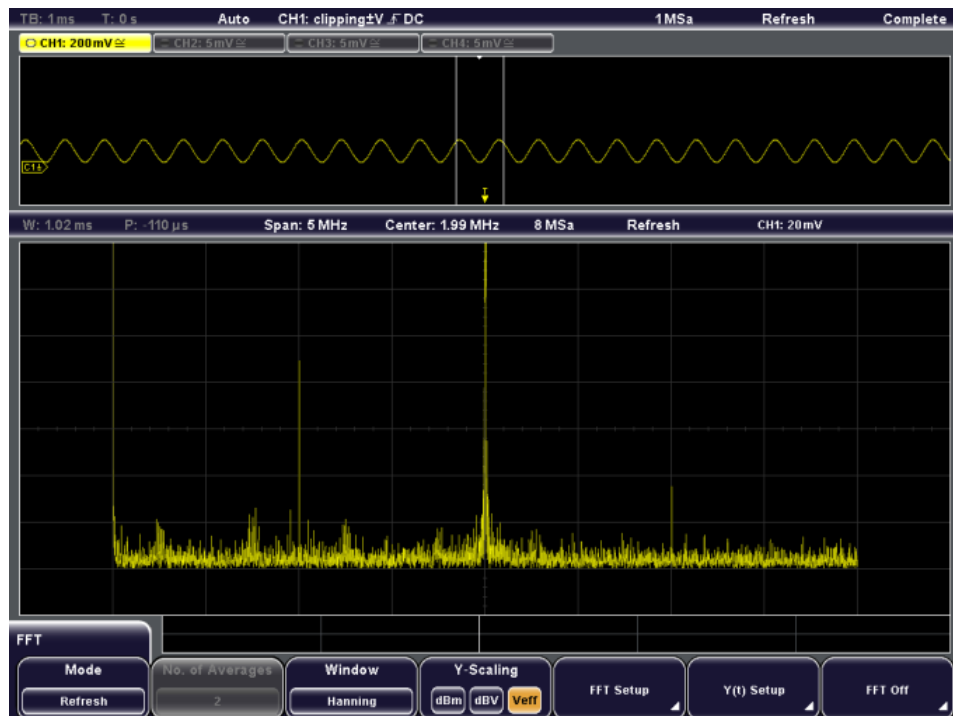
7.1 FFT

In addition to signal vs. time and signal vs. signal displays, the frequencies of a signal as determined by FFT analysis can be displayed. FFT analysis is configured and activated using the FFT key. Analysis is always performed on the signal channel that was most recently activated, however you can change the channel source.

Various parameters concerning the time base, scaling and the waveform arithmetic can be configured for the FFT display. You can configure FFT either numerically using the softkeys, or graphically using the rotary knobs.

7.1.1 FFT Display

When you activate FFT display, two windows are displayed: the signal vs. time at the top, the result of the FFT analysis at the bottom.



The display can be restricted to the results for a certain time base extract and to a specified frequency range. The time range is indicated by white lines in the Y(t)-diagram (see also [figure 7-1](#)).



Move the focus between the Y(t)-window (Time Control), the FFT time base extract (Time Section) and the FFT frequency range (FFT Control) by pressing the horizontal SCALE rotary knob. The currently selected screen element is highlighted and displayed in the information bar. Depending on the selection, the functions of the SCALE and POSITION rotary knobs may change.

The usual channel parameters are displayed in the information bar above the Y(t)-window (see the general display information described in the "Getting Started" manual).

In addition, FFT-specific parameters are indicated in the information bar above the FFT window. The following information is given there:

W: 450 μ s	P: -118 μ s	Span: 10 MHz	Center: 2.5 MHz	12.5 MSa/s	Envelope	CH1: 20 mV	Time Control
1	2	3	4	5	6	7	8

	Description	Setting
1	Width of the time base extract for which FFT is calculated	YT-Window
2	Position of time base extract	Position
3	Width of the displayed frequency range	Span
4	Center of the displayed frequency range	Center
5	Sample rate for FFT calculation	
6	FFT result mode	Waveform Arithmetic
7	Signal source and vertical scaling factor per division	CH1...CH4 / Y-Scale / Y-Scaling
8	Focus of the horizontal SCALE knob	Press SCALE

When you deactivate the FFT display, the previous display is restored.

7.1.2 Displaying and Configuring FFT Calculations

To display an FFT diagram

- ▶ Press the FFT key.

The key lights up and two windows are displayed: the signal vs. time at the top, the result of the FFT analysis at the bottom.

To deactivate the FFT display

- ▶ Press the FFT key again, or press the "FFT off" softkey in the "FFT" menu to deactivate the FFT display.

The FFT key is no longer illuminated and the previous display is restored.

To configure the general FFT display

1. Press the FFT key to activate the FFT display and open the "FFT" menu.

2. If necessary, press one of the CH1...CH4 keys to change the signal source of the FFT calculation.
3. Press "Waveform Arithmetic" to define the mode for FFT calculation and display. The waveform arithmetic defines whether the values are updated regularly, or whether values from previous spectra are included in the calculation and display. For details see "Wfm. Arithmetic" on page 96.
4. If "Average" mode is selected, press "No. of Averages" to define how many spectra are considered for the calculation.
5. Press "Window" to define which type of function is laid over the input values. If the input values are to be used unaltered, use the "Rectangle" window. To reduce noise, use a bell-shaped window. For details see "Window" on page 97.
6. Press "Y-Scaling" to select logarithmic or linear scaling of the y-axis in the FFT window (see "Y-Scaling" on page 98).
7. Define the settings for the FFT window as described in "To configure the FFT window numerically" on page 93.
8. Define the settings of the signal vs. time window as described in "To configure the Y(t)-window numerically" on page 94. These settings are identical to the general trigger and scaling settings defined for the channel (see also chapter 2.2.2, "Adjusting the Signal Input Manually", on page 17).

To configure the FFT window numerically

Alternatively to configuring the FFT window numerically via the softkeys, you can use the rotary knobs to change the settings graphically, see "To configure the FFT diagram graphically" on page 94.

1. Press "FFT-Setup" in the "FFT" menu.
2. Define the time base extract for which the FFT is to be calculated and displayed. The extract is defined by its width and position (see figure 7-1).
 - a) Press "YT-Window" to define the width of the time base extract.
 - b) Press "Position" to define the position of the time base extract. The position is defined as an offset of the center of the extract range to the 0s reference point.

The time base extract is indicated by a white frame in the Y(t)-window. The width (W) and position (P) are indicated in the information bar beneath the Y(t)-window.

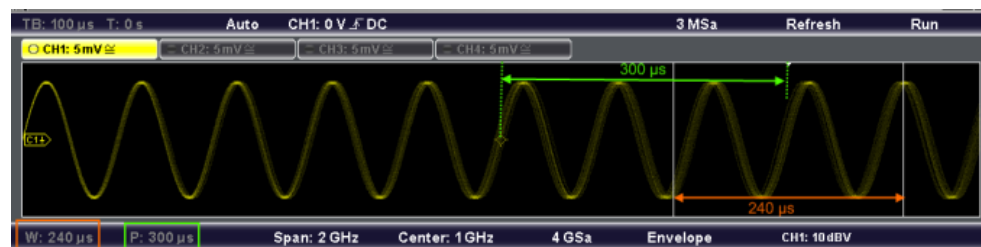


Fig. 7-1: Width and position of the time base extract for FFT calculation

3. Press "Y-Scale" to define the scaling of the FFT amplitudes.

4. Define the frequency range to be displayed in the FFT window. The range is defined as $(\text{Center} - \text{Span}/2)$ to $(\text{Center} + \text{Span}/2)$. For details see ["Span"](#) on page 98 and ["Center"](#) on page 99.
 - a) Press "Span" to define the width of the frequency range.
 - b) Press "Center" to define the center frequency of the range.

To configure the FFT diagram graphically

1. Define the time base extract for which the FFT is to be calculated and displayed. The extract is defined by its width and position (see [figure 7-1](#)).
 - a) Press the horizontal SCALE rotary knob to select the FFT time base extract ("W"/"P" settings are highlighted).
 - b) Turn the horizontal SCALE rotary knob to define the width of the time base extract. Turn the knob counter-clockwise to enlarge the extract, or clockwise to decrease it.
 - c) Turn the horizontal POSITION rotary knob to define the position of the time base extract. Turn the knob counter-clockwise to move the trigger time to the left, or clockwise to move it to the right.
2. Define the frequency range to be displayed in the FFT diagram. The range is defined as $(\text{Center} - \text{Span}/2)$ to $(\text{Center} + \text{Span}/2)$. For details see ["Span"](#) on page 98 and ["Center"](#) on page 99.
 - a) Press the horizontal SCALE rotary knob to select the FFT frequency range ("Span"/"Center" settings are highlighted).
 - b) Turn the horizontal SCALE rotary knob to define the span of the frequency range. Turn the knob counter-clockwise to enlarge the span, or clockwise to decrease it.
 - c) Turn the horizontal POSITION rotary knob to define the center of the frequency range. Turn the knob counter-clockwise to move the center to the left, or clockwise to move it to the right.
 - d) Turn the vertical SCALE rotary knob to define the scaling of the FFT amplitudes. Turn the knob counter-clockwise to decrease the amplitudes, or clockwise to enlarge them.

To configure the Y(t)-window numerically

Alternatively to configuring the Y(t)-window numerically via the softkeys, you can use the rotary knobs to change the settings graphically, see ["To configure the Y\(t\)-window graphically"](#) on page 95.

1. Press "Y(t)-Setup" in the "FFT" menu.
2. Press "Y-Scale" to define the scaling of the signal amplitudes in the Y(t)-window.
3. Press "Y-Position" to define the vertical position of the time axis in the Y(t)-window, in divisions.
4. Press "Main Time Base" to define the scaling for the time base in the Y(t)-window in seconds per division.

Note that when you change the scaling for the main time base, the width of the FFT time base extract is also changed.

- Press "Trigger Time" to define the offset of the trigger point to the reference point for 0s.

Note that when you change the trigger time, the position of the FFT time base extract is also changed.

The scaling factor for the time base (TB) and the trigger time (T) are indicated in the information bar above the Y(t)-window.

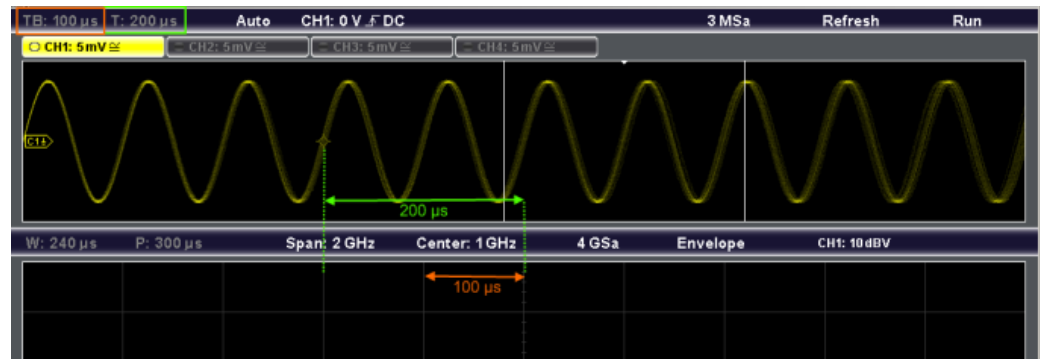


Fig. 7-2: Time base (per division) and trigger time in Y(t)-window

To configure the Y(t)-window graphically

- Press the horizontal SCALE rotary knob to select the Y(t)-window ("TB"/"T" settings are highlighted).
- Turn the vertical SCALE rotary knob to define the scaling of the signal amplitudes in the Y(t)-window. Turn the knob counter-clockwise to decrease the amplitudes, or clockwise to enlarge them.
- Turn the vertical POSITION rotary knob to define the vertical position of the time axis in the Y(t)-window. Turn the knob counter-clockwise to move the time axis down, or clockwise to move it up.
- Turn the horizontal SCALE rotary knob to define the scaling for the time base in the Y(t)-window. Turn the knob counter-clockwise to increase the scaling, or clockwise to decrease it (and thus spread the waveform).
Note that when you change the scaling for the main time base, the width of the FFT time base extract is also changed.
- Turn the horizontal POSITION rotary knob to define the offset of the trigger point to the reference point for 0s. Turn the knob counter-clockwise to move the trigger point to the left, or clockwise to move it to the right.
Note that when you change the trigger time, the position of the FFT time base extract is also changed.

7.1.3 Reference for FFT key

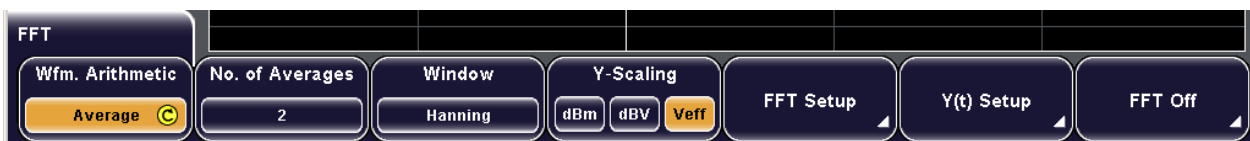
The FFT key activates and deactivates a Fast Fourier Transformation (FFT) for the most recently selected channel and provides functions to configure and display FFTs.

For details on working with these functions, see [chapter 7.1.2, "Displaying and Configuring FFT Calculations"](#), on page 92.

If activated, the FFT key lights up. Two windows are displayed: the signal vs. time at the top, the result of the FFT analysis at the bottom.

When deactivated, the previous display is restored.

To display the FFT for a different channel, press the corresponding channel key.



- Wfm. Arithmetic.....96
- No. of Averages.....97
- Window.....97
- Y-Scaling.....98
- FFT-Setup.....98
 - L Span.....98
 - L Center.....99
 - L Y-Scale.....99
 - L YT-Window.....99
 - L Position.....99
 - L Points.....100
- Y(t)-Setup.....100
 - L Y-Scale.....100
 - L Y-Position.....100
 - L Main Time Base.....100
 - L Trigger Time.....100
- FFT Off.....101

Wfm. Arithmetic

Defines the arithmetic mode for FFT calculation and display.

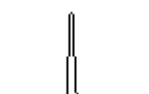
"None" The FFT is performed without any additional weighting or postprocessing of the acquired data. The new input data is acquired and displayed, and thus overwrites the previously saved and displayed data.



- "Envelope" In addition to the normal spectrum, the maximal oscillations are saved separately and updated for each new spectrum. The maximum values are displayed together with the newly acquired values and form an envelope. This envelope indicates the range of all FFT trace values that occurred.
If any signal parameters are changed, the envelope is reset.



- "Average" The average of several spectrums is calculated. The number of spectrums used for the averaging is defined using the knob or the "No. of Averages" softkey. This mode is useful for noise rejection.



SCPI command:

[CALCulate:MATH<m>:ARITHmetics](#) on page 233

No. of Averages

Defines the number of spectrums used for averaging.

This function is only available if "Average" mode is selected.

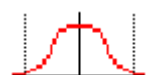
SCPI command:

Window

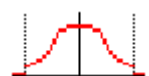
Window functions are multiplied with the input values and thus can improve the FFT display.

If discontinuities occur at the borders of the measurement interval, the algorithm interprets such discontinuities as a sudden edge, which can distort the result. For bell-shaped functions, the border values are multiplied with smaller values and thus have less influence on the result.

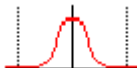
- "Hanning" The Hanning window is bell shaped. Unlike the Hamming window, its value is zero at the borders of the measuring interval. Thus, the noise level within the spectrum is reduced and the width of the spectral lines enlarges. Use this window to measure amplitudes of a periodical signal precisely.



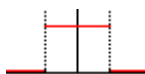
- "Hamming" The Hamming window is bell shaped. Its value is not zero at the borders of the measuring interval. Thus, the noise level inside the spectrum is higher than Hanning or Blackman, but smaller than the rectangular window. The width of the spectral lines is thinner than the other bell-shaped functions. Use this window to measure amplitudes of a periodical signal precisely.



"Blackman" The Blackman window is bell shaped and has the steepest fall in its wave shape of all other available functions. Its value is zero at both borders of the measuring interval. In the Blackman window the amplitudes can be measured very precisely. However, determining the frequency is more difficult. Use this window to measure amplitudes of a periodical signal precisely.



"Rectangle" The rectangular window multiplies all points by one. The result is a high frequency accuracy with thin spectral lines, but also with increased noise. Use this function preferably with pulse response tests where start and end values are zero.



SCPI command:

[CALCulate:MATH<m>:FFT:WINDow:TYPE](#) on page 236

Y-Scaling

Defines the scaling of the y-axis. The display values are valid for 50Ω termination impedance. To achieve this, the existing internal terminating resistor can be used, or an external terminating resistor can be connected parallel to the high impedance input.

"dBm" logarithmic scaling; related to 1 mW

"dBV" logarithmic scaling; related to 1 Veff

"Veff" linear scaling; displays the RMS value of the voltage

SCPI command:

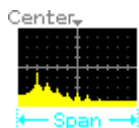
FFT-Setup

Defines 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.



Span ← FFT-Setup

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" function.



Note: If the FFT frequency range is selected ("Span"/"Center" is highlighted), the width of the span can be adjusted using the horizontal SCALE rotary knob.

SCPI command:

[CALCulate:MATH<m>:FFT:SPAN](#) on page 235

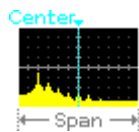
[CALCulate:MATH<m>:FFT:FULLspan](#) on page 235

[CALCulate:MATH<m>:FFT:START](#) on page 235

[CALCulate:MATH<m>:FFT:STOP](#) on page 236

Center ← FFT-Setup

Defines the position of the displayed frequency domain, which is (Center - Span/2) to (Center + Span/2). The width of the domain is defined using the "Span" function.



Note: If the FFT frequency range is selected ("Span"/"Center" is highlighted), the width of the span can be adjusted using the horizontal POSITION rotary knob.

SCPI command:

[CALCulate:MATH<m>:FFT:CFrequency](#) on page 234

[CALCulate:MATH<m>:FFT:START](#) on page 235

[CALCulate:MATH<m>:FFT:STOP](#) on page 236

Y-Scale ← FFT-Setup

Changes the vertical scaling of the FFT display (in V/dBm) per division.

Note: If the FFT frequency range is selected ("Span"/"Center" is highlighted), the Y-Scale can be defined using the vertical SCALE rotary knob.

See also "SCALE,Y-Scale" on page 25.

SCPI command:

YT-Window ← FFT-Setup

Defines the width of the time base extract from the Y(t)-window for which the FFT is calculated. The extract is indicated by white lines in the Y(t)-window. The value is indicated by "W" in the information bar above the FFT window.

Note: If the FFT time base extract is selected ("W"/"P" is highlighted), the width can be adjusted using the horizontal SCALE rotary knob.

See also [figure 7-1](#).

SCPI command:

[CALCulate:MATH<m>:FFT:START](#) on page 235

[CALCulate:MATH<m>:FFT:STOP](#) on page 236

Position ← FFT-Setup

Defines the position of the time base extract in the Y(t)-window for which the FFT is calculated. The value is indicated by "P" in the information bar above the FFT window.

Note: If the FFT time base extract is selected ("W"/"P" is highlighted), the position can be adjusted using the horizontal POSITION rotary knob.

See also [figure 7-1](#).

SCPI command:

[CALCulate:MATH<m>:FFT:START](#) on page 235

[CALCulate:MATH<m>:FFT:STOP](#) on page 236

Points ← FFT-Setup

Defines how many samples are used for FFT calculation

The value is changed in 2ⁿ steps 2048 (2¹¹) to 65536 (2¹⁶).

Y(t)-Setup

Defines the settings for the signal vs. time window.



Y-Scale ← Y(t)-Setup

Changes the vertical scaling of the Y(t)-window (channel scaling).

Note: If the Y(t)-window is selected (indicated by a white border), the Y-Scale can be adjusted using the vertical SCALE rotary knob.

See "[SCALE, Y-Scale](#)" on page 25.

SCPI command:

[CHANnel<m>:SCALE](#) on page 192

Y-Position ← Y(t)-Setup

Defines the vertical position of the time axis in the Y(t)-window, in divisions.

Note: If the Y(t)-window is selected (indicated by a white border), the Y-Position can be adjusted using the vertical POSITION rotary knob.

SCPI command:

[CHANnel<m>:POSition](#) on page 193

Main Time Base ← Y(t)-Setup

Defines the scaling for the time base in the (original) Y(t)-window in seconds per division. The scaling is indicated by "TB" in the information bar above the window.

Note: If "Time Control" is selected, the main time base can be adjusted using the horizontal SCALE rotary knob.

See also "[SCALE](#)" on page 20, "[To configure the original Y\(t\)-diagram](#)" on page 51 and [figure 7-2](#).

SCPI command:

[TIMEbase:SCALE](#) on page 188

Trigger Time ← Y(t)-Setup

Defines the horizontal position of the trigger point in relation to the reference point - to the zero point of the grid. The value is also known as trigger offset and is indicated by "T" in the information bar above the window.

Note: If a zoom or FFT window is displayed and "Time Control" is selected, the trigger time can be adjusted using the horizontal POSITION rotary knob.

See also:

- "POSITION" on page 20
- "To configure the original Y(t)-diagram" on page 51

SCPI command:

`TIMEbase:POSition` on page 189

FFT Off

Closes the FFT display and returns to the previous display.

SCPI command:

7.2 Masks

Masks can be used to determine whether the amplitude of a signal remains within specified limits, e.g. to detect errors or test compliance of digital signals. The limits are specified as a kind of frame, or "mask", which is laid over the input signal in the display. Thus you can easily detect where the signal exceeds the mask. You define masks based on existing waveforms and can save them for further use. Specific actions can be executed when limit violations occur.

7.2.1 Working with Masks

Masks define a frame with which you can compare the signal values. You can load pre-configured masks or define your own masks based on existing waveforms. When you perform a test, you can define which actions are to be taken upon violation of the mask limits.



Masks are displayed in the color used for reference waveforms.

7.2.1.1 Creating New Masks

You create a new mask based on a channel waveform, then optimize it by changing its position and proportions, and save it.

1. Select and adjust the channel waveform that will be used as basis for the mask, and run continuous acquisition.
2. Press MASKS.
The selected waveform is displayed with its envelope, other waveforms are switched off in masks mode.
3. Press "New Mask".

4. Press "Copy Channel" to create the new mask.
The mask is created from the envelope and displayed in the color used for reference waveforms.
5. To move the mask vertically on the screen, press "Y-Position" and turn the "Navigation" rotary knob to change the y-position.
The current position is indicated as an offset from the center in divisions; a positive value indicates the waveform was moved upwards; a negative value indicates the waveform was moved down.
6. To change the scaling of the mask in y-direction, press "Stretch Y" and turn the "Navigation" rotary knob.
Turn the knob clockwise to increase the factor, or counterclockwise to decrease the factor. A value over 100% stretches the amplitudes; a value less than 100% compresses the amplitudes.
7. To change the width of the waveform in vertical direction, press "Width Y" and turn the "Navigation" rotary knob.
The specified factor in divisions is added to the y-values of the upper mask limit and subtracted from the y-values of the lower mask limit. Thus, the upper half of the mask is pulled upwards, the lower half is pulled down.
8. Similarly, to change the width of the waveform in horizontal direction, press "Width X" and turn the "Navigation" rotary knob.
The left half of the mask is pulled to the left, the right half is pulled to the right.
9. Save the new mask. Otherwise it is deleted when you close the "Mask" menu.
 - a) Press "Save".
 - b) Define the storage settings as described for waveforms in [chapter 8.1.3, "Configuring Storage Settings"](#), on page 129.
 - c) Press "Save".

7.2.1.2 Loading Masks

You can load pre-configured masks for testing from the internal storage `/INT/REFERENCE`. If you have saved the required mask on a USB memory, import it before loading (see [chapter 8.2.3, "Importing and Exporting Data"](#), on page 133).

1. Press MASKS to display the "Mask Test" menu.
2. Press "Load Mask".
A file explorer is displayed.
3. Select the file that contains the mask. Use the "Navigation" knob to scroll through the directories. To change the directory, scroll to the name of the directory and press the knob, or press "Change dir."

4. Press "Load".

The selected mask is displayed on the screen.

7.2.1.3 Performing a Mask Test

Using a mask test you can detect limit violations of the measured signal compared to a pre-defined mask.

To perform a mask test

1. Perform the measurement that is to be tested as usual.
2. Press MASKS to display the "Mask Test" menu.
3. Create a mask, or load an existing mask.
See: [chapter 7.2.1.1, "Creating New Masks"](#), on page 101 and [chapter 7.2.1.2, "Loading Masks"](#), on page 102.
4. Press "Actions" to define what happens when a violation occurs. Select one or more of the available actions by pressing the corresponding softkey.
See: ["Actions"](#) on page 106.
5. Press "Test" to start the mask test.
The mask test is performed, i.e. the data from the active channel is compared to the mask. If the mask limits are exceeded, the specified action is taken.
6. Press "Pause" to stop testing temporarily without closing the "Masks" menu.
7. Press "Masks Test Off" to turn off the mask test and exit the "Mask" menu.

7.2.2 Reference for MASKS key

The MASKS key opens the "Masks" menu. Masks are used for error detection and compliance tests of digital signals.

You can:

- run mask tests.
- configure actions triggered by mask violation.
- configure new masks based on channel signals.



Test.....	104
Pause.....	104
New Mask.....	104
L Copy Channel.....	104
L Y-Position.....	104

- L Stretch Y.....105
- L Width Y.....105
- L Width X.....105
- L Save.....105
- Load Mask.....105
- Actions.....106
 - L Sound on Violation.....106
 - L Stop on 1st Violation.....106
 - L Print on 1st Violation.....106
 - L Screenshot on 1st Violation.....106
- Masks Test Off.....106

Test

Performs a mask test for the active signal, i.e. the signal's amplitudes are compared with the specified mask. If the amplitude exceeds the limits of the mask, a violation is detected.

Which action is to be taken when a violation is detected is defined using the [Actions](#) softkey. See also: [chapter 7.2.1.3, "Performing a Mask Test"](#), on page 103.

SCPI command:

[MASK:TEST](#) on page 238

Pause

Temporarily stops the mask test without closing the "Masks" menu. Counts are not deleted, and the actions cannot be changed during a pause.

SCPI command:

[MASK:TEST](#) on page 238

New Mask

Opens a submenu to define a new mask for testing.



See also: [chapter 7.2.1.1, "Creating New Masks"](#), on page 101

Copy Channel ← New Mask

Temporarily stores the envelope waveform of the active channel as a new mask. Use the "Save" softkey to store the mask permanently.

SCPI command:

[MASK:SOURce](#) on page 238

Y-Position ← New Mask

Moves the mask vertically within the display. Turn the "Navigation" rotary knob to change the y-position.

The current position is indicated as an offset from the center in divisions; a positive value indicates the waveform was moved upwards; a negative value indicates the waveform was moved down.

SCPI command:

Stretch Y ← New Mask

Changes the vertical scaling to stretch the mask in y-direction.

Turn the "Navigation" rotary knob clockwise to increase the factor, or counterclockwise to decrease the factor. A value over 100% stretches the amplitudes; a value less than 100% compresses the amplitudes.

SCPI command:

Width Y ← New Mask

Changes the width of the mask in vertical direction.

The specified factor in divisions is added to the y-values of the upper mask limit and subtracted from the y-values of the lower mask limit. Thus, the upper half of the mask is pulled upwards, the lower half is pulled down.

SCPI command:

Width X ← New Mask

Changes the width of the mask in horizontal direction. Turn the "Navigation" rotary knob to change the factor.

The specified factor in divisions is added to the positive x-values and subtracted from the negative x-values of the mask limits in relation to the mask center. Thus, the left half of the mask is pulled to the left, the right half is pulled to the right.

SCPI command:

Save ← New Mask

Masks are saved in an instrument-specific format. Modification of a mask file is not possible.

The submenu provides basic functions to configure how the data is saved and to save it. For details, see:

- "Storage" on page 135
 - "Storage (Internal/Front/Rear)" on page 135
 - "Change Directory" on page 135
 - "Create Directory" on page 135
 - "Remove Directory" on page 136
- "File name" on page 136
 - "Default name" on page 136
 - "Backspace, Cursor ←, Cursor →, Character Set, Accept, Abort" on page 136
- "Comment" on page 136
- "Save" on page 136

SCPI command:

[MASK:SAVE](#) on page 238

Load Mask

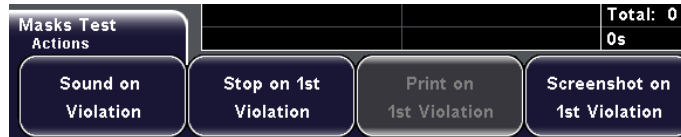
Opens a file explorer to select a previously stored mask. The selected mask is loaded and used for a subsequent test.

SCPI command:

[MASK:LOAD](#) on page 238

Actions

Opens a submenu to select the actions to be taken when a violation against the mask limits occurs.

**Sound on Violation ← Actions**

If activated, a sound is played when the signal exceeds the mask limits.

SCPI command:

Stop on 1st Violation ← Actions

If activated, the measurement is stopped when the signal exceeds the mask limits.

SCPI command:

Print on 1st Violation ← Actions

If activated, the measured waveform data is printed when the signal exceeds the mask limits.

SCPI command:

Screenshot on 1st Violation ← Actions

If activated, a screenshot of the waveform is printed when the signal exceeds the mask limits.

SCPI command:

Masks Test Off

Turns off the mask test and exits the "Mask" menu. Any temporarily stored new masks are deleted.

SCPI command:

[MASK:STATe](#) on page 237

7.3 Protocol Analysis

With the R&S RTM and some additional options, you can analyze the following parallel and serial protocols:

- Parallel
- SPI (Serial Peripheral Interface with 3 lines) and SSPI (Serial Peripheral Interface with 2 lines) - requires option R&S RTM-K1
- I²C (Inter-Integrated circuit bus) - requires option R&S RTM-K1
- UART/RS232 (EIA-232 serial interface) - requires option R&S RTM-K2

7.3.1 Basics of Protocol Analysis

The analysis of parallel and serial data consists of three main steps:

- **Protocol configuration:** Select the protocol type, and configure the input line as well as the protocol-specific settings
- **Decoding:** Configure the display of the decoded data and enable decoding. As a result, the digitized signal data is displayed on the screen together with the decoded content of the messages.
You can scale the signal display and zoom into it to see it in more detail.
- **Triggering:** You can trigger on various events that are typical for the configured bus type, for example, on start and stop of messages, on specific addresses, or on serial patterns.

7.3.1.1 Configuring Common Protocol Settings

Common settings for all bus types are the logic threshold and the decoding and display settings.

To set the logic threshold

Before you start configuration and analysis, check and set the logic thresholds for all used channels - the voltage values for digitization of analog signals. If the signal value is higher than the threshold, the signal state is 1. Otherwise, the signal state is considered 0 if the signal value is below the threshold.

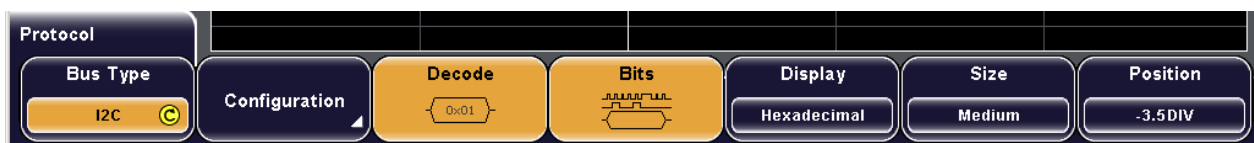
1. Press the CH N key of the required channel.
2. Press the "More" softkey.
3. Press "Threshold" and enter the voltage value.
4. Repeat step 1 to 3 for all channels that are used for protocol analysis.

To configure decoding and data display

1. Press the PROTOCOL key on the front panel.
2. Press the "Display" softkey and select the decoding format: Binary, Hexadecimal, Decimal or ASCII.
3. Press "Decode" to display the content of the messages in an easily readable and comprehensible form.
4. Configure the display of decoded information:
 - a) Set the "Size".
 - b) Define the "Position" of the bus line on the diagram.
5. To display the individual bit lines above the decoded data, press "Bits".

7.3.1.2 Reference for Protocol Decoding

The common settings in the "Protocol" menu define how the decoded signal is displayed.

**Bus Type**

Defines the bus or protocol type for analysis. For most types, a special option to the instrument is required.

SCPI command:

[BUS:TYPE](#) on page 239

Decode

Decodes the signal according to the protocol configuration and displays the decoded signal - the content of every message. The decoding format is set with "Display".

Bits

Displays the individual bit lines above the decoded bus line.

Display

Sets the decoding format: Binary, Hexadecimal, Decimal or ASCII.

Size

Sets the height of the decoded bus signal on the screen.

Position

Sets the vertical position of the decoded bus signal in divisions on the screen.

7.3.2 Parallel Bus

The R&S RTM can display up to four lines of a parallel bus depending on the number of input channels. Specific trigger settings are not available. To trigger on parallel buses, use the pattern trigger. See: [chapter 3.3.2.5, "Pattern"](#), on page 39.

7.3.2.1 Analyzing Parallel Buses

As all protocols, the parallel bus needs configuration to decode and display the signal.

To configure parallel buses

1. Press the PROTOCOL key on the front panel.
2. Press the "Bus Type" softkey and select "Parallel".
3. Press "Configuration".
4. Select the "Bus Width" and set the input channel for each bit.
5. Press "Back" and configure the data display.
See: ["To configure decoding and data display"](#) on page 107

7.3.2.2 Reference for Parallel Bus

You can configure up to four parallel bit lines depending on the number of input channels.

Bus width

Sets the number of lines to be analyzed. The maximum number is the number of input channels.

Bit 0...Bit 3

Sets the input channel to which the corresponding bit line is connected.

SCPI command:

[BUS:PARallel:DATA<m>:SOURCE](#) on page 240

7.3.3 SPI/SSPI Bus (Option R&S RTM-K1)

7.3.3.1 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.

In many applications, one data line is sufficient as data is transmitted only in one direction. Those 3-wire SPI buses can be analyzed with the R&S RTM.

As SPI is very simple and efficient for single master - single slave applications, the R&S RTM provides also an 2-wire SSPI (simple SPI) configuration that does not have a chip select line.

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 RTM provides the following trigger possibilities:

- On frame start or frame end
- On a specified bit in the message
- On a serial pattern

7.3.3.2 Analyzing SPI Buses

The analysis of SPI and SSPI buses consists of two main steps:

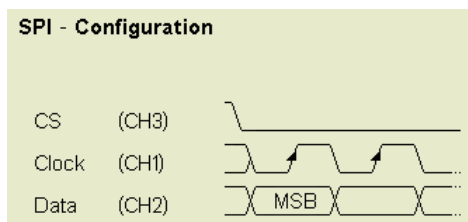
- [Configuring SPI Buses](#).....110
- [Triggering on SPI Buses](#).....110

Configuring SPI Buses

You define the input channels for the lines and some bit information on the message.

The display of the decoded data is described in "[To configure decoding and data display](#)" on page 107.

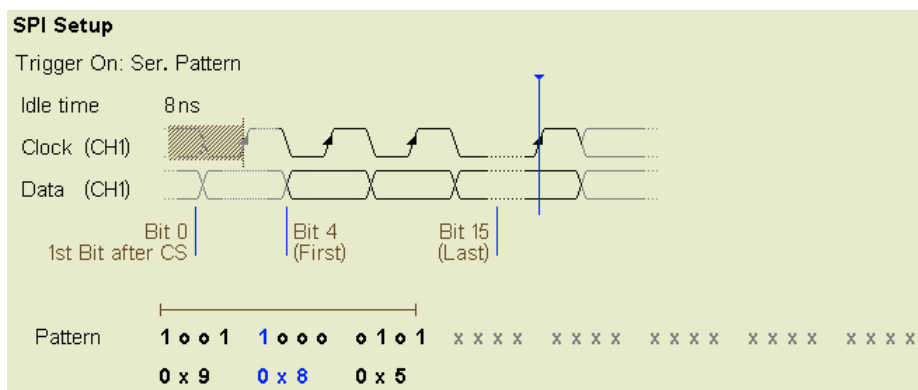
1. Press the PROTOCOL key on the front panel.
2. Press the "Bus Type" softkey and select "SPI" or "SSPI".
3. Press "Configuration".
4. Press "Source" and select "Clk".
5. Press "Clock" and select the input channel of the clock. Select the "Slope".
6. Press "Source" and select "Data".
7. Press "Data" and select the input channel. With "Active", select the active state of the data - high or low.
8. For SPI, press "Source" and select "CS". Enter the input channel with "Chip Select" and set the "Active" state.
9. For SSPI, press "Source" and select "Time". Enter the "Idle Time".
10. Set the "First Bit" and the "Symbol Size".



Triggering on SPI Buses

Prerequisites: The SPI or SSPI bus is configured. After configuration, the trigger type "Protocol (SPI)" or "Protocol (SSPI)" is available. See: "[Configuring SPI Buses](#)", on page 110.

1. Press the SETUP key in the trigger area of the front panel.
2. Select the "Trigger Type": "Protocol (SPI)" or "Protocol (SSPI)"
3. Press "Setup".
4. Press the softkey of the required trigger condition:
 - "Frame Start": begin of the message
 - "Frame End": message end
 - "Bit<x>": a specified bit inside the message
 - "Ser. Pattern": a bit pattern in the message
5. If "Bit<x>" is selected, enter the bit number.
6. If "Ser. Pattern" is selected, press the softkey again and define the pattern:
 - a) Set the "Bit Offset", the number of bits before the pattern starts.
 - b) Set the "Number of Bits" contained in the pattern.
 - c) Enter the pattern, either as binary input, or as hexadecimal input:
 - For binary input, press "Select Bit" and enter the bit number to be set. The bits are counted from the message start, the selected bit is highlighted in the pattern bit line. Then enter the "State" of this bit: 0, 1, or X (don't care). Repeat these settings until all bit states are defined.
 - For hexadecimal input, press "Select Nibble" and select the four bits (half byte) to be set. The selected nibble is highlighted in the lower pattern line. Then press "Value" and turn the navigation knob to change the bits. Repeat these settings until all nibbles are defined.



7.3.3.3 Reference for SPI/SSPI Bus

The reference explains the specific SPI/SSPI configuration and trigger.

Bus Configuration



Source.....	112
Chip Select, Clock, Data.....	112
Active.....	112
Slope.....	112
Idle Time.....	112
First Bit.....	113
Symbol Size.....	113

Source

Toggles the lines of the SPI bus. Each line has to be configured:

- CS (Chip Select, for three-wire SPI): "Chip Select" to select the input channel and the "Active" state
- Time (for two-wire SPI): "Idle Time"
- Clk (Clock): "Clock" to select the input channel and the "Slope"
- Data: "Data" to select the input channel and the "Active" state

Chip Select, Clock, Data

Select the input channels of the corresponding line. Make sure to select the "Source" before you assign the channel.

SCPI command:

[BUS:SPI:CS:SOURce](#) on page 240

[BUS:SPI:CLOCK:SOURce](#) on page 241

[BUS:SPI:DATA:SOURce](#) on page 241

[BUS:SSPI:CLOCK:SOURce](#) on page 243

[BUS:SSPI:DATA:SOURce](#) on page 244

Active

Selects whether transmitted data or the chip select signal is high active (high = 1) or low active (low = 1).

For CS, the default is low active.

For data, the default is high active.

SCPI command:

[BUS:SPI:DATA:POLarity](#) on page 241

[BUS:SPI:CS:POLarity](#) on page 241

[BUS:SSPI:DATA:POLarity](#) on page 244

Slope

Selects if data is stored with the rising or falling slope of the clock. The slope marks the begin of a new bit.

SCPI command:

[BUS:SPI:CLOCK:POLarity](#) on page 241

[BUS:SSPI:CLOCK:POLarity](#) on page 243

Idle Time

Within the idle time the data and clock lines are low. A new frame begins when the idle time has expired. If time interval between the data packets is shorter than the idle time, the packets are part of the same frame.

Idle time is only relevant for SSPI that has no chip select.

SCPI command:

[BUS:SSPI:BITime](#) on page 244

First Bit

Defines if the data of the messages starts with MSB (most significant bit) or LSB (least significant bit).

SCPI command:

[BUS:SPI:BORDER](#) on page 242

[BUS:SSPI:BORDER](#) on page 244

Symbol Size

Sets the word length, the number of bits in a message.

SCPI command:

[BUS:SPI:WSIZE](#) on page 242

[BUS:SSPI:WSIZE](#) on page 244

Trigger



[Frame Start](#)..... 113

[Frame End](#)..... 113

[Bit<x>](#)..... 114

[Ser. Pattern](#)..... 114

 L [Bit Offset](#)..... 114

 L [Number of Bits](#)..... 114

 L [Select Bit](#)..... 114

 L [State](#)..... 114

 L [Select Nibble](#)..... 114

 L [Value](#)..... 114

Frame Start

Sets the trigger to the start of the message. For SPI, the frame starts when the chip select signal CS changes to the active state. For SSPI, the frame starts when the idle time has expired.

SCPI command:

[TRIGger:A:SPI:MODE](#) on page 242 (BStart)

Frame End

Sets the trigger to the end of the message. For SPI, the frame ends when the chip select signal CS changes to the inactive state. For SSPI, the frame ends when the idle time has expired after the last clock and no new clock appeared during that time.

SCPI command:

[TRIGger:A:SPI:MODE](#) on page 242 (BEND)

Bit<x>

Sets the trigger to the specified bit number.

SCPI command:

[TRIGger:A:SPI:MODE](#) on page 242 (NTHBit)

Ser. Pattern

Sets the trigger to a specified bit pattern that is configured in the submenu.



SCPI command:

[TRIGger:A:SPI:MODE](#) on page 242 (PATtern)

[TRIGger:A:SPI:PATtern](#) on page 242

Bit Offset ← Ser. Pattern

Sets the number of bits before the first bit of the pattern. These bits are ignored.

SCPI command:

[TRIGger:A:SPI:POFFset](#) on page 243

Number of Bits ← Ser. Pattern

Defines the length of the serial pattern in bit.

SCPI command:

[TRIGger:A:SPI:PLENght](#) on page 243

Select Bit ← Ser. Pattern

Selects the bit number for binary pattern setting. For the selected bit, "State" is to be set. The bits are counted from the message start, the selected bit is highlighted in the pattern bit line.

State ← Ser. Pattern

Toggles the logic state of the selected bit: 0 (low), 1 (high), or X (don't care).

Select Nibble ← Ser. Pattern

Selects four bits (half byte) for hexadecimal entry with "Value". The selected nibble is highlighted in the lower pattern line.

Value ← Ser. Pattern

Sets the hexadecimal value for the selected nibble.

7.3.4 I²C (Option R&S RTM-K1)

The Inter-Integrated Circuit is a simple, lowbandwidth, low-speed protocol used for communication between on-board devices, for example, in LCD and LED drivers, RAM, EEPROM, and others.

7.3.4.1 The I²C Protocol

This chapter provides an overview of protocol characteristics, data format, address types and trigger possibilities. For detailed information, read the "I²C-bus specification and user manual" available on the NXP manuals web page at <http://www.nxp.com/>.

I²C characteristics

Main characteristics of I²C are:

- Two-wire design: serial clock (SCL) and serial data (SDA) lines
- Master-slave communication: the master generates the clock and addresses the slaves. Slaves receive the address and the clock. Both master and slaves can transmit and receive data.
- Addressing scheme: each slave device is addressable by a unique address. Multiple slave devices can be linked together and can be addressed by the same master.
- Read/write bit: specifies if the master will read (=1) or write (=0) the data.
- Acknowledge: takes place after every byte. The receiver of the address or data sends the acknowledge bit to the transmitter.

The R&S RTM 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

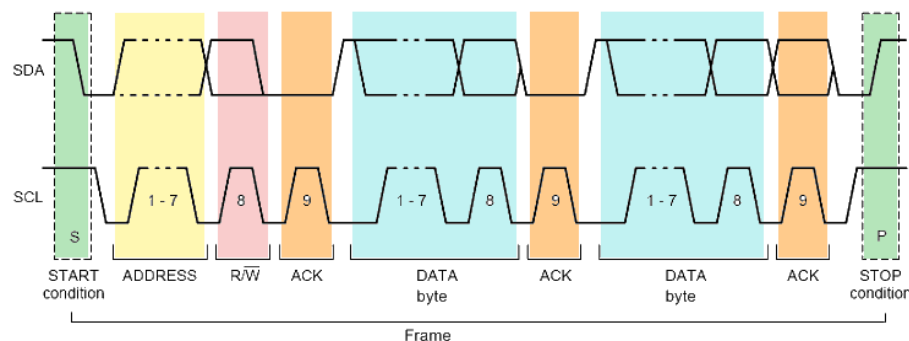


Fig. 7-3: I²C write access with 7-bit address

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.

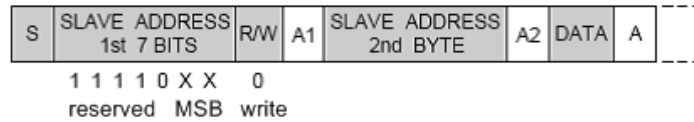


Fig. 7-4: 10-bit address, write access

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.

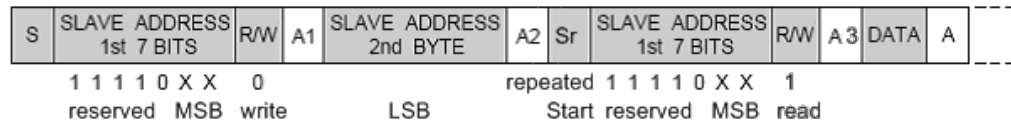


Fig. 7-5: 10-bit address, read access

Trigger

The R&S RTM 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
- Specific data pattern in the message

7.3.4.2 Analyzing I²C

The analysis of I²C consists of two main steps:

- [Configuring I²C](#)116
- [Triggering on I²C](#)117

Configuring I²C

The configuration of the I²C is simple - only assign the two lines to input channels.

The display of the decoded data is described in "[To configure decoding and data display](#)" on page 107.

1. Press the PROTOCOL key on the front panel.
2. Press the "Bus Type" softkey and select "I2C".
3. Press "Configuration".
4. Press "Clock SCL" and select the channel connected to the clock line.
5. Press "Data SDA" and select the channel connected to the data line.

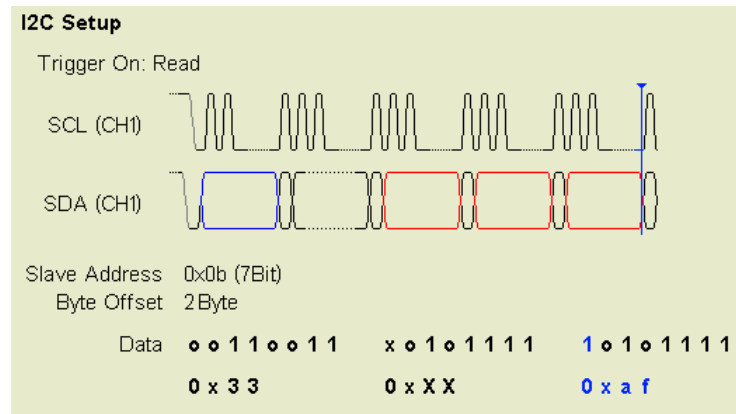
Triggering on I²C

Prerequisites: The I²C interface is configured. After configuration, the trigger type "Protocol (I2C)" is available. See: "[Configuring I²C](#)", on page 116.

1. Press the SETUP key in the trigger area of the front panel.
2. Select the "Trigger Type": "Protocol (I2C)".
3. Press "Setup".
4. Press the softkey of the required trigger condition:
 - "Start": begin of the message
 - "Stop": end of the message
 - "Restart": repeated start condition
 - "Acknowledge": transfer of a data byte is not acknowledged
 - "Read/Write": complex trigger condition containing read or write access of the master, slave address, or/and a bit pattern in the message
5. If "Read/Write" is selected, press the softkey again and define the condition:
 - a) Press "Master" and select read or write access of the master.
 - b) Configure the "Address" of the slave:
 - Select the "Address Length", 7 bit or 10 bit.
 - Press "Slave Address" and turn the navigation knob to set the address.If the address is not relevant for your trigger condition, set it to "0xX" (any address).
 - c) Press "Data Setup" to specify data bytes of the message, and/or to a serial pattern.
 - d) Set the "Byte Offset", the number of bytes to be ignored before the first byte of interest.
 - e) Set the "Number of Bytes" contained in the pattern.

- f) Enter the pattern, either as binary input, or as hexadecimal input:
- For binary input, press "Bit" and enter the bit number to be set. The bits are counted inside the selected bytes, the selected bit is highlighted in the pattern bit line. Then enter the "State" of this bit: 0, 1, or X (don't care). Repeat these settings until all bit states are defined.
 - For hexadecimal input, press "Byte" and select the byte to be set. The selected byte is highlighted in the lower pattern line. Then press "Value" and turn the navigation knob to change the bits. Repeat these settings until all bytes are defined.

If the data is not relevant for your trigger condition, set all data bytes to "0xXX".



7.3.4.3 Reference for I²C

The reference explains the specific I²C configuration and trigger.

I²C Configuration

Clock SCL.....118
 Data SDA.....118

Clock SCL

Sets the input channel to which the clock line is connected.

SCPI command:

BUS:I2C:CLOCK:SOURce on page 245

Data SDA

Sets the input channel to which the data line is connected.

SCPI command:

BUS:I2C:DATA:SOURce on page 245

I²C Trigger

Start.....	119
Stop.....	119
Restart.....	119
~Acknowledge.....	119
Read/Write.....	120
L Master.....	120
L Address Length.....	120
L Slave Address.....	120
L Data Setup.....	120
L Byte Offset.....	120
L Number of Bytes.....	121
L Bit.....	121
L State.....	121
L Byte.....	121
L Value.....	121

Start

Sets the trigger to the start of the message. The start condition is a falling slope on SDA while SCL is high.

SCPI command:

[TRIGger:A:I2C:PATtern](#) on page 247 (START)

Stop

Sets the trigger to the end of the message. The stop condition is a rising slope on SDA while SCL is high.

SCPI command:

[TRIGger:A:I2C:PATtern](#) on page 247 (STOP)

Restart

Sets the trigger to a repeated start - when the start condition occurs without previous stop condition. This can happen when a master sends multiple messages without releasing the bus.

SCPI command:

[TRIGger:A:I2C:PATtern](#) on page 247 (RESTART)

~Acknowledge

Missing acknowledge: the instrument triggers if the slave does not send the acknowledge bit. Acknowledging takes place after every byte. If the transfer failed, at the moment of the acknowledge bit the SDA line is on high level during the high period of the clock pulse.

SCPI command:

[TRIGger:A:I2C:PATtern](#) on page 247 (MACKnowledge)

Read/Write

Sets the trigger to a read or write access of the master, to an address, or/and to a bit pattern in the message. The trigger condition is specified in the submenu. All submenu settings together create the trigger condition. If you want to trigger on a specific parameter, make sure to set all other settings to "any".



SCPI command:

[TRIGger:A:I2C:PATtern](#) on page 247 (PATtern)

Master ← Read/Write

Toggles the trigger condition between Read and Write access of the master. The R/W bit is 8th bit of the first address byte of a frame. The selected condition is displayed in the I2C Settings: "Trigger On".

SCPI command:

[TRIGger:A:I2C:ACcEss](#) on page 246

Address Length ← Read/Write

Toggles the length of the slave address: 7 bit or 10 bit.

SCPI command:

[TRIGger:A:I2C:AMODe](#) on page 246

Slave Address ← Read/Write

Sets the address of the slave device in hex. If you want to trigger on any address, set it to "0xX".

SCPI command:

[TRIGger:A:I2C:ADDRess](#) on page 247

Data Setup ← Read/Write

Opens a submenu to set the trigger on specified data bytes of the message, and/or to a serial pattern.



SCPI command:

[TRIGger:A:I2C:PATtern](#) on page 247

Byte Offset ← Data Setup ← Read/Write

Sets the number of bytes before the first byte of interest, relating to the end of the address bytes. These offset bytes are ignored.

SCPI command:

[TRIGger:A:I2C:POFFset](#) on page 247

Number of Bytes ← Data Setup ← Read/Write

Sets the number of bytes you want to trigger on. Maximum 3 bytes are possible.

SCPI command:

[TRIGger:A:I2C:PLENgtH](#) on page 247

Bit ← Data Setup ← Read/Write

Selects the bit number inside the selected bytes for binary pattern input. For the selected bit, "State" is to be set. the selected bit is highlighted in the "Data" bit line.

State ← Data Setup ← Read/Write

Toggles the logic state of the selected bit: 0 (low), 1 (high), or X (don't care).

Byte ← Data Setup ← Read/Write

Selects a byte for hex input with "Value". The selected byte is highlighted in the "Data" hex line.

Value ← Data Setup ← Read/Write

Sets the hexadecimal value for the selected byte.

If the data is not relevant for your trigger condition, set all data bytes to "0xXX".

7.3.5 UART/RS-232 Interface (Option R&S RTM-K2)

7.3.5.1 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 frames. Each frame consists of a start bit, several data bits, an optional parity bit, and one or more stop bits.

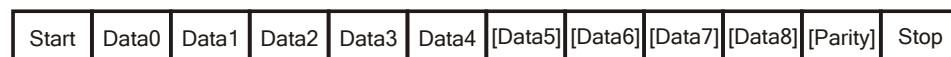


Fig. 7-6: Bit order on UART

The R&S RTM can trigger on specified parts of UART serial signals:

- Start bit
- Frame start
- A specified symbol
- Parity errors, and breaks
- Frame errors
- A serial pattern at any or a specified position

7.3.5.2 Analyzing UART/RS-232 Interfaces

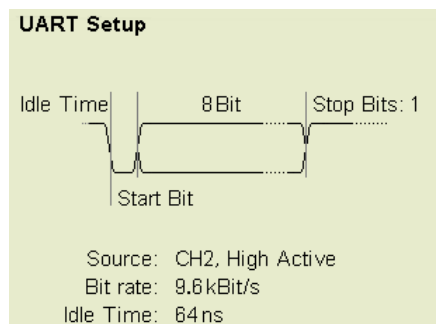
The analysis of UART consists of two main steps:

- [Configuring UART/RS-232 Interfaces](#).....122
- [Triggering on UART/RS-232 Interfaces](#).....122

Configuring UART/RS-232 Interfaces

The display of the decoded data is described in "[To configure decoding and data display](#)" on page 107.

1. Press the PROTOCOL key on the front panel.
2. Press the "Bus Type" softkey and select "UART".
3. Press "Configuration".
4. Press "Data Source" and select the channel connected to the UART.
5. Set the "Active" state, "Parity" bit and the number of "Stop Bits".
6. Press "More".
7. Press "Bit Rate" and select if you have a standard bit rate or a user defined one. Select the "Defined Bit Rate" or enter the "User Bit Rate".
8. Set the "Idle Time".

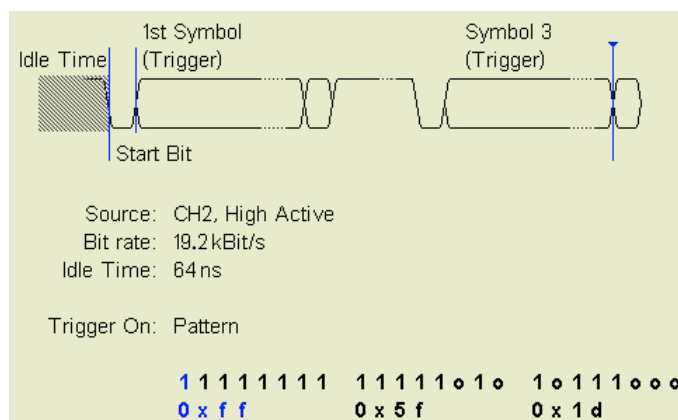


Triggering on UART/RS-232 Interfaces

Prerequisites: The UART interface is configured. After configuration, the trigger type "Protocol (UART)" is available. See: "[Configuring UART/RS-232 Interfaces](#)", on page 122.

1. Press the SETUP key in the trigger area of the front panel.
2. Select the "Trigger Type": "Protocol (UART)".
3. Press "Setup".
4. Press the softkey of the required trigger condition:
 - "Start Bit", or "Frame Start": next start bit, or first startbit after idle time
 - "Symbol<n>": frame number in a data stream
 - "Any Symbol": pattern of the data bits anywhere in the data stream

- "Pattern": serial pattern of one, two or three symbols at a defined position in the data stream
 - "Parity Error"
 - "Frame Error"
 - "Break"
5. If "Any Symbol" is selected, press the softkey again and define the symbol pattern, either as binary input, or as hexadecimal input:
 - For hex entry, select "Value" and turn the navigation knob to change the bits.
 - For binary input, press "Select Bit" and enter the data bit number to be set. Enter the "State" of this bit: 0, 1, or X (don't care). Repeat these settings until all bit states are defined.
 6. If "Pattern" is selected, press the softkey again and define the pattern:
 - a) Set the "Symbol Offset", the number of symbols to be ignored before the pattern starts.
 - b) Set the "Number of Symbols" contained in the pattern.
 - c) Enter the pattern, either as binary input, or as hexadecimal input:
 - For hexadecimal input, press "Select Symbol" repeatedly to select the symbol to be set. The selected symbol is highlighted in the hex pattern line. Then press "Value" and turn the navigation knob to change the bits. Repeat these settings until all symbols are defined.
 - For binary input, press "Select Symbol" until the required symbol is marked in the pattern hex line. Then press "Select Bit" and enter the data bit number to be set. Enter the "State" of this bit: 0, 1, or X (don't care). Repeat these settings until all bit states of all symbols are defined.



7.3.5.3 Reference for UART/RS-232 Interface

The reference explains the specific UART configuration and trigger.

Bus Configuration



Data Source..... 124
 Active..... 124
 Symbol Size..... 124
 Parity..... 124
 Stop Bits..... 125
 Bit Rate..... 125
 Idle Time..... 125

Data Source

Selects the input channel of the UART signal.

SCPI command:

[BUS:UART:DATA:SOURce](#) on page 248

Active

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:UART:DATA:POLarity](#) on page 248

Symbol Size

Sets the number of data bits in a message in a range from 5 to 9 bits.

SCPI command:

[BUS:UART:SSIZE](#) on page 248

Parity

Defines the optional parity bit that is used for error detection.

- "None" No parity bit is used.
- "Even" The parity bit is set to "1" if the number of "1"s in a given set of bits (not including the parity bit) is odd.
- "Odd" The parity bit is set to "1" if the number of "1"s in a given set of bits (not including the parity bit) is even.

SCPI command:

[BUS:UART:PARity](#) on page 248

Stop Bits

Sets the stop bits: 1; 1.5 or 2 stop bits are possible.

SCPI command:

[BUS:UART:SBIT](#) on page 248

Bit Rate

Sets the number of transmitted bits per second.

"Defined Bit Rate" Select a standard bit rate value from the list.

"User Bit Rate" Enter a user defined value.

SCPI command:

[BUS:UART:BAUDrate](#) on page 249

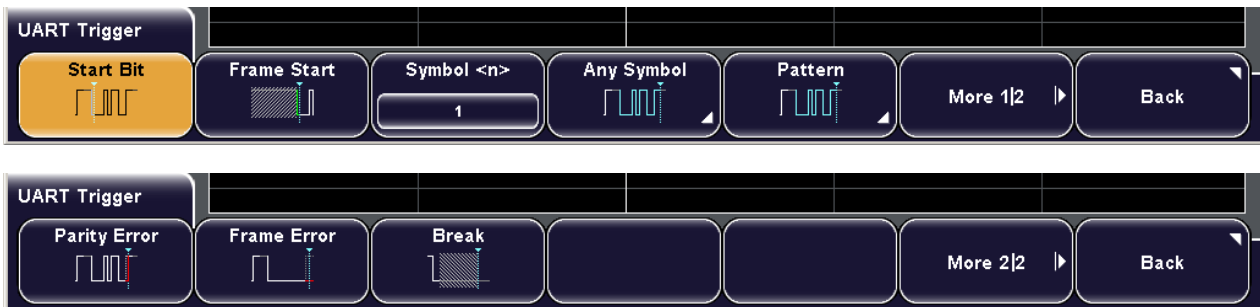
Idle Time

Sets the minimal time between the last stop bit and the next start bit. A start bit within the idle time is not recognized.

SCPI command:

[BUS:UART:BITime](#) on page 249

Trigger



Start Bit.....	126
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L Number of Symb.....	126
L Select Bit.....	127
L State.....	127
L Select Symbol.....	127
L Value.....	127
Parity Error.....	127
Frame Error.....	127
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Start Bit

Triggers on a start bit. The start bit is the first logical 0 after a stop bit.

SCPI command:

[TRIGger:A:UART:MODE](#) on page 249 (SBIT)

Frame Start

Triggers on the begin of a data frame. The frame start is the first start bit after the idle time.

SCPI command:

[TRIGger:A:UART:MODE](#) on page 249 (BStart)

Symbol <n>

Sets the trigger to the specified symbol - the n-th data frame - in a data packet.

SCPI command:

[TRIGger:A:UART:MODE](#) on page 249 (NTHSymbol)

Any Symbol

Opens a submenu to trigger if a pattern occurs in a symbol at any position in a data packet.

You can enter the pattern in binary or hex, the functions are the same as for "Pattern" setting:

- [Select Bit](#)
- [State](#)
- [Value](#)

SCPI command:

[TRIGger:A:UART:MODE](#) on page 249 (SYMBOL)

Pattern

Opens a submenu to set the trigger on a serial pattern at a defined position in the data packet. The pattern can include several subsequent symbols (data frames).



SCPI command:

[TRIGger:A:UART:MODE](#) on page 249 (PATTERN)

[TRIGger:A:UART:PATTERN](#) on page 250

Symbol Offset ← Pattern

Sets the number of symbols to be ignored before the serial pattern.

SCPI command:

[TRIGger:A:UART:POFFset](#) on page 251

Number of Symb. ← Pattern

Defines the length of the pattern - how many symbols build it up.

SCPI command:

[TRIGger:A:UART:PLENgth](#) on page 250

Select Bit ← Pattern

Selects the bit number inside the selected symbol for binary pattern input.

State ← Pattern

Toggles the logic state of the selected bit: 0 (low), 1 (high), or X (don't care).

Select Symbol ← Pattern

Selects the symbol for binary or hex input.

Value ← Pattern

Sets the hexadecimal value for the selected symbol by turning the navigation knob.

Parity Error

Triggers on a parity error indicating a transmission error.

SCPI command:

[TRIGger:A:UART:MODE](#) on page 249 (PERRor)

Frame Error

Triggers on a frame error.

SCPI command:

[TRIGger:A:UART:MODE](#) on page 249 (FERRor)

Break

Triggers if a start bit is not followed by a stop bit within a defined time. During the break the stop bits are at low state.

SCPI command:

[TRIGger:A:UART:MODE](#) on page 249 (BREak)

8 Data and Results Management

This chapter describes how to manage measurement settings and results and other data.

- [Configuring the Print and Storage Behavior](#)..... 128
- [Saving, Printing and Loading Data](#)..... 130
- [Reference for FILE Settings](#)..... 134

8.1 Configuring the Print and Storage Behavior

- [Configuring Printer Output](#)..... 128
- [Configuring the PRINT-Key Behavior](#)..... 128
- [Configuring Storage Settings](#)..... 129

8.1.1 Configuring Printer Output


You can configure the format and colors used for printing.

1. Press "SETUP > Printer > Paper format".
2. Select the required paper format using the "Navigation" knob.
3. Press "SETUP > Printer > Color mode".
4. Select the required color format using the "Navigation" knob. For details see "[Color mode](#)" on page 148.

8.1.2 Configuring the PRINT-Key Behavior


The PRINT key can either be used to print screenshots to a connected printer, or to save data to a specified storage location just by pressing a single key. However, this requires configuring the desired behavior beforehand.

To configure the PRINT key for printing

1. Define the printer settings as described in [chapter 8.1.1, "Configuring Printer Output"](#), on page 128.
2. Press FILE > "Print-Key".
3. Press  "(Print) Screenshots" to have the current display printed when the PRINT key is pressed.
4. Check the print settings for screenshots by pressing "FILE > Screenshots > Print".

After this configuration, when you press the PRINT key at any time, a screenshot will be printed by the connected printer.

To configure the PRINT key for saving

1. Configure the storage settings as described in [chapter 8.1.3, "Configuring Storage Settings"](#), on page 129.
2. Press FILE > "Print-Key".
3. Select the type of data to be saved when you press the PRINT key by pressing the corresponding softkey:
 - "Device Settings": saves the current device settings
 - "Waveform": saves the specified waveform data
 -  "(Save) Screenshots": saves the current display
 - "Screen & Setup": saves both the current display and the current device settings

After this configuration, when you press the PRINT key at any time, the configured data will be saved in a file at the specified storage location.



Saving data

You can save data directly without changing the behavior of the PRINT key by pressing "Save" for the selected data type in the FILE menu.

8.1.3 Configuring Storage Settings

You must configure the storage settings for the various data types initially. Then you can save data during measurements later simply by pressing the "Save" softkey in the FILE menu or, if configured accordingly, by pressing the PRINT key on the front panel (see ["To configure the PRINT key for saving"](#) on page 129). Before storing data to a file, you must select the storage location and the storage directory, and define the file name. For some data types, further storage settings are available.

To select the storage directory

1. Press [Storage](#) to display the file explorer for the currently selected storage location.
2. Press "Storage (Internal/Front/Rear)" until the required storage device is highlighted. For waveforms and screenshots, only a USB stick can be selected as a storage location. If no USB stick is connected to the instrument, this function is not available.
3. Use the "Navigation" knob to scroll through the directories. To change the directory, scroll to the name of the directory and press the knob, or press "Change dir."
4. Press "Create dir." to create a new subdirectory under the selected directory. Enter a name for the subdirectory as described in ["To define a new file or directory name"](#) on page 130.
5. Press "Remove dir." to remove a directory that you no longer need.
6. Press "Accept" to confirm the selected storage directory.

To define a new file or directory name

When you create a new directory or press "File name" to define the name of the storage file, a text editor is displayed in which you can enter the new name.

1. Use the "Navigate" knob to select a character.
2. Press "Character Set", if available, to display additional characters.
3. Press "Backspace" to delete the character to the left of the cursor.
4. Press the "Cursor →" and "Cursor←" softkeys to scroll through the characters of the name.
5. Press "Default name" to restore the default name.
6. Press "Accept" to save the defined name.

To configure additional storage settings

1. Optionally, define a comment to be added to the stored data using the [Comment](#) softkey for the type of data to be saved in the FILE menu.
2. For **Waveforms**, define which waveform and in which format the data is to be saved:
 - a) Press "FILE > Waveform > Trace" and select the waveform to be stored.
 - b) Press "FILE > Waveform > Format" and select the required format. For details see ["Format"](#) on page 138.
3. For **Screenshots**, define which format and color mode is to be used for storage:
 - a) Press "FILE > Screenshots > Format" to select the format of the file. For details see ["Format"](#) on page 139.
 - b) Press "FILE > Screenshots > Color mode" to define whether the screenshot is to be stored using the displayed colors, inverted colors, or black and white only. For details see ["Color mode"](#) on page 139
4. Check the storage settings by pressing "Save" for the selected data type in the FILE menu.

8.2 Saving, Printing and Loading Data

After a measurement with the R&S RTM you would usually like to save the results for further evaluation or comparison. In order to repeat measurements at different times or perform similar measurements with different test data, it is useful to save the used device settings and load them again later. In some cases you may require reference waveforms which can be saved and loaded for comparison with the measured data. Finally, you can save and load the formularies used for the mathematical operations and import or export them. These tasks are described here.

- [Documenting Results](#).....131
- [Saving and Loading Device Settings](#).....132
- [Importing and Exporting Data](#).....133

8.2.1 Documenting Results

8.2.1.1 Creating Screenshots

You can print or save the current display of your measurement results. You can configure different color modes for either operation, so that you can optimize printing, for example, while saving an authentic screenshot of the waveform as it is displayed. Different storage formats are available, as well, depending on your specific requirements.

1. Before you create a screenshot, check the printer or storage settings as described in [chapter 8.1.1, "Configuring Printer Output"](#), on page 128 and [chapter 8.1.3, "Configuring Storage Settings"](#), on page 129.
2. Configure the behavior of the PRINT key so that a screenshot is either printed or saved to a file.
See: [chapter 8.1.2, "Configuring the PRINT-Key Behavior"](#), on page 128
3. At any time during or after a measurement, press the PRINT key to create a screenshot of the current display and either print it or save it to a file, as configured.

8.2.1.2 Saving Waveform Data

You can save the waveform data resulting from a measurement to a file. The file format can be configured, depending on how the data is to be evaluated.

1. Configure the storage settings for waveforms as described in [chapter 8.1.3, "Configuring Storage Settings"](#), on page 129.
2. Configure the behavior of the PRINT key so that a waveform is saved to a file by pressing "FILE > Print-Key > Waveform".
See: [chapter 8.1.2, "Configuring the PRINT-Key Behavior"](#), on page 128
3. At any time during or after a measurement, press the PRINT key to save the waveform data to a file, as configured.



Saving data

You can save waveform data without changing the behavior of the PRINT key by pressing "FILE > Waveform > Save".



Loading Waveform Data

In order to re-load waveform data from a previous measurement, the waveform must have been stored as a *reference* waveform, see [chapter 6.2.1, "Using References"](#), on page 86.

8.2.2 Saving and Loading Device Settings

In order to repeat measurements at different times or perform similar measurements with different test data, it is useful to save the used device settings and load them again later. Furthermore, it can be helpful to refer to the device settings of a particular measurement when analyzing the results. Therefore, functions are provided so you can easily save the device settings of a measurement, with or without the corresponding screenshot.



This chapter describes how to save and load device settings. For information on saving and loading other data, see:

- [chapter 8.2.1.2, "Saving Waveform Data"](#), on page 131
- [chapter 6.1.1.3, "Saving and Loading Equation Sets"](#), on page 76
- [chapter 6.2.1, "Using References"](#), on page 86
- [chapter 7.2.1.2, "Loading Masks"](#), on page 102

To save device settings

1. Configure the storage settings as described in [chapter 8.1.3, "Configuring Storage Settings"](#), on page 129.
2. Configure the behavior of the PRINT key so that the device settings are saved to a file by pressing "FILE > Print-Key > Device Settings" (see also [chapter 8.1.2, "Configuring the PRINT-Key Behavior"](#), on page 128).
To save both the settings and a screenshot, press "FILE > Print-Key > Screen & Setup".
3. At any time during or after a measurement, press the PRINT key to save the device settings (and screenshot, if configured) to a file.
To save the device settings without changing the behavior of the PRINT key, press "FILE > Device Settings > Save > Save".

To load device settings

1. Press "FILE > Device Settings > Load".
A file explorer is displayed.
2. If necessary, switch to the storage location that contains the settings file by pressing "Storage (Internal/Front/Rear)".
3. Select the file that contains the device settings. Use the "Navigation" knob to scroll through the directories. To change the directory, scroll to the name of the directory and press the knob, or press "Change dir.".
4. Press "Load".

The saved settings are loaded to the R&S RTM.



Restoring default settings

After loading saved device settings, you can restore the default settings by pressing "FILE > Device Settings > Default sett".

8.2.3 Importing and Exporting Data

You can copy files that contain saved device settings, reference waveforms or formularies from one storage location to another.

1. In the FILE menu, press the "Import/Export" softkey for the required data type.
2. Define the source file for the copy operation.
 - a) Press "Source".
A file explorer is displayed.
 - b) If necessary, switch to the storage location that contains the source file by pressing "Storage (Internal/Front/Rear)".
 - c) Select the source file. Use the "Navigation" knob to scroll through the directories. To change the directory, scroll to the name of the directory and press the knob, or press "Change dir.".
 - d) Press "Load".
The source file is selected, but not yet loaded to the R&S RTM.
3. Define the destination directory for the copy operation. The source file will be copied here.
 - a) Press "Destination".
A file explorer is displayed.
 - b) If necessary, switch to the storage location that contains the storage directory by pressing "Storage (Internal/Front/Rear)".
 - c) Select the storage directory. Use the "Navigation" knob to scroll through the directories. To change the directory, scroll to the name of the directory and press the knob, or press "Change dir.".
Press "Create dir." to create a new subdirectory under the selected directory.
Enter a name for the subdirectory as described in ["To define a new file or directory name"](#) on page 130.
 - d) Press "Accept" to confirm the selection.
4. Press "Import/Export".
The source file is copied to the destination directory.



Imported data is not loaded to the instrument automatically. You must explicitly load it after import. See [chapter 8.2.2, "Saving and Loading Device Settings"](#), on page 132.

8.3 Reference for FILE Settings

The FILE key provides functions for saving and restoring data on the instrument.

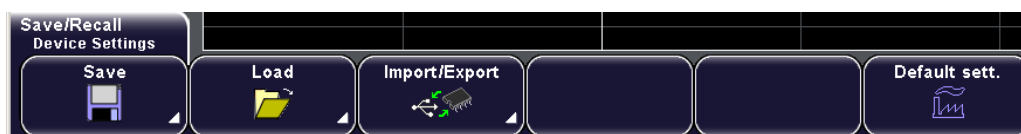


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Device Settings

Opens a submenu to manage device configuration files.



Save ← Device Settings

Provides functions to configure how the data is saved and to save it.

Storage ← Save ← Device Settings

Displays a file explorer and a submenu to select the storage directory. The softkey indicates whether an internal directory or a directory on a USB stick connected to the front or rear panel is currently selected.

See also: [chapter 8.1.3, "Configuring Storage Settings"](#), on page 129.

Storage (Internal/Front/Rear) ← Storage ← Save ← Device Settings

Defines the storage device.

Waveforms and screenshots can only be stored on a USB stick connected to the front or rear panel, not to an internal directory.

"Internal" Directly in the internal memory of the instrument

"Front" On a USB stick connected to the front panel

"Rear" On a USB stick connected to the rear panel

SCPI command:

Change Directory ← Storage ← Save ← Device Settings

Switches to the selected directory.

See also: ["To select the storage directory"](#) on page 129.

SCPI command:

`MMEMemory:CDIRectory` on page 254

Create Directory ← Storage ← Save ← Device Settings

Creates a new subdirectory of the currently selected storage directory.

See also: ["To define a new file or directory name"](#) on page 130.

SCPI command:

`MMEMemory:MDIRectory` on page 256

Remove Directory ← Storage ← Save ← Device Settings

Removes the currently selected directory.

SCPI command:

[MMEMoRY:RDIRECTORY](#) on page 256

File name ← Save ← Device Settings

Defines the file name to which the data is stored.

See also: "[To define a new file or directory name](#)" on page 130.

SCPI command:

[MMEMoRY:NAME](#) on page 254

Default name ← File name ← Save ← Device Settings

Restores the default file name.

Backspace, Cursor ←, Cursor→, Character Set, Accept, Abort ← File name ← Save ← Device Settings

Functions to define the file name of the storage file.

See also: "[To define a new file or directory name](#)" on page 130.

Comment ← Save ← Device Settings

Opens an on-screen keyboard to insert a comment to the stored data.

Save ← Save ← Device Settings

Saves the data to the selected storage directory. The used file name is displayed when storage is completed.

SCPI command:

[MMEMoRY:DATA](#) on page 255

Load ← Device Settings

Opens a file explorer to select a file to be loaded to the instrument.

SCPI command:

[MMEMoRY:LOAD:STATe](#) on page 257

Remove File ← Load ← Device Settings

Deletes the selected file.

SCPI command:

[MMEMoRY:DELeTe](#) on page 256

Load ← Load ← Device Settings

Loads the selected file to the instrument.

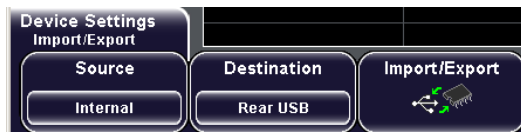
During an import/export operation, this command confirms the selection of a file and loads it temporarily. In order to actually copy the file to the selected destination, press "Import/Export"

See also "[Import/Export](#)" on page 136.

Import/Export ← Device Settings

Provides functions to import and export data between the instrument and a USB stick.

Define a source file and a destination, then press "Import/Export" to copy the file.



Source ← Import/Export ← Device Settings

Opens a file explorer to select the source file of the import/export operation. If necessary, select a different storage location or directory. After selecting the source file, press "Load" to confirm the selection.

For details see ["To select the storage directory"](#) on page 129.

If a file is no longer needed, you can remove it from the directory using the "Remove file" softkey.

SCPI command:

Storage (Internal/Front/Rear) ← Source ← Import/Export ← Device Settings

Defines the storage location, see ["Storage \(Internal/Front/Rear\)"](#) on page 135.

Remove File ← Source ← Import/Export ← Device Settings

Deletes the selected file.

SCPI command:

[MMEMory:DELeTe](#) on page 256

Load ← Source ← Import/Export ← Device Settings

Loads the selected file to the instrument.

During an import/export operation, this command confirms the selection of a file and loads it temporarily. In order to actually copy the file to the selected destination, press "Import/Export"

See also ["Import/Export"](#) on page 136.

Destination ← Import/Export ← Device Settings

Opens a file explorer to select the destination of the import/export operation. If necessary, change the storage location. The file selected as the "Source" is copied to this storage directory when you press "Import/Export".

For details see ["To select the storage directory"](#) on page 129.

For details on the menu functions, see:

- ["Storage \(Internal/Front/Rear\)"](#) on page 135
- ["Change Directory"](#) on page 135
- ["Create Directory"](#) on page 135
- ["Remove Directory"](#) on page 136

SCPI command:

Import/Export ← Import/Export ← Device Settings

Copies the selected source file to the selected destination directory.

SCPI command:

[MMEMory:COpy](#) on page 254

Default sett. ← Device Settings

Restores the default device settings.

SCPI command:

References

Provides functions to import and export reference waveforms.

Import/Export ← References

Displays a submenu to define the source file and storage directory, see ["Import/Export"](#) on page 136

Masks

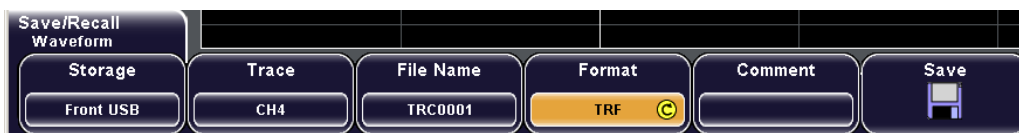
Provides functions to import and export masks.

Import/Export ← Masks

Displays a submenu to define the source file and storage directory, see ["Import/Export"](#) on page 136

Waveform

Provides functions to save waveforms.

**Storage ← Waveform**

Defines the storage directory for the waveform, see ["Storage"](#) on page 135.

This softkey is only available if a USB stick is connected to the rear or front panel.

For details on the menu functions, see:

- ["Storage \(Internal/Front/Rear\)"](#) on page 135
- ["Change Directory"](#) on page 135
- ["Create Directory"](#) on page 135
- ["Remove Directory"](#) on page 136

Waveform ← Waveform

Defines the waveform to be stored. Turn the "Navigation" knob to select one of the available channels.

SCPI command:

File name ← Waveform

Defines the file name for the data to be stored to.

See ["File name"](#) on page 136.

Format ← Waveform

Defines the format of the trace storage file. The following formats are available:

"BIN" A binary data set containing bytes of any length. The waveforms are stored without any time information.

"CSV" Comma Separated Values: the waveforms are stored in tables, the lines are separated by commas.

"TXT" The waveform is stored as an ASCII text file.

"TRF" The waveform is stored as a reference trace for the time domain.

SCPI command:

Comment ← Waveform

Opens an on-screen keyboard to insert a comment to the stored data.

Save ← Waveform

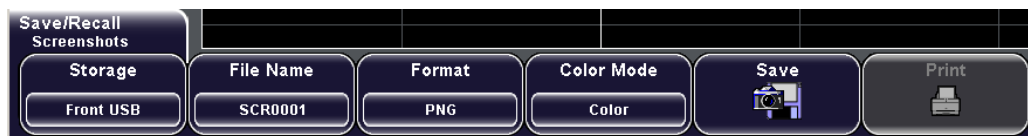
Saves the data to the selected storage directory. The used file name is displayed when storage is completed.

SCPI command:

[MMEMory:DATA](#) on page 255

Screenshots

Provides functions to save or print screenshots of the current display.



Storage ← Screenshots

Defines the storage directory for the screenshots, see ["Storage"](#) on page 135.

This softkey is only available if a USB stick is connected to the rear or front panel.

For details on the menu functions, see:

- ["Storage \(Internal/Front/Rear\)"](#) on page 135
- ["Change Directory"](#) on page 135
- ["Create Directory"](#) on page 135
- ["Remove Directory"](#) on page 136

File name ← Screenshots

Defines the file name for the screenshot to be stored.

See ["File name"](#) on page 136.

Format ← Screenshots

Defines the format of the screenshot file. The following formats are available:

- BMP
- PNG

BMP is an uncompressed format, files are large and saving might take some time.

SCPI command:

[HCOPY:LANGuage](#) on page 252

Color mode ← Screenshots

Defines the color mode for screenshots.

"Grayscale" Black and white output

"Color"	Color output
"Inverted"	Inverts the colors of the output, i.e. a dark waveform is printed on a white background

SCPI command:

[HCOPY:COLOR:SCHEME](#) on page 252

Save ← Screenshots

Saves the data to the selected storage directory. The used file name is displayed when storage is completed.

SCPI command:

[MMEMORY:DATA](#) on page 255

Print ← Screenshots

Prints the screenshot on a printer connected to the USB connector on the front or rear panel.

SCPI command:

[HCOPY\[:IMMEDIATE\]](#) on page 251

Equation Sets

Provides functions to import and export formularies for the "MATH" functions.

See [chapter 6, "Mathematics and Reference Waveforms"](#), on page 74.

Import/Export ← Equation Sets

Displays a submenu to define the source file and storage directory.

See ["Import/Export"](#) on page 136

Print - Key

Configures the behavior of the PRINT key.



Device Settings ← Print - Key

If selected, the device settings are stored as configured by the "FILE > Device Settings" softkey when you press the PRINT key.

See ["Device Settings"](#) on page 135.

SCPI command:

Waveform ← Print - Key

If selected, the current waveform is stored as configured by the "FILE > Waveform" softkey when you press the PRINT key.

See ["Waveform"](#) on page 138.

SCPI command:

(Save) Screenshots ← Print - Key

If selected, a screenshot of the current display is stored as configured by the "FILE > Screenshots" softkey when you press the PRINT key.

See "[Screenshots](#)" on page 139

SCPI command:

Screen & Setup ← Print - Key

If selected, the device settings and a screenshot of the current display are stored as configured by the "FILE > Screenshots" softkey when you press the PRINT key.

See "[Screenshots](#)" on page 139

SCPI command:

(Print) Screenshots ← Print - Key

If selected, a screenshot of the current display as configured by the "FILE > Screenshots" softkey is sent to the USB printer when you press the PRINT key.

See "[Screenshots](#)" on page 139

SCPI command:

9 General Instrument Setup

This chapter describes the firmware update, the activation of new options, and all softkeys of the "Setup" menu.

The usage of the functions except of update is described in other chapters depending on the usage context:

- chapter "Defining General Instrument Settings" in the "Getting Started" manual: configuring date, time, interface and help language, and sounds;
- [chapter 10.1.1, "Setting Up a Network \(LAN\) Connection"](#), on page 151.

9.1 Firmware and Options

9.1.1 Updating Firmware and Help

This chapter describes how to update the instrument's firmware, the interface firmware and help files.



You should update the instrument and interface firmware in regular intervals to take advantage of new functions and solve possible problems.

The online help is not included in the firmware update package. Update the online help separately to get the latest information.

To update the instrument's firmware

1. Insert a USB flash drive containing an update in the instrument.
2. Press "SETUP > Update > Firmware".
The currently installed firmware version as well as all available update versions are displayed.
3. Press "Execute" to install the available firmware updates.

To update the interface firmware

1. Insert a USB flash drive containing an update in the instrument.
2. Press "SETUP > Update > Interface".
The currently installed firmware version as well as all available update versions are displayed.
3. Press "Execute" to install the available firmware updates.

To update the online help



The online help is not included in the firmware update package. Update the online help separately to get the latest information.

Currently, the online help is only available in an English version.

1. Connect a USB flash drive containing an help update to the instrument.

2. Press "SETUP > Update > Help".

The currently installed help versions as well as all available update versions are displayed.

3. Press "Update" to install the available help updates.

The file transfer might take some time.

4. Press "Back > Back".

9.1.2 Activating Options

New R&S RTM options must be activated using the license key supplied by Rohde & Schwarz. The license key can be read from a license file or entered manually.

1. Press "SETUP > Update > Upgrade".

2. To load the key from a file:

a) Connect the USB stick to the instrument.

b) Press "Read keys from license file".

c) Select the "Storage" location, change directory, if needed, and select the license file.

d) Press "Load".

3. To enter the license key manually:

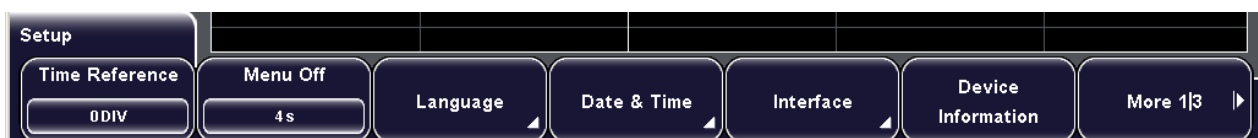
a) Press "Input key manually".

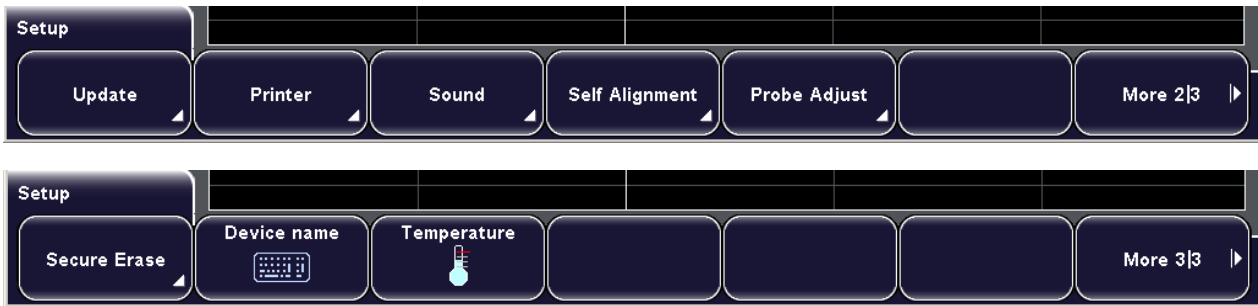
b) Enter the license key with the on-screen keyboard and press "Save and Back".

The option is enabled and can be used immediately.

9.2 Reference for Setup

The SETUP key provides functions for basic instrument settings and allows you to update the instrument's firmware and help files:





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 - Year/Month/Day/Hour/Minute.....145
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Time Reference

Defines the time reference point in the diagram, i.e. the point at which the trigger is 0s. The reference point is defined as an offset of divisions from the center in the diagram. By default, the reference point 0s is displayed in the center of the window, which corresponds to 0 divisions.

The scaling of the waveform depends on this reference point.

SCPI command:

`TIMEbase:REference` on page 189

Menu Off

Defines how long a selection menu for a softkey is displayed before it automatically closes again.

Language

Provides different languages in which the softkey labels, help and other screen information can be displayed. Currently only an English interface is available for the instrument.

SCPI command:

`DISPlay:LANGUage` on page 258

Date & Time

Provides softkeys to set the current date and time in the instrument.

Year/Month/Day/Hour/Minute ← Date & Time

Change the date and time settings individually. Changes are only adopted by the instrument after you press "Save and Back".

SCPI command:

`SYSTem:DATE` on page 258

`SYSTem:TIME` on page 258

Interface

Activates or deactivates additional instrument interfaces. Using these interfaces you can communicate with the instrument, for example to read out data or automate the measuring station. Various interfaces are available as options for the instrument and are installed in a specific slot at the rear. Depending on the installed interface, additional parameters may be definable via the "Parameter" softkey after the interface has been activated.

**USB ← Interface**

Activates the (Type B) USB interface for remote control. The USB interface provides a simple way to connect the instrument to a PC. The USB 2.0 standard is supported. Use a connection cable that is suitable for a "Type B" USB interface.

No settings are available for the USB interface.

Note: You cannot connect a printer via the Type B USB interface. Use one of the Type A USB interfaces to connect a printer.

**LAN ← Interface**

Activates the LAN interface which allows you to connect the instrument to various other devices. Access to the instrument is controlled via its IP address.

By default, the instrument is set to use DHCP. If the instrument cannot find a DHCP server, it takes about two minutes until the LAN menu is available.

The interface is configured using the [Parameter](#) softkey. See also: [chapter 10.1.1, "Setting Up a Network \(LAN\) Connection"](#), on page 151.

**IEEE488 ← Interface**

Activates the IEEE488 interface, also known as a "General Purpose Interface Bus" (GPIB). Using this interface, up to 15 devices can be connected to the instrument. Each device is identified by a unique number, which is defined within the device.

The interface is configured using the [Parameter](#) softkey. For details see [chapter 10.1.1, "Setting Up a Network \(LAN\) Connection"](#), on page 151.

Parameter ← Interface

Provides a settings dialog to configure the active additional interface. Changes are only adopted by the instrument after you press "Save".

DHCP ← Parameter ← Interface

Activates or deactivates usage of the Dynamic Host Configuration Protocol (DHCP). If the network supports dynamic TCP/IP configuration using DHCP, all address information can be assigned automatically.

Next ← Parameter ← Interface

For settings that require several entries in one row, "Next" selects the next entry.

To select the next setting in the dialog, press "Down", to select the previous setting, press "Up".

Up ← Parameter ← Interface

Selects the previous setting in the dialog.

Down ← Parameter ← Interface

Selects the next setting in the dialog.

Default ← Parameter ← Interface

Restores the default interface settings.

Save ← Parameter ← Interface

Saves the changes to the instrument and closes the dialog.

Device Information

Displays information on the instrument, such as its serial number, the installed software version and hardware information. This information is required in case of a support request.

Update

Provides functions to update the help files or firmware of the instrument or interfaces.

Firmware ← Update

Allows you to update the instrument firmware. The currently installed firmware version is displayed, as well as all available update versions if a USB flash drive containing an update is identified. The instrument is only updated when you press "Execute".

Note: You should update the instrument firmware in regular intervals to take advantage of new functions and solve possible problems.

The online help is not included in the firmware update package. Update the online help separately to get the latest information.

Execute ← Firmware ← Update

The instrument firmware is updated.

Interface ← Update

Some interfaces are provided with their own instrument-independent firmware. This interface firmware can also be updated. The currently installed firmware version is displayed, as well as all available update versions, if a USB flash drive containing an update is identified. The instrument is only updated when you press "Execute".

Note: You should update the interface firmware in regular intervals to take advantage of new functions and solve possible problems.

Execute ← Interface ← Update

The interface firmware is updated.

Help ← Update

Displays the installed languages for the online help. If a USB flash drive containing an update is identified, the available languages are displayed.

Language ← Help ← Update

Selects the language of the help files to be added, removed or updated. Currently only English help files are available.

Add ← Help ← Update

Adds the help files in the language selected using the "Language" softkey to the instrument.

To change the displayed language in the help window, use the [Language](#) softkey.

Remove ← Help ← Update

Removes the help files in the language selected using the "Language" softkey from the instrument.

Update ← Help ← Update

Updates the help files in the language selected using the "Language" softkey on the instrument.

Upgrade ← Update

Provides functions to activate options.

Read keys from license file ← Upgrade ← Update

Select the storage and directory where your license file is stored, and press "Load" to activate the options.

Input key manually ← Upgrade ← Update

Opens the on-screen keyboard to enter the license key of the option.

Printer

Defines the output format of the printer. The printer has to be connected to a (Type A) USB port and must be able to handle PostScript documents.

Paper format ← Printer

Defines the paper format for printing.

Color mode ← Printer

Defines the color mode for printing.

"Grayscale" Black and white output

"Color" Color output

"Inverted" Inverts the colors of the output, i.e. a dark waveform is printed on a white background

Sound

Defines the event types for which a sound is to be generated by the instrument. Switch the sound for a particular event type on or off by selecting the corresponding softkey. Active sounds are highlighted.

Control Beep ← Sound

Generates a sound for general control events, e.g. reaching the rotary encoder end or changing the measuring mode in the "Automeasure" menu.

Error Beep ← Sound

Generates a sound if an error occurs in the instrument, e.g. when the input exceeds 50 Ω or a false value is entered in a dialog.

Trigger Beep ← Sound

Generates a sound when the trigger condition is fulfilled.

Self Alignment

Opens a submenu to perform selftest and self-alignment of the instrument and to check the results.

Self Test & Self Alignment ← Self Alignment

Checks if a self-alignment has been executed successfully. If not, the self-alignment is executed. To start the process, press the "Start" softkey.

Self Alignment ← Self Alignment

Allows you to execute an internal self-alignment of the instrument. Alignment is only executed when you press the "Start" softkey.

When data from several input channels is displayed at the same time, it may be necessary to align the data in order to synchronize the time bases, amplitudes, and positions. This is the case, for example, when strong temperature changes occur.

Start ← Self Alignment

Starts the internal self-calibration of the instrument. Status information is displayed on the screen.

Abort ← Self Alignment

Aborts the internal self-calibration of the instrument.

Log File ← Self Alignment

The log file records the results of the self-alignment. You can set the extend of the log file and export it.

"No Log File" No log file is written

"Standard Log File" Default logging

"Extended Log File" Complete log results are written

"Export" Opens the submenu to store the log file on USB stick.
See also: ["Storage \(Internal/Front/Rear\)"](#) on page 135.

Probe Adjust

A R&S RTM allows you to adjust a probe without further devices. Two connector pins are located on the front panel. The left pin is on ground level. The right pin supplies a square wave signal for the adjustment. In this menu you can choose between two frequencies (1 kHz, 1 MHz) or allow the detection of an automatic setting by the instrument. The rise time does not differ between the settings.

1kHz ← Probe Adjust

A square wave with a frequency of $f = 1$ kHz is generated at the "Probe Adjust" pin. Use this setting to adjust the LF band of the probe.

1MHz ← Probe Adjust

A square wave with a frequency of $f = 1$ MHz is generated at the "Probe Adjust" pin. Use this setting to adjust the HF band of the probe.

Automatic ← Probe Adjust

A square wave is generated at the "Probe Adjust" pin. The frequency of the square wave depends on the defined time base. If the time base becomes too small to display the 1 kHz wave, it is automatically switched to a 1 MHz wave.

Device Name

Enter the name of the instrument.

Temperature

Shows the measurement results of internal temperature sensors and the fan speed.

10 Remote Control

10.1 Basics

This chapter provides basic information on operating an instrument via remote control.

10.1.1 Setting Up a Network (LAN) Connection

The R&S RTM 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, 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.

10.1.1.1 Connecting the Instrument to the Network

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 network connection, connect a commercial RJ-45 cable to one of the LAN ports of the instrument and to a PC.

The network card can be operated with a 10 Mbps Ethernet IEEE 802.3 or a 100 Mbps Ethernet IEEE 802.3u interface.

10.1.1.2 Configuring the LAN Parameters

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), and a DHCP server is available, all address information can be assigned automatically.
- Otherwise, the address must be set manually. Automatic Private IP Addressing (APIPA) is not supported.

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.

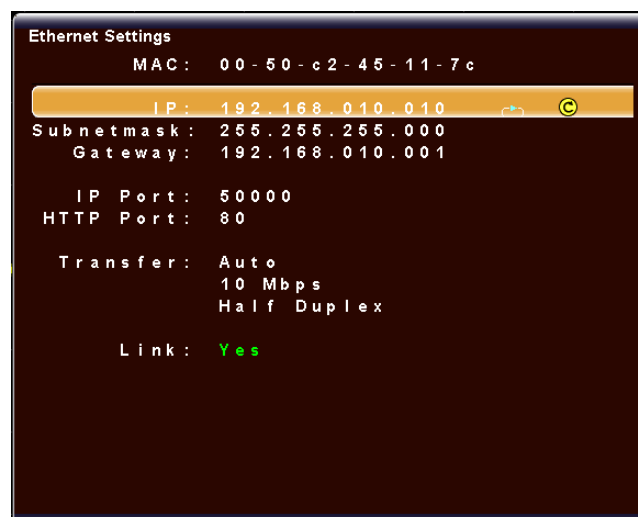
Configuring the LAN parameters

1. Press the SETUP key and then the "Interface" softkey.

2. Press the "LAN" softkey and then the "Parameter" softkey.

Note: By default, the instrument is set to use DHCP. If the instrument cannot find a DHCP server, it takes about two minutes until the LAN menu is available.

The "LAN settings" dialog box is displayed.



Some data is displayed for information only and cannot be edited. This includes the "MAC" (physical) address of the connector and the "Link" status information.

3. If the LAN does not support DHCP, or the instrument is directly connected with a computer, disable DHCP: Press the "DHCP" softkey so that "OFF" is highlighted.
4. Define the IP address of the instrument by entering each of the four blocks individually.
 - a) Define the first block number using the Navigation knob.
 - b) Press "Next" to move to the next block and define the number.
 - c) When the IP address is complete, press "Down" to continue with the next setting.
5. Define the "Subnetmask" and "Gateway" in the same way as the IP address.
6. Select the "IP Port" used by the instrument.
7. Select the "HTTP Port" used by the instrument.

8. Select the "Transfer" mode. This mode can either be determined automatically ("Auto" setting), or you can select a combination of a transfer rate and half or full duplex manually.
9. Press "Save" to save the LAN parameters on the instrument.

The "Link" status information at the bottom of the dialog box indicates whether a LAN connection was established successfully.

Checking LAN and SCPI connection

1. Enter the IP address of the R&S RTM in the address line of the internet browser on your computer: *http://:xxx.yyy.zzz.xxx*
2. If the computer can access the instrument via LAN, the "Instrument Home" page appears. It provides information on the instrument and the LAN connection.

Instrument Home

Screen Data

SCPI Device Control

Instrument Home
[Print](#)

Device Class:	Oscilloscope	Interface Type:	USB_LAN
Device Type:	RTM1054	Serial Number IF:	058100096
KMAT:	1305.0008K54	HW Version:	1.001
Serial Number:	101634	SW Version:	3.003
Firmware Version:	03.031		

Ethernet Port	
MAC Address:	00-50-C2-45-11-FA
DHCP:	Off
IP Address:	169.254.238.10
Subnet Mask:	255.255.255.0
Default Gateway:	192.168.10.1
IP Port:	5025
HTTP Port:	80
USB Port	
Vendor ID:	0AAD (hex)
Product ID:	00A1 (hex)

3. On the "Screen Data" page, a copy of the instrument screen is shown. To get the current screen content from the instrument, click "Update". To save the screen copy, right-click the picture and select "Save picture as".
4. On the "SCPI Device Control" page, you can check if the transfer of remote commands is working. You can enter a single command, for example; *IDN?, and transmit it with "Send". Do not press the Enter key.

Instrument Home

Screen Data

SCPI Device Control

SCPI Device Control

The device may be controlled with special commands (SCPI - Standard Commands for Programmable Instruments). Please take the respectively valid instruction set from the documentation delivered with the device. If you type a wrong command or use a wrong syntax, the device creates an error message which is not send immediately, complying with the standard, but can be requested separately. In this case you will **not** get a response. An easy way to request the error messages is to use the two buttons.

Command:

Response:

```
Rohde & Schwarz, RTM1054, 1305.0008K54/101634, 03.031
```

10.1.2 Starting and Stopping Remote Control

10.1.2.1 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.

- ▶ To start remote control, send a command from the controller, e.g. `GTR`.

While remote control is active, the instrument settings are optimized for maximum measurement speed; the display remains on. Operation via the front panel is disabled (except for the "Remote" menu, if not locked explicitly via `LLO`).

10.1.2.2 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" entry in the "Remote" menu in the display.
If operation via the front panel is disabled (via `LLO`), send a command from the controller, e.g. `GTL`.

10.1.3 Remote Control Interfaces and Protocols

The instrument supports different interfaces for remote control. The following table gives an overview.

Table 10-1: Remote control interfaces and protocols

Interface	Protocols, address string	Remarks
Local Area Network (LAN)	TCPIP:: <host address<="" td=""> <td>A LAN connector is located on the rear panel of the instrument. The interface is based on TCP/IP.</td> </host>	A LAN connector is located on the rear panel of the instrument. The interface is based on TCP/IP.
USB	USB:: <vendor id="">::<product ID>::<serial number>[:instr]<="" td=""> <td>A USB type B connector is located on the rear panel of the instrument. For a description of the interface refer to chapter 10.1.3.3, "USB Interface", on page 157.</td> </serial></vendor>	A USB type B connector is located on the rear panel of the instrument. For a description of the interface refer to chapter 10.1.3.3, "USB Interface" , on page 157.
GPIB (IEC/IEEE Bus Interface)	GPIB:: <primary address="">[:INSTR] (no secondary address)</primary>	An optional GPIB bus interface according to standard IEC 625.1/IEEE 488.1 can be mounted on the rear panel of the instrument. For a description of the interface refer to chapter 10.1.3.4, "GPIB Interface (IEC/IEEE Bus Interface)" , on page 158.



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.

10.1.3.1 Messages

Instrument messages are employed in the same way for all interfaces, if not indicated otherwise in the description.

See also:

- Structure and syntax of the instrument messages: [chapter 10.1.4, "SCPI Command Structure"](#), on page 159
- Detailed description of all messages: [chapter 10.2, "Command Reference"](#), on page 182

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.

10.1.3.2 LAN Interface

To be integrated in a LAN, the instrument is equipped with a LAN interface, consisting of a connector, a network interface card and protocols. For remote control via a network, the PC and the instrument must be connected via the LAN interface to a common network with TCP/IP network protocol. They are connected using a commercial RJ45 cable. The TCP/IP network protocol and the associated network services are preconfigured on the instrument. Software for instrument control must be installed on the controller.

IP address

Only the IP address or the computer name is required to set up the connection. The IP address is part of the "resource string" used by the programs to identify and control the instrument. The resource string has the form:

TCPIP::host address[:LAN device name]

where:

- **TCPIP** designates the network protocol used
- **host address** is the IP address

Example:

If the instrument has the IP address 192.1.2.3; the valid resource string is:

TCPIP::192.1.2.3

**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.

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.
>L	Go to Local	Transition to the "local" state (manual control).
>R	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.

10.1.3.3 USB Interface

For remote control via the USB connection, the PC and the instrument must be connected via the USB type B interface. 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

10.1.3.4 GPIB Interface (IEC/IEEE Bus Interface)

The GBIP interface is optional (option RTM-B10). It replaces the LAN / USB type B interface module on the rear panel. Thus, remote control is possible either with LAN or USB connection, or with GBIP.

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 159).

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 length 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.

Command	Effect on the instrument
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 or in the "Setup" menu under "Interface > Parameter". For remote control, addresses 0 through 30 are allowed. The GPIB address is maintained after a reset of the instrument settings.

10.1.4 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.

10.1.4.1 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.

10.1.4.2 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>`
- `MMEMemory: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 10.1.4.3, "SCPI Parameters"](#), on page 163.

Example:

Definition: `HardCOpy:DEVice:CMAP:COLor:RGB <red>,<green>,<blue>`

Command: `HCOP:DEV:CMAP:COL:RGB 3,32,44`

Special characters

	<p>Parameters</p> <p>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.</p> <p>Example:</p> <p>Definition:HardCOpy:PAGE:ORientation LANDscape PORtTrait</p> <p>Command HCOP:PAGE:ORI LAND specifies landscape orientation</p> <p>Command HCOP:PAGE:ORI PORT specifies portrait orientation</p> <p>Mnemonics</p> <p>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.</p> <p>Example:</p> <p>DefinitionSENSE:BANDwidth BWIDTH[:RESolution] <numeric_value></p> <p>The two following commands with identical meaning can be created:</p> <p>SENS:BAND:RES 1</p> <p>SENS:BWID:RES 1</p>
[]	<p>mnemonics in square brackets are optional and may be inserted into the header or omitted.</p> <p>Example: HardCOpy[:IMMediate]</p> <p>HCOP:IMM is equivalent to HCOP</p>
{ }	<p>Parameters in curly brackets are optional and can be inserted once or several times, or omitted.</p> <p>Example: SENSE:LIST:FREQuency <numeric_value>{,<numeric_value>}</p> <p>The following are valid commands:</p> <p>SENS:LIST:FREQ 10</p> <p>SENS:LIST:FREQ 10,20</p> <p>SENS:LIST:FREQ 10,20,30,40</p>

10.1.4.3 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 (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.

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 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.

10.1.4.4 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. <ul style="list-style-type: none"> • 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.

10.1.4.5 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
```

10.1.4.6 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`

10.1.5 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.

10.1.5.1 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 10-2: 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.	<ul style="list-style-type: none"> 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.

10.1.6 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).

10.1.6.1 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.

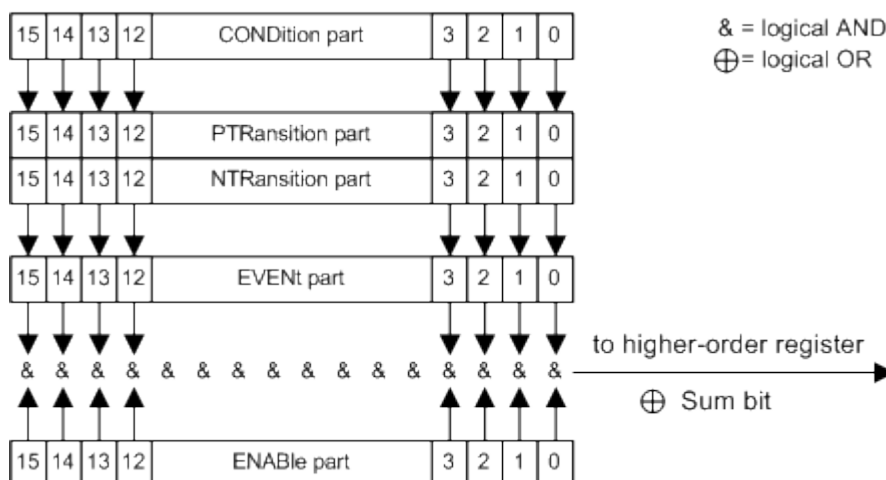


Fig. 10-1: The status-register model

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.

10.1.6.2 Hierarchy of status registers

As shown in the following figure, the status information is of hierarchical structure.

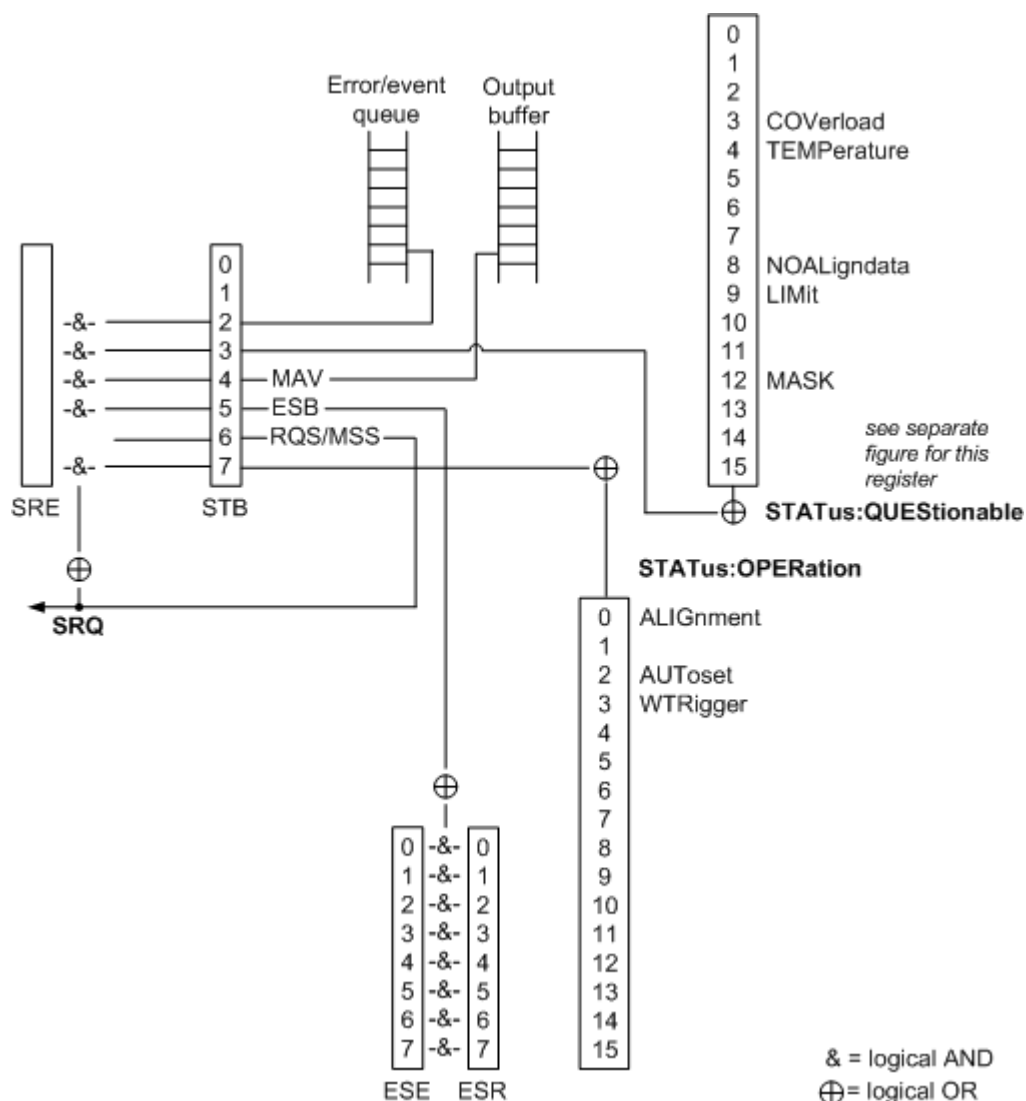


Fig. 10-2: Overview of the status registers hierarchy

- 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.
- 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`.

10.1.6.3 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 10-3: 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 <code>EVENT</code> bit is set in the <code>QUESTIONable</code> status register and the associated <code>ENABLE</code> bit is set to 1. A set bit indicates a questionable instrument status, which can be specified in greater detail by polling the <code>QUESTIONable</code> status register.
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.

Bit No.	Meaning
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.

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 10-4: 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 <code>*OPC</code> exactly when all previous commands have been executed.
1	Not used
2	Query Error This bit is set if either the controller wants to read data from the instrument without having sent a query, or if it does not fetch requested data and sends new instructions to the instrument instead. The cause is often a query which is faulty and hence cannot be executed.
3	Device-dependent Error This bit is set if a device-dependent error occurs. An error message with a number between -300 and -399 or a positive error number, which denotes the error in greater detail, is entered into the error queue.
4	Execution Error This bit is set if a received command is syntactically correct but cannot be performed for other reasons. An error message with a number between -200 and -300, which denotes the error in greater detail, is entered into the error queue.
5	Command Error This bit is set if a command is received, which is undefined or syntactically incorrect. An error message with a number between -100 and -200, which denotes the error in greater detail, is entered into the error queue.
6	User Request This bit is set when the instrument is switched over to manual control.
7	Power On (supply voltage on) This bit is set on switching on the instrument.

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 10.2.10.1, "STATus:OPERation Register"](#), on page 259.

Table 10-5: Bits in the STATus:OPERation register

Bit No.	Meaning
0	<code>ALIGNment</code> This bit is set as long as the instrument is performing a self alignment.
1	Used by WFA kernel
2	<code>AUToset</code> This bit is set while the instrument is performing an auto setup.
3	<code>WTRigger</code> This bit is set ...
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` on page 262 and `STATus:QUEStionable[:EVENT]` on page 263

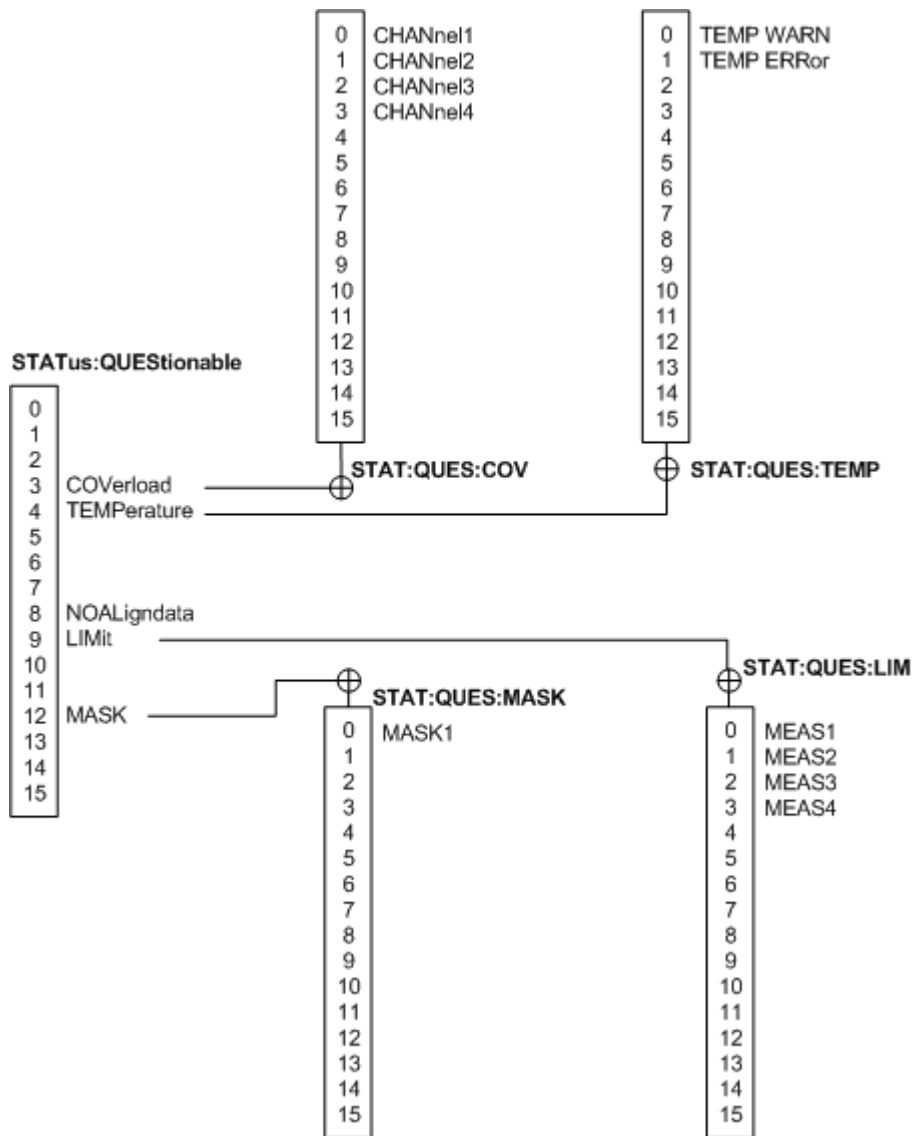


Fig. 10-3: Overview of the STATus:QUEStionable register

Table 10-6: 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 178).
4	TEMPerature This bit is set if a questionable temperature occurs (see "STATus:QUEStionable:TEMPerature register", on page 178).
5 to 7	Not used
8	NOALigndata This bit is set if no alignment data is available - the instrument is uncalibrated.

Bit No.	Meaning
9	LIMit This bit is set if a limit value is violated (see "STATus:QUEStionable:LIMit register", on page 178).
10	MARGin This bit is set if a margin value is violated (see "STATus:QUEStionable:LIMit register", on page 178).
11	Not used
12	MASK This bit is set if a mask value is violated (see "STATus:QUEStionable:MASK register", on page 179).
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 10-7: 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 10-8: 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 occurred.
1	TEMP ERROr This bit is set if a temperature error on channel 1, 2, 3 or 4 occurred.

STATus:QUEStionable:LIMit register

This register contains information about the observance of the limits of measurements. This bit is set if the limits of the main or additional measurement of the assigned measurement are violated.

Table 10-9: Bits in the STATus:QUEStionable:LIMit register

Bit No.	Meaning
0	MEAS1
1	MEAS2
2	MEAS3
3	MEAS4

STATus:QUEStionable:MASK register

This register contains information about the violation of masks. This bit is set if the assigned mask is violated.

Table 10-10: Bits in the STATus:QUEStionable:MASK register

Bit No.	Meaning
0	MASK1

10.1.6.4 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 10-2](#), 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.

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.

Bits	0	1	2	3	4	5	6	7	...
Weight	1	2	4	8	16	32	64	128	...

Example:

The decimal value $40 = 32 + 8$ indicates that bits no. 3 and 5 in the status register (e.g. the `QUEStionable` status summary bit and the `ESB` bit in the `STatus Byte`) are set.

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.

10.1.6.5 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 10-11: Reset 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
	0	1				
Clear STB, ESR	-	yes	-	-	-	yes
Clear SRE, ESE	-	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.						

10.1.7 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.

10.2 Command Reference

This chapter provides the description of all remote commands available for R&S RTM. The commands are sorted according to the menu structure of the instrument. A list of commands in alphabetical order is given in the "List of Commands" at the end of this documentation.

10.2.1 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.....	183
*CLS.....	183
*ESE.....	183
*ESR.....	183
*IDN.....	184
*IST.....	184
*OPC.....	184
*OPT.....	184
*PCB.....	184
*PRE.....	185

*PSC.....	185
*RST.....	185
*SRE.....	185
*STB.....	186
*TRG.....	186
*TST.....	186
*WAI.....	186

*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 SStatus 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 occurred.

Usage: Query only

***WAI**

WAI 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

10.2.2 Acquisition and Setup

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- [Time Base](#).....187
- [Acquisition](#).....189
- [Vertical](#).....191
- [Waveform Data](#).....195
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10.2.2.1 Starting and Stopping Acquisition

RUN.....	187
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RUNSingle.....	187
STOP.....	187

RUN

Starts the continuous acquisition.

Usage: Event
 Asynchronous command

RUNContinuous

Same as RUN.

Usage: Event
 Asynchronous command

SINGle

Starts a defined number of acquisition cycles. The number of cycles is set with `ACquire:COUNT`.

Usage: Event
 Asynchronous command

RUNSingle

Same as SINGle.

Usage: Event
 Asynchronous command

STOP

Stops the running acquisition.

Usage: Event
 Asynchronous command

10.2.2.2 Time Base

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TIMebase:ACQTime.....	188

TIMebase:RANGe.....	188
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TIMebase:POSition.....	189
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TIMebase:SCALE <TimeScale>

Sets the horizontal scale for all channel and math waveforms.

Parameters:

<TimeScale>

Range: 25e-12 to 50
 Increment: 1e-12
 *RST: 100e-6
 Default unit: s/div

TIMebase:RATime?

Queries the real acquisition time used in the hardware. If FFT analysis is performed, the value can differ from the adjusted acquisition time ([TIMebase:ACQTime](#)).

Return values:

<HWAcqTime>

Range: 250e-12 to 500
 Increment: 1e-12
 Default unit: s

Usage: Query only

TIMebase:ACQTime <AcquisitionTime>

Defines the time of one acquisition, that is the time across the 10 divisions of the diagram:
*Timebase Scale*10.*

Parameters:

<AcquisitionTime>

Range: 250e-12 to 500
 Increment: 1e-12
 Default unit: s

TIMebase:RANGe <AcquisitionTime>

Defines the time of one acquisition, that is the time across the 10 divisions of the diagram:
*Timebase Scale*10.*

Parameters:

<AcquisitionTime>

Range: 250e-12 to 500
 Increment: 1e-12
 Default unit: s

TIMEbase:DIVisions?

Queries the number of horizontal divisions on the screen.

Return values:

<HorizDivCount>

Range: 1 to 20

Increment: 2

*RST: 10

Usage: Query only

TIMEbase:POSition <Offset>

Defines the trigger position (trigger offset) - the time interval between trigger point and reference point to analyze the signal some time before or after the trigger event.

See also: [TIMEbase:REFerence](#) on page 189

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 (Time Reference) in % of the display. The reference point defines which part of the waveform is shown. If the trigger position is zero, the trigger point matches the reference point.

See also: [TIMEbase:POSition](#) on page 189

Parameters:

<ReferencePoint>

Range: 10 to 90

Increment: 10

*RST: 50

Default unit: %

10.2.2.3 Acquisition

ACQUIRE:POINTS:ARATE	190
ACQUIRE:MODE	190
ACQUIRE:COUNT	190
CHANnel<m>:TYPE	190
CHANnel<m>:ARITHmetics	191

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>

Default unit: Hz

Usage:

Query only

ACQUIRE:MODE <EnhancementMode>

Selects the method of adding waveform points to the samples of the ADC in order to fill the record length.

Parameters:

<EnhancementMode>RTIME | ETIME

RTIME

Real Time Mode: At slow time base settings the sampled points of the input signal are used to build the waveform, no waveform points are added. With fast time base settings, the sample rate is higher than the ADC sample rate. Waveform samples are added to the ADC samples with $\sin(x)/x$ interpolation.

ETIME

Equivalent time: The waveform points are taken from several acquisitions of a repetitive signal at a different time in relation to the trigger point.

ACQUIRE:COUNT <MaxAcqCount>

The command has a double effect:

- It defines the number of waveforms used to calculate the average waveform. The higher the number, the better the noise is reduced.
- It sets the number of waveforms acquired with RUN N× SINGLE.

Parameters:

<MaxAcqCount>

CHANNEL<m>:TYPE <DecimationMode>

Selects the method to reduce the data stream of the ADC to a stream of waveform points with lower sample rate.

Suffix:

<m>

The command affects all channels regardless of the indicated channel number. The suffix can be omitted.

Parameters:

<DecimationMode> SAMPLE | PDETECT | HRESOLUTION

SAMPLE

Input data is acquired with a sample rate which is aligned to the time base (horizontal scale) and the record length.

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.

*RST: SAMPLE

CHANnel<m>:ARITHmetics <TrArith>

Selects the method to build the resulting waveform from several consecutive acquisitions of the signal.

Suffix:

<m> The command affects all channels regardless of the indicated channel number. The suffix can be omitted.

Parameters:

<TrArith> OFF | ENVELOPE | AVERAGE | SMOOTH

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](#).

SMOOTH

Calculates a mean value of several adjacent sample points. Smoothing works like a low pass, it increases the vertical resolution at the expense of bandwidth reduction. The signal must not be triggered.

*RST: OFF

10.2.2.4 Vertical

CHANnel<m>:STATE	192
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CHANnel<m>:RANGe	193

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CHANnel<m>:BANDwidth.....	193
CHANnel<m>:OVERload.....	194
CHANnel<m>:SKEW.....	194
CHANnel<m>:THReshold.....	194

CHANnel<m>:STATe <State>

Switches the channel signal on or off.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<State> ON | OFF

CHANnel<m>:COUPling <Coupling>

Selects the connection of the indicated channel signal.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<Coupling> DC | DCLimit | AC

DC

Direct connection with 50 Ω termination.

DCLimit

Direct connection with 1 M Ω termination.

AC

Connection through DC capacitor that removes the DC offset voltage from the input signal.

CHANnel<m>:SCALe <Scale>

Sets the vertical scale for the indicated channel.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<Scale> Scale value, given in Volts per division.

Range: 1e-3 to 10

*RST: 5e-3

Default unit: V/div

CHANnel<m>:RANGe <Range>

Sets the voltage range across the 10 vertical divisions of the diagram. Use the command alternatively instead of [CHANnel<m>:SCALE](#).

Suffix:

<m> Selects the input channel. The maximum channel number is instrument-dependent.

Parameters:

<Range> Voltage range value
 Range: 8e-3 to 80
 *RST: 40e-3
 Default unit: V

CHANnel<m>:POSition <Position>

Sets the vertical position of the indicated channel and its horizontal axis in the window.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<Position> Position value, given in divisions.
 Range: -5 to 5
 *RST: 0
 Default unit: div

CHANnel<m>:OFFSet <Offset>

The offset voltage is subtracted to correct an offset-affected signal.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<Offset> Offset value
 Range: -10 to 10
 *RST: 0
 Default unit: V

CHANnel<m>:BANDwidth <BandwidthLimit>

Selects the bandwidth limit for the indicated channel.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<BandwidthLimit> FULL | B400 | B200 | B20

FULL

Use full bandwidth.

B400 | B200 | B20

Limit to 400MHz, 200 MHz, or 20 MHz respectively.

*RST: FULL

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> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<Overload> ON | OFF

Use OFF to reset the overload status bit.

*RST: OFF

Example:

CHANnel12:OVERload?

Queries the overload status of channel 2.

CHANnel12:OVERload OFF

Resets the overload status bit.

CHANnel<m>:SKEW <Skew>

Skew or deskew compensates delay differences between channels caused by the different length of cables, probes, and other sources. Correct deskew values are important for accurate triggering.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<Skew> Deskew value

Default unit: s

CHANnel<m>:THReshold <Threshold>

Threshold value for digitization of analog signals. If the signal value 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.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<Threshold> Default values are:
 TTL: 1,4 V
 ECL: -1,3 V
 CMOS: 2,5 V
 Default unit: V

10.2.2.5 Waveform Data**CHANnel<m>:DATA? [<Header>]**

Returns the data of the channel waveform points. The waveforms data can be used in Matlab, for example.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

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.

Query parameters:

<Header> ON | OFF
 Enables or disables the output of a header containing setup and acquisition settings. If you omit the parameter, the header is off. The header content is described in the table below.

Example:

Simple query, without header: Returns 1000 voltage values in floating data format.
 CHAN1:WAV1:DATA?
 1000,float,-0.125000,-0.123016,-0.123016,
 -0.123016,-0.123016,-0.123016,...

Example:

Query, with header: Returns the header data and then 1000 voltage values in floating data format.
 CHAN1:WAV1:DATA? ON
 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,50,0,1000,float,-0.125000,
 -0.123016,-0.123016,-0.123016,-0.123016,
 -0.123016,-0.123016,...

Usage: Query only

Table 10-12: 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
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: <ul style="list-style-type: none"> • 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

Position	Meaning	Example
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>:DATA:POINTs <PointSelection>

Returns the number of samples for the given range.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<Points>

Default unit: Samples

Setting parameters:

<PointSelection> DEFault | MAXimum | DMAXimum

DEFault

Number of waveform samples in the current waveform record, displayed on the screen.

MAXimum

Range is the complete memory.

DMAXimum

Number of ADC samples in the current waveform record.

10.2.2.6 Probes

PROBe<m>:SETup:ATTenuation.....	198
PROBe<m>:SETup:BANDwidth.....	198
PROBe<m>:SETup:CAPacity.....	198
PROBe<m>:SETup:DCOFFset.....	199
PROBe<m>:SETup:IMPedance.....	199
PROBe<m>:SETup:MODE.....	199
PROBe<m>:SETup:NAME.....	200
PROBe<m>:SETup:OFFSwitch.....	200
PROBe<m>:SETup:TYPE.....	200
PROBe<m>:SETup:UOFFset.....	200
PROBe<m>:ID:BUILd.....	201
PROBe<m>:ID:FWFLash.....	201
PROBe<m>:ID:FWPath.....	201
PROBe<m>:ID:FWService.....	201
PROBe<m>:ID:PARTnumber.....	202

PROBe<m>:ID:PRDate.....	202
PROBe<m>:ID:SRNumber.....	202
PROBe<m>:ID:SWVersion.....	202

PROBe<m>:SETup:ATTenuation?

Queries the attenuation of the probe.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<ProbeAtt>

Range: 0.001 to 1000

Usage: Query only

PROBe<m>:SETup:BANDwidth?

Queries the bandwidth of the probe.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<Bandwidth>

Range: 10e5 to 20e8

Increment: 10

Default unit: Hz

Usage: Query only

PROBe<m>:SETup:CAPacity?

Queries the input capacity of the probe.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<InputCapacity>

Range: 0.1e-12 to 1.0e-9

Increment: 1.0e-12

Default unit: F

Usage: Query only

PROBe<m>:SETup:DCOffset?

Retrieves the DC voltage that is measured by the integrated voltmeter of R&S active probes. Switch the voltmeter on before, see [PROBe<m>:SETup:OFFSwitch](#) on page 200.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<Offset>

Range: -1.0e26 to 1.0e-26

Increment: 1e-3

Default unit: V

Usage: Query only

PROBe<m>:SETup:IMPedance?

Queries the termination of the probe.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<Termination> 50OHm | 1MOHm | unknown

Usage: Query only

PROBe<m>:SETup:MODE <Mode>

Select the action that is started with the probe button.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<Mode> RCONTinuous | RSINGle | AUTOSET

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.

PROBe<m>:SETup:NAME?

Queries the name of the probe.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<Name> string

Usage: Query only

PROBe<m>:SETup:OFFSwitch <DCOffsetOnOff>

Switches the integrated voltmeter of an R&S active probe on or off.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<DCOffsetOnOff> ON | OFF

PROBe<m>:SETup:TYPE?

Queries the type of the probe.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<Type> NONE | ACTIVE | PASSive

NONE

not detected

ACTIVE

active probe

PASSive

passive probe

Usage: Query only

PROBe<m>:SETup:UOFFSET <UserOffset>

Sets an additional probe offset.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Parameters:

<UserOffset>

Range: -4 to 4

Increment: 10e-3

Default unit: V

PROBe<m>:ID:BUILd?

Queries the build number of the probe software.

Suffix:

<m>

Selects the input channel. The number of channels depends on the instrument.

Return values:

<BuildNumber>

Range: 0 to INT_MAX

Increment: 1

Usage:

Query only

PROBe<m>:ID:FWFLash

Starts the update of the probe firmware.

Suffix:

<m>

Selects the input channel. The number of channels depends on the instrument.

Usage:

Event

PROBe<m>:ID:FWPath <Path>

Indicates the location of the firmware update package.

Suffix:

<m>

Selects the input channel. The number of channels depends on the instrument.

Parameters:

<Path>

string

PROBe<m>:ID:FWService?

Queries the update status of the probe firmware.

Suffix:

<m>

Selects the input channel. The number of channels depends on the instrument.

Return values:

<ServiceState>

MEASuring | UPDate | FAILED | UNKNown

Usage: Query only

PROBe<m>:ID:PARTnumber?

Queries the R&S part number of the probe.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<PartNumber> string
Returns the part number in a string.

Usage: Query only

PROBe<m>:ID:PRDate?

Queries the production date of the probe.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<ProductionDate> string
Returns the date in a string.

Usage: Query only

PROBe<m>:ID:SRNumber?

Queries the serial number of the probe.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<SerialNumber> string

Usage: Query only

PROBe<m>:ID:SWVersion?

Queries the version of the probe firmware.

Suffix:

<m> Selects the input channel. The number of channels depends on the instrument.

Return values:

<Softwareversion> string
Returns the version number in a string.

Usage: Query only

10.2.3 Trigger**10.2.3.1 General A Trigger Settings**

TRIGger:A:MODE.....	203
TRIGger:A:LEVel<n>[:VALue].....	203
TRIGger:A:FINDlevel.....	204
TRIGger:A:SOURce.....	204
TRIGger:A:TYPE.....	204

TRIGger:A:MODE <TriggerMode>

Sets the trigger mode. The trigger mode determines the behaviour of the instrument if no trigger occurs.

Parameters:

<TriggerMode> AUTO | NORMAl

AUTO

The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence.

NORMAl

The instrument acquires a waveform only if a trigger occurs.

TRIGger:A:LEVel<n>[:VALue] <Level>

Sets the trigger treshold voltage for all A trigger types that require a trigger level.

Suffix:

<n> Selects the trigger input. 1...4 select the corresponding channel, 5 is the external trigger input. The number of channels depends on the instrument.

Parameters:

<Level>

Range: -10 to 10

Increment: 1e-3

Default unit: V

TRIGger:A:FINDlevel

Sets the trigger level to 50% of the signal amplitude.

Usage: Event

TRIGger:A:SOURce <Source>

Sets the trigger source for the selected A trigger type.

Parameters:

<Source> CH1 | CH2 | CH3 | CH4 | EXTernalog

CH1 | CH2 | CH3 | CH4

One of the input channels is the trigger source. Available channels depend on the instrument type.

EXTernalog

External Trigger Input on the rear panel

TRIGger:A:TYPE <Type>

Sets the trigger type for the A trigger.

Parameters:

<Type> EDGE | WIDTH | TV | SERPattern | BUS

EDGE: edge trigger

WIDTH: width trigger

TV: video trigger

SERPattern: pattern trigger, logic trigger

BUS: bus trigger require options, see [chapter 7.3, "Protocol Analysis"](#), on page 106

10.2.3.2 Edge Trigger

TRIGger:A:EDGE:SLOPe.....	204
TRIGger:A:EDGE:COUPling.....	205
TRIGger:A:EDGE:FILTer:LPASs.....	205
TRIGger:A:EDGE:FILTer:NREJect.....	205

TRIGger:A:EDGE:SLOPe <Slope>

Sets the slope for the edge trigger (A trigger).

Parameters:

<Slope>	POSitive NEGative EITHer
	POSitive
	Rising edge, a positive voltage change
	NEGative
	Falling edge, a negative voltage change
	EITHer
	Rising as well as the falling edge

TRIGger:A:EDGE:COUPLing <Coupling>

Sets the coupling for the trigger source.

Parameters:

<Coupling>	DC AC HF
	DC
	Direct Current coupling. The trigger signal remains unchanged.
	AC
	Alternating Current coupling. A 5 Hz high pass filter removes the DC offset voltage from the trigger signal.
	HF
	High frequency coupling. A 15 kHz high-pass filter removes lower frequencies from the trigger signal. Use this mode only with very high frequency signals.

TRIGger:A:EDGE:FILTer:LPASs <State>

Turns an additional 5 kHz low-pass filter in the trigger path on or off. This filter removes higher frequencies and is available with AC and DC coupling.

Parameters:

<State>	ON OFF
---------	----------

TRIGger:A:EDGE:FILTer:NREJect <State>

Turns an additional 100 MHz low-pass filter in the trigger path on or off. This filter removes higher frequencies and is available with AC and DC coupling.

Parameters:

<State>	ON OFF
---------	----------

10.2.3.3 Width Trigger

TRIGger:A:WIDTh:POLarity.....	206
TRIGger:A:WIDTh:RANGe.....	206

TRIGger:A:WIDTh:POLarity <Polarity>

Sets the polarity of the pulse.

Parameters:

<Polarity> POSitive | NEGative

POSitive

Positive going pulse, the width is defined from the rising to the falling slopes.

NEGative

Negative going pulse, the width is defined from the falling to the rising slopes.

TRIGger:A:WIDTh:RANGe <RangeMode>

Sets how the measured pulse width is compared with the given limit(s).

Parameters:

<RangeMode> INSRange | OUTRange | LTHan | GTHan

INSRange

Triggers on pulses inside a range specified with ...

OUTRange

Triggers on pulses outside a range specified with ...

LTHan

Lower than. Triggers on pulses shorter than the reference time specified with ...

GTHan

Greater than. Triggers on pulses longer than the reference time specified with ...

10.2.3.4 Video/TV Trigger

TRIGger:A:VIDeo:POLarity.....	206
TRIGger:A:TV:FIELD.....	207
TRIGger:A:TV:LINE.....	207

TRIGger:A:VIDeo:POLarity <Polarity>

Sets the polarity of the sync pulses. The edges of the sync pulses are used for triggering.

See also: "[Signal](#)" on page 39

Parameters:

<Polarity> POSitive | NEGative

POSitive

If the video modulation is positive, the sync pulses are negative.

NEGative

If the modulation is negative, sync pulses are positive.

TRIGger:A:TV:FIELD <Field>

Sets the trigger on the beginning of the video signal fields, or on the beginning of video signal lines.

Parameters:

<Field> EVEN | ODD | ALL | LINE | ALINe

EVEN

Triggers only on even half frames.

ODD

Triggers only on odd half frames.

ALL

Triggers on all frames.

LINE

Triggers on the beginning of a specified line in any field. The line number is set with [TRIGger:A:TV:LINE](#).

ALINe

Triggers on the beginning of all video signal lines.

TRIGger:A:TV:LINE <Line>

Sets an exact line number if [TRIGger:A:TV:FIELD](#) is set to LINE.

Parameters:

<Line>

Range: 1 to 1080

Increment: 1

10.2.3.5 Pattern Trigger**TRIGger:A:PATtern:SOURce** <SourceString>

Select the state for each digital channel.

Parameters:

<SourceString> string containing 0, 1, or X for each channel

1: high, the signal voltage is higher than the trigger level.

0: low, the signal voltage is lower than the trigger level.

X: Don't care. the channel does not affect the trigger.

Example: TRIG:A:PATT:SOUR "1X10"
 CH1, CH3, and NOT CH4 are logically combined with
 TRIGger:A:PATtern:FUNCTion, CH2 does not matter (don't
 care).

TRIGger:A:PATtern:FUNCTion <Function>

Sets the logical combination of the trigger states of the channels.

Parameters:

<Function> AND | OR

AND

The required states of all channels must appear in the input signal at the same time.

OR

At least one of the channels must have the required state.

TRIGger:A:PATtern:CONDition <Condition>

Sets the trigger point depending on the result of the logical combination of the channel states.

Parameters:

<Condition> TRUE | FALSE

10.2.3.6 B-Trigger

TRIGger:B:ENABLE.....	208
TRIGger:B:EDGE:SOURce.....	209
TRIGger:B:EDGE:SLOPe.....	209
TRIGger:B:EDGE:LEVel.....	209
TRIGger:B:MODE.....	209
TRIGger:B:DELaY.....	209
TRIGger:B:EVENT:COUNt.....	210

TRIGger:B:ENABLE <State>

Activates or deactivates the second trigger. The instrument triggers if both trigger event conditions (A and B) are fulfilled.

Parameters:

<State> ON | OFF

*RST: OFF

TRIGger:B:EDGE:SOURce <Source>

Selects one of the input channels as B-trigger source. Available channels depend on the instrument type.

Parameters:

<Source> CHANnel1 | CHANnel2 | CHANnel3 | CHANnel4
*RST: CH1

TRIGger:B:EDGE:SLOPe <Slope>

Sets the edge for the B-trigger.

Parameters:

<Slope> POSitive | NEGative | EITHer
*RST: POSitive

TRIGger:B:EDGE:LEVel <Level>

Sets the trigger level for the B-trigger event.

Parameters:

<Level>
Default unit: V

TRIGger:B:MODE <Mode>

Defines the delay type of the B-trigger.

Parameters:

<Mode> DELay | EVENTs
DELay
Time delay, set with [TRIGger:B:DELay](#)
EVENTs
Event count delay, set with [TRIGger:B:EVENT:COUNT](#)
*RST: DELay

TRIGger:B:DELay <DelayTime>

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

Before setting the delay time, [TRIGger:B:MODE](#) must be set to DELAY.

Parameters:

<DelayTime>

Range: 8e-9 to 134.21e-3

Increment: 8e-9

*RST: 8e-9

Default unit: s

TRIGger:B:EVENT:COUNT <EventCnt>

Sets a number of B-trigger events that fulfill all B-trigger conditions but do not cause the trigger. The oscilloscope triggers on the n-th event (the last of the specified number of events).

Before setting the event number, **TRIGger:B:MODE** must be set to **EVENTs**.

Parameters:

<EventCnt>

Number of B-events

Range: 1 to 65535

Increment: 1

*RST: 1

10.2.4 Display

10.2.4.1 Basic Display Settings

This chapter describes commands that configure the screen display.

General Display Settings

DISPlay:MODE	210
DISPlay:PALETTE	211

DISPlay:MODE <Mode>

Sets the diagram mode.

Parameters:

<Mode>

YT | XY

YT

Default time diagram with a time axis in x-direction and the signal amplitudes displayed in y-direction.

XY

XY-diagram, combines the voltage levels of two waveforms in one diagram.

DISPlay:PALETTE <Palette>

Sets the color and brightness of the displayed waveform samples depending on their cumulative occurrence.

Parameters:

<Palette>

NORMAL | INVERSE | FColor | IFColor

NORMAL

Values that occur frequently are brighter than rare values.

INVERSE

Rare values are brighter than frequent values, inverse to the NORMAL brightness.

FColor

Rare values are displayed in blue, while more frequent values are red and very frequent values are displayed in yellow or white, with various colors inbetween.

IFColor

Inverses the FColor setting: rare values are yellow or white while frequent values are blue.

XYZ-Setup

DISPlay:XY:XSource.....	211
DISPlay:XY:Y1Source.....	211
DISPlay:XY:Y2Source.....	212
DISPlay:XY:ZMODE.....	212
DISPlay:XY:ZSource.....	212

DISPlay:XY:XSource <Source>

Defines the source to be displayed in x direction in an XY-diagram, replacing the usual time base.

Parameters:

<Source>

CH1 | CH2 | CH3 | CH4

CH3 and CH4 are only available with 4-channel R&S RTM oscilloscopes.

DISPlay:XY:Y1Source <Source>

Defines the (first) source to be displayed in y direction in an XY-diagram.

Parameters:

<Source>

CH1 | CH2 | CH3 | CH4

CH3 and CH4 are only available with 4-channel R&S RTM oscilloscopes.

DISPlay:XY:Y2Source <Source>

Defines an optional second source to be displayed in y direction in an XY-diagram. The command is only relevant for 4-channel R&S RTM instruments.

Parameters:

<Source> NONE | CH1 | CH2 | CH3 | CH4

DISPlay:XY:ZMODE <Mode>

Activates or deactivates the intensity control of the waveform via an additional signal source and sets the intensity mode.

Parameters:

<Mode> ANALog | DIGital | OFF

ANALog

Modulated intensity; Intensity is modulated continuously according to the selected Source Z.

DIGital

Intensity is determined by a "Threshold" value. If the Z signal value is below the selected threshold, the corresponding x/y point is not displayed. If the Z signal value is above the threshold, the x/y point is displayed with the defined intensity level.

OFF

Intensity control is deactivated.

DISPlay:XY:ZSource <Source>

Defines the source to be used to determine the intensity of the xy-waveform.

Parameters:

<Source> CH1 | CH2 | CH3 | CH4

CH3 and CH4 are only available with 4-channel R&S RTM oscilloscopes.

Intensities

DISPlay:INTensity:WAVeform.....	213
DISPlay:INTensity:BACKlight.....	213
DISPlay:INTensity:GRID.....	213
DISPlay:PERsistence:STATe.....	213
DISPlay:PERsistence:TIME.....	214
DISPlay:PERsistence:INFinite.....	214
DISPlay:PERsistence:TIME:AUTO.....	214
DISPlay:PERsistence:CLEar.....	214

DISPlay:INTensity:WAVeform <Intensity>

Defines the strength of the waveform line in the diagram.

Parameters:

<Intensity> Value in percent
Range: 0 to 100
Increment: 1
Default unit: %

DISPlay:INTensity:BACKlight <Intensity>

Defines the intensity of the background lighting of the display.

Parameters:

<Intensity> Value in percent
Range: 10 to 100
Increment: 1
Default unit: %

DISPlay:INTensity:GRID <Intensity>

Defines the intensity of the grid on the screen.

Parameters:

<Intensity> Value in percent
Range: 0 to 100
Increment: 1
Default unit: %

DISPlay:PERsistence:STATe <State>

Defines whether the waveform persists on the screen or whether the screen is refreshed continuously.

Parameters:

<State> ON | OFF

ON

The waveform persists for the time defined using [DISPlay:PERsistence:TIME](#).

OFF

The waveform does not persist on the screen. Only the currently measured values are displayed at any time.

DISPlay:PERsistence:TIME <Time>

Persistence time if persistence is active (see [DISPlay:PERsistence:STATe](#) on page 213).

Each new data point in the diagram area remains on the screen for the duration defined here. To set infinite persistence, use [DISPlay:PERsistence:INFinite](#).

Parameters:

<Time>

Range: 50 ms to 9.6 s

Default unit: s

DISPlay:PERsistence:INFinite <InfinitePersistence>

Sets the persistence time to infinite if [DISPlay:PERsistence:STATe](#) is ON. each new data point remains on the screen infinitely until this setting is changed or the persistence is cleared.

Parameters:

<InfinitePersistence> ON | OFF

DISPlay:PERsistence:TIME:AUTO <Auto>

The optimal persistence time is determined automatically by the instrument.

Parameters:

<Auto> ON | OFF

DISPlay:PERsistence:CLEar

Removes the displayed persistent waveform from the screen.

Usage: Event**Waveform, Auxiliary Cursors and Grid Settings**

DISPlay:STYLE	214
DISPlay:GRID:STYLE	215

DISPlay:STYLE <Style>

Defines how the waveform data is displayed

Parameters:

<Style> VECTors | DOTs

VECTors

Individual data points are connected by a line.

DOTs

Only the data points are displayed.

DISPlay:GRID:STYLe <Style>

Defines how the grid is displayed.

Parameters:

<Style> LINes | RETicle | NONE

LINes

Displays the grid as horizontal and vertical lines.

RETicle

Displays crosshairs instead of a grid.

NONE

No grid is displayed.

10.2.4.2 Zoom

TIMebase:ZOOM:STATe.....	215
TIMebase:ZOOM:SCALe.....	215
TIMebase:ZOOM:TIME.....	216
TIMebase:ZOOM:POSition.....	216

TIMebase:ZOOM:STATe <ZoomState>

Switches the zoom window on or off.

Parameters:

<ZoomState> ON | OFF

*RST: OFF

TIMebase:ZOOM:SCALe <ZoomScale>

Defines the time base in the zoom diagram in seconds per division.

Parameters:

<ZoomScale> Scaling of the zoom time base

*RST: 50e-6

Default unit: s/div

TIMEbase:ZOOM:TIME <Time>

Defines the offset of the trigger point to the reference point of the zoom diagram.

Parameters:

<Time>

Default unit: s

TIMEbase:ZOOM:POSITION <Position>

Defines the position of the zoom reference point (the reference point of the zoom window) in relation to the reference point of original time base.

Parameters:

<Position>

*RST: 50

Default unit: %

10.2.4.3 Markers (Timestamps)

TSTamp:SET.....	216
TSTamp:NEXT.....	216
TSTamp:PREVIOUS.....	216
TSTemp:CLEAR.....	217
TSTamp:AClear.....	217

TSTamp:SET

Sets a new marker (timestamp) at the reference point of the display, unless an existing marker is already set there. The reference point is set with [TIMEbase:REFERENCE](#).

Usage: Event

TSTamp:NEXT

Usage: Event

Moves the next marker (timestamp, to the right) to the reference point of the display or zoom area.

TSTamp:PREVIOUS

Moves the previous marker (timestamp, to the left) to the reference point of the display or zoom area.

Usage: Event

TSTemp:CLEar

Deletes the marker (timestamp) at the reference point. The reference point is set with `TIMEbase:REference`.

Usage: Event

TSTamp:AClear

Deletes all markers (timestamps).

Usage: Event

10.2.5 Measurements

This chapter describes functions that configure or perform cursor and automatic measurements.

10.2.5.1 Cursor

<code>CURSor<m>:AOFF</code>	217
<code>CURSor<m>:STATe</code>	218
<code>CURSor<m>:FUNCTioN</code>	218
<code>CURSor<m>:SOURce</code>	218
<code>CURSor<m>:TRACKing[:STATe]</code>	219
<code>CURSor<m>:X1Position</code>	219
<code>CURSor<m>:X2Position</code>	219
<code>CURSor<m>:X3Position</code>	220
<code>CURSor<m>:Y1Position</code>	220
<code>CURSor<m>:Y2Position</code>	220
<code>CURSor<m>:Y3Position</code>	220
<code>CURSor<m>:XCOupling</code>	221
<code>CURSor<m>:YCOupling</code>	221
<code>CURSor<m>:XDELta:INVerse</code>	221
<code>CURSor<m>:XDELta[:VALue]</code>	222
<code>CURSor<m>:YDELta:SLOPe</code>	222
<code>CURSor<m>:YDELta[:VALue]</code>	222
<code>CURSor<m>:XRATio:UNIT</code>	222
<code>CURSor<m>:XRATio[:VALue]</code>	223
<code>CURSor<m>:YRATio:UNIT</code>	223
<code>CURSor<m>:YRATio[:VALue]</code>	223

CURSor<m>:AOFF

Switches the cursor off.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Usage: Event

CURSor<m>:STATe <State>

Activates or deactivates the cursor measurement.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Parameters:

<State> ON | OFF

CURSor<m>:FUNCTioN <Type>

Defines the cursor measurement type.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Parameters:

<Type> HORIZontal | VERTical | PAIRed | HRATio | VRATio | PPCount | NPCount | RECount | FECount | MEAN | RMS | RTIME | FTIME | PEAK | UPEakvalue | LPEakvalue

HORIZontal: Measures the time from the trigger time to each cursor point, the time between the two cursors and the frequency calculated from that time.

VERTical: Measures the voltages at the two cursor positions and the delta of the two values.

PAIRed:

HRATio:

VRATio:

PPCount: Count positive pulses

NPCount: Count negative pulses

RECount: Count rising edges

FECount: Count falling edges

MEAN: Mean value

RMS: Root mean square

RTIME: Rise time

FTIME: Fall time

PEAK:

UPEakvalue: Upper peak value

LPEakvalue: Lower peak value

CURSor<m>:SOURce <Source>

Defines the source of the cursor measurement as one of the active signal, reference or math channels.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Parameters:

<Source> NONE | CH1 | CH2 | CH3 | CH4 | M1 | M2 | M3 | M4 | M5 | R1 | R2
| R3 | R4 | XY1

CH1 | CH2 | CH3 | CH4

Active signal channels 1 to 4

M1 | M2 | M3 | M4 | M5

Active math channels 1 to 5

R1 | R2 | R3 | R4

Active reference channels 1 to 4

XY1

Active XY-waveform

CURSor<m>:TRACking[:STATe] <State>

If set to ON, the V-Marker cursor measurement is enabled.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Parameters:

<State> ON | OFF

CURSor<m>:X1Position <Xposition1>

Specifies the position of the first cursor on the time axis.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Parameters:

<Xposition1>

Range: 0 to 500

Increment: 0.1

Default unit: s

CURSor<m>:X2Position <Xposition2>

Specifies the position of the second cursor on the time axis.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Parameters:

<Xposition2>

Range: 0 to 500

Increment: 0.1

Default unit: s

CURSor<m>:X3Position <Xposition3>

Specifies the position of the third cursor on the time axis for the Ratio X measurement.

Suffix:

<m>

1

The numeric suffix is irrelevant.

Parameters:

<Xposition3>

Range: 0 to 500

Increment: 0.1

Default unit: s

CURSor<m>:Y1Position <Yposition1>

Specifies the position of the first horizontal cursor on the y-axis.

Suffix:

<m>

1

The numeric suffix is irrelevant.

Parameters:

<Yposition1>

Range: -50 to 50

Increment: 0.01

Default unit: V

CURSor<m>:Y2Position <Yposition2>

Specifies the position of the second horizontal cursor on the y-axis.

Suffix:

<m>

1

The numeric suffix is irrelevant.

Parameters:

<Yposition2>

Range: -50 to 50

Increment: 0.01

Default unit: V

CURSor<m>:Y3Position <Yposition3>

Specifies the position of the third horizontal cursor on the y-axis for Ratio Y measurements.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Parameters:

<Yposition3>
Range: -50 to 50
Increment: 0.01
Default unit: V

CURSor<m>:XCOupling <Coupling>

If enabled, the cursors of a set are coupled so that the distance between the two remains the same if one cursor is moved.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Parameters:

<Coupling> ON | OFF

CURSor<m>:YCOupling <Coupling>

If enabled, the cursor lines are adjusted automatically if the vertical or horizontal scales are changed. The cursor lines keep their relative position to the waveform.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Parameters:

<Coupling> ON | OFF

CURSor<m>:XDELta:INVerse?

Returns the inverse time difference between the two cursors ($1/\Delta t$).

Suffix:

<m> 1
The numeric suffix is irrelevant.

Return values:

<DeltaInverse>
Range: -100e24 to 100e24
Increment: 0.1
Default unit: 1/s

Usage: Query only

CURSor<m>:XDELta[:VALue]?

Returns the time difference between the two cursors (Δt).

Suffix:

<m> 1
The numeric suffix is irrelevant.

Return values:

<Delta>
Range: -100e24 to 100e24
Increment: 0.1
Default unit: s

Usage: Query only

CURSor<m>:YDELta:SLOPe?**Suffix:**

<m> 1
The numeric suffix is irrelevant.

Usage: Query only

CURSor<m>:YDELta[:VALue]?

Queries the delta of the values in y-direction at the two cursors.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Usage: Query only

CURSor<m>:XRATio:UNIT <Unit>

Sets the unit for X Ratio measurements with `CURSor<m>:XRATio[:VALue]`.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Parameters:

<Unit> RATio | PCT | GRD | PI
RATio - floating value
PCT - percent
GRD - degree
PI - radian

CURSor<m>:XRATio[:VALue]?

Returns the ratio of the x-values (e.g. a duty cycle) between the first and second cursors and the first and third cursors: $(x_2-x_1)/(x_3-x_1)$.

Set the unit of the result with `CURSor<m>:XRATio:UNIT`.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Return values:

<Ratio> Numeric value corresponding to the specified unit.

Usage: Query only

CURSor<m>:YRATio:UNIT <Unit>

Sets the unit for Y Ratio measurements with `CURSor<m>:YRATio[:VALue]` on page 223.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Parameters:

<Unit> RATio | PCT
RATio - floating value
PCT - percent

CURSor<m>:YRATio[:VALue]?

Provides three cursors and measures the ratio of the y-values (e.g. overshooting) between the first and second cursors and the first and third cursors: $(y_2-y_1)/(y_3-y_1)$.

Set the unit of the result with `CURSor<m>:YRATio:UNIT`.

Suffix:

<m> 1
The numeric suffix is irrelevant.

Return values:

<Ratio> Numeric value corresponding to the specified unit.

Usage: Query only

10.2.5.2 Automatic Measurements

<code>MEASurement<m>[:ENABLE]</code>	224
<code>MEASurement<m>:SOURce</code>	224
<code>MEASurement<m>:AOFF</code>	224
<code>MEASurement<m>:AON</code>	225
<code>MEASurement<m>:ARES</code>	225

MEASurement<m>:CLEar.....	225
MEASurement<m>:CATegory.....	225
MEASurement<m>:LCHeck.....	225
MEASurement<m>:MAIN.....	226
MEASurement<m>:RESult.....	228

MEASurement<m>[:ENABLE] <State>

Activates or deactivates the selected measurement (1-4). Only the results of active measurements are displayed in the result table.

Suffix:

<m> 1..4
Selects the measurement.

Parameters:

<State> ON | OFF

MEASurement<m>:SOURce <SignalSource>[,<SignalSource2>]

Selects one of the active signal, reference or math channels as the source of the selected measurement.

Suffix:

<m> 1..4

Parameters:

<SignalSource> NONE | CH1 | CH2 | CH3 | CH4 | M1 | M2 | M3 | M4 | M5 | R1 | R2
| R3 | R4 | XY1

CH1 | CH2 | CH3 | CH4

Active signal channels 1 to 4

M1 | M2 | M3 | M4 | M5

Active math channels 1 to 5

R1 | R2 | R3 | R4

Active reference channels 1 to 4

XY1

Active XY-waveform

<SignalSource2> NONE | CH1 | CH2 | CH3 | CH4 | M1 | M2 | M3 | M4 | M5 | R1 | R2
| R3 | R4 | XY1

MEASurement<m>:AOFF

Resets and deactivates all four measurements.

Suffix:

<m> 1..4
The numeric suffix is irrelevant.

Usage: Event

MEASurement<m>:AON

Activates all four measurements.

Suffix:

<m> 1..4
The numeric suffix is irrelevant.

Usage: Event

MEASurement<m>:ARES?

Returns the results of all four measurements. The measurement type for each measurement is defined with [MEASurement<m>:MAIN](#).

Suffix:

<m> 1..4
The numeric suffix is irrelevant.

Return values:

<sData> string

Usage: Query only

MEASurement<m>:CLEar

Clears the settings for the selected measurement.

Suffix:

<m> 1..4
Selects the measurement.

Usage: Event

MEASurement<m>:CATegory <Category>

Suffix:

<m> 1..4
Selects the measurement.

Parameters:

<Category> AMPTime | SPECTrum

MEASurement<m>:LCHeck <LimitCheckState>

Suffix:

<m> 1..4

Parameters:

<LimitCheckState> OFF | LIMit | LMARgin

MEASurement<m>:MAIN <MeasType>

Defines the measurement type to be performed on the selected source. To query the results, use [MEASurement<m>:RESult](#).

Suffix:

<m> 1..4
Selects the measurement.

Parameters:

<MeasType>

HIGH | LOW | AMPLitude | MEAN | RMS | RTIME | FTIME | PERiod
| FREQuency | PDCYcle | NDCYcle | CYCMean | CYCRms | PEAK
| UPEakvalue | LPEakvalue | TFRequency | TPERiode | PPWidth
| NPWidth | PPCount | NPCount | RECount | FECount

For a detailed description, see "[Meas. Type](#)" on page 68.

HIGH

Mean value of the high level of a square wave.

LOW

Mean value of the low level of a square wave.

AMPLitude

Amplitude of a square wave.

MEAN

Mean value of the complete displayed waveform of the selected channel.

RMS

RMS (Root Mean Square) value of the voltage of the complete displayed waveform of the selected channel.

RTIME

Rise time of the left-most rising edge within the displayed section of the waveform of the selected channel.

FTIME

Falling time of the left-most falling edge within the displayed section of the waveform of the selected channel.

PERiod

Length of the left-most signal period within the displayed section of the waveform of the selected channel.

FREQuency

Frequency of the signal. The result is based on the length of the left-most signal period within the displayed section of the waveform of the selected channel.

PDCycle

Measures the positive duty cycle.

NDCycle

Measures the negative duty cycle.

CYCMean

Mean value of the left-most signal period of the waveform of the selected channel.

CYCRms

RMS (Root Mean Square) value of the voltage of the left-most signal period of the waveform of the selected channel.

PEAK

Peak-to-peak value within the displayed section of the waveform of the selected channel.

UPEakvalue

Maximum value within the displayed section of the waveform of the selected channel.

LPEakvalue

Minimum value within the displayed section of the waveform of the selected channel.

TFRequency

Measures the frequency of the trigger signal based on the length of its period.

TPERiode

Measures the length of the trigger signal periods (hardware counter).

PPWidth

Measures the width of positive pulses.

NPWidth

Measures the width of negative pulses.

PPCount

Counts positive pulses.

NPCount

Counts negative pulses.

RECount

Counts the number of rising edges.

FECCount

Counts the number of falling edges.

MEASurement<m>:RESult? [<MeasType>]

Returns the result of the specified measurement type.

Suffix:

<m> 1..4
Selects the measurement.

Return values:

<Value> Measurement result

Query parameters:

<MeasType> HIGH | LOW | AMPLitude | MEAN | RMS | RTIME | FTIME | PERiod
| FREQuency | PDCYcle | NDCYcle | CYCMean | CYCRms | PEAK
| UPEakvalue | LPEakvalue | TFRequency | TPERiode | PPWidth
| NPWidth | PPCount | NPCount | RECount | FECCount

Specifies the measurement type. See [MEASurement<m>:MAIN](#) on page 226.

Usage: Query only

10.2.6 Mathematics and Reference Waveforms

10.2.6.1 Mathematics

This chapter describes commands that configure or perform mathematical functions.

CALCulate:MATH<m>:STATe.....	229
CALCulate:MATH<m>[:EXPRession][:DEFine].....	229
CALCulate:MATH<m>:DATA.....	229

CALCulate:MATH<m>:STATe <State>

Defines whether the selected mathematical channel is active or not. Only if a channel is active it is visible on the screen and can be selected as a source for analysis and display functions.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<State> ON | OFF

*RST: OFF

CALCulate:MATH<m>[:EXPRession][:DEFine] <RemComplExpr>

Defines the equation to be calculated for the selected math channel as a regular expression.

For details on available operators see "[Operator](#)" on page 79.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<RemComplExpr> Regular expression

CALCulate:MATH<m>:DATA? [<Header>]

Returns the data of the math waveform points. The waveforms data can be used in Matlab, for example.

Suffix:

<m> 1..4
Selects the math waveform.

Return values:

<Data> commaseparated value list

Query parameters:

<Header> ON | OFF

Usage:

Query only

10.2.6.2 Reference Waveforms

REFCurve<m>:SOURCE.....	230
REFCurve<m>:UPDATE.....	230
REFCurve<m>:SAVE.....	230
REFCurve<m>:LOAD.....	231
REFCurve<m>:LOAD:STATE.....	231
REFCurve<m>:HORIZONTAL:SCALE.....	231
REFCurve<m>:HORIZONTAL:POSITION.....	231
REFCurve<m>:VERTICAL:SCALE.....	232
REFCurve<m>:VERTICAL:POSITION.....	232
REFCurve<m>:DATA.....	232

REFCurve<m>:SOURCE <Source>

Defines the source of the reference waveform.

Suffix:

<m> 1..4

Selects the reference waveform, the internal reference storage.

Parameters:

<Source> CH1 | CH2 | CH3 | CH4 | M1 | M2 | M3 | M4

Any active channel or math waveform. Available channels depend on the instrument type.

*RST: CH1

REFCurve<m>:UPDATE

Updates the selected reference by the waveform defined with [REFCurve<m>:SOURCE](#).

To keep the new reference permanently, you must save it with [REFCurve<m>:SAVE](#).

Suffix:

<m> 1..4

Selects the reference waveform, the internal reference storage.

Usage:

Event

REFCurve<m>:SAVE <file_name>

Stores the reference waveform the specified file.

Suffix:

<m> 1..4

Selects the reference waveform, the internal reference storage.

Setting parameters:

<file_name> String parameter
Path and file name

Usage: Setting only

REFCurve<m>:LOAD <file_name>

Loads the data from the indicated file to the reference storage.

Suffix:

<m> 1..4
Selects the reference waveform, the internal reference storage.

Setting parameters:

<file_name> String parameter
Path and file name

Usage: Setting only

REFCurve<m>:LOAD:STATE**Suffix:**

<m> 1..4
Selects the reference waveform.

Usage: Event

REFCurve<m>:HORIZontal:SCALE <Scale>

Changes the horizontal scale (timebase) of the reference waveform independent of the channel waveform settings.

Suffix:

<m> 1..4
Selects the reference waveform, the internal reference storage.

Parameters:

<Scale>
Default unit: s/div

REFCurve<m>:HORIZontal:POSition <Position>

Changes the horizontal position of the reference waveform independent of the channel waveform settings.

Suffix:

<m> 1..4
Selects the reference waveform, the internal reference storage.

Parameters:

<Position>
Default unit: s

REFCurve<m>:VERTical:SCALE <Scale>

Changes the vertical scale of the reference waveform.

Suffix:

<m> 1..4
Selects the reference waveform, the internal reference storage.

Parameters:

<Scale>
Default unit: V/div

REFCurve<m>:VERTical:POSition <Position>

Changes the vertical position of the reference waveform.

Suffix:

<m> 1..4
Selects the reference waveform, the internal reference storage.

Parameters:

<Position>
Default unit: div

REFCurve<m>:DATA? [<Header>]

Returns the data of the reference waveform.

Suffix:

<m> 1..4
Selects the reference waveform, the internal reference storage.

Return values:

<Data> Comma-separated value list

Query parameters:

<Header> ON | OFF
Enables or disables the output of a header containing setup and acquisition settings. If you omit the parameter, the header is off. The header content is described in the table below.

Usage: Query only

10.2.7 Analysis

This chapter describes commands that configure or execute analysis functions.

- [FFT](#).....233
- [Masks](#).....237
- [Protocol Analysis](#).....239

10.2.7.1 FFT

CALCulate:MATH<m>:ARITHmetics.....	233
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:ADJusted.....	233
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO.....	234
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:RATio.....	234
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CALCulate:MATH<m>:FFT:FULLspan.....	235
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CALCulate:MATH<m>:FFT:START.....	235
CALCulate:MATH<m>:FFT:STOP.....	236
CALCulate:MATH<m>:FFT:WINDow:TYPE.....	236

CALCulate:MATH<m>:ARITHmetics <Arithmetics>

Defines the mode for FFT calculation and display.

Suffix:

<m> 1..4
The numeric suffix is irrelevant.

Parameters:

<Arithmetics> OFF | ENVELOpe | AVERAge

OFF

The FFT is performed without any additional weighting or postprocessing of the acquired data. The new input data is acquired and displayed, and thus overwrites the previously saved and displayed data.

ENVELOpe

In addition to the normal spectrum, the maximal oscillations are saved separately and updated for each new spectrum. The maximum values are displayed together with the newly acquired values and form an envelope. This envelope indicates the range of all FFT trace values that occurred.

AVERAge

The average of several spectrums is calculated. The number of spectrums used for the averaging is defined using the command. This mode is useful for noise rejection.

*RST: OFF

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:ADJusted? <AdjResBW>

Queries the effective resolution bandwidth.

Suffix:

<m> 1..4
The numeric suffix is irrelevant.

Parameters:

<AdjResBW>

Range: -100e24 to 100e24

Increment: 0.1

Default unit: Hz

Usage:

Query only

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO <SpanRBWCoupling>

Couples the frequency span to the RBW.

Suffix:

<m>

1..4

The numeric suffix is irrelevant.

Parameters:

<SpanRBWCoupling> ON | OFF

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:RATio <SpanRBWRatio>

Defines the ratio resolution bandwidth (Hz) / span (Hz).

Suffix:

<m>

1..4

The numeric suffix is irrelevant.

Parameters:

<SpanRBWRatio>

Range: 1 to 1000

Increment: 1

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution][:VALue] <ResolutionBW>

Defines the resolution bandwidth.

Suffix:

<m>

1..4

The numeric suffix is irrelevant.

Parameters:

<ResolutionBW>

Range: 100 to 2e6

Increment: 0.1

Default unit: Hz

CALCulate:MATH<m>:FFT:CFRequency <CenterFreq>Defines the position of the displayed frequency domain, which is (Center - Span/2) to (Center + Span/2). The width of the domain is defined using the [CALCulate:MATH<m>:FFT:SPAN](#) command.[CALCulate:MATH<m>:FFT:SPAN](#) command.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<CenterFreq>
Range: 0 to 2e12
Increment: 1
*RST: 500e6
Default unit: Hz

CALCulate:MATH<m>:FFT:FULLspan

Performs FFT calculation for the full frequency span.

Suffix:

<m> 1..4
The numeric suffix is irrelevant.

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
The numeric suffix is irrelevant.

Parameters:

<FreqSpan>
Range: 10000 to 4e12
Increment: 100
*RST: 1e9
Default unit: Hz

CALCulate:MATH<m>:FFT:START <StartFreq>

Defines the start frequency of the displayed frequency domain (instead of defining a center frequency and span).

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<StartFreq>
Range: 0 to 100e24
Increment: 1
Default unit: Hz

CALCulate:MATH<m>:FFT:STOP <StopFreq>

Defines the stop frequency of the displayed frequency domain (instead of defining a center frequency and span).

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<StopFreq>
Range: 0 to 2e9
Increment: 1
Default unit: Hz

CALCulate:MATH<m>:FFT:WINDow:TYPE <WindowType>

Window functions are multiplied with the input values and thus can improve the FFT display.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<WindowType> RECTangular | HAMMing | HANNing | BLACkmanharris

RECTangular

The rectangular window multiplies all points by one. The result is a high frequency accuracy with thin spectral lines, but also with increased noise. Use this function preferably with pulse response tests where start and end values are zero.

HAMMing

The Hamming window is bell shaped. Its value is not zero at the borders of the measuring interval. Thus, the noise level inside the spectrum is higher than Hanning or Blackman, but smaller than the rectangular window. The width of the spectral lines is thinner than the other bell-shaped functions. Use this window to measure amplitudes of a periodical signal precisely.

HANNing

The Hanning window is bell shaped. Unlike the Hamming window, its value is zero at the borders of the measuring interval. Thus, the noise level within the spectrum is reduced and the width of the spectral lines enlarges. Use this window to measure amplitudes of a periodical signal precisely.

BLACkmanharris

The Blackman window is bell shaped and has the steepest fall in its wave shape of all other available functions. Its value is zero at both borders of the measuring interval. In the Blackman window the amplitudes can be measured very precisely. However, determining the frequency is more difficult. Use this window to measure amplitudes of a periodical signal precisely.

*RST: HANNing

10.2.7.2 Masks

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MASK:TEST.....	238
MASK:LOAD.....	238
MASK:SOURce.....	238
MASK:SAVE.....	238
MASK:COUNT.....	238
MASK:VCOunt.....	239

MASK:STATe <State>

Turns the mask test mode on or off. When turning off, any temporarily stored new masks are deleted.

Parameters:

<State> ON | OFF

*RST: OFF

MASK:TEST <Test>

Starts, finishes or interrupts a mask test.

Parameters:

<Test> RUN | STOP | PAUSE
 *RST: STOP

MASK:LOAD <file_name>

Loads a stored mask from the specified file.

Setting parameters:

<file_name> String parameter
 Path and file name

Usage: Setting only

MASK:SOURce <Source>

Creates a new mask from the envelope waveform of the specified channel.

Parameters:

<Source> CH1 | CH2 | CH3 | CH4
 CH3 and CH4 are only available on 4-channel R&S RTM models.
 *RST: CH1

MASK:SAVE <file_name>

Saves the current mask in the specified file.

Setting parameters:

<file_name> String parameter
 Path and file name

Usage: Setting only

MASK:COUNT?

Returns the number of tested acquisitions.

Return values:

<TotalCount> Total number

Usage: Query only

MASK:VCOunt?

Returns the number of mask hits.

Return values:

<ViolationCount>

Usage: Query only

10.2.7.3 Protocol Analysis

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• Parallel Bus	240
• SPI/SSPI	240
• I2C	245
• UART	247

General

BUS:STATe	239
BUS:TYPE	239
BUS:DATA	239

BUS:STATe <State>**Parameters:**

<State> ON | OFF
*RST: OFF

BUS:TYPE <Type>

Defines the bus or interface type for analysis. For most types, a special option to the instrument is required.

Parameters:

<Type> PARallel | CPARallel | I2C | SPI | SSPI | UART
*RST: PARallel

BUS:DATA? [<Header>]

Returns the data of the bus signal.

Return values:

<Data> Comma-separated value list

Query parameters:

<Header> ON | OFF

Enables or disables the output of a header containing setup and acquisition settings. If you omit the parameter, the header is off. The header content is described in the table below.

Usage: Query only

Parallel Bus

BUS:PARAllel:DATA<m>:SOURce <Source>

Sets the input channels for the data bit lines. The suffix <m> selects the bit line.

Parameters:

<Source> CH1 | CH2 | CH3 | CH4

*RST: CH1

SPI/SSPI

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BUS:SPI:CS:POLarity.....	241
BUS:SPI:CLOCK:SOURce.....	241
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BUS:SSPI:DATA:POLarity.....	244
BUS:SSPI:BITime.....	244
BUS:SSPI:BORDER.....	244
BUS:SSPI:WSIZE.....	244

BUS:SPI:CS:SOURce <Source>

Selects the input channel of the chip select line.

Parameters:

<Source> CH1 | CH2 | CH3 | CH4

*RST: CH1

BUS:SPI:CS:POLarity <POLarity>

Selects whether the chip select signal is high active (high = 1) or low active (low = 1).

Parameters:

<POLarity> POSitive | NEGative
 POSitive = high active
 NEGative = low active
*RST: POSitive

BUS:SPI:CLOCK:SOURce <Source>

Selects the input channel of the clock line.

Parameters:

<Source> CH1 | CH2 | CH3 | CH4
 *RST: CH1

BUS:SPI:CLOCK:POLarity <POLarity>

Selects if data is stored with the rising or falling slope of the clock. The slope marks the begin of a new bit.

Parameters:

<POLarity> POSitive | NEGative
 POSitive: rising slope
 NEGative: falling slope
*RST: POSitive

BUS:SPI:DATA:SOURce <Source>

Selects the input channel of the data line.

Parameters:

<Source> CH1 | CH2 | CH3 | CH4
 *RST: CH1

BUS:SPI:DATA:POLarity <POLarity>

Selects whether transmitted data is high active (high = 1) or low active (low = 1).

Parameters:

<POLarity> POSitive | NEGative
 POSitive = high active
 NEGative = low active
*RST: POSitive

BUS:SPI:BORDER <BitOrder>

Defines if the data of the messages starts with MSB (most significant bit) or LSB (least significant bit).

Parameters:

<BitOrder> MSBFirst | LSBFirst
 *RST: MSBFirst

BUS:SPI:WSIZE <WordSize>

Sets the symbol size, the number of bits in a message.

Parameters:

<WordSize>
 Range: 4 to 32
 Increment: 1
 Default unit: Bit

TRIGger:A:SPI:MODE <Mode>

Specifies the trigger mode for SPI/SSPI protocols.

Parameters:

<Mode> BStart | BEND | NTHBit | PATtern

BStart

Burst start, sets the trigger event to the start of the frame. The frame starts when the chip select signal CS changes to the active state.

BEND

Burst end, sets the trigger event to the end of the message.

NTHBit

Sets the trigger event to the specified bit number.

PATtern

Sets the trigger event to a serial pattern. To define the pattern, use [TRIGger:A:SPI:PATtern](#).

For a complete configuration of the pattern mode, you also have to set [TRIGger:A:SPI:PLENgtH](#) and [TRIGger:A:SPI:POFFset](#).

TRIGger:A:SPI:PATtern <DataPattern>

Defines the bit pattern as trigger condition.

Parameters:

<DataPattern> String containing up to 32 bit states of the pattern: 0, 1, and X.

Example: TRIGger:A:SPI:Pattern "0011XXXX0110"
Sets a 12bit pattern.

TRIGger:A:SPI:PLENght <PatternLength>

Defines how many bits build up the serial pattern.

Parameters:

<PatternLength>

Range: 1 to 3

Increment: 1

*RST: 1

TRIGger:A:SPI:POFFset <PatternByteOffset>

Sets the number of bits before the first bit of the pattern.

Parameters:

<PatternByteOffset> Number of ignored bits

Range: 0 to 4096

Increment: 1

*RST: 0

BUS:SSPI:CLOCK:SOURce <Source>

Selects the input channel of the clock line.

Parameters:

<Source> CH1 | CH2 | CH3 | CH4

CH3 and CH4 are only available with 4-channel R&S RTM oscilloscopes.

*RST: CH1

BUS:SSPI:CLOCK:POLarity <POLarity>

Selects if data is stored with the rising or falling slope of the clock. The slope marks the begin of a new bit.

Parameters:

<POLarity> POSitive | NEGative

POSitive: rising slope

NEGative: falling slope

*RST: POSitive

BUS:SSPI:DATA:SOURce <Source>

Selects the input channel of the data line.

Parameters:

<Source> CH1 | CH2 | CH3 | CH4

CH3 and CH4 are only available with 4-channel R&S RTM oscilloscopes.

*RST: CH1

BUS:SSPI:DATA:POLarity <POLarity>

Selects whether transmitted data is high active (high = 1) or low active (low = 1).

Parameters:

<POLarity> POSitive | NEGative

POSitive = high active

NEGative = low active

*RST: POSitive

BUS:SSPI:BITime <BurstIdleTime>

Within the idle time the data and clock lines are low. A new frame begins when the idle time has expired. If time interval between the data packets is shorter than the idle time, the packets are part of the same frame.

Parameters:

<BurstIdleTime>

Increment: 16e-9

Default unit: s

BUS:SSPI:BORDER <BitOrder>

Defines if the data of the messages starts with MSB (most significant bit) or LSB (least significant bit).

Parameters:

<BitOrder> MSBFirst | LSBFirst

*RST: MSBFirst

BUS:SSPI:WSIZE <WordSize>

Sets the symbol size, the number of bits in a message.

Parameters:

<WordSize>

Range: 4 to 32

Increment: 1

Default unit: Bit

I2C

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BUS:I2C:CLOCK:SOURce <Source>

Sets the input channel to which the clock line is connected.

Parameters:

<Source>

CH1 | CH2 | CH3 | CH4

CH3 and CH4 are only available with 4-channel R&S RTM oscilloscopes.

*RST: CH1

BUS:I2C:DATA:SOURce <Source>

Sets the input channel to which the data line is connected.

Parameters:

<Source>

CH1 | CH2 | CH3 | CH4

CH3 and CH4 are only available with 4-channel R&S RTM oscilloscopes.

*RST: CH1

TRIGger:A:I2C:MODE <Mode>Specifies the trigger mode for I²C.

Parameters:

<Mode>

START | REStart | STOP | MACKnowledge | PATTErn

START

Start of the message. The start condition is a falling slope on SDA while SCL is high.

REStart

Restarted message. The restart is a repeated start condition.

STOP

End of the message. The stop condition is a rising slope on SDA while SCL is high.

MACKnowledge

Not acknowledged transmission. If the transfer failed, at the moment of the acknowledge bit the SCL and the SDA lines are both on high level.

PATTErn

Triggers on a set of trigger conditions: read or write access of the master, to an address, or/and to a bit pattern in the message. For a complete configuration of the pattern mode, you have to set: [TRIGger:A:I2C:ACCess](#) (read/write access), and [TRIGger:A:I2C:AMODE](#) and [TRIGger:A:I2C:ADDRess](#) (address), and/or [TRIGger:A:I2C:POFFset](#) and [TRIGger:A:I2C:PLENght](#) and [TRIGger:A:I2C:PATTErn](#) (pattern)

*RST: START

TRIGger:A:I2C:ACCess <Access>

Toggles the trigger condition between Read and Write access of the master.

Parameters:

<Access>

READ | WRITe

*RST: READ

TRIGger:A:I2C:AMODE <AdrMode>

Sets the length of the slave address.

Parameters:

<AdrMode>

NORMal | EXTended

NORMal: 7 bit address

EXTended: 10 bit address

*RST: NORMal

TRIGger:A:I2C:ADDRESS

Sets the address of the slave device. The address can have 7 bits or 10 bits.

Parameters:

<AddressString> String containing up to 10 bit states of the address: 0, 1, and X.

TRIGger:A:I2C:PATTERN

Defines the bit pattern as trigger condition.

Parameters:

<DataPattern> String containing up to 32 bit states of the pattern: 0, 1, and X.

TRIGger:A:I2C:PLENgtH <PatternLength>

Defines how many bytes are considered in the trigger condition. To set the pattern for these bytes, use [TRIGger:A:I2C:PATTERN](#).

Parameters:

<PatternLength> Number of bytes
 Range: 1 to 3
 Increment: 1
 *RST: 1

TRIGger:A:I2C:POFFset <PatternByteOffset>

Sets the number of bytes before the first byte of interest, relating to the end of the address bytes.

Parameters:

<PatternByteOffset> Number of ignored bytes
 Range: 0 to 4096
 Increment: 1
 *RST: 0

UART

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BUS:UART:DATA:SOURce <Source>

Selects the input channel of the UART signal.

Parameters:

<Source> CH1 | CH2 | CH3 | CH4

CH3 and CH4 are only available with 4-channel R&S RTM oscilloscopes.

*RST: CH1

BUS:UART:DATA:POLarity <Polarity>

Defines if the transmitted data on the bus is high (high = 1) or low (low = 1) active.

Parameters:

<Polarity> POSitive | NEGative

POSitive = high active

NEGative = low active

*RST: POSitive

BUS:UART:SSIZe <SymbolSize>

Sets the number of data bits in a message.

Parameters:

<SymbolSize>

Range: 5 to 9

Increment: 1

*RST: 8

Default unit: Bit

BUS:UART:PARity <Parity>

Defines the optional parity bit that is used for error detection.

Parameters:

<Parity> ODD | EVEN | NONE

See: "[Parity](#)" on page 124

*RST: NONE

BUS:UART:SBIT <StopBitNumber>

Sets the stop bits.

Parameters:

<StopBitNumber> 1; 1.5 or 2 stop bits are possible.
Range: 1 to 2
Increment: 0.5
*RST: 1
Default unit: Bit

BUS:UART:BAUDrate <Baudrate>

Sets the number of transmitted bits per second.

Parameters:

<Baudrate>
Range: 300 to ???
Default unit: Baud

BUS:UART:BITime <BurstIdleTime>

Sets the minimal time between the last stop bit and the next start bit. A start bit within the idle time is not recognized.

Parameters:

<BurstIdleTime>
Increment: 16e-9
Default unit: s

TRIGger:A:UART:MODE <Mode>

Specifies the trigger mode for UART/RS-232 interfaces.

Parameters:

<Mode>

BStArT | SBIT | NTHSymbol | SYMBol | PATTErn | PERRor | FERRor | BREak

BStArT

Burst start. Sets the trigger to the begin of a data frame. The frame start is the first start bit after the idle time.

SBIT

Start bit. The start bit is the first low bit after a stop bit.

NTHSymbol

Sets the trigger to the n-th symbol of a burst.

SYMBol

Triggers if a pattern occurs in a symbol at any position in a burst.

PATTErnTriggers on a serial pattern at a defined position in the burst. To define the pattern, use [TRIGger:A:UART:PLENgtH](#) and [TRIGger:A:UART:PATTErn](#).To define the position, use [TRIGger:A:UART:POFFset](#) on page 251.**PERRor**

Parity Error: Triggers if a bit error occurred in transmission.

FERRor

Triggers on frame error.

BREak

Triggers if a start bit is not followed by a stop bit within a defined time. During the break the stop bits are at low state.

TRIGger:A:UART:PATTErn <DataPattern>

Defines the bit pattern as trigger condition.

Parameters:

<DataPattern>

String containing up to 32 bit states of the pattern: 0, 1, and X.

TRIGger:A:UART:PLENgtH <PatternLength>

Defines how many symbols build up the serial pattern.

Parameters:

<PatternLength>

Number of symbols

Range: 1 to 3

Increment: 1

*RST: 1

TRIGger:A:UART:POFFset <PatternByteOffset>

Sets the number of symbols before the first symbol of the pattern.

Parameters:

<PatternByteOffset> Number of ignored symbols
 Range: 0 to 4096
 Increment: 1
 *RST: 0

10.2.8 Data and Results Management

This chapter describes commands that store or restore data and measurement results.

10.2.8.1 Printer Control

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HCOPy:DESTination <Medium>

Defines whether the screenshot is saved or printed.

Parameters:

<Medium> MMEM | SYST:COMM:PRIN

MMEM

Saves the screenshot to a file. Specify the file name and location with **MMEMory:NAME**.

SYST:COMM:PRIN

Prints on the printer specified with **SYSTem:COMMunicate:PRINter:SElect**. The printer must be specified before the **HCOPy:DESTination** is sent.

*RST: MMEM

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** setting.

The printer is defined by **SYSTem:COMMunicate:PRINter:SElect**.

The file name for storage is defined by `MMEMoRY:NAME`.

Usage: Event

HCOPY:LANGUage <Format>

Defines the format of the printed or saved screenshot.

Parameters:

<Format> GDI | BMP | PNG

GDI

For output on printer

BMP | PNG

File formats for saved screenshots

*RST: PNG

HCOPY:PAGE:SIZE <Size>

Defines the page size to be used.

Parameters:

<Size> A4 | A5 | B5 | B6 | EXECutive

HCOPY:PAGE:ORientation <Orientation>

Defines the page orientation.

Parameters:

<Orientation> LANDscape | PORTRait

HCOPY:COLOR:SCHeme <ColorScheme>

Defines the color mode for saved and printed screenshots.

Parameters:

<ColorScheme> COLor | GRAYscale | INVerted

INVerted inverts the colors of the output, i.e. a dark waveform is printed on a white background.

*RST: COLor

SYSTem:COMMunicate:PRINter:SElect <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> String parameter

SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?

Returns the name string of the standard printer.

Return values:

<PrinterName> String parameter

Usage:

Query only

SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]?

...

Return values:

<PrinterName> String parameter

Usage:

Query only

10.2.8.2 MMEMemory Commands

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MMEMemory:CATalog? <path_name>[,<format>]

Returns the contents of the 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> String parameter
All files of the directory are listed with their file name, format and size in bytes.

Query parameters:

<path_name> String parameter
Specifies the directory.

<format> ALL | WTime

Usage: Query only

MMEMory:CATalog:LENGth? <path_name>

Returns the number of files and subdirectories of the 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

Usage: Query only

MMEMory:CDIRectory [<directory_name>]

Changes the default directory.

Setting parameters:

<directory_name> String parameter to specify the directory.

For the names of directories and files, only the 8.3 format with ASCII characters is supported, no special characters are allowed. Use / (slash) instead of \ (backslash).

Usage: Setting only

MMEMory:NAME <file_name>

Defines the file name to store an image of the display with [HCOPY\[:IMMediate\]](#).

Parameters:

<file_name> String parameter

MMEMory:COPY <file_source>,<file_destination>

Copies data between the instrument and a USB stick.

Setting parameters:

<file_source> String parameter
Name of the file to be copied

<file_destination> String parameter
Name and directory of the new file

Usage: Setting only

MMEMory:DATA <file_name>, <Data>

Stores data to the storage location specified using [MMEMory:CDIRectory](#).

Parameters:

<Data> 488.2 block data

Parameters for setting and query:

<file_name> String parameter
The name of the file the data is stored to.

MMEMory:DCATalog? <path_name>

Returns the subdirectories of the current or of a specified directory.

Return values:

<file_entry> String parameter
Names of the subdirectories separated by colons. The first two strings are related to the parent directory.

Query parameters:

<path_name> String parameter
Specifies the directory.

Usage: Query only

MMEMory:DCATalog:LENGth? <path_name>

Returns the number of subdirectories of 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
Specifies the directory.

Usage: Query only

MMEMory:DELeTe <file_source>

Removes a file from the specified directory.

Setting parameters:

<file_source> String parameter
 Name and directory of the file to be removed

Usage: Setting only

MMEMory:DRIVes? <drive>

Returns the letters of the drives available on the R&S RTM.

Parameters:

<drive> List of strings, for example, "/INT", "/USB_FRONT", "/USB_REAR"

Usage: Query only

MMEMory:MDIRectory <directory_name>

Creates a new directory with the specified name.

Setting parameters:

<directory_name> String parameter

Usage: Setting only

MMEMory:MOVE <file_source>, <file_destination>

Moves an existing file to a new location.

Setting parameters:

<file_source> String parameter
 Path and name of the file to be moved

<file_destination> String parameter
 Path and name of the new file

Usage: Setting only

MMEMory:RDIRectory <directory_name>

Deletes the specified directory.

Setting parameters:

<directory_name> String parameter

Usage: Setting only

MMEMory:MSIS [<msus>]**Parameters:**

<msus> msus

MMEMory:LOAD:STATE <sav_rcl_state_number>,<file_name>[,<msus>]

Loads the device settings from the specified file.

Setting parameters:

<sav_rcl_state_number>

Range: 1 to 1

Increment: 0

*RST: 1

<file_name> String parameter

<msus> ???

Usage: Setting only**MMEMory:STORe:STATE** <sav_rcl_state_number>,<file_name>[,<msus>]

Saves the device settings to the specified file.

Setting parameters:

<sav_rcl_state_number>

Range: 1 to 1

Increment: 0

*RST: 1

<file_name> String parameter

<msus> ???

Usage: Setting only**10.2.9 General Instrument Setup**

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DISPlay:LANGUage

Sets the language in which the softkey labels, help and other screen information can be displayed. Currently only an English interface is available

Parameters:

<Language> String parameter containing the english language name, for example, "English".

SYSTem:DATE <Year>,<Month>,<Day>

Specifies the internal date for the instrument.

Parameters:

<Year> Increment: 1
 Default unit: a

<Month> Range: 1 to 12
 Increment: 1

<Day> Range: 1 to 31
 Increment: 1
 Default unit: d

Usage: SCPI conform

SYSTem:TIME <Hour>,<Minute>,<Second>

Specifies the internal time for the instrument.

Parameters:

<Hour> Range: 0 to 23
 Increment: 1
 Default unit: h

<Minute> Range: 0 to 59
 Increment: 1
 Default unit: min

<Second> Range: 0 to 59
 Increment: 1
 Default unit: s

Usage: SCPI conform

SYSTem:SET <Setup>

Defines or queries the device settings that can be saved and load manually with FILE > "Device Settings".

Parameters:

<Setup> 488.2 block data

Usage: SCPI conform

SYSTem:ERRor?

Returns a list of error numbers and their description.

Return values:

<Error> Error/event_number,"Error/event_description>[:Device-dependent info]"

Example: 0, "No error"

Usage: Query only
SCPI conform

SYSTem:ERRor:ALL?**Return values:**

<ErrorList> List of ErrorFormat

Usage: Query only
SCPI conform

10.2.10 Status Reporting

10.2.10.1 STATus:OPERation Register

The commands of the STATus:OPERation subsystem control the status reporting structures of the STATus:OPERation register:

See also:

- [chapter 10.1.6.1, "Structure of a SCPI Status Register"](#), on page 171
- ["STATus:OPERation Register"](#), on page 176

The following commands are available:

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STATus:OPERation:CONDition?

Return values:

<Condition>

Range: 1 to 65535

Increment: 1

Usage: Query only

STATus:OPERation:ENABLE <Enable>

Parameters:

<Enable>

Range: 1 to 65535

Increment: 1

STATus:OPERation:NTRansition <NegativeTransition>

Parameters:

<NegativeTransition>

Range: 1 to 65535

Increment: 1

STATus:OPERation:PTRansition <PositiveTransition>

Parameters:

<PositiveTransition>

Range: 1 to 65535

Increment: 1

STATus:OPERation[:EVENT]?

Return values:

<Event>

Range: 1 to 65535

Increment: 1

Usage: Query only

10.2.10.2 STATus:QUEStionable Registers

The commands of the `STATus:QUEStionable` subsystem control the status reporting structures of the `STATus:QUEStionable` registers:

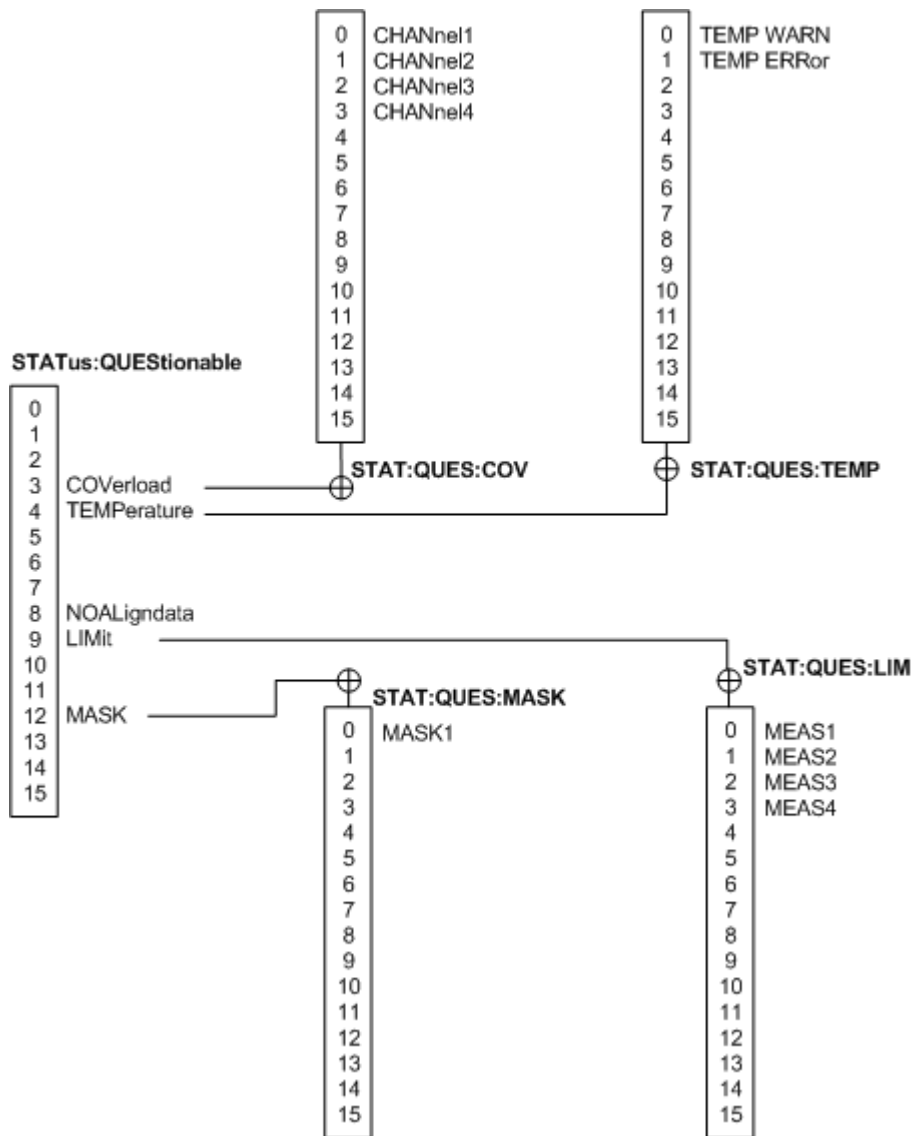


Fig. 10-4: Structure of the STATus:QUEStionable register

See also:

- [chapter 10.1.6.1, "Structure of a SCPI Status Register"](#), on page 171
- ["STATus:QUEStionable Register"](#), on page 176

The following commands are available:

STATus:QUEStionable:CONDition	262
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STATus:QUEStionable:CONDition?**STATus:QUEStionable:COVerload:CONDition?****STATus:QUEStionable:NOALigndata:CONDition?****STATus:QUEStionable:LIMit: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.

Return values:

<Condition> Condition bits in decimal representation
 Range: 1 to 65535
 Increment: 1

Usage: Query only

STATus:QUEStionable:ENABle <Enable>**STATus:QUEStionable:COVerload:ENABle <Enable>****STATus:QUEStionable:NOALigndata:ENABle <Enable>****STATus:QUEStionable:LIMit:ENABle <Enable>****STATus:QUEStionable:MASK:ENABle <Enable>**

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:

<Enable> Bit mask in decimal representation
 Range: 1 to 65535
 Increment: 1

Example: `STATUS:QUESTIONABLE:MASK:ENABLE 24`
 Set bits no. 3 and 4 of the `STATUS:QUESTIONABLE:MASK:ENABLE`
 register part: $24 = 8 + 16 = 2^3 + 2^4$

STATUS:QUESTIONABLE[:EVENT]?

STATUS:QUESTIONABLE:COVERLOAD[:EVENT]?

STATUS:QUESTIONABLE:NOALIGNDATA[:EVENT]?

STATUS:QUESTIONABLE:LIMIT[: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.

Return values:

<Event> Event bits in decimal representation
 Range: 1 to 65535
 Increment: 1

Usage: Query only

STATUS:QUESTIONABLE:NTRANSITION <NegativeTransition>

STATUS:QUESTIONABLE:COVERLOAD:NTRANSITION <NegativeTransition>

STATUS:QUESTIONABLE:NOALIGNDATA:NTRANSITION <NegativeTransition>

STATUS:QUESTIONABLE:LIMIT:NTRANSITION <NegativeTransition>

STATUS:QUESTIONABLE:MASK:NTRANSITION <NegativeTransition>

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:

<NegativeTransition> Bit mask in decimal representation
 Range: 1 to 65535
 Increment: 1

Example: `STATUS:QUESTIONABLE:MASK:NTRANSITION 24`
 Set bits no. 3 and 4 of the `STATUS:QUESTIONABLE:MASK:NTRANSITION`
 register part: $24 = 8 + 16 = 2^3 + 2^4$

STATUS:QUESTIONABLE:PTRANSITION <PositiveTransition>

STATUS:QUESTIONABLE:COVERLOAD:PTRANSITION <PositiveTransition>

STATUS:QUESTIONABLE:NOALIGNDATA:PTRANSITION <PositiveTransition>

STATUS:QUESTIONABLE:LIMIT:PTRANSITION <PositiveTransition>

STATus:QUEStionable:MASK:PTRansition <PositiveTransition>

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:

<PositiveTransition> Bit mask in decimal representation

Range: 1 to 65535

Increment: 1

Example:

STATus:QUEStionable:MASK:PTRansition 24

Set bits no. 3 and 4 of the STATus:QUEStionable:MASK:PTRansition register part: $24 = 8 + 16 = 2^3 + 2^4$

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