R&S®MXO 4 Series Oscilloscope User Manual

1335533702
Version 03

ROHDE&SCHWARZ

Make ideas real

This manual describes the following R&S®MXO 4 series models with firmware version 1.2.x.x:

- R&S®MXO 4 (1335.5050K04)

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1335.5337.02 | Version 03 | R&S®MXO 4 Series

Throughout this manual, products from Rohde & Schwarz are indicated without the ® symbol, e.g. R&S®MXO 4 series oscilloscope is indicated as R&S MXO 4.

Contents

1 Safety and regulatory information

The product documentation helps you to use the product safely and efficiently. Follow the instructions provided here and in the Chapter 1.1, "Safety instructions", on page 15.

Intended use

The R&S MXO 4 oscilloscope is designed for measurements on circuits that are only indirectly connected to the mains or not connected at all. It is not rated for any measurement category.

The product is intended for the development, production and verification of electronic components and devices in industrial, administrative, and laboratory environments. Use the product only for its designated purpose. Observe the operating conditions and performance limits stated in the data sheet.

Where do I find safety information?

Safety information is part of the product documentation. It warns you of potential dangers and gives instructions on how to prevent personal injury or damage caused by dangerous situations. Safety information is provided as follows:

- In Chapter 1.1, "Safety instructions", on page 15. The same information is provided in many languages as printed "Safety Instructions". The printed "Safety Instructions" are delivered with the product.
- Throughout the documentation, safety instructions are provided when you need to take care during setup or operation.

1.1 Safety instructions

Products from the Rohde & Schwarz group of companies are manufactured according to the highest technical standards. To use the products safely, follow the instructions provided here and in the product documentation. Keep the product documentation nearby and offer it to other users.

Use the product only for its intended use and within its performance limits. Intended use and limits are described in the product documentation such as the data sheet, manuals and the printed "Safety Instructions". If you are unsure about the appropriate use, contact Rohde & Schwarz customer service.

Using the product requires specialists or specially trained personnel. These users also need sound knowledge of at least one of the languages in which the user interfaces and the product documentation are available.

Reconfigure or adjust the product only as described in the product documentation or the data sheet. Any other modifications can affect safety and are not permitted.

Never open the casing of the product. Only service personnel authorized by Rohde & Schwarz are allowed to repair the product. If any part of the product is damaged or broken, stop using the product. Contact Rohde & Schwarz customer service at https://www.rohde-schwarz.com/support.

In these safety instructions, the term "product" covers instruments (oscilloscopes), probes and their accessories.

Lifting and carrying the instrument

Check the data sheet for the maximum weight of the instrument. A single person can only carry a maximum of 18 kg safely depending on age, gender and physical condition. If your instrument is heavier than 18 kg, do not move or carry it by yourself.

Use the instrument handles to move or carry the instrument. Do not use the mounted accessories instead of the handles. Accessories are not designed to carry the weight of the instrument.

To move the instrument safely, you can use lifting or transporting equipment such as lift trucks and forklifts. Follow the instructions provided by the equipment manufacturer.

Choosing the operating site

Only use the product indoors. The product casing is not waterproof. Water that enters can electrically connect the casing with live parts, which can lead to electric shock, serious personal injury or death if you touch the casing. If Rohde & Schwarz provides accessories designed for your product, e.g. a carrying bag, you can use the product outdoors.

Unless otherwise specified in the data sheet, you can operate the product up to an altitude of 2000 m above sea level.

The product is suitable for pollution degree 2 environments where nonconductive contamination can occur. For more information on environmental conditions such as ambient temperature and humidity, see the data sheet.

Setting up the product

Always place the product on a stable, flat and level surface with the bottom of the product facing down. If the product is designed for different positions, secure the product so that it cannot fall over.

If the product has foldable feet, always fold the feet completely in or out to ensure stability. The feet can collapse if they are not folded out completely or if the product is moved without lifting it. The foldable feet are designed to carry the weight of the product, but not an extra load.

If stacking is possible, keep in mind that a stack of products can fall over and cause injury.

If you mount products in a rack, ensure that the rack has sufficient load capacity and stability. Observe the specifications of the rack manufacturer. Always install the products from the bottom shelf to the top shelf so that the rack stands securely. Secure the product so that it cannot fall off the rack.

Connecting to power and grounding

The mains power supply input of the instrument complies with overvoltage category II. It has to be connected to a fixed installation used to supply energy-consuming equipment such as household appliances and similar loads. Be aware that electrically powered products have risks, such as electric shock, fire, personal injury or even death.

Take the following measures for your safety:

- Do not use an isolating transformer to connect the instrument to the mains power supply.
- Before switching on the product, ensure that the voltage and frequency indicated on the product match the available power source. If the power adapter does not adjust automatically, set the correct value and check the rating of the fuse.
- Only use the power cable delivered with the product. It complies with country-specific safety requirements. Only insert the plug into an outlet with protective conductor terminal.
- If a product has an exchangeable fuse, its type and characteristics are indicated next to the fuse holder. Before changing the fuse, switch off the instrument and disconnect it from the power source. How to change the fuse is described in the product documentation.
- Only use intact cables and route them carefully so that they cannot be damaged. Check the power cables regularly to ensure that they are undamaged. Also ensure that nobody can trip over loose cables.
- If the product needs an external power supply, use the power supply that is delivered with the product or that is recommended in the product documentation or a power supply that conforms to the country-specific regulations.
- Ensure that you can disconnect the product from the power source at any time. Pull the power plug to disconnect the product. The power plug must be easily accessible. If the product is integrated into a system that does not meet these requirements, provide an easily accessible circuit breaker at the system level.
- Replace parts that are relevant to safety only by original parts, e.g. power cables or fuses.

Performing measurements

Take the following measures for your safety:

- To ascertain voltage-free state, use an appropriate voltage tester. Any measurement setup including an oscilloscope is not suitable for this purpose.
- The maximum input voltage on channel inputs and the external trigger input must not exceed the value specified in the data sheet.
- Observe all voltage and current ratings of the instrument, the probes, and the accessories. Exceeding the allowed voltages can lead to an electric shock. Limits and ratings are marked on the products and listed in the data sheets. Consider that the rated voltage depends on the frequency. The voltage limitation curves or values are provided in the data sheet.
- Never cause any short circuits when measuring sources with high output currents.
- Use only probes and accessories that comply with the measurement category (CAT) of your measurement task. The measurement category of the products is

defined in the data sheet. If you use other than Rohde & Schwarz accessories, make sure that they are suitable for the instrument and the measurement task.

- Set the correct attenuation factor on the instrument according to the probe being used. Otherwise, the measurement results do not reflect the actual voltage level, and you might misjudge the actual risk.
- When working with high voltages and current probes, observe the additional operating conditions specified in this safety instructions.
- The probe pins are extremely pointed and can easily penetrate clothes and the skin. Handle the probe pins with great care. To exchange a probe pin, use tweezers or pliers to avoid injuries. When transporting the accessories, always use the box supplied with the probe.
- Prevent the probe from receiving mechanical shock. Avoid putting excessive strain on the probe cable or exposing it to sharp bends. Touching a broken cable during measurements can cause injuries.
- Set up all probe connections to the instrument before applying power.

Working with hazardous voltages

Voltages higher than 30 V RMS, or 42 V peak, or 60 V DC are regarded as hazardous contact voltages. Direct contact with them can cause serious injuries.

Make sure that only electrically skilled persons use the products for measurements on hazardous contact voltages. These working conditions require special education and experience to perceive risks and to avoid hazards which electricity can create.

When working with hazardous contact voltages, use protective measures to preclude direct contact with the measurement setup:

- Do not touch exposed connections and components when power is applied.
- Switch off the test circuit while connecting and disconnecting probe leads.
- Use only insulated voltage probes, test leads and adapters.
- Make sure that the input leads fulfill the safety requirements for your measurement. The delivered input leads might have a jacket wear indicator that indicates a worn jacket by different jacket color. In this case, do not use the input lead. Replace it with a new one.
- Do not use 4 mm banana plugs without protection against contact.

Working with current probes

When working with current probes, you can measure high-frequency currents or currents that contain high-frequency components.

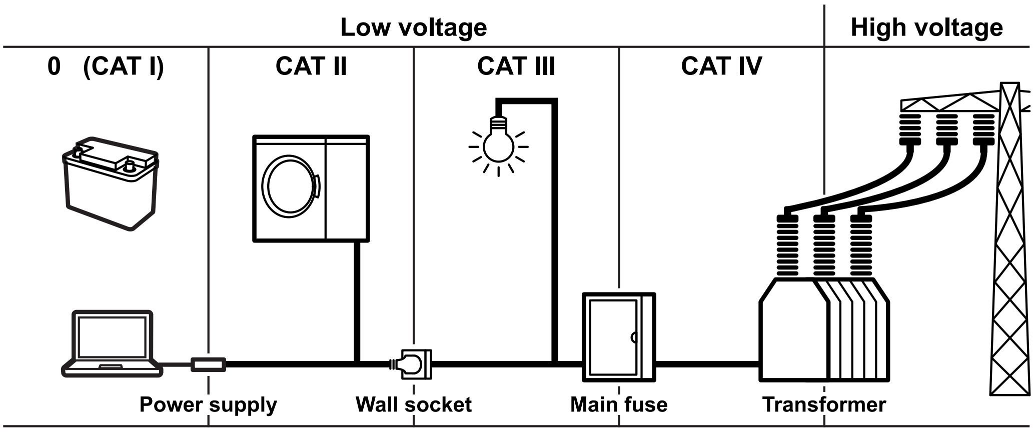
- Switch off the test circuit while connecting the probe.
- Do not attach the clamp to bare unisolated conductors. To avoid injury from a short circuit, measure at a location on an insulated wire where the insulation is sufficient for the circuit voltage.
- Connect the probe only to the secondary side of a breaker. With this measure, you avoid injury, if a short circuit occurs.
- The following effects can cause burns and fire or damage to the measurement site:

– Eddy current loss can cause heating of the sensor head.
– Dielectric heating can cause heating of cord insulation and other materials.

Measurement categories

IEC 61010-2-030 defines measurement categories that rate instruments on their ability to resist short transient overvoltages that occur in addition to the working voltage. Use the measurement setup only in electrical environments for which they are rated.

- 0 - Instruments without rated measurement category
  For measurements performed on circuits not directly connected to mains, for example, electronics, circuits powered by batteries, and specially protected secondary circuits. This measurement category is also known as CAT I.
- CAT II:
  For measurements performed on circuits directly connected to the low-voltage installation by a standard socket outlet, for example, household appliances and portable tools.
- CAT III:
  For measurements performed in the building installation, such as junction boxes, circuit breakers, distribution boards, and equipment with permanent connection to the fixed installation.
- CAT IV:
  For measurements performed at the source of the low-voltage installation, such as electricity meters and primary overcurrent protection devices.



Cleaning the product

Use a dry, lint-free cloth to clean the product. When cleaning, keep in mind that the casing is not waterproof. Do not use liquid cleaning agents.

Meaning of safety labels

Safety labels on the product warn against potential hazards.

	Potential hazard Read the product documentation to avoid personal injury or product damage.
	Electrical hazard Indicates live parts. Risk of electric shock, fire, personal injury or even death.
	Protective conductor terminal Connect this terminal to a grounded external conductor or to protective ground. This protects you against electric shock should an electric problem occur.

1.2 Labels on the product

Labels on the casing inform about:

- Personal safety, see "Meaning of safety labels" on page 19
- Product and environment safety, see Table 1-1
- Identification of the product

Table 1-1: Labels regarding product and environment safety

	Chassis grounding terminal
	Take care when handling electrostatic sensitive devices.
	Labeling in line with EN 50419 for disposal of electrical and electronic equipment after the product has come to the end of its service life. For more information, see "Disposing electrical and electronic equipment" on page 641.

1.3 Warning messages in the documentation

A warning message points out a risk or danger that you need to be aware of. The signal word indicates the severity of the safety hazard and how likely it will occur if you do not follow the safety precautions.

WARNING

Potentially hazardous situation. Could result in death or serious injury if not avoided.

CAUTION

Potentially hazardous situation. Could result in minor or moderate injury if not avoided.

NOTICE

Potential risks of damage. Could result in damage to the supported product or to other property.

1.4 Where to find key documents on Rohde & Schwarz

Certificates issued to Rohde & Schwarz that are relevant for your country are provided at www.rohde-schwarz.com/key-documents, e.g. concerning:

- Quality management
- Environmental management
- Information security management
- Accreditations

1.5 Korea certification class A

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며, 가정외의 지역에서 사용하는 것을 목적으로 합니다.

2 Preface

2.1 Documentation overview

This section provides an overview of the R&S MXO 4 user documentation.

2.1.1 Manuals and instrument help

You find the manuals on the product page at:

www.rohde-schwarz.com/manual/mxo4

Getting started manual

Introduces the R&S MXO 4 and describes how to set up the product. A printed English version is included in the delivery.

User manual and help

Contains the description of all instrument modes and functions. It also provides an introduction to remote control, a complete description of the remote control commands with programming examples, and information on maintenance and instrument interfaces. Includes the contents of the getting started manual.

The contents of the user manual are available as help in the R&S MXO 4. The help offers quick, context-sensitive access to the complete information on the instrument and its firmware.

The user manual is available for download or for immediate display on the internet.

Safety instructions

Provides safety information in many languages. The printed document is delivered with the product.

Instrument security procedures manual

Deals with security issues when working with the R&S MXO 4 in secure areas. It is available for download on the internet.

Service manual

Describes the performance test for checking compliance with rated specifications, firmware update, adjustments, installing options and maintenance. The service manual is available for registered users on the global Rohde & Schwarz information system (GLORIS, https://gloris.rohde-schwarz.com).

2.1.2 Specifications and brochure

The data sheet contains the technical specifications of the R&S MXO 4. It also lists the firmware applications and their order numbers, and optional accessories. The brochure provides an overview of the instrument and deals with the specific characteristics.

www.rohde-schwarz.com/brochure-datasheet/mxo4

2.1.3 Calibration certificate

The document is available on https://gloris.rohde-schwarz.com/calcert. You need the device ID of your instrument, which you can find on a label on the rear panel.

2.1.4 Release notes, open source acknowledgment

The release notes list new features, improvements and known issues of the current firmware version, and describe the firmware installation. The open source acknowledgment document provides verbatim license texts of the used open source software. It can also be read directly on the instrument.

www.rohde-schwarz.com/firmware/mxo4

3 Getting Started

3.1 Preparing for use

Here, you can find basic information about setting up the instrument for the first time or when changing the operating site.

3.1.1 Lifting and carrying

See: "Lifting and carrying the instrument" on page 16.

3.1.2 Unpacking and checking

1. Unpack the product carefully.
2. Retain the original packing material. Use it when transporting or shipping the product later.
3. Using the delivery notes, check the equipment for completeness.
4. Check the equipment for damage.

   If the delivery is incomplete or equipment is damaged, contact Rohde & Schwarz.

3.1.3 Choosing the operating site

Specific operating conditions ensure proper operation and avoid damage to the product and connected devices. For information on environmental conditions such as ambient temperature and humidity, see the data sheet.

See also "Choosing the operating site" on page 16.

Electromagnetic compatibility classes

The electromagnetic compatibility (EMC) class indicates where you can operate the product. The EMC class of the product is given in the data sheet.

- Class B equipment is suitable for use in:
  – Residential environments
  – Environments that are directly connected to a low-voltage supply network that supplies residential buildings
- Class A equipment is intended for use in industrial environments. It can cause radio disturbances in residential environments due to possible conducted and radiated disturbances. It is therefore not suitable for class B environments.

If class A equipment causes radio disturbances, take appropriate measures to eliminate them.

3.1.4 Setting up the product

When setting up the instrument, follow the safety instructions:

- "Setting up the product" on page 16
- "Intended use" on page 15

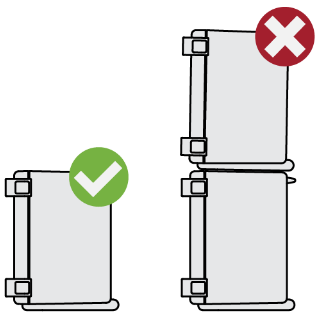
3.1.4.1 Placing the product on a bench top

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

To place the product on a bench top

1. Place the product on a stable, flat and level surface.
2. **CAUTION!** The top surface of the product is too small for stacking. If you stack another product on top of the product, the stack can fall over and cause injury.

   If you want to save space, mount several products in a rack.



3. **CAUTION!** Foldable feet can collapse. See "Setting up the product" on page 16.

   Always fold the feet completely in or out. With folded-out feet, do not place anything on top or underneath.
4. **NOTICE!** Overheating can damage the product.

   Prevent overheating as follows:
   - Keep a minimum distance of 10 cm between the fan openings of the product and any object in the vicinity.
   - Do not place the product next to heat-generating equipment such as radiators or other products.

3.1.4.2 Mounting the product in a rack

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

To prepare the rack

1. Observe the requirements and instructions in "Setting up the product" on page 16.
2. **NOTICE!** Insufficient airflow can cause overheating and damage the product.
   Design and implement an efficient ventilation concept for the rack.

To mount the R&S MXO 4 in a rack

1. Use an adapter kit that fits the dimensions of the R&S MXO 4 to prepare the instrument for rack mounting. For information on the dimensions, see data sheet.
   a) Order the rack adapter kit designed for the R&S MXO 4. For the order number, see data sheet.
   b) Mount the adapter kit. Follow the assembly instructions provided with the adapter kit.
2. Push the product onto the shelf until the rack brackets fit closely to the rack.
3. Tighten all screws at the rack brackets with a tightening torque of 1.2 Nm to secure the product at the rack.

To unmount the product from a rack

1. Loosen the screws at the rack brackets.
2. Remove the product from the rack.
3. If placing the product on a bench top again, unmount the adapter kit from the product. Follow the instructions provided with the adapter kit.

3.1.5 Considerations for test setup

Observe safety instructions, see "Performing measurements" on page 17.

Cable selection and electromagnetic interference (EMI)

Electromagnetic interference (EMI) can affect the measurement results.

To suppress electromagnetic radiation during operation:

- Use high-quality shielded cables, for example, double-shielded RF and LAN cables.
- Always terminate open cable ends.
- Ensure that connected external devices comply with EMC regulations.

Measuring accessories

Use only probes and measuring accessories that comply with IEC 61010-031.

Signal input and output levels

Information on signal levels is provided in the data sheet. Keep the signal levels within the specified ranges to avoid damage to the product and connected devices.

Preventing electrostatic discharge (ESD)

Electrostatic discharge is most likely to occur when you connect or disconnect a DUT.

► **NOTICE!** Electrostatic discharge can damage the electronic components of the product and the device under test (DUT).

Ground yourself to prevent electrostatic discharge damage:

a) Use a wrist strap and cord to connect yourself to ground.
b) Use a conductive floor mat and heel strap combination.

During operation, if the firmware observes a serious unexpected disturbance (e.g. due to ESD), it resets some hardware components and initiates a new alignment to ensure proper instrument functioning. Then it restores the user settings to the state before the disturbance.

3.1.6 Connecting to power

For safety information, see "Connecting to power and grounding" on page 17.

The R&S MXO 4 can be used with different AC power voltages and adapts itself automatically to it.

The nominal ranges are indicated on a label near the power connector on the instrument and in the data sheet.

1. Plug the AC power cable into the AC power connector on the rear panel of the product. Only use the AC power cable delivered with the product.
2. Plug the AC power cable into a power outlet with ground contact.

   The required ratings are listed next to the AC power connector and in the data sheet.

3.1.7 Switching on or off

The instrument is switched on or off with the power switch and the [Power] key. The [Power] key is located in the bottom left corner of the front panel. The power switch is located at the rear panel of the instrument.

Table 3-1: Overview of power states

Status	LED	Power switch
Off	(unlighted)	[0] (off)
Standby	yellow	[I] (on)
Ready	green	[I] (on)

To switch on the product

The product is off but connected to power.

1. Set the switch on the power supply to position [I].

   The power key on the front panel lights up.

2. Press the [Power] key on the front panel.

   The instrument performs a system check, boots the operating system, and then starts the R&S MXO 4 firmware.
   The [Power] key turns green and the illuminated keys on the front panel light up. If the previous session was terminated regularly, the oscilloscope uses the last settings.

Before you start measurements, be sure to comply with the warm-up phase specified in the data sheet.

To shut down the product

The product is in the ready state.

► Press the [Power] key.

   All current settings are saved, and the software shuts down. The [Power] key turns yellow. The standby power supplies only the power switch circuits.

The "Power" icon in the "Menu" shuts down only the firmware application. To shut down the instrument completely, use the [Power] key.

To disconnect from power

The product is in the standby state.

1. **NOTICE!** Risk of data loss. If you disconnect the product from power when it is in the ready state, you can lose settings and data. Shut it down first.

   Set the switch on the power supply to position [0].

   The LED of the [Power] key is switched off.

2. Disconnect the product from the power source.

3.1.8 Connecting external devices

The following interfaces for external devices are provided:

- USB connectors at the front and rear panel of the instrument
- HDMI connector at the rear panel of the instrument

3.1.8.1 Connecting USB devices

You can connect USB flash drives to save screenshots and measurement results, and keyboard and/or mouse to simplify the operation and the entry of data. You can connect or disconnect all USB devices during operation of the instrument.

USB devices are plug&play, the operating system automatically uses the suitable device driver.

3.1.8.2 Connecting an external monitor

Using the HDMI connector on the rear panel, you can connect an external monitor or projector to the R&S MXO 4.

Before connecting an external monitor, ensure that the monitor and the R&S MXO 4 are connected to a ground contact. Otherwise the instrument can be damaged.

The touchscreen of the R&S MXO 4 has a screen resolution of 1920x1080 pixels. If the screen resolution of the monitor is set higher than the instrument's resolution, the application window uses a 1920x1080 pixels area of the monitor display. For full screen display, adjust the monitor's screen resolution.

3.2 Instrument tour

This section describes the front, rear and side view of the instrument including all function keys and connectors.

The meanings of the labels on the product are described in Chapter 3.2, "Instrument tour", on page 29.

3.2.1 Front view

This section provides an overview of the R&S MXO 4 front panel.

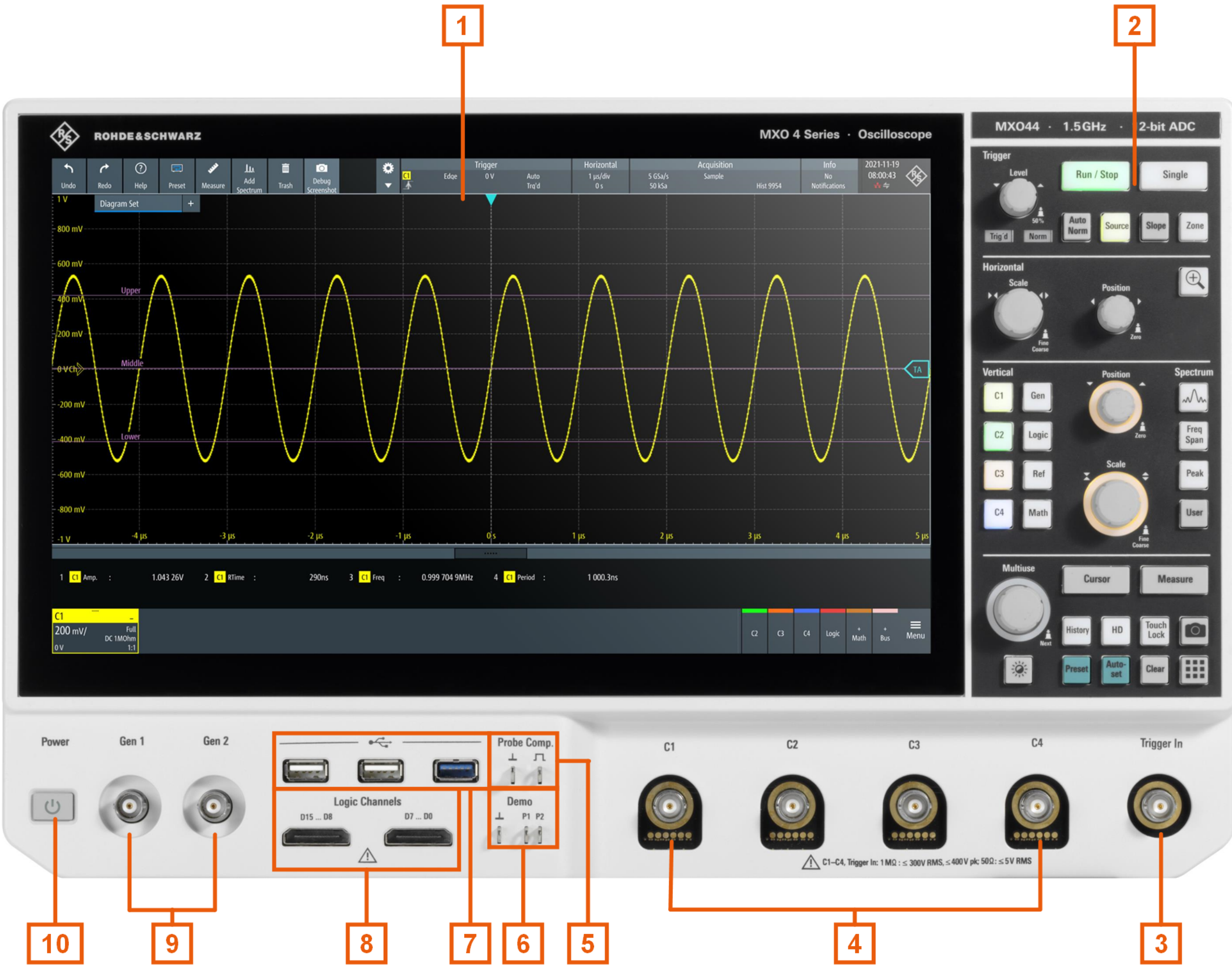


Figure 3-1: Front panel of R&S MXO 4 with 4 input channels

1 = Display
2 = Keys and controls
3 = External trigger input
4 = Analog input channels
5 = Connectors for probe compensation
6 = Connectors for demo signal output
7 = USB connectors
8 = Connectors for logic probe (R&S MXO4-B1 Mixed Signal Option)
9 = Connector for optional function generator output (BNC, R&S MXO4-B6 Arbitrary waveform generator option)
10 = [Power] key

3.2.1.1 Input connectors

Channel inputs

The R&S MXO 4 has four channel inputs (4) to connect the input signals.

For channel connectors, the input impedance is selectable, the values are 50 Ω and 1 MΩ.

The maximum input voltage on channel inputs is:

- 400 V (V_p) and 300 V (RMS) at 1 MΩ input impedance
- 30 V (V_p) and 5 V (RMS) at 50 Ω input impedance

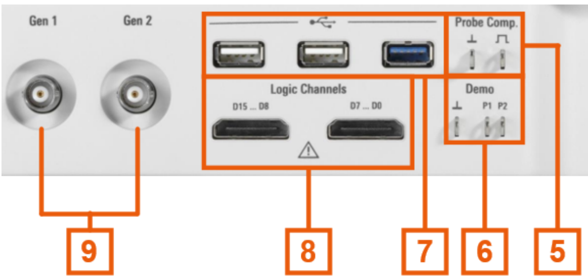
Trigger input

The external trigger input (3) is used to control the measurement by an external signal. The trigger level can be set from -5 V to 5 V.

For the external trigger input, the maximum input voltage is 400 V (V_p) and 300 V (RMS) at 1 MΩ input impedance.

Transient overvoltages on all input connectors must not exceed 400 V (V_p).

3.2.1.2 Other connectors on the front panel



Gen: Function Generator (9)
BNC output of the function generator, requires option R&S MXO4-B6.

Logic Channels (8)
Two connectors for logical probes with 8 digital channels each (D0 to D7 and D8 to D15). Using logic channels requires the Mixed Signal Option R&S MXO4-B1.

The maximum input voltage is 40 V (Vp) at 100 kΩ input impedance. The maximum input frequency for a signal with the minimum input voltage swing and medium hysteresis of 800 mV (Vpp) is 400 MHz.

USB (7)
Two USB 2.0 type A and one USB 3.0 interfaces. They are used to connect a mouse or keyboard, a USB flash drive for storing and reloading instrument settings and measurement data, and to update the firmware.

Demo (6)
The pins are intended for demonstration purposes.

Probe Comp. (5)
Probe compensation terminal to adjust passive probes to the oscilloscope channel.

⎍	Square wave signal for probe compensation.
⊥	Ground connector for probes.

3.2.2 Side view

Figure 3-2: Side view of R&S MXO 4

1 = Grounding

On the side of the instrument, you can find the ground connector for probes.

3.2.3 Rear view

On the rear panel of the R&S MXO 4, you find more connectors and the power supply switch.

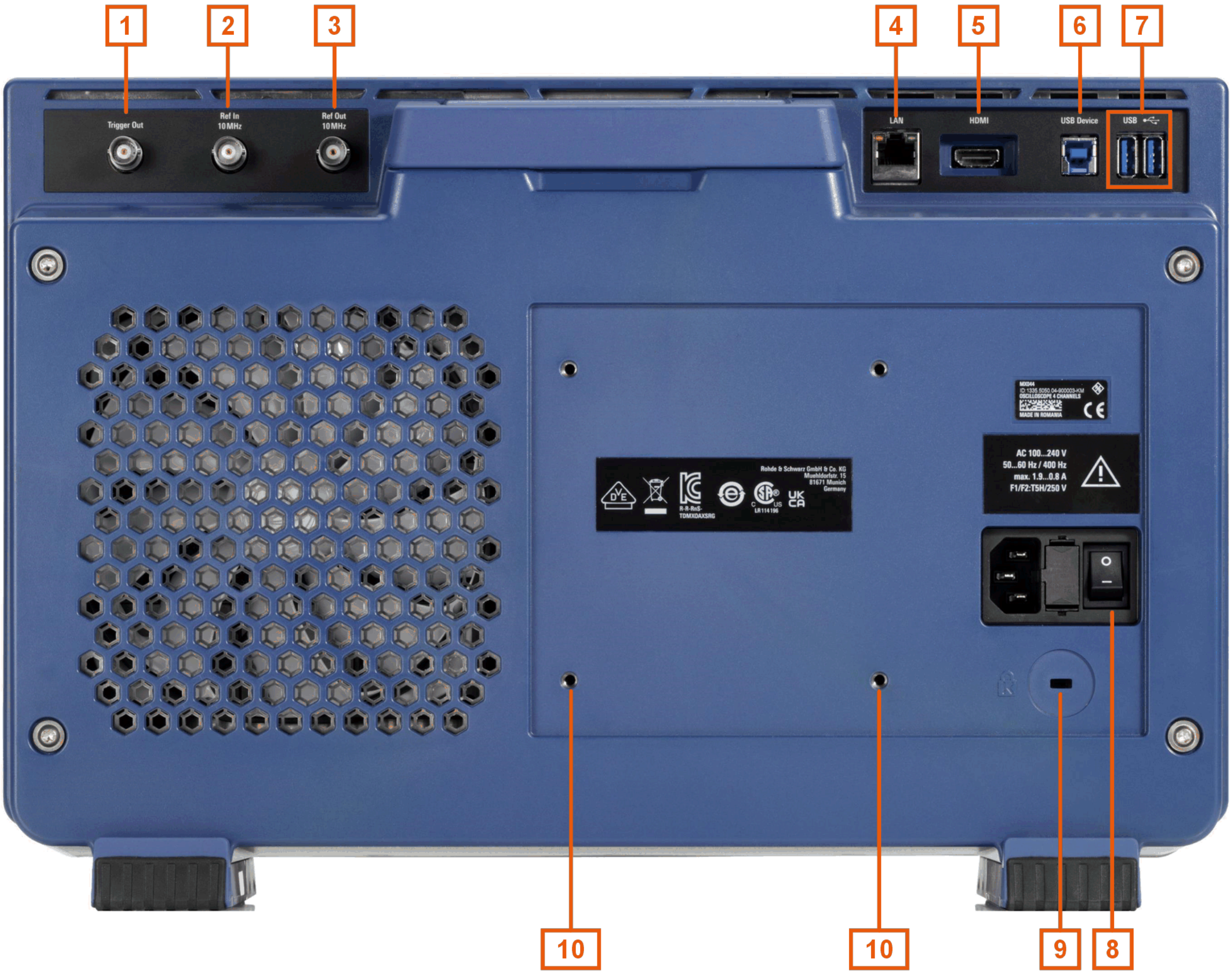


Figure 3-3: Rear panel view of R&S MXO 4

1 = Aux Out connector
2 = Ref. In 10MHz
3 = Ref. Out
4 = LAN connector
5 = HDMI display output
6 = USB B connector, type B
7 = USB connector
8 = AC power supply connector and main power switch
9 = Kensington lock slot to secure the instrument against theft
10 = VESA mounting holes to mount the instrument on a monitor arm

Aux Out
BNC output that can function as pass/fail output or trigger output.

Ref. In 10MHz
BNC input connector for 10 MHz reference frequency signals.

Ref. Out
BNC output for 10 MHz frequency reference. Can be switched between internal and external reference.

LAN
8-pin connector RJ-45 used to connect the instrument to a Local Area Network (LAN). It supports up to 1 Gbit/s.

HDMI
HDMI Version 2.0 connector for an external monitor or projector. The monitor shows the complete content of the instrument's screen.

AC power supply connector and main power switch
The instrument supports a wide range power supply. It automatically adjusts to the correct range for the applied voltage. There is no line voltage selector.

The AC main power switch disconnects the instrument from the AC power line.

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

3.2.4 Keys and controls

For an overview of the front panel keys, see Figure 3-1.

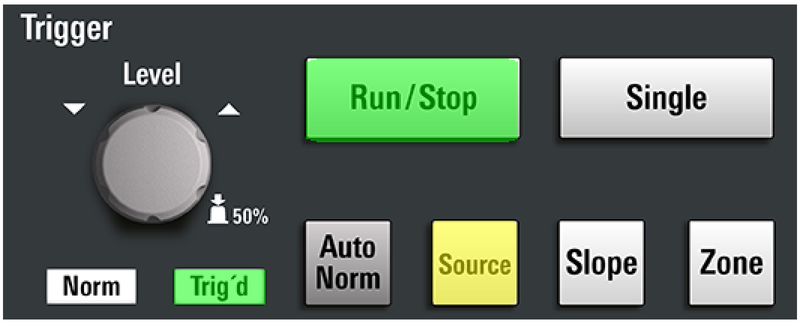
3.2.4.1 Power key

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

The light of the key shows the instrument state, see Chapter 3.1.7, "Switching on or off", on page 27.

3.2.4.2 Trigger controls

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



[Level]
The rotary knob sets the trigger level for all trigger types that require one level. For trigger types with two levels, the knob sets the lower level. Turn clockwise to move up the trigger level. Press the knob to set the trigger level to 50% of the signal amplitude.

Remote command:
TRIGger:EVENt<m>:LEVel<n>[:VALue] on page 408

[Run / Stop]
Starts and stops the continuous acquisition. The [Run / Stop] key lights green when the acquisition is running. When the acquisition is stopped, the key lights red.

Remote command:
RUN on page 377
STOP on page 378

[Single]
Starts a defined number of acquisitions. The [Single] key lights green when the acquisition is running. When the acquisition is stopped, the key lights red.

Press the key again to stop a running acquisition. To set the number of acquisitions, select "Menu" > "Acquisition", and set "N-single/Avg count".

Remote command:
SINGle on page 378

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

Auto	The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. The time interval depends on the time base.
Norm	The instrument acquires a waveform only if a trigger occurs. The "Norm" LED lights up in green.

Remote command:
TRIGger:MODE on page 431

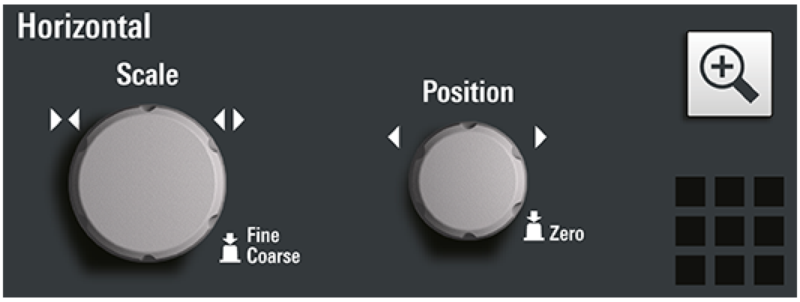
[Source]
Toggles the trigger source: C1, C2, C3, C4. The key lights up in the color of the selected channel.

[Slope]
Toggles the trigger slope or trigger polarity, dependent on the trigger type. The current setting is shown on the trigger label.

[Zone]
For future use.

3.2.4.3 Horizontal controls

The rotary knobs in the Horizontal functional block adjust the horizontal parameters. These settings are effective for all channel waveforms. In addition, a [Zoom] key is available.



[Position]
The rotary knob changes the horizontal position of the waveforms. Turn clockwise to move the waveforms to the right. To set the value to zero, press the knob. The current value is shown in the "Horizontal" label above the diagram.

The horizontal position defines the zero point of the diagram. It is the time distance to the reference point, which marks the rescaling center of the time scale.

Remote command:
`TIMebase:HORizontal:POSition` on page 379

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

Turn clockwise to stretch the waveforms. Doing so, the scale value *time/div* decreases. Press the knob to toggle between coarse and fine scale adjustment.

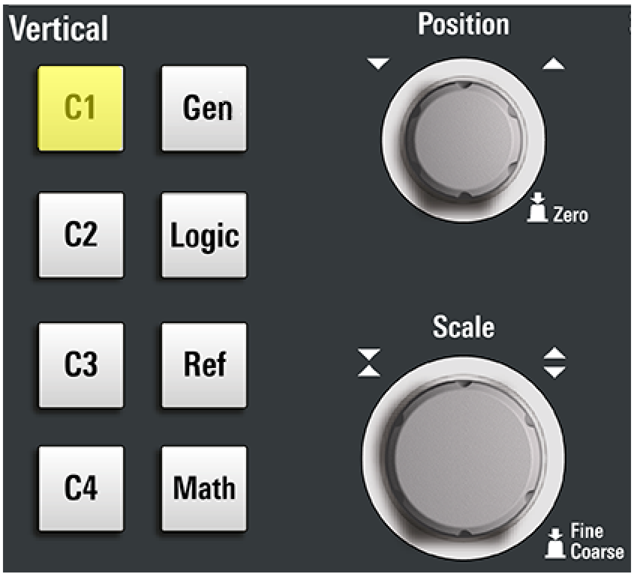
Remote command:
`TIMebase:SCALe` on page 378

[Zoom]
Activates a zoom and supports the zoom setup.

If no zoom is on, the first press opens a zoom diagram for the active diagram. If at least one zoom is shown, the keypress opens the "Zoom" dialog. If only one zoom is defined, the next press closes the dialog and removes the zoom. If several zooms are defined and the dialog is open, the key toggles the zooms.

3.2.4.4 Vertical controls

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



[C <n>]
Turns on and selects a channel. If the channel is active, the key lights up in the corresponding channel color.

The effect of the keypress depends on state of the channel:
- If channel is off: turns on the channel and selects it.
- If the channel is on and in focus (selected): opens the corresponding channel dialog.
- If the channel is on, but not in focus (not selected): selects the channel waveform.
- If the channel is selected, and the dialog is open: turns off the channel, and closes the dialog.

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

Remote command:
`CHANnel<ch>:STATe` on page 380

[Position]
The vertical [Position] knob changes the vertical offset or the position of the selected waveform. The horizontal axis and the selected waveform are moved vertically. You can select whether the knob changes the offset or the position in the "Menu" > "Settings" > "Frontpanel" > "Knobs" dialog.

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

If the selected waveform is a math or reference waveform, serial bus, or logic channel, the knob changes its vertical position.

The knob lights up in the color of the selected waveform. Turn clockwise to move up the waveform. To set the value to zero, press the knob.

The current offset value is shown in the channel icon.

Remote command:
`CHANNel<ch>:POSition` on page 381
`CHANNel<ch>:OFFSet` on page 381

[Scale]
Sets the vertical scale in Volts per division. The vertical scale defines the displayed amplitude of the selected waveform.

The [Scale] knob lights up in the color of the selected waveform.

Turn the knob clockwise to stretch the waveform. Doing so, the scale value V/div decreases. Press the knob to toggle between fine and coarse adjustment. For analog waveforms, the scale value is shown in the signal icon.

To get the maximum resolution of the waveform amplitude, make sure that the waveforms cover most of the diagram's height.

Remote command:
`CHANNel<ch>:SCALe` on page 380
`CALCulate:MATH<m>:VERTical:SCALe[:VALue]` on page 448
`REFCurve<rc>:SCALe` on page 457

[Gen]
Opens the "Waveform Generator" dialog, if option R&S MXO4-B6 is installed.

The waveform generator can generate various function and arbitrary waveforms, sweeps, and parallel patterns. For detailed specifications, refer to the data sheet.

[Logic]
Opens the "Logic" dialog to configure and enable the logic buses L1 to L4. A logic bus (or parallel bus) has up to 16 logic (digital) channels. If logic buses are active, pressing the key toggles these buses.

The key lights up if at least one logic bus is enabled.

[Ref]
Opens the "Reference" dialog box, where you can configure and display reference waveforms. Press the key repeatedly to switch the reference waveform.

If a reference waveform is selected, the vertical rotary knobs are illuminated in white or light gray (default colors), depending on the selected waveform.

[Math]
Opens the "Math" dialog, where you can configure the calculation of mathematical waveforms using various mathematic operations on other waveforms. Press the key repeatedly to toggle the selected math waveform. If no math waveform is active, the key closes the dialog.

If a math waveform is selected, the vertical rotary knobs are illuminated in blue (default color).

3.2.4.5 Spectrum keys

[Spectrum]
Opens and closes the "Spectrum" dialog. The key lights up if an FFT is active.

[Freq Span]
Opens and closes the overlay menu to configure the spectrum settings.

[Peak]
Opens the overlay menu to identify the peaks and to create a peak list table of a spectrum. If the "Spectrum" dialog is open, the keypress opens and closes the peak list table.

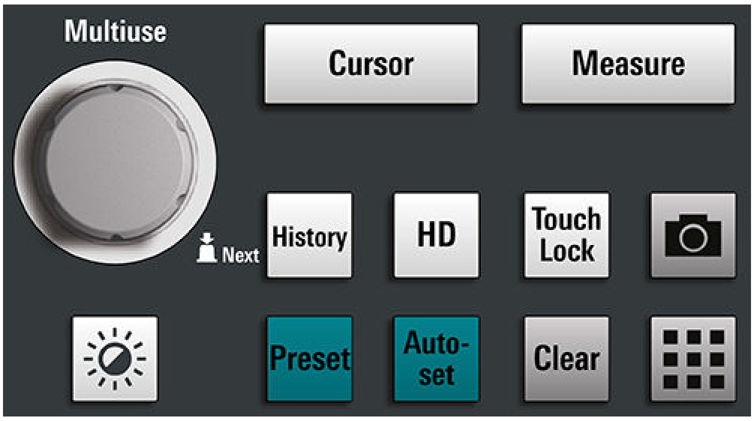
[User]

Performs the action that is assigned to the key in "Settings" > "Front panel" > "Hardkeys". You can assign one of the following functions to the key:

- Force trigger (default)
- Save a saveset with instrument settings
- Load a saveset with instrument settings

3.2.4.6 Analysis keys

The controls in the bottom functional block have various functions.



[Multiuse]
The multiuse knob changes the element that is in focus. It lights up when a function is active on the knob.

- If a numeric entry field in a dialog has the focus: turn to increase or decrease the value.
- If a cursor set has the focus: press to toggle the cursor line, and turn to adjust its position.
- If a zoom has the focus: press to toggle the edges of the zoom, and turn to adjust its position.
- To change the intensity, press the [Intensity] key and turn the knob.

[Intensity]
Adjusts the intensity of the waveforms on the screen: Press the [Intensity] key and turn the [Multiuse] knob. The current value is shown in the input box in the upper right corner of the screen.

[Cursor]
Starts a cursor measurement: sets vertical and horizontal cursors in the active diagram, and displays results of the cursor measurement. If cursors are already set, the keypress opens the "Cursor" dialog, where you can adjust the settings. The next keypress closes the dialog.

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

[Measure]
Opens the "Measurement" dialog, where you can set up various measurements.

[History]
Activates the history and opens the history player. The next keypress closes the player. The history shows stored acquisitions that were acquired before the current one. The key is illuminated as long as the history is active.

[HD]
Activates the high definition mode and opens the "HD Mode" dialog box.

[Touch Lock]
Locks the touchscreen to prevent unintended use. When the touchscreen is off, the key is illuminated. Press again to unlock the touchscreen.

Camera
Performs the action that is assigned to the key in "Settings" > "Front panel" > "Hard-keys". By default, the key saves a screenshot of the waveform display.

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

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

[Clear]
Deletes all measurement results including long-term measurement and statistics, all waveforms, and the history.

Apps
Opens the "Apps" dialog, where you can start an application, serial protocol or another analysis function.

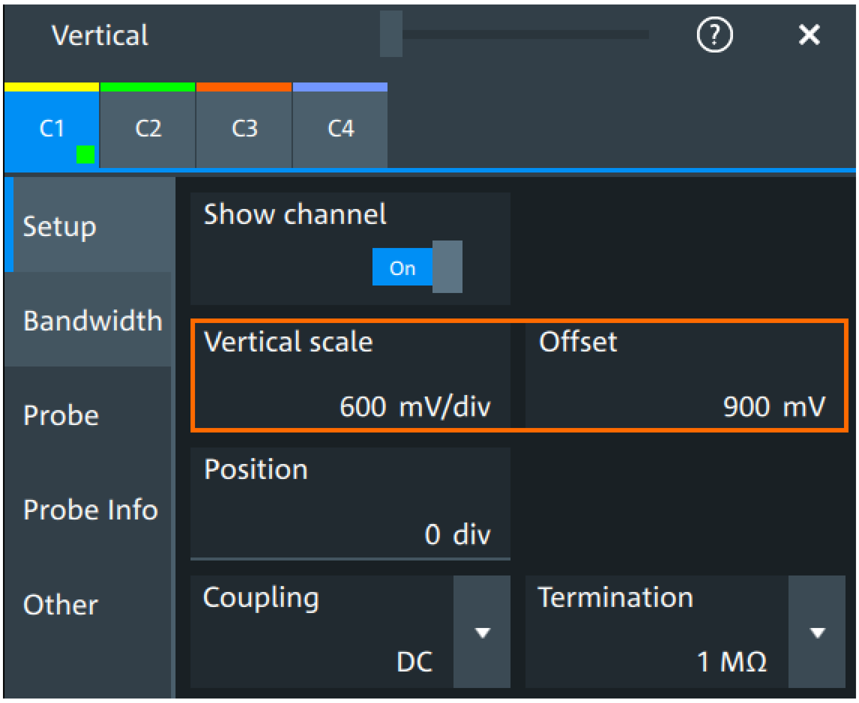
3.2.5 Checking the functionality

To check if the instrument works correctly, you can use the probe compensation signal and check the displayed signal.

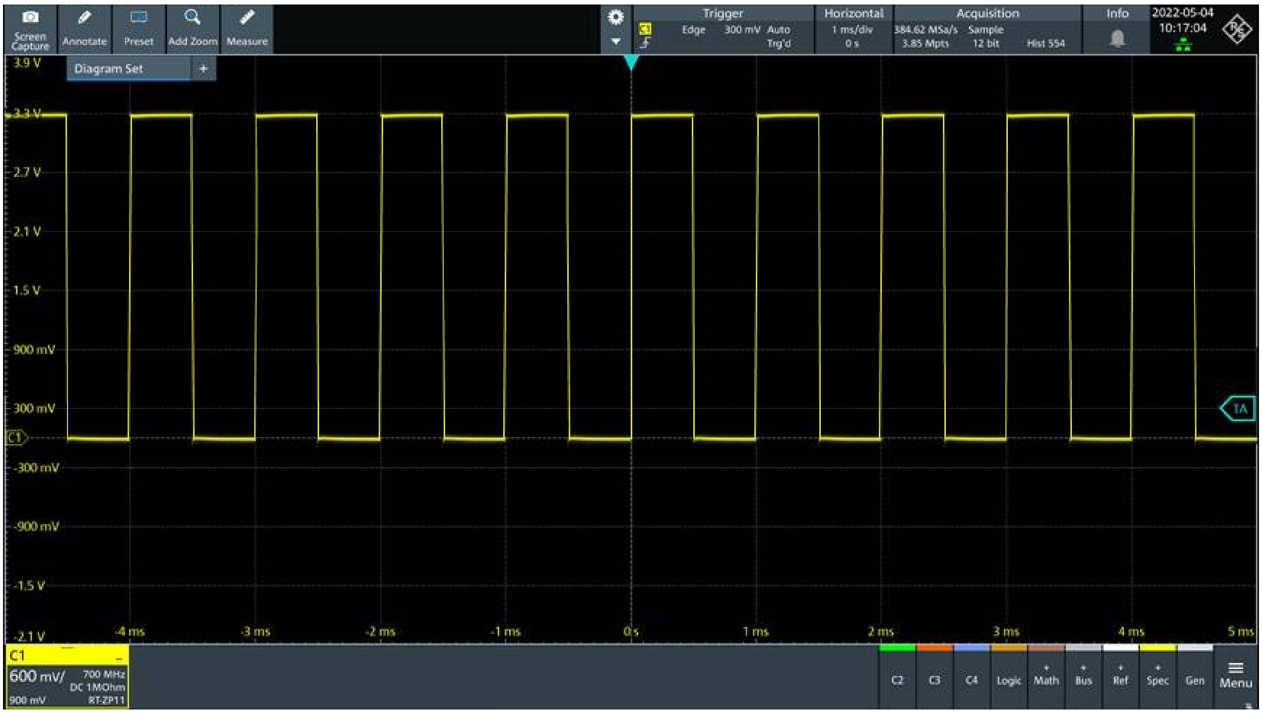
1. Perform a self-alignment of the instrument:
   a) Warm up the instrument. The minimum warm-up time is indicated in the data sheet.
   b) Remove all probes from the input connectors.
   c) Open the "Menu", and select "Settings" > "Maintenance" > "Alignment".
   d) Tap "Start Alignment". Wait until the alignment has finished successfully.
2. Connect the probe's ground connector to the ground pin ⊥, and the tip to the square wave pin ⎍.
3. Press the [Preset] key.
4. Connect the probe to the input connector [C1].

   The instrument recognizes the probe, and a signal is displayed in the diagram.
5. Tap the signal icon of C1 to open the vertical settings.
6. In the "Vertical" > "Setup" dialog, adjust the following:

- "Vertical scale" = 600 mV/div
- "Offset" = 900 mV



7. Turn the horizontal [Scale] knob to set the horizontal scale to 1 ms/div.
8. Press the [Source] key to set the trigger source to C1. The color of the key indicates the selected channel.
9. Turn the [Level] knob to set the trigger level to 300 mV.
10. Check the rectangle signal on the screen. The displayed signal should have an amplitude of about 3.3 V, which covers 5.5 divisions.



11. Repeat steps 4 to 10 for channels C2, C3 and C4. Make sure to adjust the vertical settings for the connected channel, and also to set the trigger source to the connected channel.

4 Operating the instrument

There are three ways to operate the R&S MXO 4.

Manual operation

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

Remote control

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

This way of operation is described in: Chapter 17, "Remote control commands", on page 351.

Remote operation

For remote monitoring and operation of the instrument, a VNC server is installed on the R&S MXO 4. You need a LAN connection to the computer, and a VNC client or web browser to connect to the instrument.

For details, refer to Chapter 16, "Network operation and remote control", on page 333.

4.1 Means of manual interaction

The R&S MXO 4 provides the following means of manual interaction, which you can use alternatively or complementary:

- Touchscreen:
  Using the touchscreen allows for direct interaction with the instrument. Use your finger to place waveforms on the screen, mark areas for zoom, set parameters in dialogs, enter data, and much more. The control elements and actions on the screen are based on common concepts, and you easily become familiar with the user interface.

  Tapping the screen works like clicking mouse buttons:
  - Tap = click: Selects a waveform or parameter, or provokes an action.
  - Double-tap = double-click: Has the same effect as touch and hold, it opens the on-screen keyboard or keypad, or a specific editor if available.
- Function keys and rotary knobs:
  The front panel provides frequently used functions and controls to operate the instrument. Use knobs to set levels and scales, and keys to initiate actions and to open dialogs.
- Optional mouse and/or keyboard
  These devices work in the normal manner.

4.2 Touchscreen display

4.2.1 Information on the display

The touchscreen of the instrument shows the waveforms and measurement results, and also information and everything that you need to control the instrument. All waveform-related display elements are shown in Figure 4-1. An overview of control elements - like dialog box, toolbar - is given in Chapter 4.2.2, "Control elements on the touchscreen", on page 48.

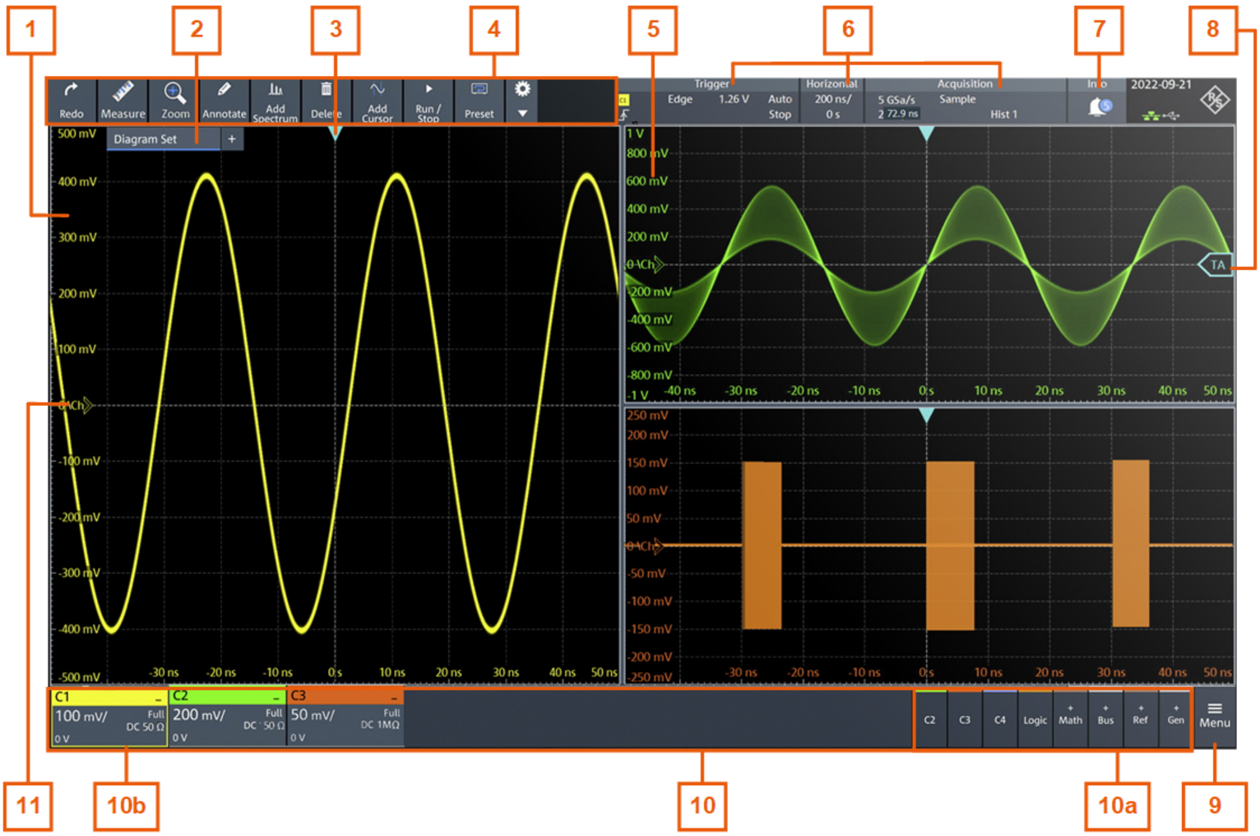


Figure 4-1: Display information

1 = Diagram
2 = Layout
3 = Trigger position
4 = Toolbar
5 = Grid
6 = Trigger, horizontal and acquisition label
7 = Info
8 = Trigger level
9 = Menu
10 = Signal bar with signal activators (10a), and active waveforms (10b)
11 = Channel markers indicate the ground levels

Diagram
A diagram shows one or more waveforms: channel, reference, and math waveforms. Zoom details, spectrum and other special waveforms are shown in separate diagrams.

To arrange the diagrams on the screen, the Rohde & Schwarz SmartGrid function helps you to find the target place simply and quickly. For details, see Chapter 4.5, "Rohde & Schwarz SmartGrid", on page 52. You can also adjust the diagram size by dragging the diagram border.

Layout
A layout shows a set of diagrams and result tables. You can configure up to four layouts using the SmartGrid functionality. For details, see Chapter 4.5, "Rohde & Schwarz SmartGrid", on page 52.

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

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

The trigger position can be moved outside the diagram.

Trigger, Horizontal, Acquisition
The "Trigger", "Horizontal" and "Acquisition" labels show the main timebase and trigger settings. If you tap a label, the relevant dialog box opens.

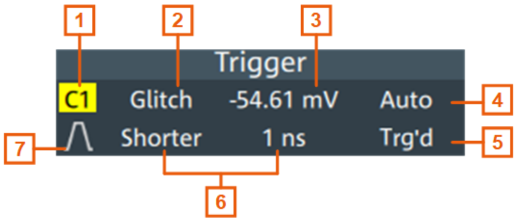


Figure 4-2: Trigger label on the toolbar

1 = Trigger source
2 = Trigger type
3 = Trigger level
4 = Trigger mode
5 = Trigger state
6 = Trigger type specific settings
7 = Trigger slope

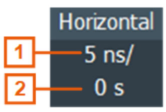


Figure 4-3: Horizontal label on the toolbar

1 = Time scale
2 = Horizontal position

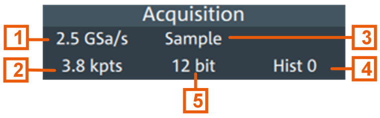


Figure 4-4: Acquisition label on the toolbar

1 = Sample rate
2 = Record length
3 = Acquisition mode
4 = Number of acquired waveforms
5 = Resolution

Info

The "Info" button on the toolbar points to the status messages of the instrument. To open the message box, tap the button. See also: Chapter 4.10, "Instrument information and notifications", on page 61.

Signal bar

The signal bar is the control center for all waveforms. All enabled waveforms are shown on the left side of the signal bar. On the right side of the signal bar, you see the signal activators of inactive waveforms. Tap a signal activator to enable the waveform.

Each waveform is represented by a signal icon. If the waveform is shown in a diagram, the signal icon displays its main vertical and probe settings. If you tap a signal icon, the dialog with vertical settings for this waveform opens. If you tap the "Minimize" icon on the signal icon, the waveform switches from the diagram area to the signal icon: the icon is greyed out. See Chapter 4.4, "Working with waveforms", on page 50 for a detailed description.

In Figure 4-1, the signal icons C1, C2 and C3 show the main settings, and the wave-forms are displayed in diagrams.

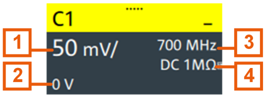


Figure 4-5: Signal label

1 = Vertical scale
2 = Offset
3 = Bandwidth
4 = Coupling and termination

If many waveforms are active, then waveforms of the same type are grouped in one signal icon. Tap the group icon to open the individual signal icons.

4.2.2 Control elements on the touchscreen

The touchscreen provides everything that you need to control the instrument, to analyze waveforms, and to get measurement results. Figure 4-6 shows the control elements at a glance.

Figure 4-6: Control elements on the touchscreen

1 = Toolbar
2 = Tab in a dialog box
3 = Dialog box
4 = Result table
5 = Signal bar
6 = Menu

Toolbar (1)

The icons on the toolbar provide quick and easy access to the most important functionality. For a detailed description, refer to Chapter 4.6, "Toolbar", on page 54.

If you adjust the settings of an analyzing function, e.g., cursor measurement, the overlay menu is shown instead of the icons. The overlay menu provides the most important settings of the current action. If you need more settings, "Setup" opens the corresponding dialog box.

Dialog box (2, 3)

The tabs of the dialog boxes contain all task-oriented settings and operations, and buttons for calling related tabs. The usage of dialog boxes is described in Chapter 4.8, "Using dialog boxes", on page 58.

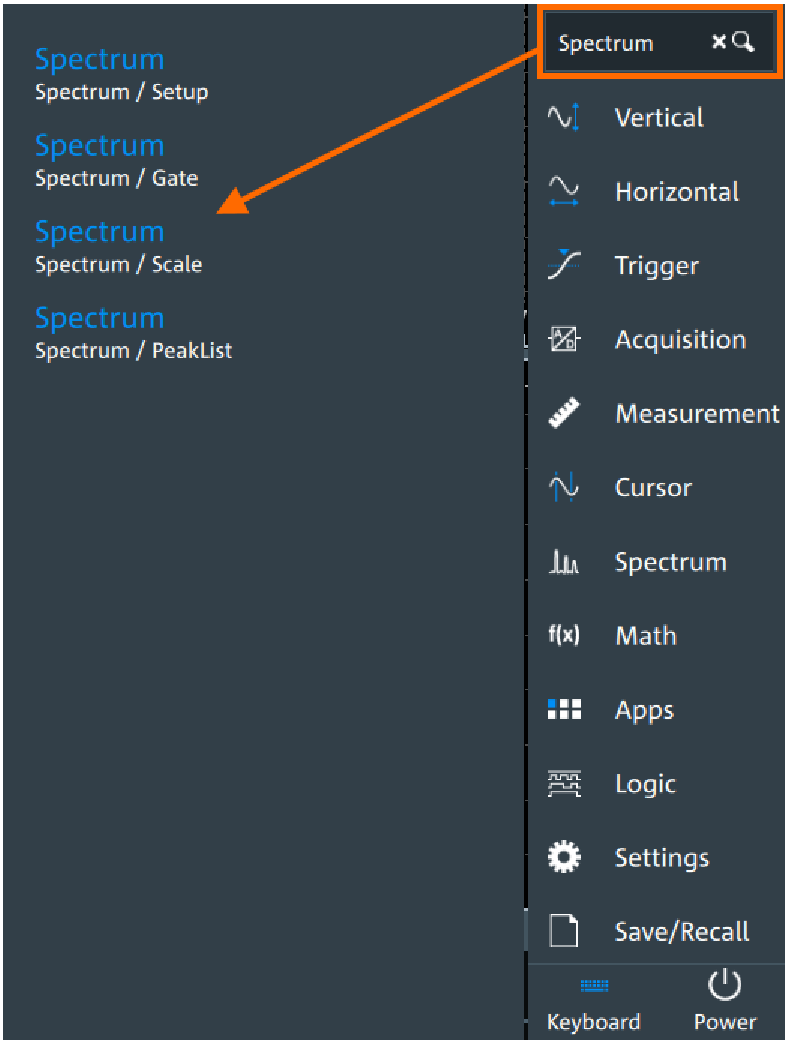
Result table (4)
If you perform cursor or automatic measurements, the result table shows the results of the action below the diagrams. You can move the result tables to the left or right of the diagrams.

See also: Chapter 4.7, "Displaying results", on page 57.

Signal bar (5)
The signal bar summarizes all waveforms as described in "Signal bar" on page 47.

Menu (6)
The menu provides access to the complete functionality of the R&S MXO 4.

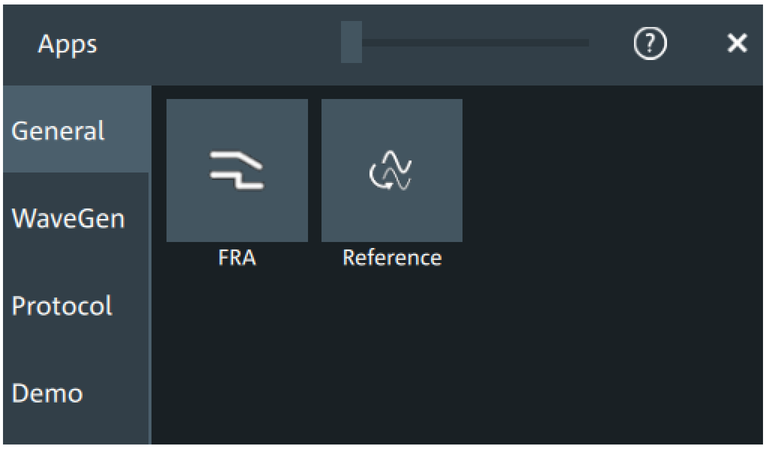
At the top of the menu, you can find a search box for a quick access to any parameter you need. A list of all found results is shown on the left side of the menu. Tap the result entry and the dialog containing this parameter opens.



4.3 Applications

The "Apps" dialog provides fast access to all available applications, for example, to serial protocols or frequency response analysis.

► To open the "Apps" dialog:
- Open "Menu" > "Apps".
- Press the [Apps] key on the front panel.



4.4 Working with waveforms

The R&S MXO 4 can create and display many waveform types. The most important are:

- Channel waveforms:
  For each input channel, one channel waveform is shown.
- Reference waveforms:
  Four waveforms can be used as reference for comparison and analysis.
- Math waveforms:
  Five mathematic waveforms can be created with mathematic operations performed on channel, reference, and other math waveforms.
- Zoom waveforms:
  Show the details of waveforms.
- Digital waveforms:
  The Mixed Signal Option R&S MXO4-B1 provides 16 digital channels grouped in two logic probes (pods) with 8 channels each.

Waveform handling

The R&S MXO 4 can show and analyze many waveforms. To handle this multitude while keeping track of it, the R&S MXO 4 provides intelligent support:

- The color system helps to distinguish the waveforms. The color of the vertical rotary knobs indicates the signal that is focused (selected). The color of each

waveform can be changed, the color of its signal icon and of the illuminated keys is adjusted to the new color. Alternatively, a color table can be assigned to a waveform.
Settings: "Menu" > "Settings" > "Appearance" > "Colors" tab.
- You can arrange the waveforms in one diagram, or in separate diagrams. The Rohde & Schwarz SmartGrid function helps to arrange the waveforms.

Waveform states

Depending on its place on the screen and the effect of settings, a waveform has one of the following states:
- Off
- Active:
The waveform is shown in a diagram
- Selected:
One of the active waveforms that has the focus. In each diagram, one of the assigned waveforms is selected – it appears "on top" in the diagram, and the grid labels have the color of the selected waveform.
The vertical [Position] and the [Scale] knobs are illuminated with the color of the selected waveform.
- Minimized:
The waveform signal icon is greyed out, and the waveform is removed from the diagram.

To switch a waveform on

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

► Choose one of the following ways:
  - Press the channel key.
  - In the "Vertical" dialog box, select the channel. Tap "Show channel" > "On".

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

Remote command: `CHANnel<ch>:STATe` on page 380

To select a waveform

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

  Note: Zoom waveforms in zoom diagrams cannot be selected.

To minimize a waveform

► Tap the "Minimize" icon in the upper right corner of the waveform's signal icon in the signal bar.

The waveform disappears from the diagram and the signal icon turns lighter gray.

To arrange a waveform using the SmartGrid

See Chapter 4.5, "Rohde & Schwarz SmartGrid", on page 52.

To switch off a waveform

► Do one of the following:
- Tap the "Delete" icon in the toolbar, and then signal icon of the waveform.
  You can also tap the waveform directly. If several waveforms overlap or lie close together, a selection list is shown.
- To switch off a minimized waveform, tap the "Close" icon in the upper right corner of the signal icon.
- If the waveform is an input channel:
  – Disable "Show channel" in the "Vertical" > "Setup" tab.
  – Select the channel. Then press its channel key twice.

Remote command: `CHANnel<ch>:STATe` on page 380

4.5 Rohde & Schwarz SmartGrid

The Rohde & Schwarz SmartGrid helps to create and arrange the diagrams on the screen with drag&drop. The diagram layout depends on the position where you drop the signal icon, in relation to an existing diagram.

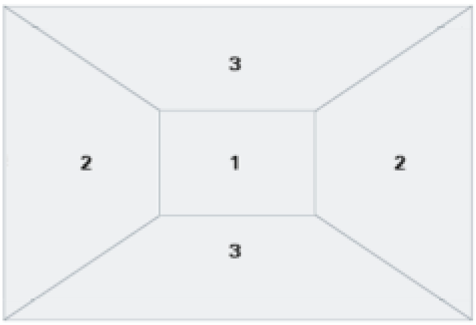


Figure 4-7: SmartGrid positions

1 = In the existing diagram, overlay of signal
2 = New diagram on the left or right
3 = New diagram above or below

The diagram configuration is deleted when you use [Preset] and `*RST`.

Working with layouts

A SmartGrid configuration of one or more diagrams is called "tab" or "layout". You can define several layouts and switch between them.

1 = Tab 1 (layout 1, blue underline indicates that the set is currently displayed)
2 = Tab 2 (layout 2)
3 = Tap to remove a layout
4 = Tap to add a layout

You can add up to four layouts at the upper left corner of the screen:

1. Tap on the + icon next to the layout.

   A new layout is created.

2. To change the layout name, touch and hold the tab name. The on-screen keyboard opens to enter the new name. Names must be unique.

3. To remove the layout, tap on the × next to the layouts title.

To arrange a waveform using the SmartGrid

1. Select the layout that you want to rearrange.

2. Drag the signal icon to the diagram area, and move it around.
   The Rohde & Schwarz SmartGrid appears and a blue or highlighted area shows where the waveform will be placed.

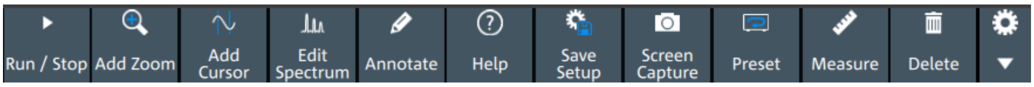
3. Drop the waveform in the target area.
   The waveform appears in an existing or in a new diagram, and it is selected for further actions.

4. To change the size of a diagram, touch the border between two diagram frames and drag it to the required position.

Remote commands: see Chapter 17.7.2, "SmartGrid", on page 364

4.6 Toolbar

The toolbar provides direct access to important control and measurement functions.



By default, the toolbar shows the most frequently used functions. You can configure the content of the toolbar, see Chapter 4.6.2, "Configuring the toolbar", on page 54.

4.6.1 Using the toolbar

Using the toolbar is easy and straightforward.

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

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

To use analyzing functions (interactive actions)

1. Tap the icon of the function in the toolbar.
2. Check and adjust the settings in the overlay menu.
3. Select the source waveform if it is needed. For zoom, drag a rectangle, or tap the diagram to define the zoom area.
4. If the overlay menu does not close automatically, tap the icon.

4.6.2 Configuring the toolbar

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

1. To open the toolbar configuration, tap the icon in the toolbar:

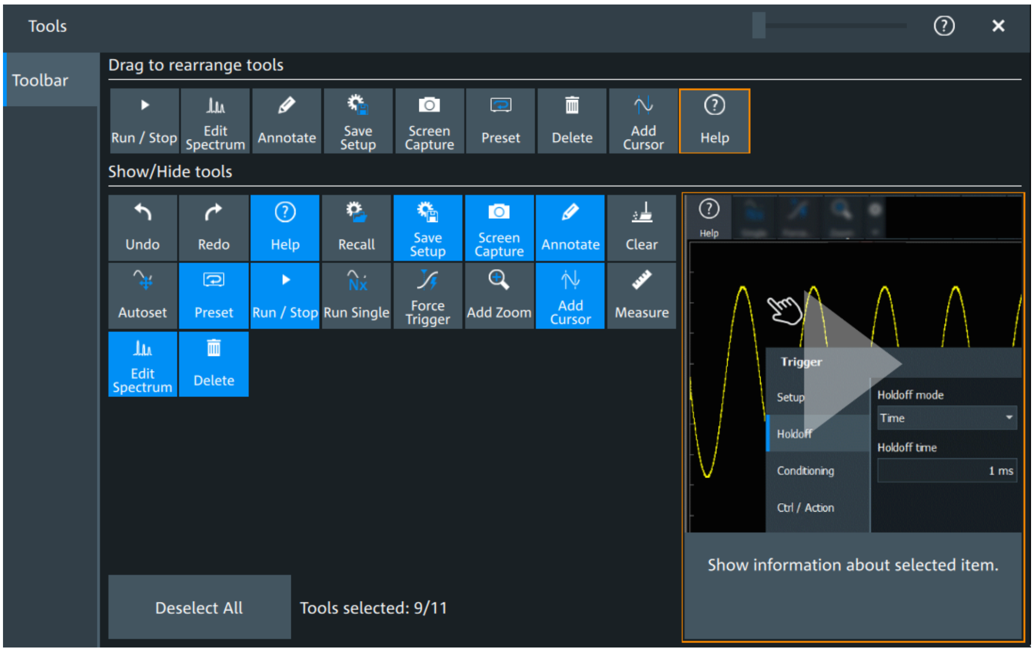
2. Select the required toolbar functions:
   a) In the "Show/Hide tools" section, disable all functions that you do not need.
   b) In the "Show/Hide tools" section, enable the functions that you want to add to the toolbar.
   You can select up to 10 tools.

c) In the "Drag to rearrange tools" section, move the icons to arrange them as required.

A detailed description of the toolbar functions is given in Chapter 4.6.3, "Toolbar functions", on page 55.

4.6.3 Toolbar functions

This section describes all toolbar functions in detail.



You can configure the content of the toolbar, see Chapter 4.6.2, "Configuring the toolbar", on page 54.

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

Undo
Undoes the last setting actions step by step. Some actions cannot be revoked: locking the touchscreen with [Touch Lock], and saving data.

Redo
Recovers the undo steps in reverse order.

Help
Enables the context help display. The help window opens when you tap a parameter.

See also: "To display the context help" on page 62.

Recall
Opens a window to select and load instrument settings that were previously stored in a saveset.

Save Setup
Saves the current instrument settings in a saveset.

You can reload the saveset using the "Recall" toolbar icon, or using "Menu" >"Save/Recall" > "Recall" tab > "Saveset".

The filename is created according to the autonaming pattern, defined in "Menu" > "Settings" > "Save / Recall" > "Autonaming" tab.

Screen Capture
Saves a screenshot of the current display using the settings defined in "Menu" >"Save/Recall" > "Save" tab > "Screenshot".

Annotate
Displays drawing tools for marking areas on the diagram, and for adding text. You can also select the color.

See also: Chapter 4.12, "Adding annotations", on page 63.

Clear
Deletes all measurement results including all waveforms and statistics.

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

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

Force Trigger
Starts an immediate single acquisition. If the acquisition is running in normal mode and no valid trigger occurs, use "Force Trigger" to confirm that a signal is available. Then you can use the displayed waveform to determine how to trigger on it.

Add Zoom
Adds a zoom diagram, an area of the acquired waveform which is visually enlarged. Click on a diagram to create a zoom or draw a rectangle to define the range of the zoom.

Add Cursor
Adds a cursor set. Select the cursor type and the source to be measured.

See also: Chapter 9.1, "Cursor measurements", on page 184.

Measure
Adds one or more measurements to the waveform.

Tap the icon, and select the category and the measurements in the overlay menu. Select the waveform to be measured, and close the overlay menu.

Edit Spectrum
Edit the existing spectrum settings in the overlay menu.

Delete
Removes waveforms, diagrams and zooms from the display.

Tap the "Delete" icon. A recycle bin icon marks all objects that can be deleted. Tap this icon to remove an object. Tap the "Delete" icon again to disable the function.

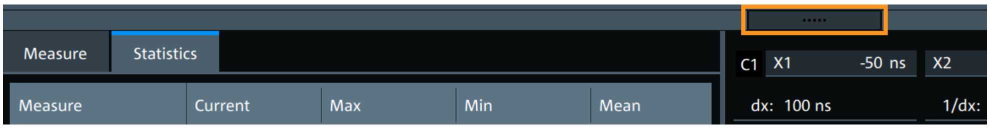
4.7 Displaying results

The results of measurements, protocol decoding and others are displayed immediately.

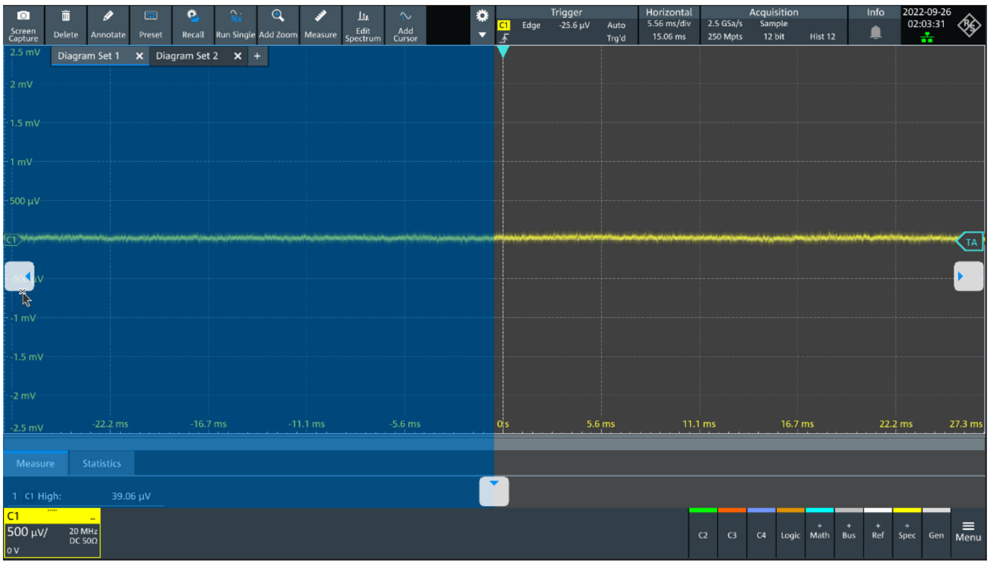
The font size can be adjusted.

To arrange the results on the display

1. Touch and hold the "....." field on top of the results table.



2. Drag on the screen. The SmartGrid indicates where the result table can be placed. Drop the box on one of the buttons. The results are shown at the left the right, or below the diagrams.



To open the corresponding settings

► Double-tap one of the result values.

The corresponding dialog opens.

To adjust the font size of results

1. Open the "Menu" > "Settings" > "Appearance" dialog.
2. Select the "Dialogs" tab.
3. Set the "Result dialog" > "Font size".

4.8 Using dialog boxes

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

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

	Closes the dialog box
	Opens the help window for the dialog
	Shift sideways to change the transparency of the dialog box

For direct access to important control and measurement functions, use the toolbar, see Chapter 4.6, "Toolbar", on page 54.

To open a dialog box

► Perform one of the following actions:
- Open the "Menu", and select the menu entry.
- Press the function key on the front panel.
- Double-tap a result icon, or tap the icon in a result box to open the corresponding dialog box.
- To open the "Vertical" dialog box of a waveform, tap the signal icon.
- Tap the "Horizontal", "Acquisition" or "Trigger" label to open the corresponding dialog box.

To close a dialog box

► Tap the "Close" icon in the upper right corner.

4.9 Entering data

To set parameter values and enter other data, you use the various knobs and the on-screen keypad or keyboard.

Using scale, position and level knobs

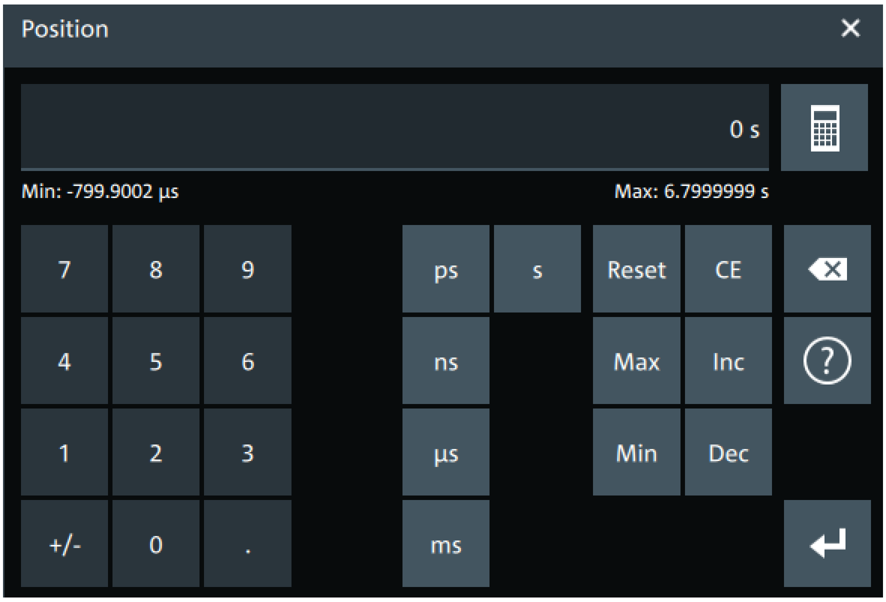
The instrument has dedicated rotary knobs to set vertical and horizontal positions and scale, and the trigger level.

1. Turn the knob to change the value.
2. Press the knob:
   - [Scale]: to toggle the increment.
   - [Position]: to set to zero.
   - [Level]: to set the trigger level to 50% of the signal.

To enter values with the on-screen keypad

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

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



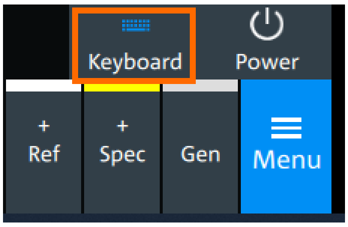
2. Enter the numeric value using the following methods:
   - To use the default value, tap "Reset" (if available).
   - To get the value that was used before the keypad was displayed, tap "CE".
   - To use the minimum or maximum value, tap "Min" or "Max", respectively.
   - To increase the displayed value in fixed steps, tap "Inc".
     To decrease the value in fixed steps, tap "Dec".
   - To enter a user-defined value, tap the numbers and complete the entry by tapping the unit button.

- "±" changes the sign of the value.
- To calculate a value, tap the calculator to display the arithmetic operators. Use the displayed fields to calculate your values.

3. Tap to complete the entry.

To enable the on-screen keyboard

1. Tap "Menu".
2. Tap on "Keyboard" to enable the on-screen keyboard.



If the on-screen keyboard is enabled, the keyboard icon is colored blue. If it is disabled, the color is white.

To enter data with the on-screen keyboard

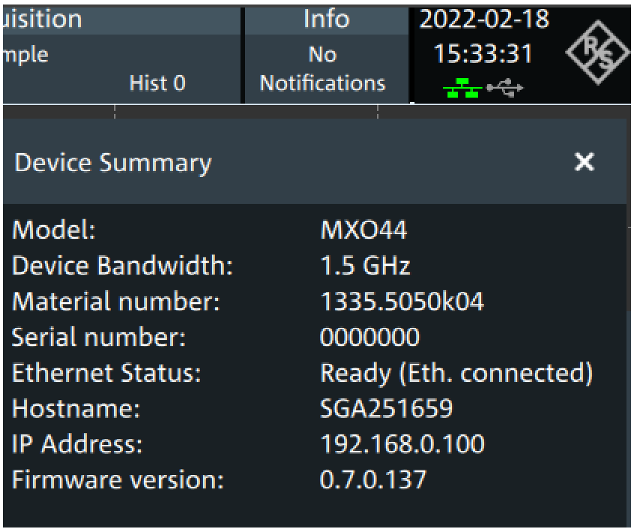
1. Double-tap the entry field to open the on-screen keyboard.

2. Enter the text as you would on a normal keyboard.
   - To change the language, tap . The current language is shown on the blank key.
   - To display numbers and signs, tap .
3. Tap to complete the entry or to minimize the keyboard.

4.10 Instrument information and notifications

In the upper right corner of the screen, you see the Rohde & Schwarz logo, date and time, the symbolic information on LAN connection and the notifications status.

► To see the instrument information, tap the Rohde & Schwarz logo.

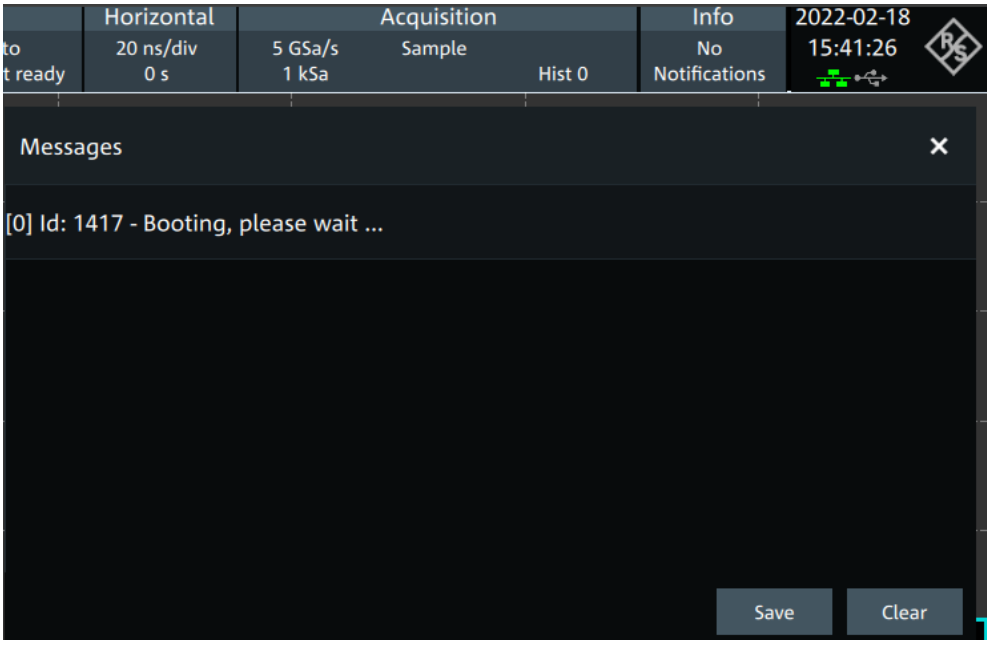


► To hide the date and time or change the display format, tap on the date/time display.

Notifications are status messages, information on mismatching settings and similar information. They are displayed for a few seconds and saved.

The color of the dot before the text indicates the severity: gray for information, orange for warnings, and red for errors.

► To read the notifications, tap "Notification".
You can save or delete the list of notifications.



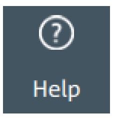
4.11 Getting information and help

If you need information on the instrument's functionality, you can use the instrument help. It provides contextual information on a setting or dialog. If the help window is open, you can browse and search for further information using links, table of contents, and search.

4.11.1 Displaying help

To display the context help

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



2. Tap the parameter for which you need information.

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

To open a dialog help

1. Open a dialog.
2. Tap the "Help" icon on the right side of the dialog header.
3. Tap a subtab or menu item.

   The help window opens with the dialog help page, where you can select the topics.

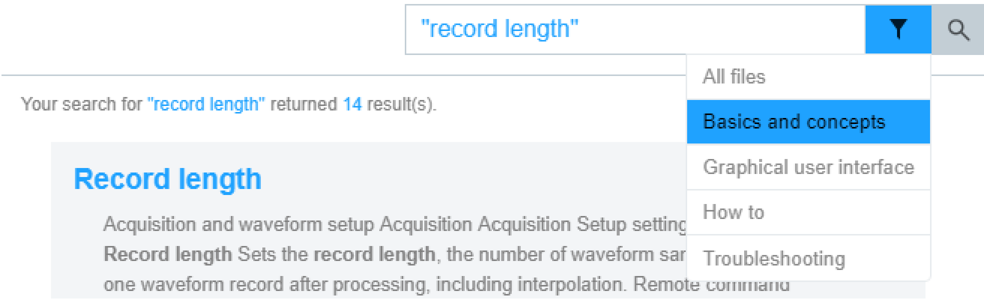
4.11.2 Using help

You can find a specific information and navigate the contents by following means:

- Table of contents
- Buttons in the help window title:

  – "Home": Go to the start page
  – "Back", "Forward": Browse the pages that you visited before
- Search with filter:

  – Enter the word to be found, or a phrase in quotes.
  – Tap the filter icon and select the information type.

4.12 Adding annotations

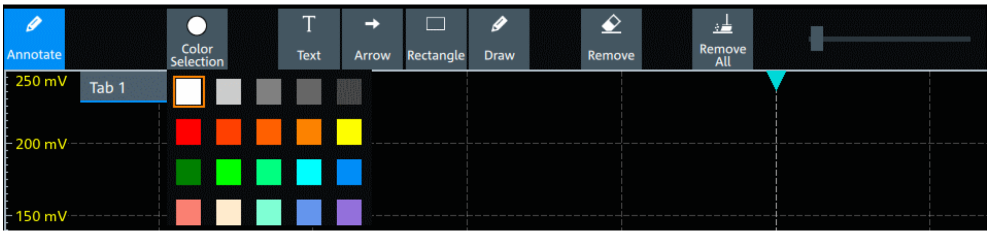
The R&S MXO 4 provides an easy way to add annotations to the screen. With the tool-bar "Annotate" you can add text, forms or even draw.

To add an annotation

1. On the toolbar, tap on the "Annotate" icon.

   The annotation overlay menu opens.



2. Tap "Color selections" and select the color that you want to use for your annotations.
3. Add one or more of the following:
   - One of the predefined forms: "Arrow" or "Rectangle"
   - "Text": adds a text element to the screen and opens on-screen keyboard. You can change the text later, by tapping on an existing annotation and typing in the new text.
   - "Draw": you can draw any form on the screen.

4. To move one of the annotations, tap on it and drag it to the required position.

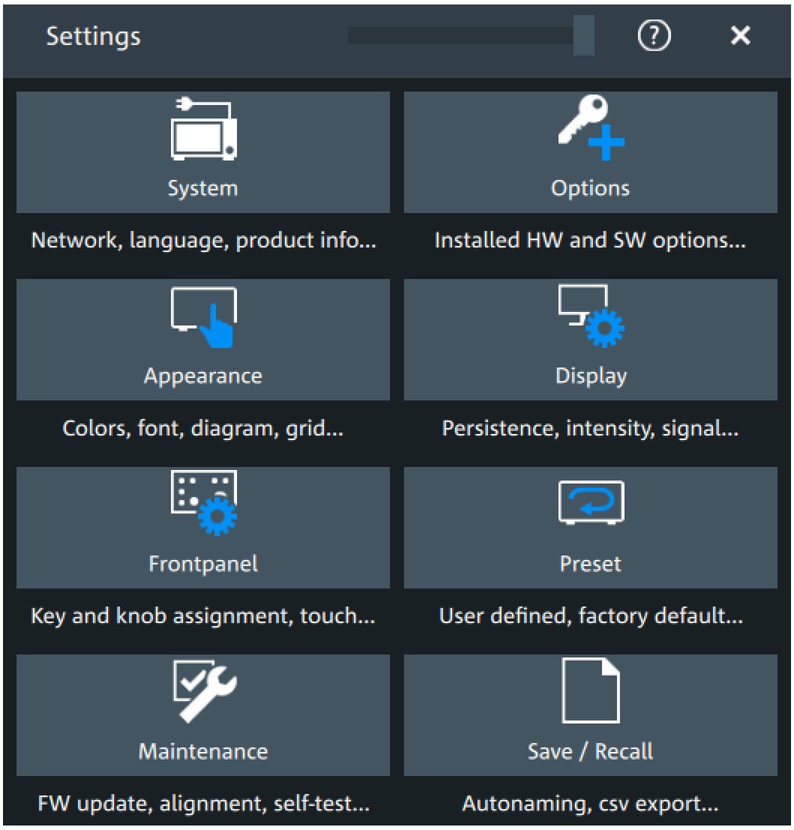
To remove an annotation

1. In the "Annotate" overlay menu, tap on "Remove".
2. Tap on any existing "Arrow", "Rectangle" or "Text" annotation to remove it.
3. The "Remove" function, acts as an eraser on drawings: it enables you to erase only certain parts of your drawing. Drag your finger over any part of your drawing to erase it.
4. To remove all annotations from the screen, tap on "Remove All".

5 Instrument setup

Access: "Menu" > "Settings".

In the "Settings" dialog, you can adapt various instrument settings to your requirements, such as language, display appearance, and assign functions to some keys.



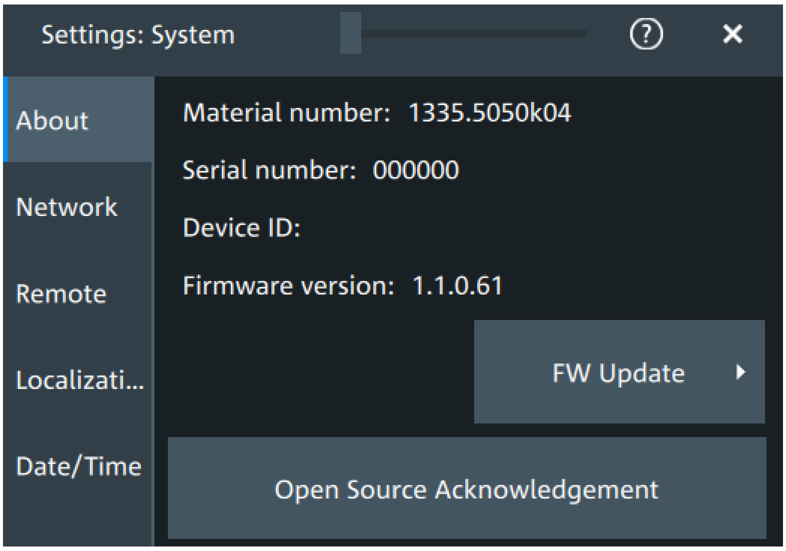
The following settings and procedures are described in the current section:

5.1 System settings

In the "Settings" > "System" dialog box, you find all instrument, firmware and network-related information. Here you can also set the language that is used in the dialogs.

5.1.1 About settings

Access: "Menu" > "Settings" > "System" > "About".



Instrument
Displays general information about the instrument, including:

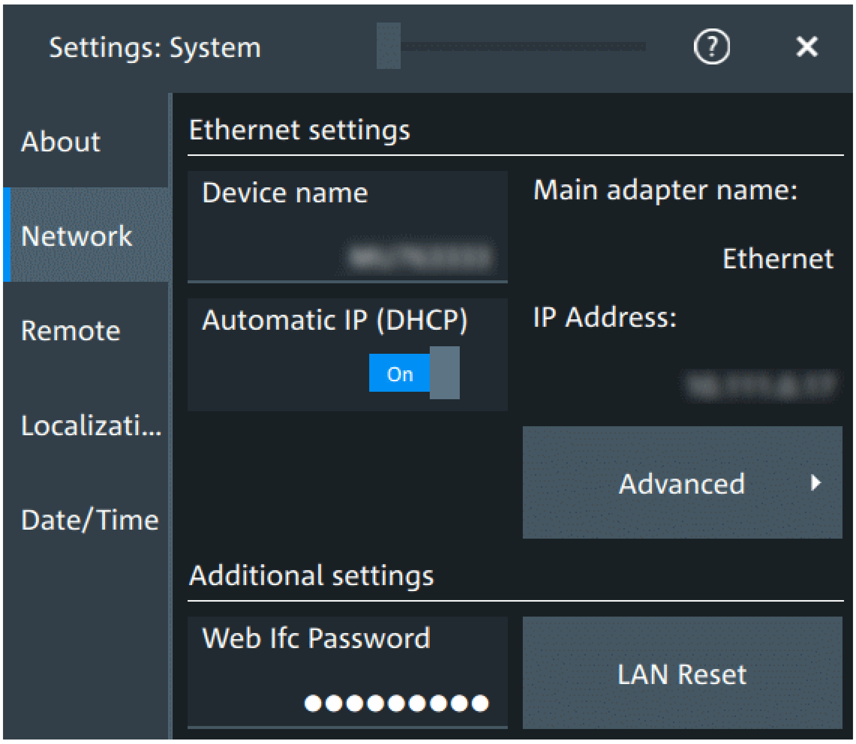
- "Material number"
- "Serial number"
- "Device ID"
- "Firmware version"

FW Update
Opens the "FW Update" dialog box. See Chapter 5.7.1, "Firmware update", on page 87.

Open Source Acknowledgment
Displays the "Open Source Acknowledgment" document.

5.1.2 Network settings

Access: "Menu" > "Settings" > "System" > "Network".



Device name
Indicates the currently defined device name. This value is required to configure the instrument for work in a network.

NOTICE! Risk of network problems. Incorrect configuration of the device name can create network problems. Consult your network administrator before changing the name.

Remote command:
`DIAGnostic:SERVice:COMPutername` on page 362

Automatic IP (DHCP)
If enabled, the IP address of the oscilloscope is obtained automatically.

IP address
Shows the current IP address of the instrument. If "Automatic IP (DHCP)" is "Off", you can change the IP address here. For complete manual configuration, select "Advanced". See also: Chapter 16.1, "Connecting the instrument to the network (LAN)", on page 333.

Web Ifc Password
Password for LAN configuration. The default password is *LxiWebIfc*.

LAN Reset
Resets the LAN configuration to its default settings using the network configuration reset mechanism (LCI) for the instrument.

The LAN settings are configured in the "Advanced" dialog, or using the instrument's web browser (see Chapter 16.2, "Web interface", on page 335).

Advanced

Opens a dialog box to configure the network connection.

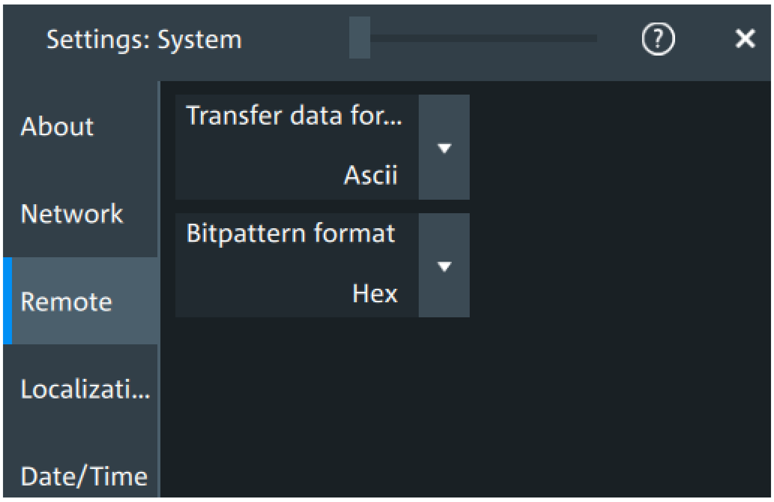
You need these settings to configure the LAN connection manually, without DHCP.

NOTICE! Connection errors can affect the entire network. You must assign valid address information before connecting the instrument to the LAN. Contact your network administrator to obtain a valid IP address and other connection data.

See also: Chapter 16.1, "Connecting the instrument to the network (LAN)", on page 333.

5.1.3 Remote settings

Access: "Menu" > "Settings" > "System" > "Remote".



The following settings are required for remote control of the instrument via a connected computer.

Transfer data format
Selects the data format that is used for transmission of waveform data from the instrument to the controlling computer.

Waveform data can be retrieved using the following commands:
- `DIGital<m>:DATA[:VALues]`

"Ascii"	Data values are returned in ASCII format as a list of comma-separated values in floating point format.
"FLOAT"	Binary format. Up to 7 significant digits are stored. If there are more than 7 digits, the number is rounded off.
"DOUBLE"	Binary format. Up to 15 significant digits of the numbers are stored.
"INT8/16/32"	Signed integer data with length 8/16/ 32 bit.

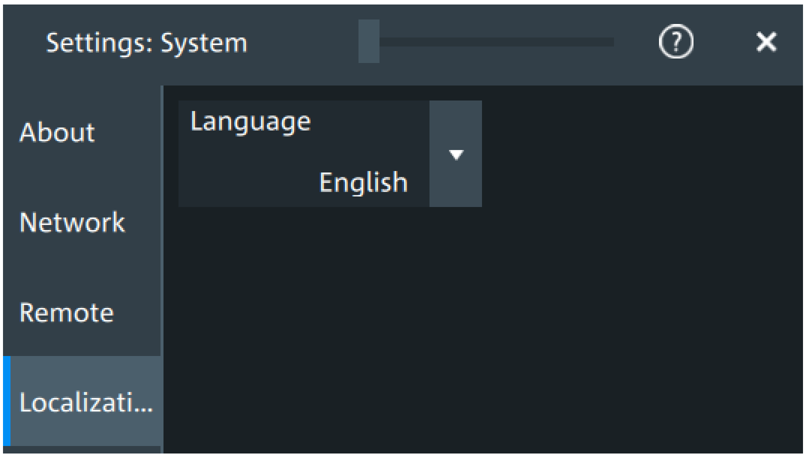
Remote command:
`FORMat[:DATA]` on page 360

Bitpattern format
Sets the format for all bit pattern queries.

Remote command:
`FORMat:BPATtern` on page 361

5.1.4 Localization settings

Access: "Menu" > "Settings" > "System" > "Localization".

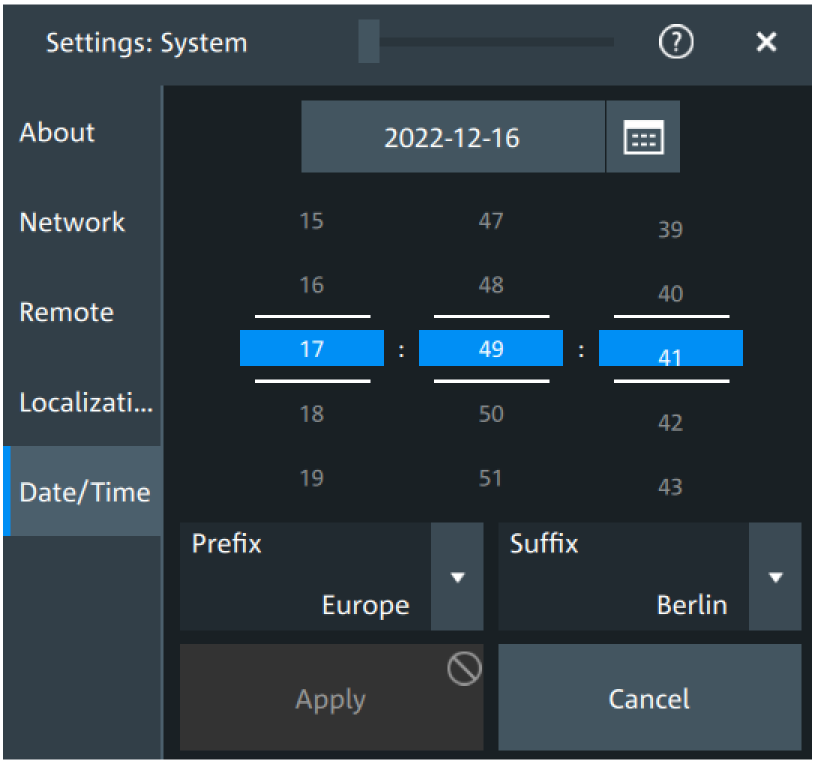


Language
Selects the language in which the dialog boxes, result boxes and other screen information is displayed. You can change the instrument language while the instrument is running.

Available languages are, for example, English, German, French, Japanese. For a complete list of supported languages, refer to the data sheet.

5.1.5 Date and time settings

Access: "Menu" > "Settings" > "System" > "Date/Time".



Date and time
Adjust the date and time of the instrument.

Remote command:
SYSTem:DATE on page 363
SYSTem:TIME on page 363

5.2 Option settings

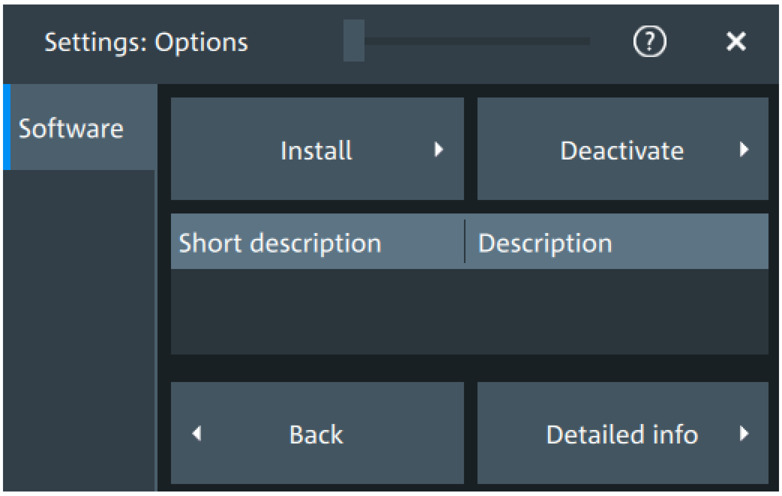
Additional options for the R&S MXO 4 are enabled using a license key. To obtain the license key, consult your sales representative.

You can obtain registered or unregistered licenses.

Unregistered licenses
Unregistered licenses are not assigned to a particular instrument. The instrument accepts only registered licenses. If your license is delivered unregistered, use the online tool R&S License Manager to register the license for your instrument. The registration of a permanent license is irreversible, so ensure that you register it for the correct instrument. The address of the tool is https://extranet.rohde-schwarz.com/service. For registration, you need the device ID of the instrument on which the option will be installed.

5.2.1 Software options settings

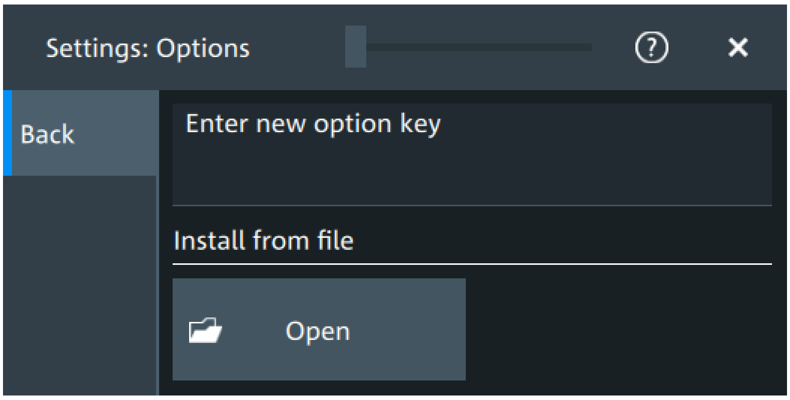
Access: "Settings" > "Options" > "Software"



In this dialog, you can access settings for installing and deactivating options. In the "Detailed Info" dialog, you can get an overview of all options installed on your R&S MXO 4.

5.2.1.1 Install options

Access: "Settings" > "Options" > "Software" > "Install"



In the "Install" tab, you can install new options or deactivate existing options using license keys.

Enter new option key
Enter the license key here to activate the option. For license keys delivered as a file, use "Install from file" on page 72.

Install from file
If you got a license file, install the license here.

Tap "Open" to open the file selection dialog, or enter the complete path and filename.

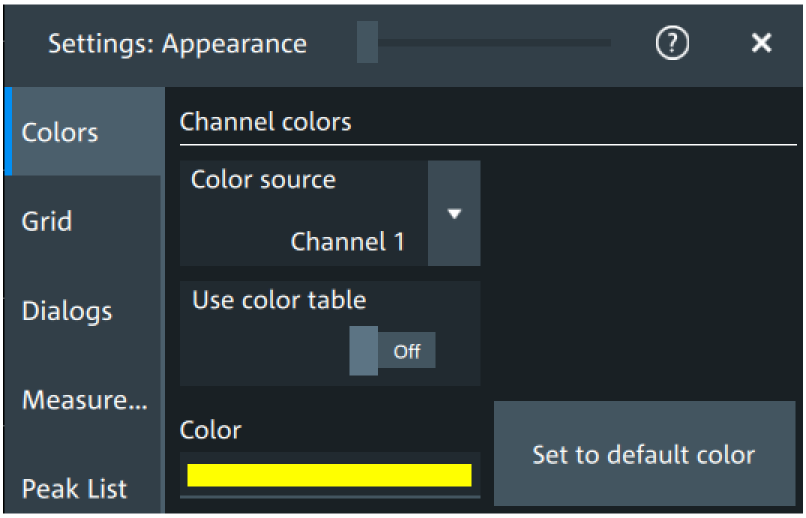
5.3 Appearance settings

In the "Settings" > "Appearance" dialog box, you define the look and feel of the display element, e.g. waveform colors, result position, or grid behavior.

5.3.1 Colors

Access: "Settings" > "Appearance" > "Colors"

By default, various colors are assigned to the different waveform types for better visibility and distinguishability. You can change the color assignment and select another color or a color table to waveforms.



Color source
Selects the waveform to which the color or the color table is assigned.

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

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

Remote command:
`DISPlay:COLor:SIGNal:USE` on page 370

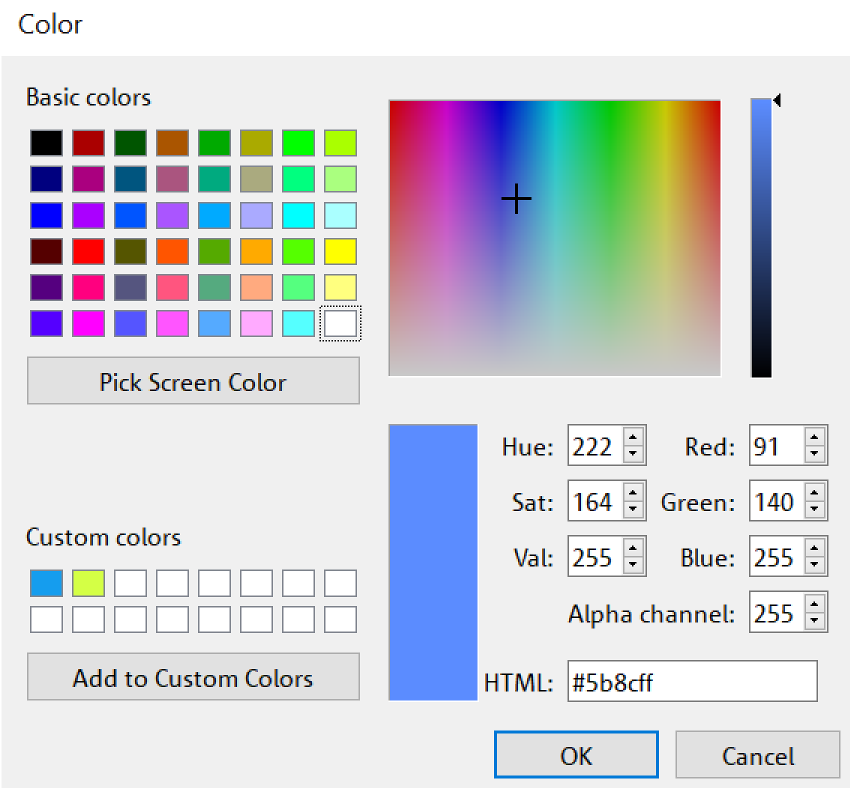
Assigned color table
Assigns a color table to the source waveform instead of a dedicated color. Color tables define the color of the waveform pixels depending on the cumulative occurrence of the associated values.

The following color tables are provided:
- "False colors": color changes gradually in a wide color spectrum.
- "Single Event": single events and very seldom events appear yellow, a higher cumulative occurrence is shown with blue color. This view helps to identify specific events.
- "Spectrum": colors display the wave lengths of the light. Low cumulative occurrence is displayed blue like high wave length.
- "Temperature": color changes gradually from blue (low temperature) to red (high temperature) with increasing cumulative occurrence.

Remote command:
`DISPlay:COLor:SIGNal:ASSign` on page 370

Color
Shows the current color of the selected waveform. To change the color, tap the button to open the "Color" dialog.

In the dialog, you can pick from a list of basic colors, or define a color with the color picker.



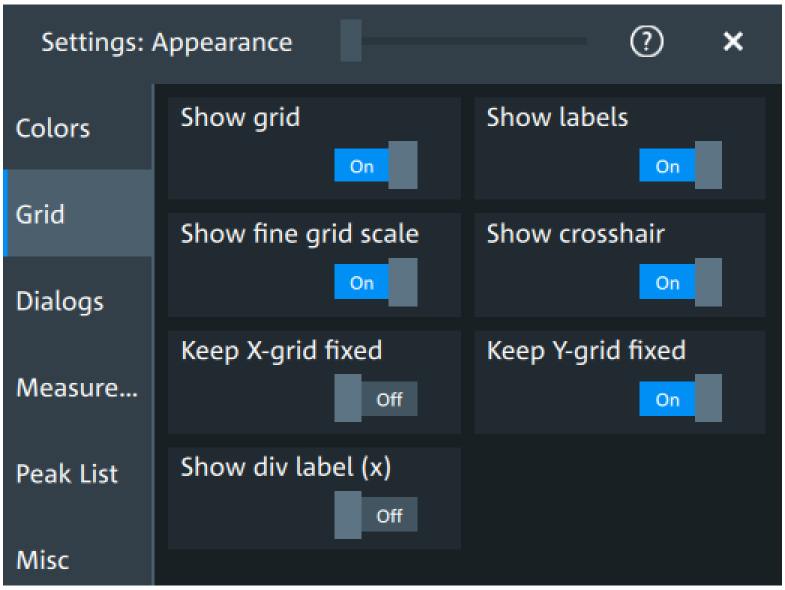
The color of the waveform, its signal icon, channel icon, and of the illuminated keys is adjusted to the new color.

Remote command:
`DISPlay:COLor:SIGNal:COLor` on page 369

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

5.3.2 Grid

Access: "Settings" > "Appearance" > "Grid"



Show grid

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

Remote command:

DISPlay:DIAGram:GRID on page 371

Show labels

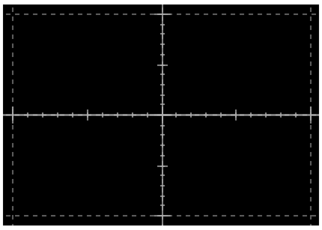
If selected, labels mark values on the x- and y-axes in specified intervals in the diagram.

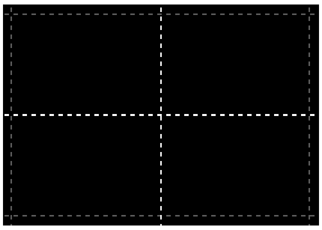
Remote command:

DISPlay:DIAGram:LABels on page 371

Show fine grid scale

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





Remote command:

DISPlay:DIAGram:FINegrid on page 371

Show crosshair

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

Remote command:
`DISPlay:DIAGram:CROSshair` on page 370

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

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

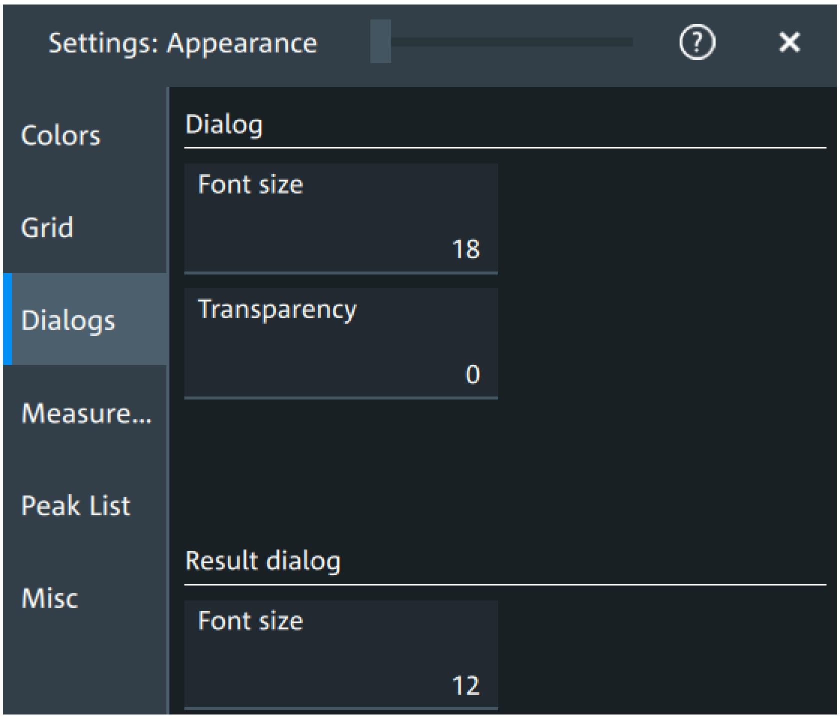
Fixed horizontal grid lines correspond to the behavior of traditional oscilloscopes.

Remote command:
`DISPlay:DIAGram:YFIXed` on page 371

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

5.3.3 Dialogs

Access: "Settings" > "Appearance" > "Dialogs"



Font size (Dialog)
Defines the font size of the text in dialog boxes.

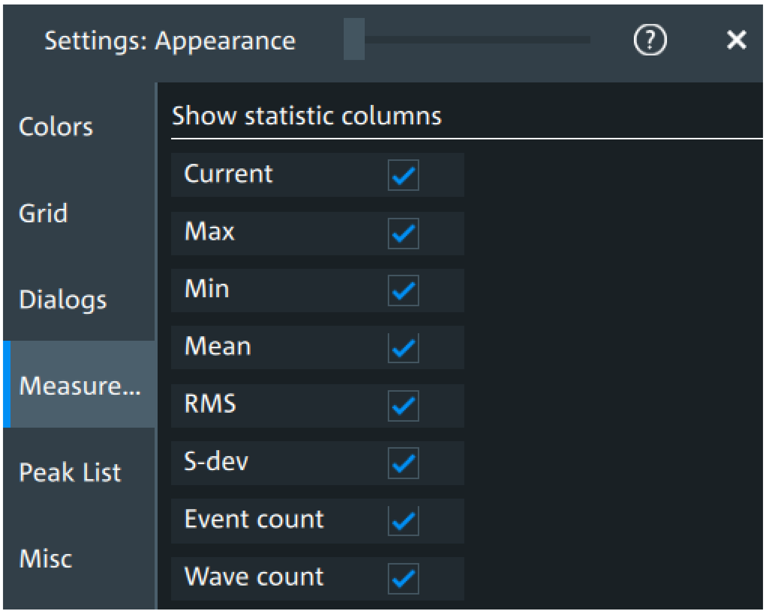
Transparency (Dialog)
Defines the transparency of the dialog box background. For high transparency values, you can see the waveform display in the background, and possibly check the effect of the changed setting. For lower transparency values, readability in the dialog box improves.

You can also set the dialog transparency, by moving the transparency bar at the top of the dialog.

Font size (Result dialog)
Defines the font size of the text in result tables.

5.3.4 Measure

Access: "Settings" > "Appearance" > "Measurements"

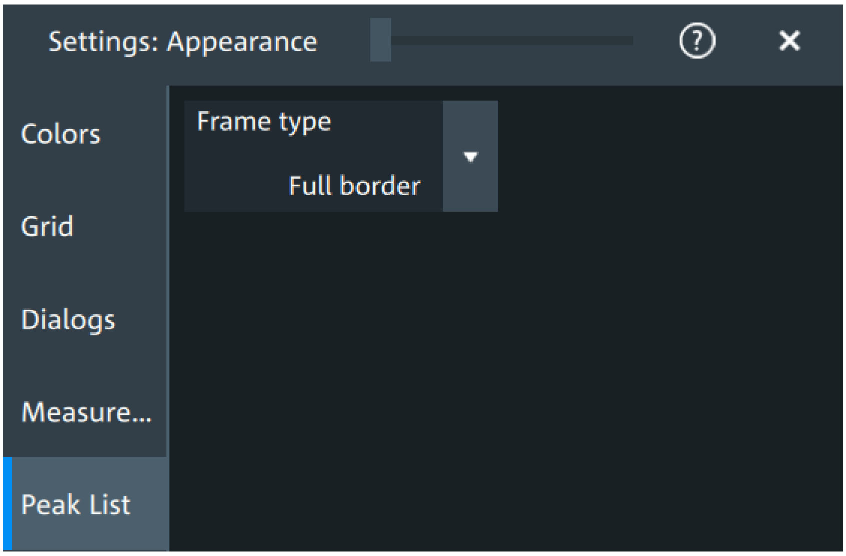


Show statistic columns
Select the statistical values that you want to see in the results table.

You can display the following values:
- "Current"
- "Max"
- "Min"
- "Mean"
- "RMS"
- "S-dev"
- "Event count"
- "Wave count"

5.3.5 Peak list

Access: "Settings" > "Appearance" > "Peak list"



Peak list settings apply to peak list measurements. They are visible when the peak list for spectrum measurements is enabled.

Frame type

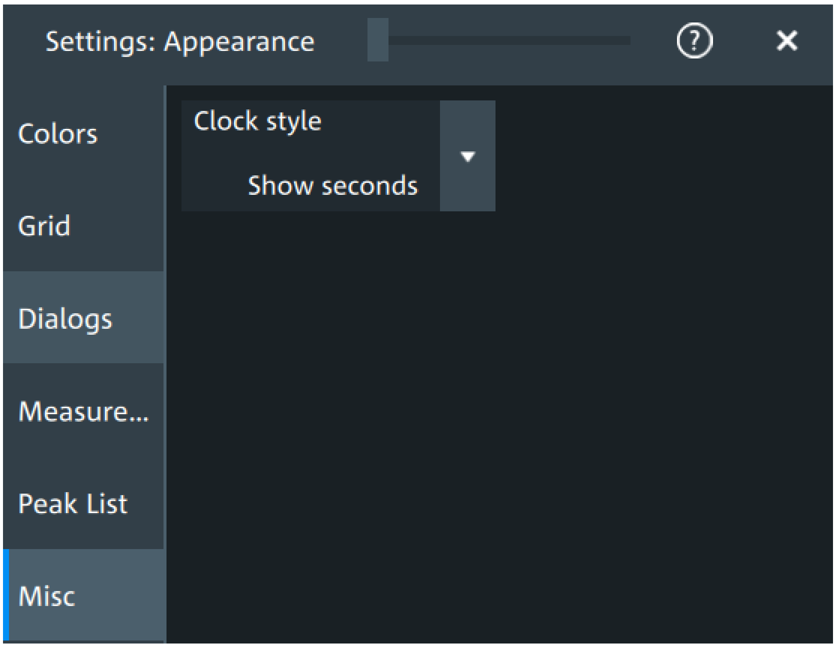
Defines the layout of the labels, full border or none.

Remote command:

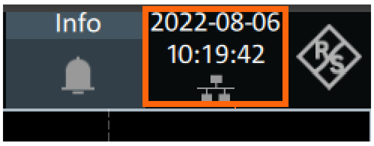
`CALCulate:SPECtrum<sp>:PLISt:LABel:BORDer` on page 372

5.3.6 Miscellaneous

Access: "Settings" > "Appearance" > "Misc"



Clock style
Select how the clock in the upper right corner of the screen is displayed:



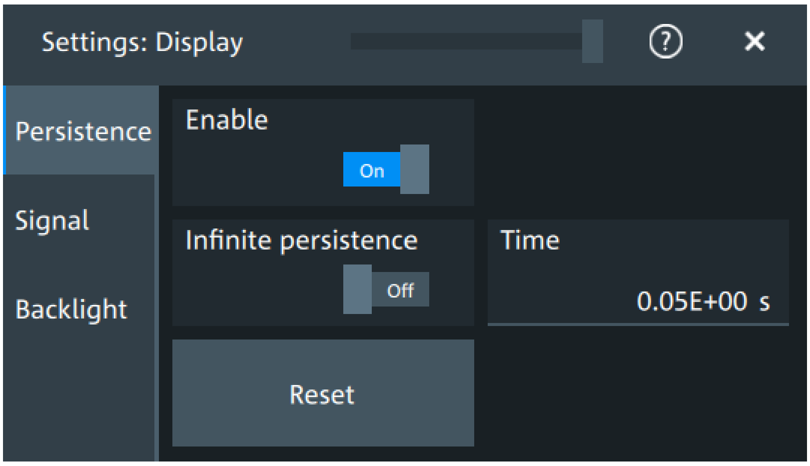
- "Show seconds": format is hh:mm:ss
- "Hide seconds": format is hh:mm
- "Hide clock": no time is shown

5.4 Display settings

In the "Settings" > "Display" dialog, you can define the display settings like brightness and signal intensity.

5.4.1 Persistence settings

Access: "Menu" > "Settings" > "Display" > "Persistence".



Enable
If enabled, each new data point in the diagram area remains on the screen for the duration that is defined using Time, or as long as Infinite persistence is enabled.

If disabled, the waveform points are displayed only for the current acquisition.

Remote command:
`DISPlay:PERSistence[:STATe]` on page 373

Infinite persistence
If infinite persistence is enabled, each new waveform point remains on the screen until this option is disabled. Use infinite persistence to display rare events in the signal.

Remote command:
`DISPlay:PERSistence:INFinite` on page 372

Time
Sets a time factor that controls how long the waveforms points fade away from the display. Thus, the R&S MXO 4 emulates the persistence of analog phosphor screens.

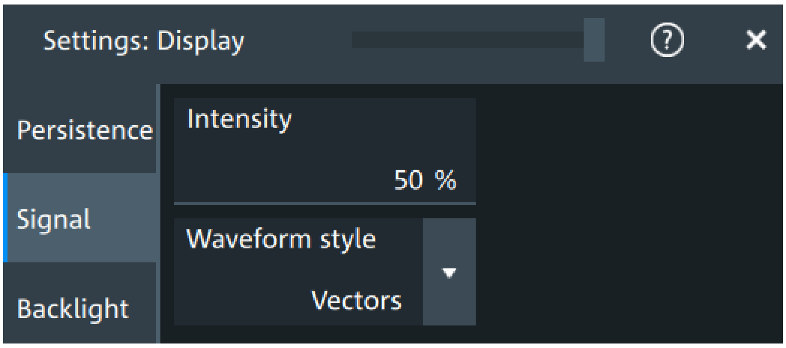
Remote command:
`DISPlay:PERSistence:TIME` on page 373

Reset
Resets the display, removing persistent all waveform points.

Remote command:
`DISPlay:PERSistence:RESet` on page 372

5.4.2 Signal settings

Access: "Menu" > "Settings" > "Display" > "Signal".



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

You can also use the [Intensity] knob to adjust the waveform intensity directly.

Remote command:
`DISPlay:INTensity` on page 373

Waveform style
Selects the style in which the waveform is displayed.

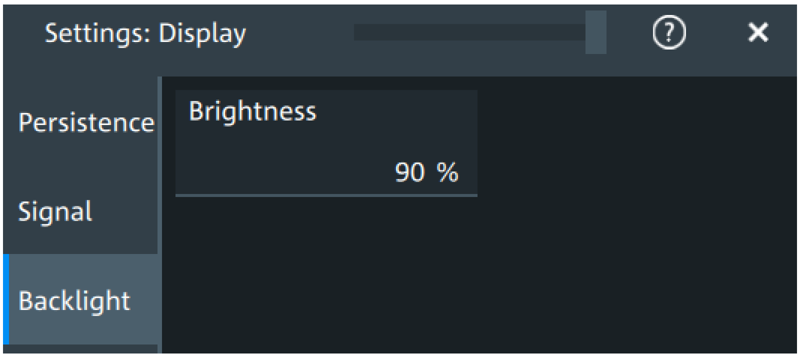
"Vectors" The individual waveform points are connected by a line.
Define the strength of the line using the [Intensity] knob.

"Dots" Only the individual waveform points are displayed.
To see the dots of one waveform, perform one acquisition with [Single] and N=1 (N-single/Avg count). During continuous acquisition, or a [Single] acquisition with N > 1, the dots of multiple subsequent waveforms are displayed on the screen, and the waveform looks like a line.

Remote command:
`DISPlay:DIAGram:STYLe` on page 374

5.4.3 Backlight settings

Access: "Menu" > "Settings" > "Display" > "Backlight".



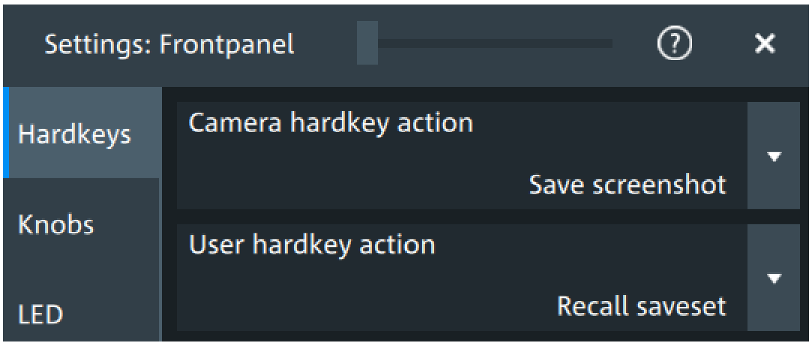
Brightness
Changes the background luminosity of the touchscreen.

5.5 Front panel settings

In the "Front panel" dialog box, you can assign functions to keys and knobs and adjust the brightness of the keys.

5.5.1 Hardkeys: function assignment

Access: "Settings" > "Front panel" > "Hardkeys"



Camera hardkey action
The Camera key on the bottom right is a shortcut key that initiates an associated action.

You can assign one of the following actions:
- Save screenshot
- Open screenshot setup

Configure the settings for the selected action.
- Screenshots: "Save/Recall" key > "Save" tab > "Screenshot", see Chapter 12.4, "Screenshots", on page 246.

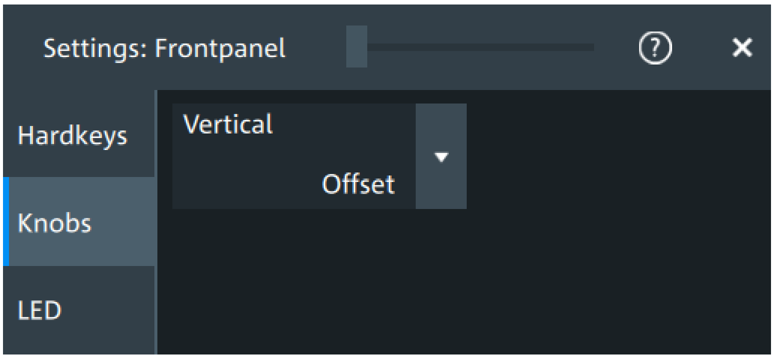
User hardkey action
The [User] key below the spectrum keys is a shortcut key that initiates an associated action.

You can assign one of the following actions:
- Force trigger
- Save saveset
- Recall saveset

For details of saveset configuration, see Chapter 12.1, "Save and recall user settings", on page 234.

5.5.2 Knobs

Access: "Settings" > "Front panel" > "Knobs"

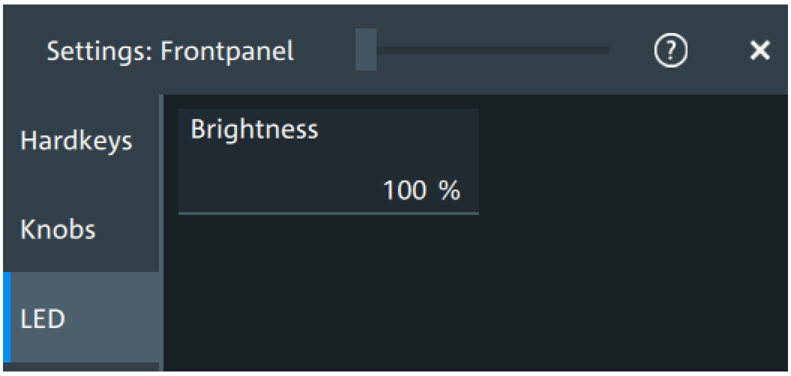


Vertical
The vertical Position knob can change the waveform position or the offset of the selected waveform. Select the action that you want to perform.

See also: "[Position]" on page 37.

5.5.3 LED

Access: "Settings" > "Front panel" > "LED".



Brightness
Defines the luminosity of illuminated front panel keys and knobs.

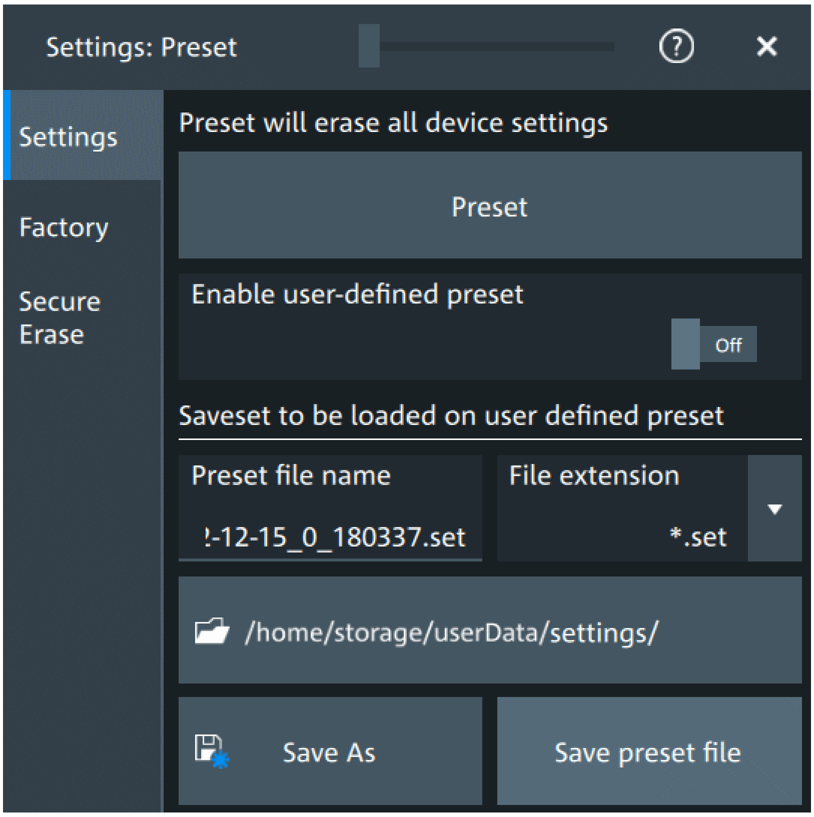
5.6 Preset setup

The preset sets the instrument to a default configuration, or to a user-defined configuration. A user-defined preset file is one of the saveset files, which are stored on the instrument. It contains the instrument setup including display settings, except for transparency and intensity. You can save the current configuration to a preset file, and enable saved preset file to be applied with the [Preset] key.

See also: Chapter 12.1, "Save and recall user settings", on page 234.

5.6.1 Preset settings

Access: "Menu" > "Settings" > "Preset" > "Settings".



Preset
Set the instrument to a default configuration, or to a user-defined configuration.

Enable user-defined preset
If enabled, the settings from the selected saveset are restored when the [Preset] key is pressed.

If disabled, [Preset] sets the instrument to the factory defaults.

Saveset to be loaded on preset
Select the saveset file that contains the required settings. If "Enable user-defined preset" is enabled, this saveset is loaded when you press the [Preset] key.

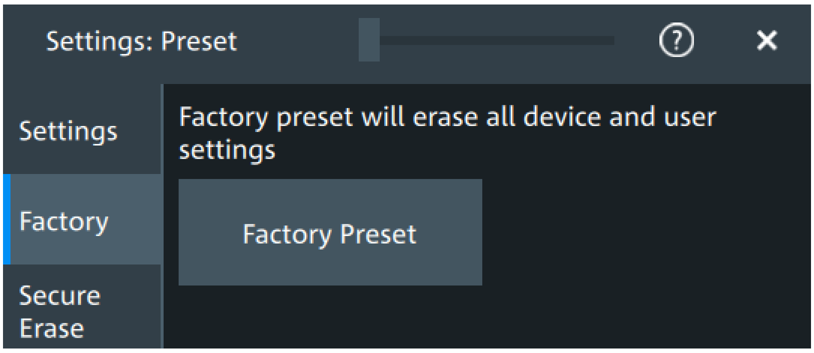
"Preset file name" Enter the filename of the preset file. This file will be loaded on user-defined preset. The filename is also used when you save a preset file with "Preset file name".

"File extension"	The file extension is `.set`.
<Directory>	Shows the currently used directory. To change the directory, tap the button and select the correct directory in the file dialog.

Save as, Save preset file
"Save as" opens the file selection dialog, where you can select the directory and enter the filename of the preset file. "Save preset file" saves the current settings immediately to the file that is named in "Preset file name" in the current dirctory.

5.6.2 Factory preset

Access: "Menu" > "Settings" > "Preset" > "Factory".



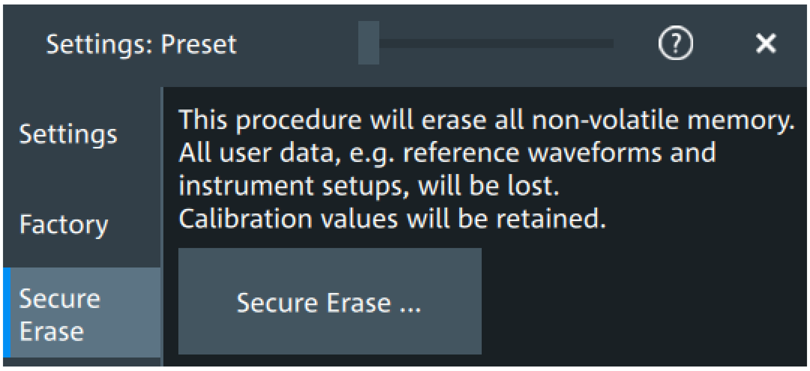
Factory Preset
Resets the instrument to the factory default settings, to the initial state. Factory settings comprise all instrument settings, including display, intensity and transparency settings. After loading factory defaults, perform a self-alignment to synchronize the signal data, see Chapter 5.7.2, "Alignment", on page 87.

5.6.3 Secure erase

Access: "Menu" > "Settings" > "Preset" > "Secure Erase"

To purge all non-volatile memory, a special delete function is available. This function erases all user data, including instrument setups and reference waveforms. Calibration data is retained on the instrument. The instrument reboots after erasing the data.

The procedure is required if user data must not leave the test area with the instrument, e.g. when working in highly secured environments.



5.6.4 Restoring settings

When you have changed many settings on the instrument, and you are not sure which settings are causing which effect, you can restore the default settings and start anew. The following methods are available:

- Saving instrument settings as a user-defined preset and restoring the instrument settings to user-defined default values
- Restoring all settings on the R&S MXO 4 to the factory-defined values
- Restoring settings from a file

To save a user-defined preset

1. Open the "Menu" > "Settings" > "Preset" tab.
2. Enter a name for the preset file. Select the file format.
3. Tap "Save preset file".

   Note: If you want to store the file in another directory than the displayed one, select "Save as". See also: Chapter 12.5, "File selection dialog", on page 249.

To restore the instrument settings to user-defined default values

1. Open the "Menu" > "Settings" > "Preset" > "Settings" tab.
2. In "Preset file name", enter the name of the file that contains the required settings.
3. To use these settings as preset values, select "Enable user-defined preset".
4. Press the [Preset] key.

To restore all settings to the factory defaults

1. Open the "Menu" > "Settings" > "Preset" > "Factory" tab.
2. Tap the "Factory Preset" button.

   All settings on the R&S MXO 4 are reset to their factory-defined values.
   As long as no user-defined preset file is loaded and "Enable user-defined preset" is disabled, the [Preset] key also resets the instrument settings to factory defaults.

5.7 Maintenance settings

In the "Settings" > "Maintenance" dialog box, you can update the firmware, perform self-alignment.

5.7.1 Firmware update

Access: "Menu" > "Settings" >"Maintenance" > "FW Update".

Your instrument is delivered with the latest firmware version. Firmware updates are provided on the internet at:

www.rohde-schwarz.com/firmware/mxo4.

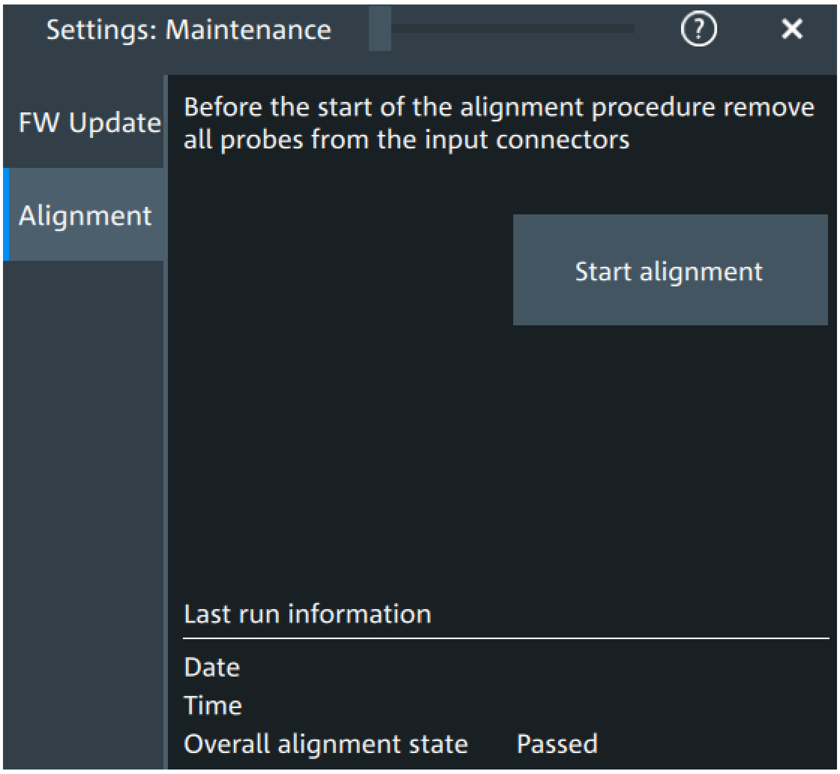
The "Release Notes" describe the improvements and modifications of all firmware versions. They also explain how to update the firmware. They are available along with the firmware on the same web page.

5.7.2 Alignment

When data from several input channels is displayed at the same time, it can be necessary to align the data. Alignment is done vertically or horizontally to synchronize the time bases or amplitudes and positions. Perform an alignment, for example, when strong temperature changes occur (> 5°).

5.7.2.1 Alignment settings

Access: "Menu" > "Settings" > "Maintenance" > "Alignment"



Start alignment

Starts the self-alignment procedure for all channels.

Date, Time, Overall alignment state

Show the date, time and the summary result of the self-alignment process: not aligned, passed or failed. Detailed results are provided on the "Results" tab.

Remote command:

`CALibration:DATE?` on page 376

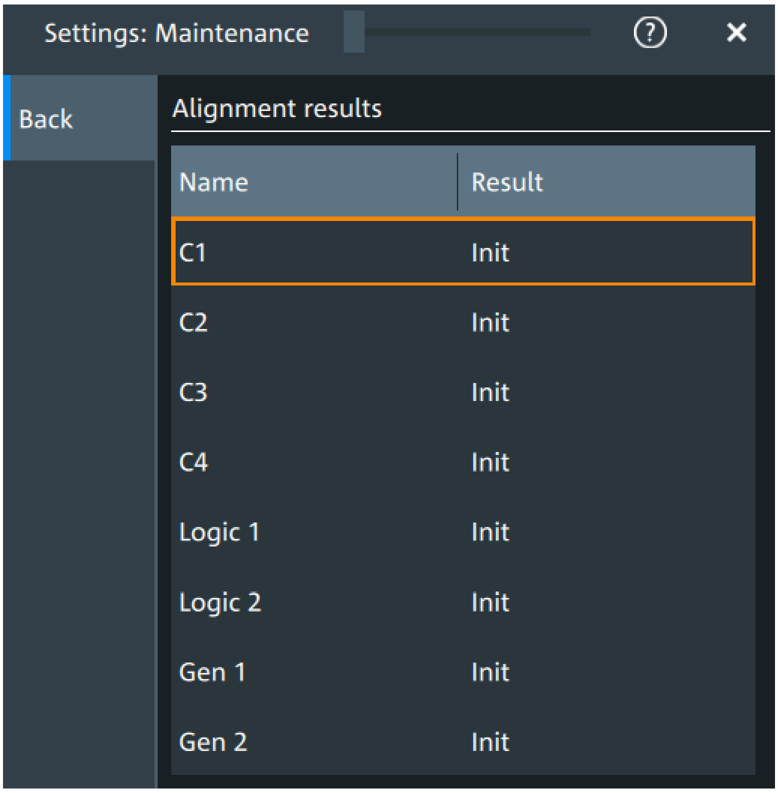
`CALibration:TIME?` on page 376

`CALibration:RESult?` on page 377

Show results

Opens a dialog to display the alignment results.

For each channel, the results of the individual alignment steps are shown for all technical channel component. In case you require support, you may be asked to provide this information.



5.7.2.2 Performing a self-alignment

The self-alignment aligns the data from several input channels vertically and horizontally to synchronize the timebases, amplitudes and positions. The self-alignment process includes a basic hardware check.

Recommendation on performing the self-alignment:

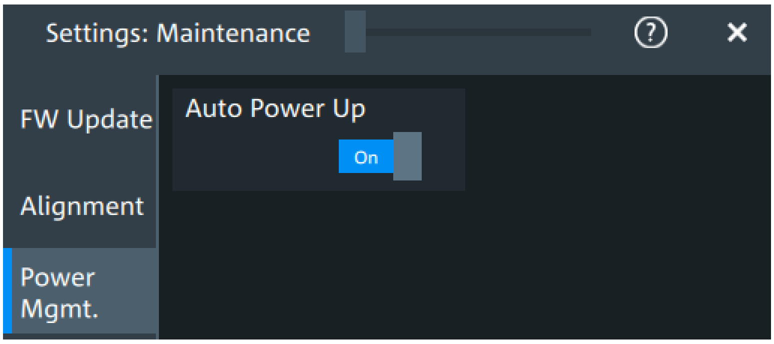
- When putting the instrument into operation for the first time
- After a firmware update
- Once a week
- When major temperature changes occur (> 5°)

1. Warm up the instrument before you start the self-alignment. The minimum warm-up time is indicated in the data sheet.
2. Remove the probes from the input connectors.
3. Open "Menu" > "Settings" > "Maintenance".
4. In the "Alignment" tab, tap "Start alignment".

   The alignment is performed, the process can take several minutes. A message box informs you about the running process, wait until this message box closes.
   The overall pass/fail result is shown in the "Overall alignment state" field.

5.7.3 Power management

Access: "Menu" > "Settings" > "Maintenance" > "Power Mgmt."



Auto power up
If enabled, the instrument powers up automatically when it is connected to the mains voltage.

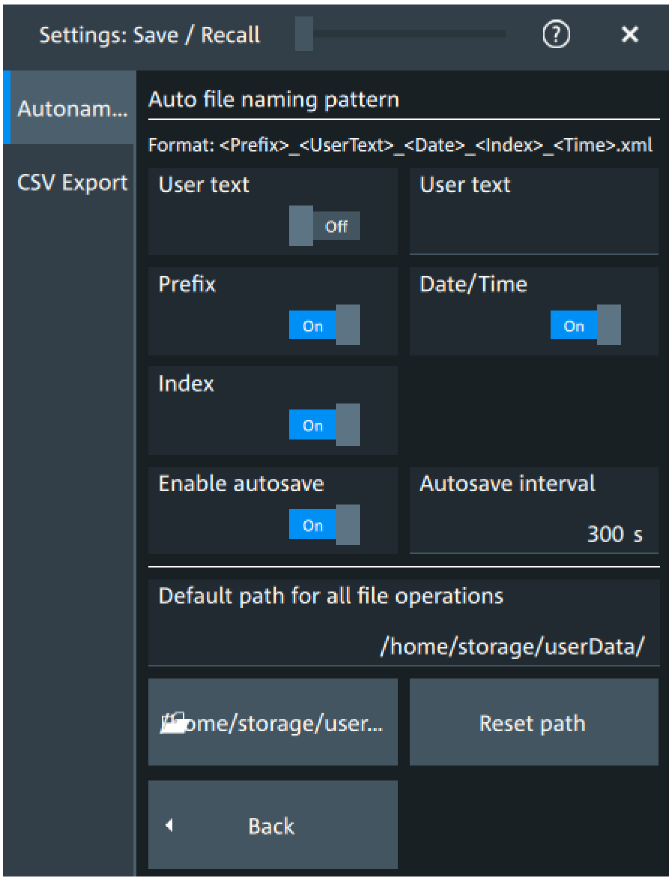
Remote command:
`SYSTem:APUP` on page 377

5.8 Save / recall

5.8.1 Autonaming

Access:"Menu" > "Settings" key > "Save/Recall" > "Autonaming" tab.

5.8.1.1 Autonaming settings



In the "Autonaming" tab, you can define the pattern for automatic file name generation. This name is used as the default file name. The default path is the storage location for all saved files and their subdirectories.

User text

If enabled, inserts the specified user text after the prefix.

Remote command:
`MMEMory:AUTonaming:USERtext` on page 375
`MMEMory:AUTonaming:TEXT` on page 376

Prefix

If enabled, inserts the default prefix in the file name. The prefix indicates the type of data that is saved, for example, RefCurve, Settings.

Remote command:
`MMEMory:AUTonaming:PREFix` on page 374

Date/Time

If enabled, the current date and time are inserted in the filename pattern.

Remote command:
`MMEMory:AUTonaming:TIME` on page 374

Index
If enabled, inserts an index.

Remote command:
`MMEMory:AUTonaming:INDex` on page 374

Enable autosave
Enables the automatic saving of the waveform. With "Autosave interval", you can define the time interval for the automatic saving.

Remote command:
`MMEMory:AUSave:ENABle` on page 375
`MMEMory:AUSave:INTerval` on page 375

Default path for all file operations
Defines the path that is displayed in the file selection dialog box for loading and storing operations. On the instrument, all user data is written to `home/storage/userData`. You can create subfolders in this folder.

If a USB flash drive is connected, the path is set automatically to the drive letter of the USB flash drive.

To switch the directory quickly, double-tap the path button. Use the symbols on the left of the file explorer box to change the directory.

Remote command:
`MMEMory:AUTonaming:DEFaultpath` on page 375

Reset path
Resets the default file path to the factory default.

Remote command:
`MMEMory:AUTonaming:RESPath` on page 376
`MMEMory:AUTonaming:RESall` on page 375

5.8.1.2 Defining default file paths and names

When a save or load operation is performed, a default file name and path is provided. You can configure which path is used and how the file name is generated. In the file selection dialog box, you can change the folder and name as desired.

To define the default file path

1. Tap "Menu" > "Settings".
2. Select the "Save/Recall" tab.
3. Select the "Autonaming" tab.
4. Double-tap the path button.

   The directory selection dialog box is opened.
5. Select the folder in which the data is stored by default. Use the symbols on the left of the file explorer box to switch to often used directories.

Alternatively, you can tap the "Default path for all file operations" field and type the path.

6. To restore the factory-set default path, tap "Reset" next to the path field.

To define the automatic file name pattern

The automatic file name pattern can consist of the following elements:

<Prefix>_<UserText>_<Date>_<Index>_<Time>

The prefix depends on the data type to be stored and cannot be changed by the user. The other elements can be enabled or disabled as required.

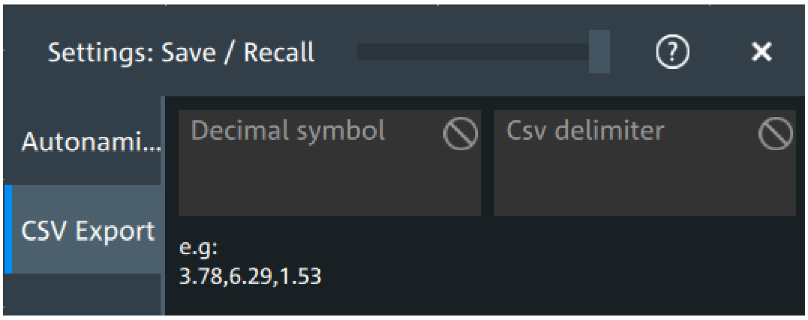
1. Tap "Menu" > "Settings".
2. Select the "Save/Recall" tab.
3. Select the "Autonaming" tab.
4. If you want to exclude the "Prefix", "Date/Time" or an "Index" (serial number), disable the corresponding option.
5. To insert a user-defined text after the prefix, enable "User text". Enter the text in the edit field.

   The specified elements are used to generate the default file name for the next storage operation.

5.8.2 CSV export

Access:"Menu" > "Settings" key > "Save/Recall" > "CSV export" tab.

In this dialog, you can define the format of your CSV file.



Decimal symbol
Selects if point or comma is used as a decimal symbol in the exported CSV file.

CSV delimiter
Selects the list separator symbol from a list. Available are semicolon, comma, space, tab and colon.

Remote command:
`EXPort:RESult:DELimiter` on page 376

6 Acquisition and waveform setup

6.1 Horizontal setup

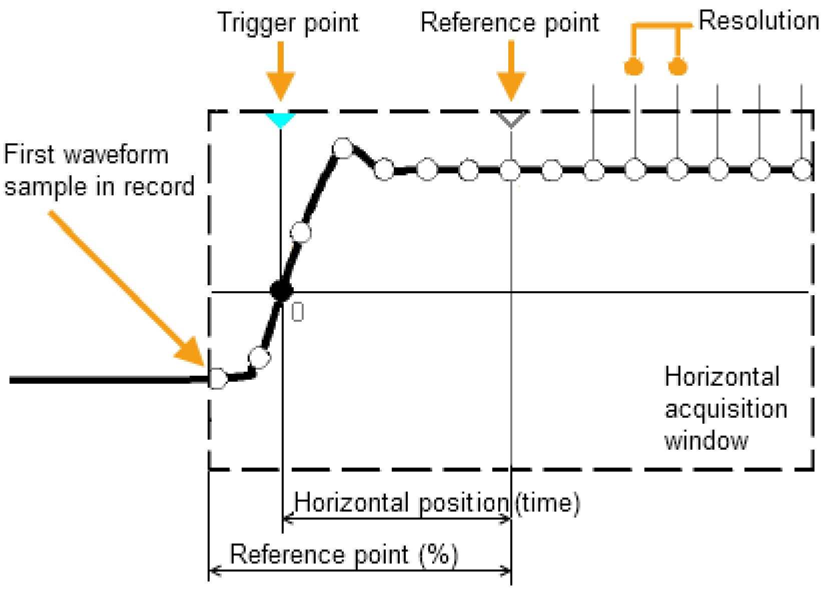
The "Horizontal" dialog provides the time base configuration for channel and spectrum waveforms.

6.1.1 About the horizontal system

Horizontal settings, also known as timebase settings, adjust the waveforms in horizontal direction.

Typically, the trigger is the determining point of the waveform record. In many scenarios, you want to analyze the waveform some time before or after the trigger. To adjust the horizontal acquisition window to the waveform section of interest, you can use the following parameters:

- The **horizontal position** defines the time distance of the trigger point (the zero point of the diagram) to the reference point. Changing the horizontal position, you can move the trigger point, even outside the screen.
- The **reference point** is the rescaling center of the time scale on the screen. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.



Unlike vertical settings, which are waveform-specific, the horizontal settings apply to all active waveforms.

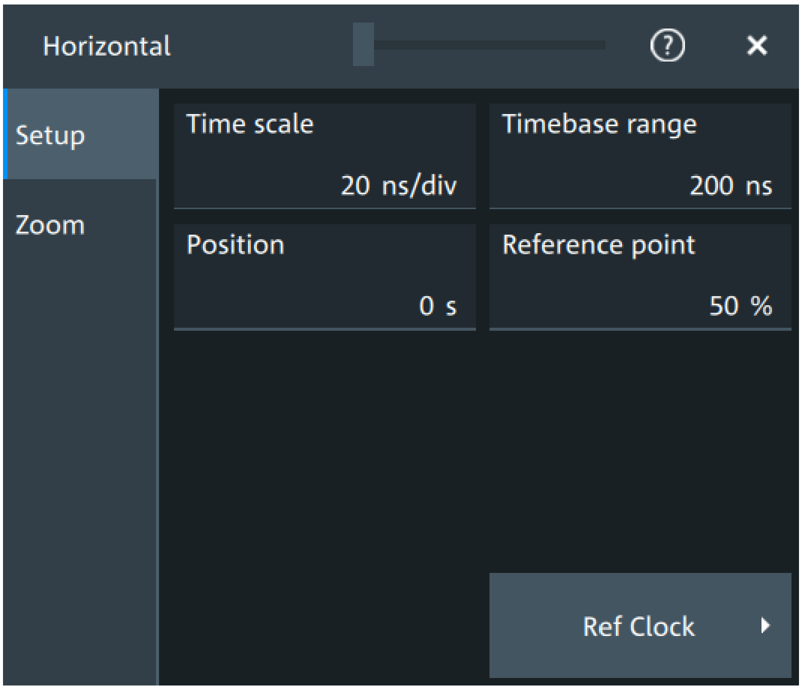
Timebase settings are interdependent:

*Timebase range = Time scale * Number of divisions*

The number of divisions is 10, which is the only constant parameter.

6.1.2 Horizontal Setup settings

Access: "Menu" > "Horizontal" > "Setup" tab, or tap the "Horizontal" label above the diagram.



Time scale
Sets the horizontal scale, the time per division, for all waveforms in the time domain, for example, channel and math waveforms.

Increase the scale to see a longer time interval of the waveform. Decrease the scale to see it in more detail. The scale has a point that remains fixed on the screen when the scale value is changing: the reference point.

Remote command:
`TIMebase:SCALe` on page 378

Timebase range
Sets the time of one acquisition, which is the time across the 10 divisions of the diagram: *Acquisition time = Time scale * 10 divisions*.

Changing the acquisition time changes the time scale, too.

Remote command:
`TIMebase:RANGe` on page 379

Position
Defines the time distance between the reference point and the trigger point, which is the zero point of the diagram. The horizontal position is also known as trigger offset.

If you want to see a section of the waveform some time before or after the trigger, enter this time as horizontal position. The requested waveform section is shown around the reference point. Use positive values to see waveform sections after the trigger - the waveform and the diagram origin move to the left.

Remote command:
TIMebase:HORizontal:POSition on page 379

Reference point
Sets the position of the reference point in % of the screen. It defines which part of the waveform is shown.

The reference point marks the rescaling center of the time scale on the screen. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point. If the "Position" is 0, the trigger point is on the reference point.

The reference point is not marked in the diagram.

Remote command:
TIMebase:REFerence on page 380

6.1.3 Zoom settings

The zoom settings are described in Chapter 8.1, "Zoom", on page 160.

6.1.4 Reference clock

Access: "Menu" > "Horizontal" > "Setup" tab > "Ref Clock"

The oven-controlled crystal oscillator (OCXO) produces a 10 MHz internal reference signal with precise and stable frequency. You can output this clock signal for synchronization of other instruments. Conversely, you can also use an external 10 MHz reference signal. The input and output connectors for reference signals are on the rear panel of the instrument.

Use external ref. clock
Enables the use of an external 10 MHz reference signal instead of the internal reference clock.

Remote command:
SENSe[:ROSCillator]:SOURce on page 407

Output 10 MHz ref. signal
Sends the internal reference clock signal to the Ref. Out connector.

If "Use external ref. clock" is enabled, the external reference signal is output instead of the internal clock.

Remote command:
SENSe[:ROSCillator]:OUTPut[:ENABle] on page 406

6.2 Acquisition

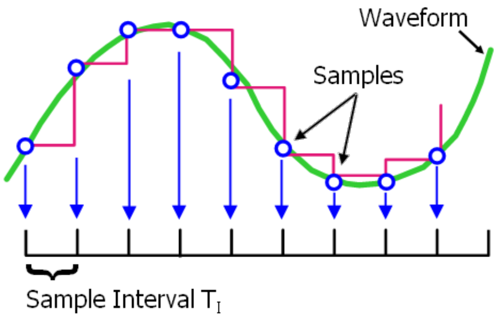
Access: "Menu" > "Acquisition".

Acquisition settings define the processing of the captured samples in the instrument.

6.2.1 About the acquisition system

Sampling and processing

The A/D converter samples the continuous signal under test at specific points in time and captures digital values. The converter is working at a constant rate specified in GHz.



The captured values are processed according to the acquisition settings. The result is a waveform record that contains **waveform samples** and is stored in the **waveform memory**. The waveform samples are displayed on the screen and build up the waveform.

The number of waveform samples in one waveform record is called **record length**. The rate of recording waveform samples - the number of waveform samples per second - is the **sample rate**. The higher the sample rate, the better the resolution is and the more details of the waveform are visible.

Sample rate = 1 / Resolution

The sample rate can be the same as the constant rate of the A/D converter, or higher, or lower. To get a higher sample rate, interpolation is used. Several interpolation methods are available. Other processing methods reduce the sample rate, or build the resulting waveform from several consecutive acquisitions of the signal. These methods are called acquisition modes.

Minimum sample rate and aliasing

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, the sample rate must be at least 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.

Interleaving

The R&S MXO 4 achieves its highest sample rate by interleaving two channels: channels 1 and 2 are interleaved, and also channel 3 and 4. Interleaving assumes that only one of the paired channels can be used - either channel 1 or channel 2, and either channel 3 or 4. If the second channel of a pair is used (on display, or as trigger source, math source, or measurement source), the interleaving mode is disabled.

6.2.2 Acquisition Setup settings

Access: "Menu" > "Acquisition" > "Setup" tab.

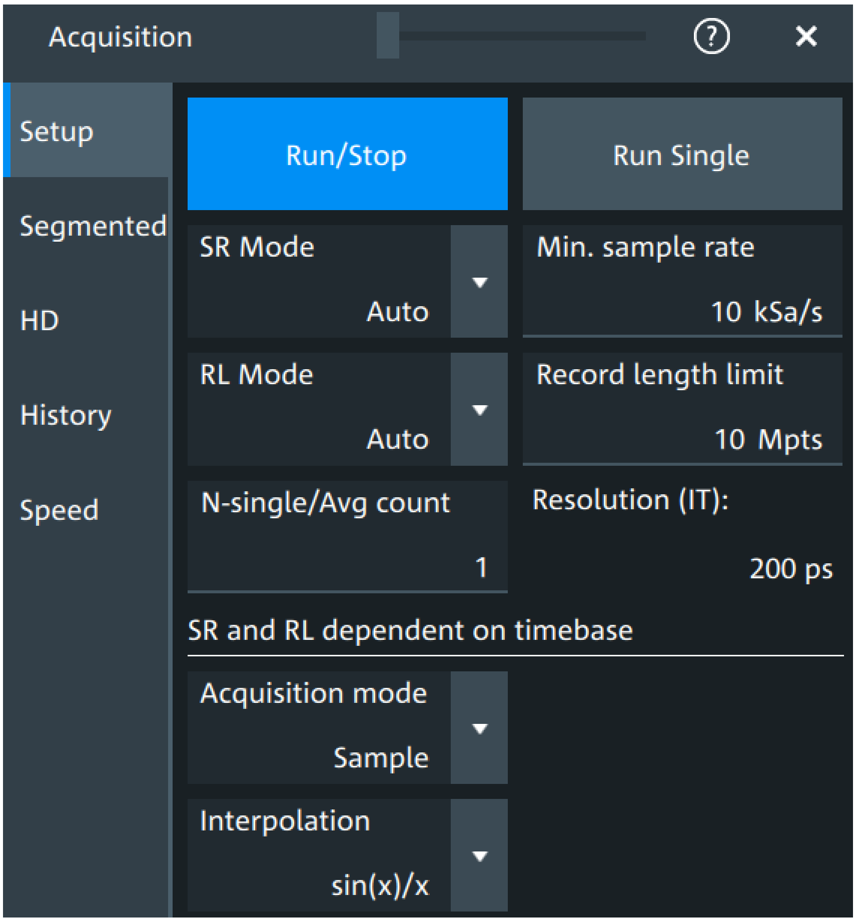


Figure 6-1: Acquisition settings: automatic sample rate and record length

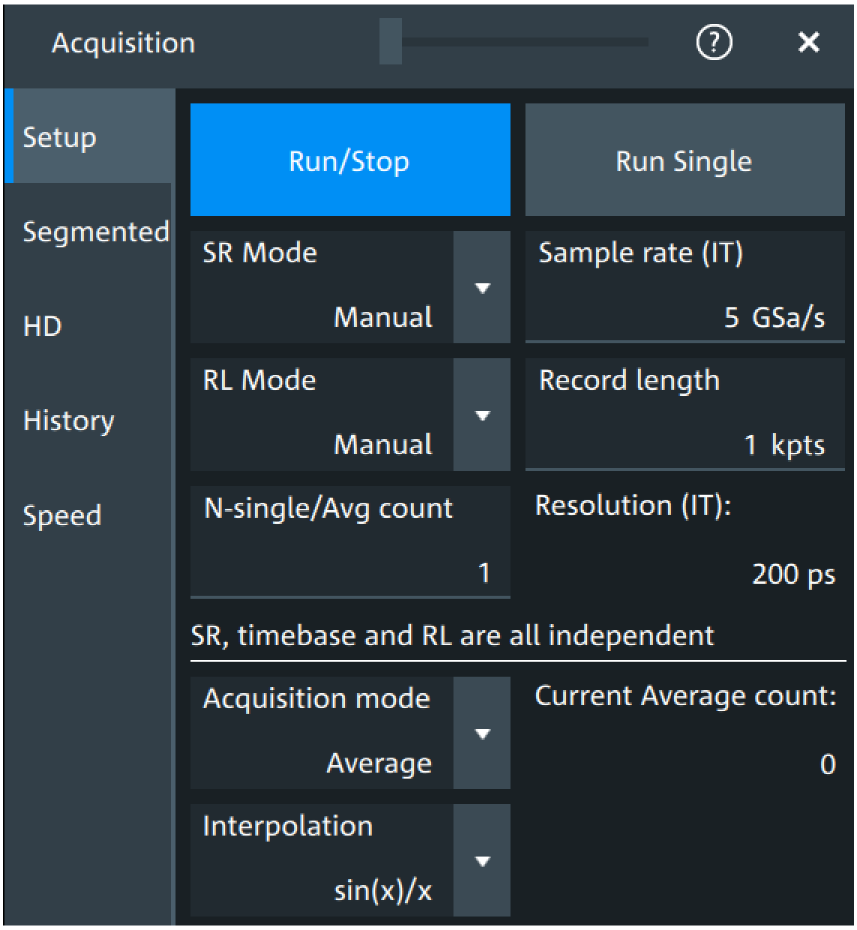


Figure 6-2: Acquisition settings: manual sample rate and record length

Run/Stop
Starts and stops the continuous acquisition. The [Run / Stop] key lights green when the acquisition is running. When the acquisition is stopped, the key lights red.

Remote command:
`RUN` on page 377
`STOP` on page 378

Run Single
Starts a defined number of acquisitions. The [Single] key lights green when the acquisition is running. When the acquisition is stopped, the key lights red.

To set the number of acquisitions, set "N-single/Avg count" in the "Acquisition" setup.

Remote command:
`SINGle` on page 378

SR mode
Defines how the sample rate is set.

"Auto" Sample rate is determined automatically and changes due to instrument internal adjustments due to other setting changes.

"Manual" The sample rate is manually defined with "Sample rate", "Min. sample rate".

Remote command:
ACQuire:SRATe:MODE on page 390

RL mode
Selects the mode of the waveform record length adjustment.

"Auto" Record length is determined automatically and changes due to instrument internal adjustments due to other setting changes.

"Manual" The waveform record length is manually defined with "Record length", "Record length limit".

Remote command:
ACQuire:POINts:MODE on page 389

Sample rate, Min. sample rate
Sets the number of waveform points per second in manual sample rate mode. In automatic sample rate mode, it sets the minimum value of the sample rate for automatic calculation.

The sample rate considers the samples of the ADC, and the processing of the captured samples including interpolation.

The setting is relevant, if "SR mode" is set to "Manual".

Remote command:
ACQuire:SRATe[:VALue] on page 390

Record length, Record length limit
Sets the record length in manual record length mode. In automatic record length mode, it sets the maximum value of the record length for automatic calculation.

The record length is the number of waveform samples that are stored in one waveform record after processing, including interpolation.

Remote command:
ACQuire:POINts[:VALue] on page 388

N-single/Avg count
The acquisition and average count has several effects:
- It sets the number of waveforms acquired with [Single].
- It defines the number of waveforms used to calculate the average waveform. Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the value is, the better the noise is reduced.
- It sets the number of acquisitions to be acquired in a fast segmentation acquisition series. Thus, you can acquire exactly one fast segmentation acquisition series with [Single].

Remote command:
ACQuire:COUNt on page 387

Resolution

Defines the time between two waveform samples in the waveform record. It considers the processing of the captured samples including interpolation. A fine resolution with low values produces a more precise waveform record.

The resolution is the reciprocal of the sample rate.

Remote command:
`ACQuire:RESolution` on page 389

Acquisition mode

Sets how the waveform is built from the captured samples.

"Sample"	Usually, most signals are displayed optimally with this acquisition mode but very short glitches can remain undiscovered by this method.
"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.
"Envelope"	Each acquisition is done in sample mode, and the minimum and maximum values over some consecutive acquisitions build the envelope.
"Average"	The average is calculated from the data of the current acquisition and a specific number of consecutive acquisitions before. The method reduces random noise. It requires a stable, triggered and repetitive signal. The number of acquisitions for average calculation is defined with N-single/Avg count. If the waveform is clipped, the instrument shows a distorted average waveform to indicate the clipping. Adjust the vertical scale to avoid the clipping.

Remote command:
`ACQuire:TYPE` on page 391

Current Average count

Shows the current number of acquired waveforms that contribute to the average, for Acquisition mode = "Average".

Remote command:
`ACQuire:AVERage?` on page 387

Interpolation

Selects the interpolation method.

If the defined sample rate ("Sample rate", "Min. sample rate") is higher than the ADC sample rate, interpolation adds points between the captured samples of the waveform by various mathematic methods. The selected interpolation method is also used for zooming.

"Linear"	Two adjacent ADC sample points are connected by a straight line, the interpolated points are located on the line. You see a polygonal waveform similar to the real signal, and also the ADC sample points as vertexes.

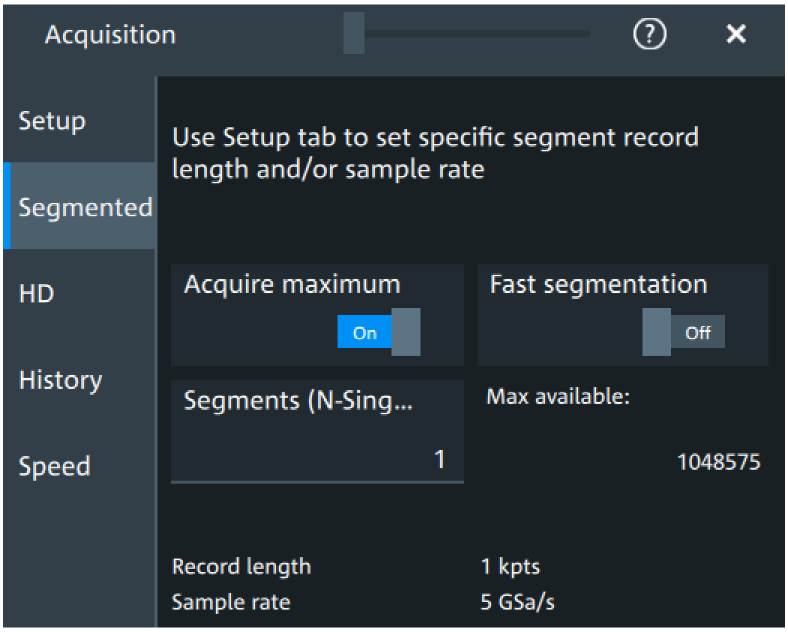
"sin (x)/x"	Two adjacent ADC sample points are connected by a sin(x)/x curve, and also the adjoining sample points are considered by this curve. The interpolated points are located on the resulting curve. This interpolation method is precise and shows the best signal curve.
"Sample/Hold"	The ADC sample points are displayed like a histogram. For each sample interval, the voltage is taken from the sample point and considered as constant, and the intervals are connected with vertical lines. Thus, you see the discrete values of the ADC - the measured samples.

Remote command:
`ACQuire:INTerpolate` on page 388

6.2.3 Segmentation settings

Access: "Menu" > "Acquisition" > "Segmented" tab.

You can acquire a limited number of segments, or the maximum number.



Acquire maximum
If "On", the instrument acquires the maximum number of segments that can be stored in the memory. The maximum number depends on the current sample rate and record length settings and is shown in the "Max available" field.

If "Off", set the number of segments in "Segments (N-Single)" that is the same setting as "N-single/Avg count" on the "Setup" tab. Thus you can acquire exactly one fast segmentation acquisition series with [Single].

You can stop the running acquisition before the series is completed.

The number of acquired waveforms is shown in the "History" dialog, when the history is active.

Remote command:
`ACQuire:SEGMented:MAX` on page 391

Fast segmentation
If fast segmentation is enabled, the acquisitions are performed as fast as possible, without processing and displaying the waveforms. When acquisition has been stopped, the data is processed and the latest waveform is displayed. Older waveforms are stored in segments. You can display and analyze the segments using the history.

Remote command:
`ACQuire:SEGMented:STATe` on page 391

Segments (N-Single)
See "N-single/Avg count" on page 100.

Max available
Shows the maximum number of segments that can be captured with current sample rate and record length settings.

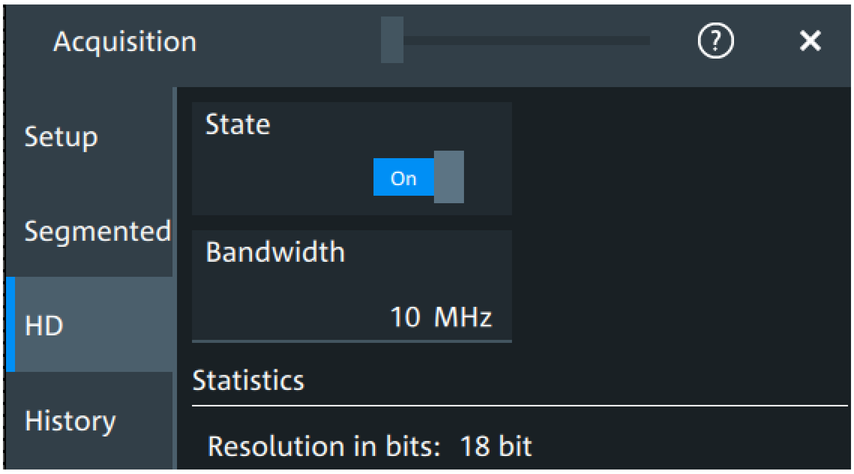
6.2.4 High definition mode

The high definition mode increases the numeric resolution of the waveform signal by using digital filtering, leading to reduced noise. The higher vertical resolution reduces quantization noise and acquires waveforms of higher accuracy with finer details of the signal to be seen. The high definition is also applied to the digital trigger, thus the R&S MXO 4 can trigger with the same high resolution with which they can display signals.

The maximum numeric resolution in high definition mode is 18 bit. The actual value depends on the selected bandwidth. Increasing the bandwidth reduces the resulting digital resolution. For dependencies and details, refer to the R&S MXO 4 specifications.

6.2.4.1 High definition settings

Access: [HD]



High definition is a special acquisition mode of the oscilloscope. This mode has only one setting - the filter bandwidth.

State
Enables high definition mode, which increases the numeric resolution of the waveform signal.

Remote command:
`HDEFinition:STATe` on page 406

Bandwidth
Sets the filter bandwidth for the high definition mode.

Increasing the bandwidth reduces the resulting digital resolution. For dependencies and details, refer to R&S MXO 4 specifications.

Remote command:
`HDEFinition:BWIDth` on page 405

Resolution in bits
Displays the resulting vertical resolution in high definition mode. The higher the filter bandwidth, the lower the resolution.

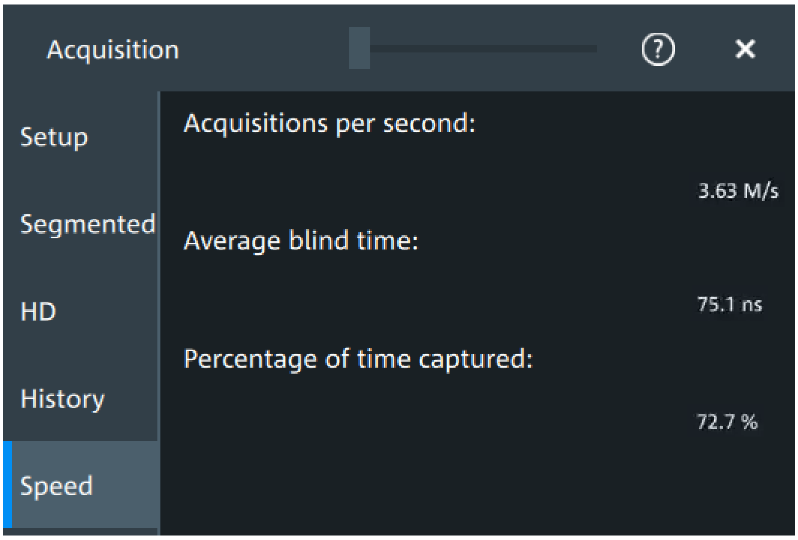
Remote command:
`HDEFinition:RESolution?` on page 406

6.2.5 History settings

The history settings are described in Chapter 8.3.2, "History setup", on page 171.

6.2.6 Speed

Access: "Menu" > "Acquisition" > "Speed" tab.



The "Speed" dialog shows information on the current acquisition performance values of the R&S MXO 4.

You can see the number of "Acquisitions per second", "Average blind time" and the "Percentage of time captured".

6.3 Vertical setup

The controls and parameters of the vertical system adjust the vertical scale and position of the waveform, and the waveform display. The probe settings also belong to the vertical setup.

The signal icons at the bottom of the display show the most important actual settings for each channel. The signal icon also indicates if the incoming data is clipped before processing, i.e. the input range of the ADC is exceeded.

There are several ways to adjust vertical settings:

- Use the keys and knobs in the Vertical functional block of the front panel to select the channel, to scale the waveform, and to set the position or offset. See Chapter 3.2.4.4, "Vertical controls", on page 36.
- Drag one finger vertically on the screen to change the position of the selected channel waveform.
- Spread or pinch two fingers in vertical direction to change the vertical scale of the selected waveform.
- Use the "Vertical" dialog to adjust all vertical settings. See:
  - Chapter 6.3.2, "Vertical Setup settings", on page 106
  - Chapter 6.3.3, "Bandwidth settings", on page 109
  - Chapter 6.4, "Probes", on page 111
  - Chapter 6.3.5, "Other vertical settings", on page 110

6.3.1 About the vertical system

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

Vertical scale and resolution

Vertical scale and vertical position directly affect the resolution of the waveform amplitude. The vertical scale corresponds to the ADC input range. To get the full resolution of the ADC, set up the waveforms to cover most of the height of the diagram.

With an R&S MXO 4, you work with multiple diagrams, and each diagram obtains the full vertical resolution, no matter where the diagram is placed. Therefore, use a separate diagram for each waveform instead of the traditional setup that arranges the waveforms side by side in one diagram.

Bandwidth

For analog applications, the highest signal frequency determines the required oscilloscope bandwidth. The oscilloscope bandwidth should be higher than the maximum frequency included in the analog test signal to measure the amplitude with very little measurement error. To avoid aliasing, the oscilloscope bandwidth should be at least 3 times higher than the maximum frequency included in the signal.

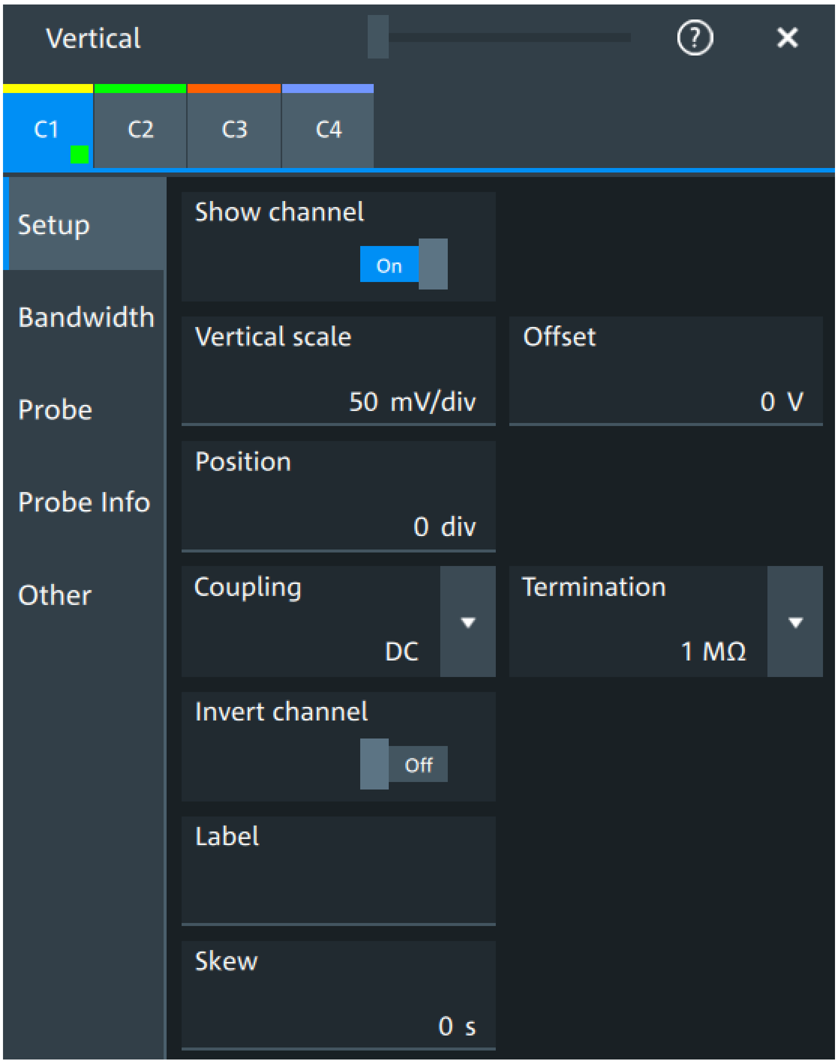
Most test signals are more complex than a simple sine wave and include several spectral components. A digital signal, for example, is built up of several odd harmonics. For digital signals, the oscilloscope bandwidth should be at least 5 times higher than the clock frequency to be measured.

The oscilloscope is not a stand-alone system. You need a probe to measure the signal of interest, and the probe has a limited bandwidth, too. The combination of oscilloscope and probe creates a system bandwidth. To reduce the effect of the probe on the system bandwidth, the probe bandwidth should exceed the bandwidth of the oscilloscope, the recommended factor is 1.5 x oscilloscope bandwidth.

6.3.2 Vertical Setup settings

Access: "Menu" > "Vertical" > "Setup" tab

The "Setup" tab provides all basic vertical settings. The channels are listed in horizontal subtabs. Make sure to select the correct channel tab before you enter the settings.



Show channel

Switches the selected channel signal on or off.

The signal icon opens on the signal bar. The waveform of the last acquisition is displayed in the diagram.

Remote command:

`CHANnel<ch>:STATe` on page 380

Vertical scale

Sets the vertical scale in Volts per division. The vertical scale defines the displayed amplitude of the selected waveform.

The current value is shown in the signal icon. Vertical scale directly affects the resolution of the waveform amplitude. To get the best resolution of the ADC, set the waveforms to cover most of the height of the diagram.

Remote command:

`CHANnel<ch>:SCALe` on page 380

Offset

Sets the offset voltage, which corrects an offset-affected signal. The vertical center of the selected channel is shifted by the offset value and the signal is repositioned within the diagram.

To set the offset automatically, use [Autoset]. The current value is shown in the signal icon.

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.

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

If a Rohde & Schwarz differential probe is connected, set the common-mode offset to compensate for a common DC voltage applied to both input sockets (referenced to the ground socket). Thus, you can measure on differential signals with high common mode levels. You can measure the common mode input voltage using the R&S ProbeMeter.

Remote command:
`CHANnel<ch>:OFFSet` on page 381

Position

Moves the selected signal up or down in the diagram. While the offset sets a voltage, position is a graphical setting given in divisions. The visual effect is the same as for offset.

Remote command:
`CHANnel<ch>:POSition` on page 381

Coupling

Sets the filter for the input signal. The coupling determines what part of the signal is used for waveform analysis and triggering.

The selected coupling is shown in the signal icon.

"DC" Passes both DC and AC components of the signal.

"AC" Connection through DC capacitor, removes DC and very low-frequency components. AC coupling is useful if the DC component of a signal is of no interest. The waveform is centered on zero volts.

If AC coupling is set, the attenuation of passive probes has no effect, and voltage is applied to the instrument with factor 1:1. Observe the voltage limits, otherwise you can damage the instrument.

Remote command:
`CHANnel<ch>:COUPling` on page 382

Termination

Selects the input impedance of the channel input according to the connected probe.

Connection with 50 Ω termination is used to connect, for example, active probes. Connection with 1 MΩ termination is used to connect standard passive probes.

Remote command:
`CHANnel<ch>:COUPling` on page 382

Invert channel
Turns the inversion of the signal amplitude on or off. To invert means to reflect the voltage values of all signal components against the ground level.

Inversion is indicated in the signal icon by line above the channel name.

Remote command:
`CHANnel<ch>:INVert` on page 382

Label
Defines a label text. The label is shown at the waveform on the right edge of the display.

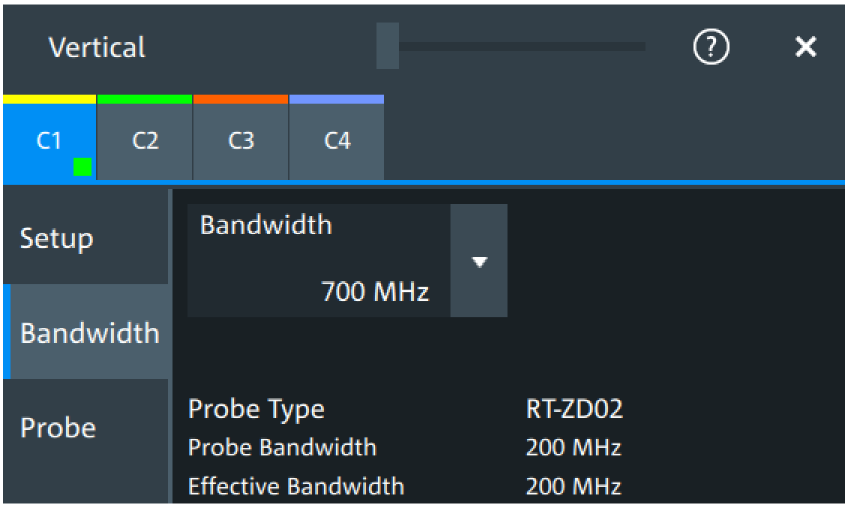
Skew
Sets a skew value to compensate for the delay of the measurement setup or from the circuit specifics that the instrument cannot compensate automatically. It affects only the selected input channel.

Remote command:
`CHANnel<ch>:SKEW:TIME` on page 383

6.3.3 Bandwidth settings

Access: "Menu" > "Vertical" > "Bandwidth" tab

The "Bandwidth" tab provides all settings that affect the bandwidth of the measurement system. The channels are listed in horizontal subtabs. Make sure to select the correct channel tab before you enter the settings.



Bandwidth
Sets the bandwidth limit. The specified bandwidth indicates the range of frequencies that the instrument can acquire and display accurately with less than 3 dB attenuation. Frequencies above the limit are removed from the signal, and noise is reduced.

The selected bandwidth is shown on the signal icon.

For basic information, see also: "Bandwidth" on page 106.

"Full" At full bandwidth, all frequencies in the instrument's frequency range are acquired and displayed. Full bandwidth is used for most applications. However, at full bandwidth, the displayed bandwidth can be less than the instrument bandwidth depending on the number of active channels and other settings.

"xx MHz" Frequencies above the selected limit are removed to reduce noise.

Remote command:
`CHANnel<ch>:BANDwidth` on page 383

Probe Type, Probe Bandwidth
Shows the type of the connected probe and its bandwidth. The probe is recognized automatically, or selected in the "Probe" tab. See Chapter 6.4.1, "Common probe settings", on page 111.

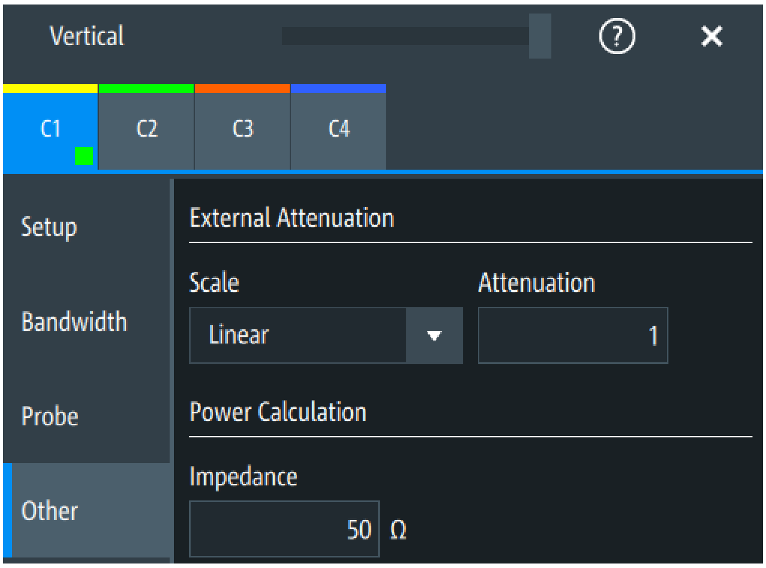
Effective Bandwidth
Shows the effective bandwidth of probe and oscilloscope system.

6.3.4 Probe settings

See Chapter 6.4, "Probes", on page 111.

6.3.5 Other vertical settings

Access: "Menu" > "Vertical" > "Other" tab



External Attenuation: Scale, Attenuation
Consider a voltage divider that is part of the DUT before the measuring point. The external attenuation is included in the measurement, and the instrument shows the results that would be measured before the divider. External attenuation can be used with all probes.

"Scale" Select linear or logarithmic attenuation scale.

"Attenuation" Enter the attenuation of the voltage divider according to the selected scale. The conversion from linear to logarithmic values depends on the "Vertical unit" of the probe:
For voltage-based unit (V and A):
$attenuation\ (dB) = 20 * log_{10}(attenuation\ factor)$
For power-based unit (W):
$attenuation\ (dB) = 10 * log_{10}(attenuation\ factor)$

Remote command:
`CHANnel<ch>:EATScale` on page 384
`CHANnel<ch>:EATTenuation` on page 384

Impedance
Sets the impedance of the connected probe for power calculations and measurements.

Remote command:
`CHANnel<ch>:IMPedance` on page 384

6.4 Probes

With R&S MXO 4 oscilloscopes, you can use various probe types. Mostly these probes are passive and active voltage probes. The instrument can detect many probes and read out the probe-specific parameters, for example, bandwidth and attenuation.

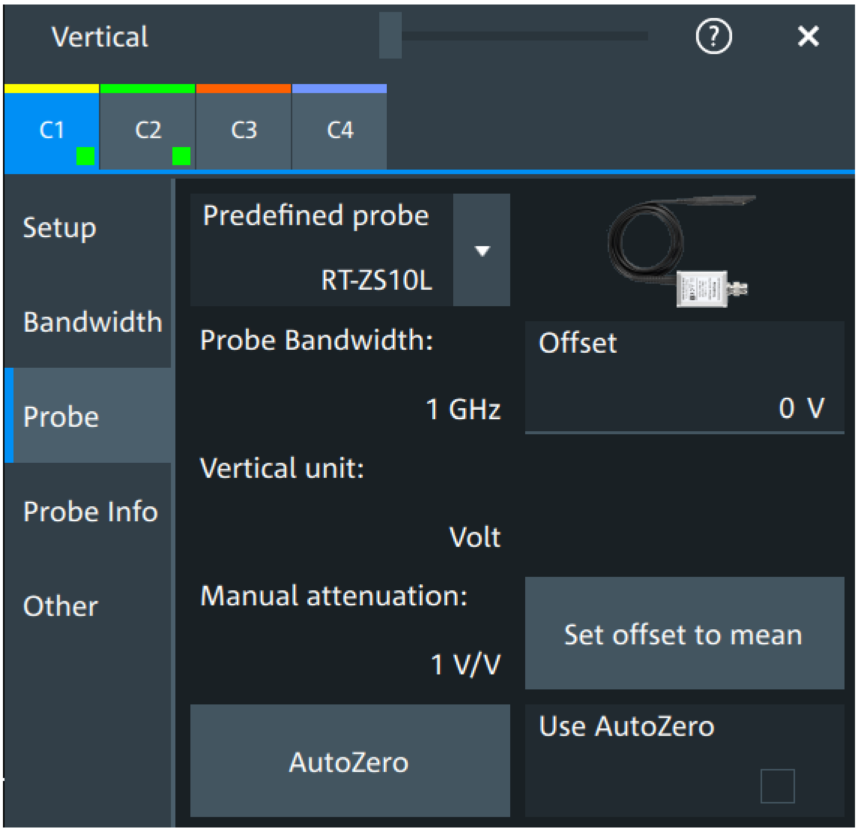
You find all settings that are relevant for the connected probe in the "Vertical" > "Probe" tab. The settings on the "Probe" tab change according to the type of the attached probe. Probes with Rohde & Schwarz probe interface (probe box), and also many other passive voltage probes, are recognized by the instrument. The R&S MXO 4 reads out the main characteristics of the probe and displays them. Other probes cannot be detected, but their characteristics are known to the instrument. These known probes are called "Predefined probes". Probes that are not recognized automatically and not predefined are unknown probes, they require manual setting of measurement unit and attenuation.

The complete characteristic of the connected probe is shown on the "Vertical" > "Probe Info" tab.

6.4.1 Common probe settings

Access: "Menu" > "Vertical" > "Probe" tab

Most the settings in the "Probe" tab are available for all probes. For some probe types, additional settings are needed. These settings are described in the sections for the individual probe types.



An external attenuation can be set on the "Other" tab, see Chapter 6.3.5, "Other vertical settings", on page 110.

The common probe settings are:

Predefined probe, name and type of the probe

The model name and type of a detected probe are shown in the dialog.

If the instrument cannot recognize the probe, "None" is indicated in the "Predefined probe" list. Select the used probe on the list. The corresponding bandwidth, and attenuation or gain are shown.

If the probe is not detected and not listed as predefined probe, it is an unknown probe. To configure these probes, set "Predefined probe" to "User-Defined". Then adjust the Vertical unit and Manual attenuation.

Remote command:
PROBe<ch>:SETup:NAME? on page 395
PROBe<ch>:SETup:TYPE? on page 396

PROBe<ch>:SETup:STATe? on page 395
PROBe<ch>:SETup:ATTenuation:DEFProbe on page 393

Probe Bandwidth
Shows the bandwidth of the connected probe. For probes that are not detected or predefined, set the bandwidth manually.

Remote command:
PROBe<ch>:SETup:BANDwidth? on page 394

Offset
Channel offset that is also set on "Vertical" > "Setup" tab. See "Offset" on page 108.

Vertical unit
Shows the unit of the connected probe if the probe is detected or predefined. For unknown probes, select the unit that the probe can measure.

Remote command:
PROBe<ch>:SETup:ATTenuation:UNIT on page 393

Manual attenuation
Shows the attenuation of the connected probe if the probe is detected or predefined. For unknown probes, set the correct attenuation of the probe.

The vertical scaling and measured values are multiplied by this factor so that the displayed values are equal to the actual measured signal values.

Make sure to set the attenuation factor on the instrument according to the probe being used. Otherwise, the measurement results do not reflect the actual voltage level, and you might misjudge the actual risk.

Remote command:
PROBe<ch>:SETup:ATTenuation[:AUTO]? on page 392
PROBe<ch>:SETup:ATTenuation:MANual on page 393

Set offset to mean
Compensates automatically for a DC component of the input signal using the result of a background mean measurement.

The result is shown in "Offset". The function is probe-independent and supports quick and convenient measurements of input signals with different DC offsets. It detects offset values even when the signal is out of the current measurement range. It also sets the zero level to the determined DC offset in the middle of the screen and thus prevents clipping of the waveform.

Remote command:
PROBe<ch>:SETup:OFFSet:TOMean on page 394

AutoZero, Use AutoZero
Differences in DUT and oscilloscope ground levels can cause larger zero errors, which affect the waveform. If the DUT is ground-referenced, the AutoZero function corrects the zero error of the probe to optimize measurement results at small signal levels. The validation limit depends on the probe attenuation because probes with high attenuation often have to compensate high offsets. AutoZero detects offset values even when the signal is out of the current measurement range.

To correct the zero error of voltage probes, short the signal pin and the ground pin together and connect them to the ground of the DUT. Then tap "AutoZero". While the alignment is running, the instrument switches to DC coupling to display the waveform correctly.

To include the measured offset in measurement results, enable "Use AutoZero".

If a current probe is connected, the function demagnetizes the probe's sensor head and sets the waveform to zero position.

Remote command:
`PROBe<ch>:SETup:OFFSet:AZERo` on page 394
`PROBe<ch>:SETup:OFFSet:USEautozero` on page 395

6.4.2 Setup for passive probes

Passive probes are the most widely used probes for voltage measurements with oscilloscopes. If a passive probe is connected, the probe attenuation is read out and shown in the "Probe" tab.

Passive probes require compensation, see Chapter 6.4.6, "Adjusting passive probes", on page 125.

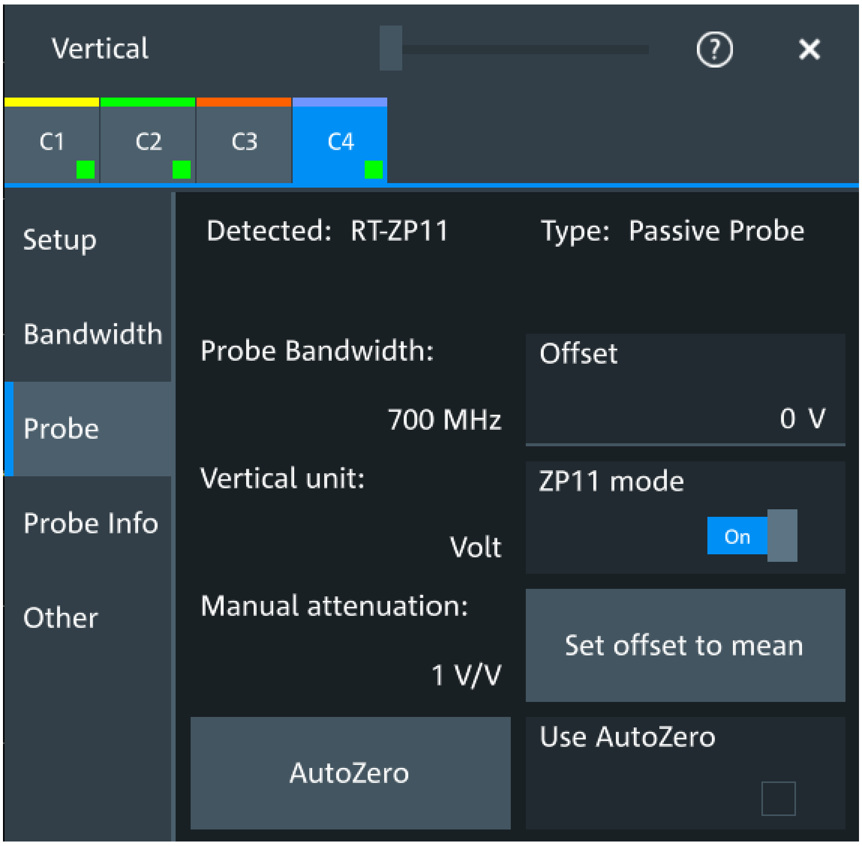


Figure 6-3: Passive probe R&S RT-ZP11, detected by the oscilloscope

The settings for passive probes are common settings, which are available for all probe types. See Chapter 6.4.1, "Common probe settings", on page 111 for description of the settings.

For R&S RT-ZP11, a special setting is available.

ZP11 mode
Enable if R&S RT-ZP11 is connected to adjust the probe bandwidth to 700 MHz.

If you use 500 MHz passive probe, e.g. R&S RT-ZP10, disable the setting.

6.4.3 Setup for active voltage probes

Active voltage probes with Rohde & Schwarz probe interface have an integrated data memory that contains identification data and individual probe correction parameters. The R&S MXO 4 can detect these probes and read out the data. Furthermore, the Rohde & Schwarz probe interface provides special features: the micro button and the ProbeMeter.

Active voltage probes that are offered by Rohde & Schwarz but not equipped with a Rohde & Schwarz probe interface are known to the R&S MXO 4 as predefined probes.

6.4.3.1 Settings for the Rohde & Schwarz probe interface

The Rohde & Schwarz probe interface provides special features: the micro button and the ProbeMeter.

MicroButton

The micro button is located on the probe head. Pressing this button, you initiate an action on the instrument directly from the probe. The button is disabled during internal automatic processes, for example, during self alignment, autoset, and level detection.

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

"Run Continuous"
Starts or stops the acquisition (same as Run / Stop key).

"Run single" Starts a defined number of acquisitions (same as [Single] key).

"Auto set" Starts the autoset procedure (same as Autoset key).

"AutoZero" Starts an auto zero measurement.

"Set offset to mean"
Performs an automatic compensation for a DC component of the input signal using the result of a background mean measurement.

"Save image to file"
Saves the current display as image according to the image settings.

"No action" Select this option to prevent unwanted actions due to unintended usage of the micro button.

"Find trigger level" Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*.

"Probe Setup" Opens the probe setup on the screen.

Remote command:
`PROBe<ch>:SETup:MODE` on page 396

ProbeMeter

Activates the integrated R&S ProbeMeter on probes with Rohde & Schwarz probe interface.

The R&S ProbeMeter is a voltmeter. It measures DC voltages between the probe tip and ground connection or between the probe tips with very high precision. The measurement runs continuously and in parallel to the measurements of the oscilloscope.

If a single-ended or power rail probe is connected, the ProbeMeter measures DC voltages between the probe tip and ground connection and enables ground-referenced measurements of voltages.

If a differential probe is connected, you can select if the ProbeMeter measures differential and common mode voltages, or single-ended voltages. See "Display" on page 118.

Remote command:
`PROBe<ch>:PMETer:STATe` on page 399
`PROBe<ch>:PMETer:RESults:SINGle?` on page 399
`PROBe<ch>:PMETer:RESults:COMMon?` on page 399
`PROBe<ch>:PMETer:RESults:DIFFerential?` on page 400

`PROBe<ch>:PMETer:RESults:NEGative?` on page 400
`PROBe<ch>:PMETer:RESults:POSitive?` on page 400

6.4.3.2 Setup for R&S RT-ZD differential probes

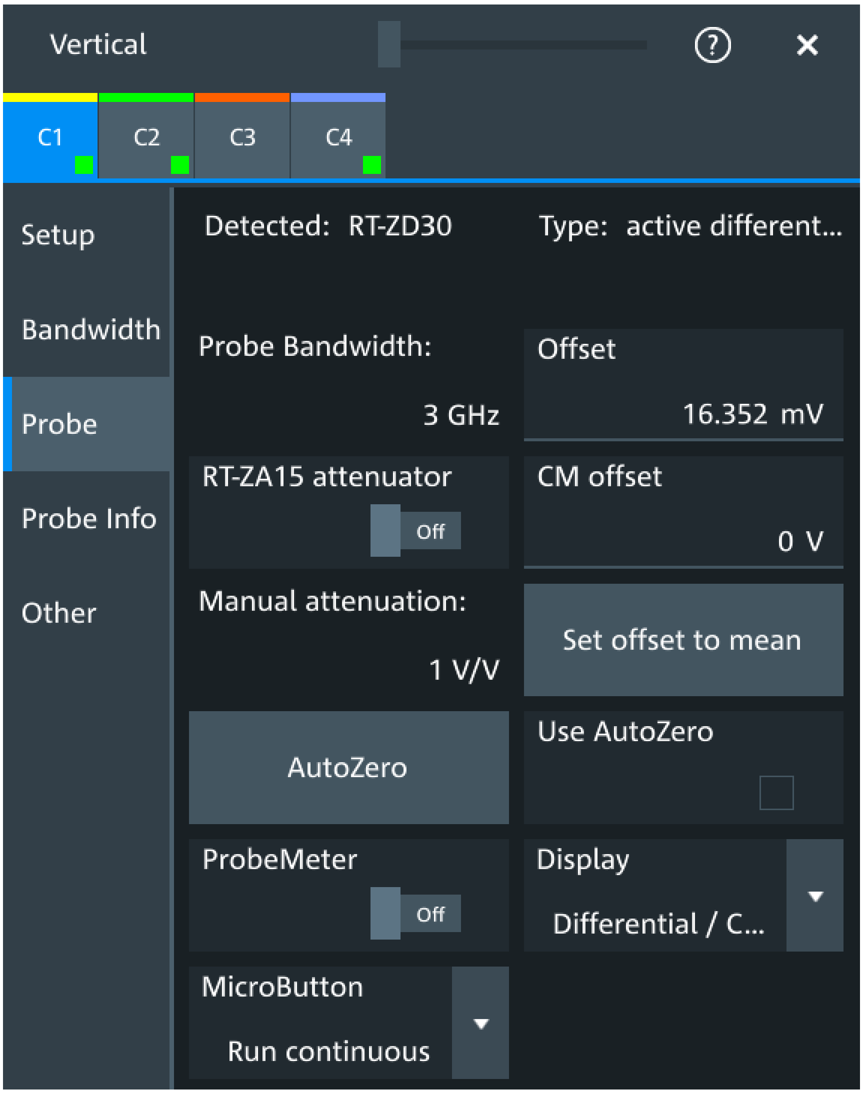


Figure 6-4: Probe setup for active differential probe R&S RT-ZD30

Most settings are common settings, which are available for all probe types. See Chapter 6.4.1, "Common probe settings", on page 111 for description of these settings.

R&S RT-ZD differential probes have the Rohde & Schwarz probe interface and support its functions. For details, see Chapter 6.4.3.1, "Settings for the Rohde & Schwarz probe interface", on page 116.

The "Offset" is the differential offset, see "Offset" on page 108.

Specific settings for R&S RT-ZD probes are the following:

CM offset

Sets the common-mode offset to compensate for a common DC voltage that is applied to both input sockets (referenced to the ground socket). The setting is available for Rohde & Schwarz differential probes.

Offset compensation is particularly helpful for measurements on differential signals with high common mode levels, for example, current measurements using a shunt resistor. You can measure the common mode input voltage using the R&S ProbeMeter.

Remote command:
`PROBe<ch>:SETup:CMOFfset` on page 398

RT-ZA15 attenuator

If you use the external attenuator R&S RT-ZA15 together with one of the differential active probes R&S RT-ZD10/20/30, enable "RT-ZA15 attenuator" to include the external attenuation in the measurements.

Remote command:
`PROBe<ch>:SETup:ZAXV` on page 398

Display

Selects the voltage to be measured by the ProbeMeter of differential active probes:

- "Differential / Common Mode":
  Differential voltage is the voltage between the positive and negative signal sockets. Common mode voltage is the mean voltage between the signal sockets and the ground socket. It measures the voltage level relative to ground, for example, to check the operating voltage window.
- "Single Ended Pos/Neg":
  Measures the voltage between the positive/negative signal socket and the ground. The ProbeMeter always measures the common mode and differential voltages. Single-ended voltages are calculated values:
  $V_p = V_{cm} + 0.5 * V_{in}$ and $V_n = V_{cm} - 0.5 * V_{in}$

Remote command:
`PROBe<ch>:SETup:DISPlaydiff` on page 398

6.4.3.3 Setup for R&S RT-ZPR power rail probes

R&S RT-ZPR power rail probes are designed for power integrity measurements. They can measure small signals in the millivolt range with large DC-offset components.

R&S RT-ZPR probes require 50 Ω input termination.

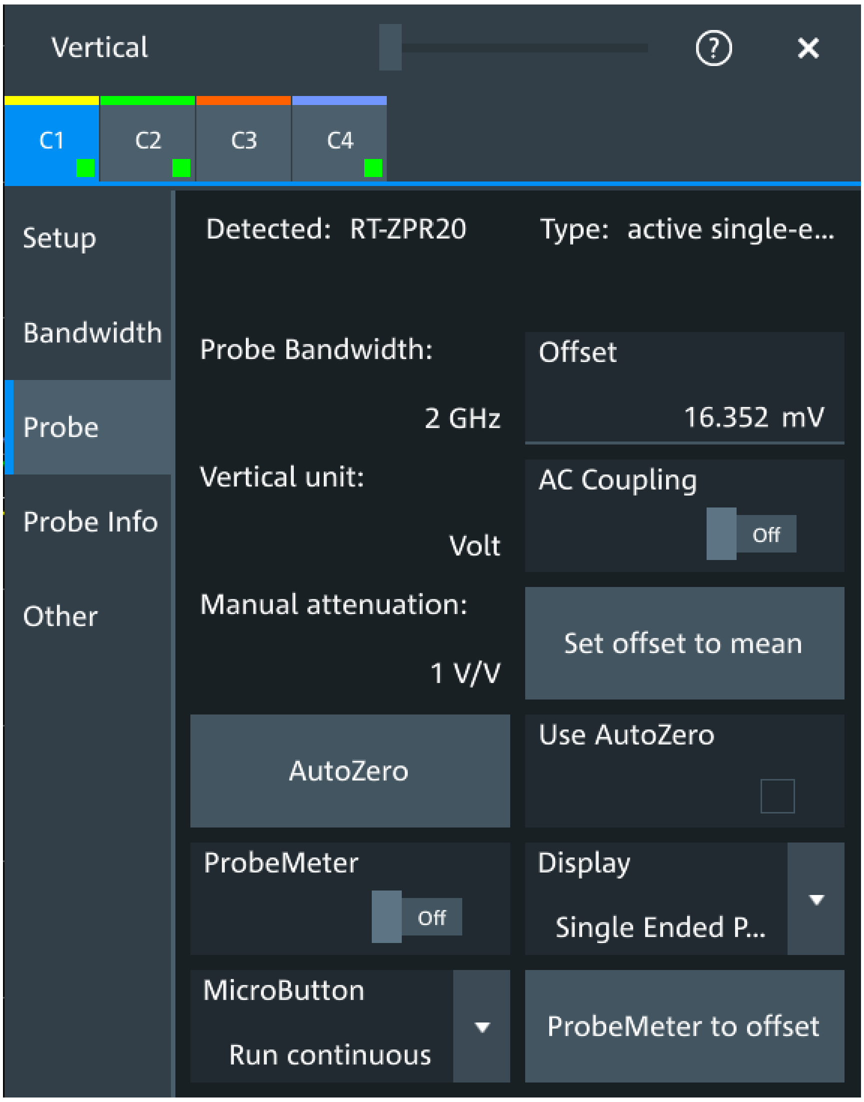


Figure 6-5: Probe setup for power rail probe R&S RT-ZPR20

Most settings are common settings, which are available for all probe types. See Chapter 6.4.1, "Common probe settings", on page 111 for description of these settings.

R&S RT-ZPR power rail probes have the Rohde & Schwarz probe interface and support its functions. For details, see Chapter 6.4.3.1, "Settings for the Rohde & Schwarz probe interface", on page 116.

The "Offset" is the channel offset, see "Offset" on page 108.

Specific settings for R&S RT-ZPR probe are the following:

AC Coupling
Enables AC coupling in R&S RT-ZPR power rail probes, which removes DC and very low-frequency components. The R&S RT-ZPR probe requires 50 Ω input termination, for which the channel AC coupling is not available. The probe setting allows AC coupling also at 50 Ω inputs.

Remote command:
`PROBe<ch>:SETup:ACCoupling` on page 397

ProbeMeter to offset
Sets the measured ProbeMeter value as offset. Thus, the value is considered in measurements.

Remote command:
`PROBe<ch>:SETup:ADVanced:PMToffset` on page 402

6.4.3.4 Setup for R&S RT-ZHD high-voltage differential probes

R&S RT-ZHD high-voltage differential probes are designed to measure safely high-voltage floating circuits using a grounded oscilloscope. They extend the measurement capability of oscilloscopes to measure electronic power converters, inverters, motor speed controls, switch mode power supplies and many other applications.

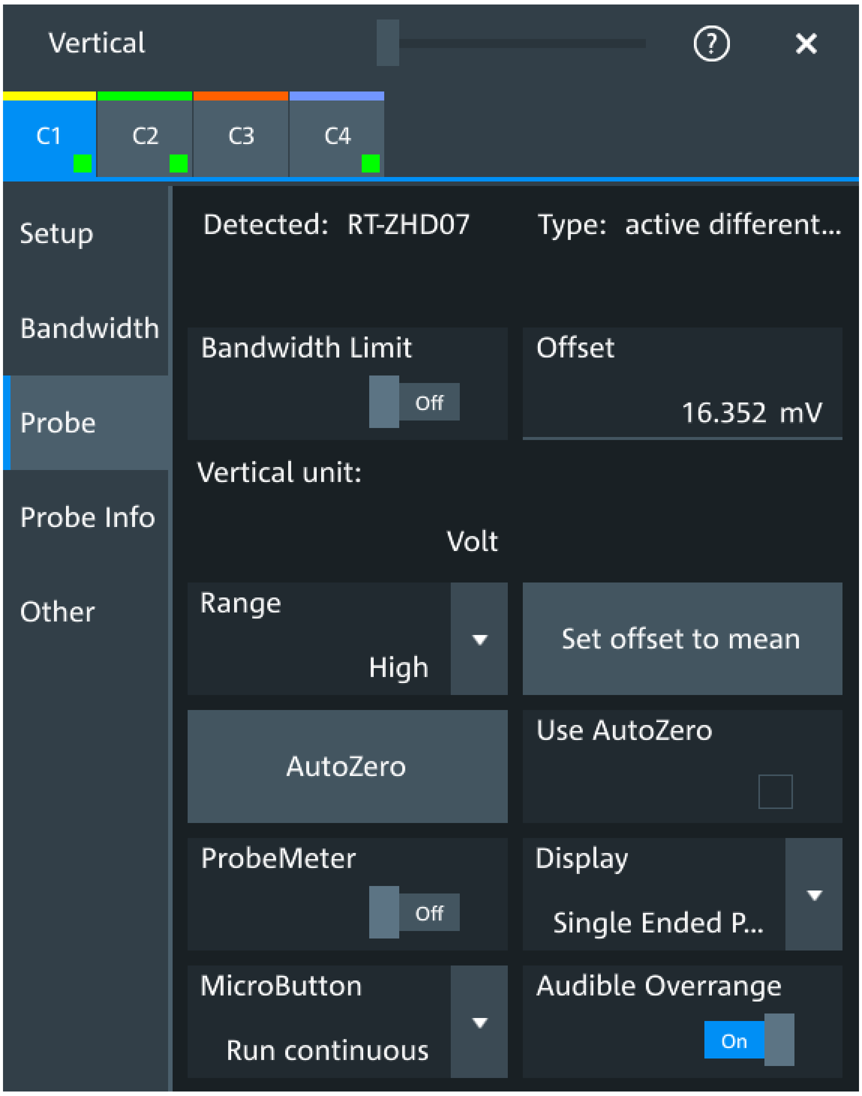


Figure 6-6: Setup for high-voltage differential probe R&S RT-ZHD07

Most settings are common settings, which are available for all probe types. See Chapter 6.4.1, "Common probe settings", on page 111 for description of these settings.

Bandwidth and attenuation values are indicated on the probe control box. The "Offset" is the differential offset, see "Offset" on page 108.

R&S RT-ZHD high-voltage differential probes have the Rohde & Schwarz probe interface and support its functions. For details, see Chapter 6.4.3.1, "Settings for the Rohde & Schwarz probe interface", on page 116.

Specific settings for R&S RT-ZHD probes are the following:

Bandwidth Limit

Activates the lowpass filter in the probe control box. The filter frequency depends on the probe type and is indicated on the probe control box.

You can set the filter on the probe control box or at the oscilloscope.

Remote command:
`PROBe<ch>:SETup:ADVanced:FILTer` on page 401

Range
Sets the voltage range of an R&S RT-ZHD probe. You can set the range on the probe control box or at the oscilloscope.

"Auto"	The voltage range is set only at the oscilloscope with "Vertical scale".
"Low"	Sets the lower voltage range of the connected probe. The range values depend on the probe type and are indicated on the probe control box.
"High"	Sets the higher voltage range of the connected probe. The range values depend on the probe type and are indicated on the probe control box.

Remote command:
`PROBe<ch>:SETup:ADVanced:RANGe` on page 401

Audible Overrange
Activates the acoustic overrange warning in the probe control box. You can also activate the sound directly on the probe control box.

Remote command:
`PROBe<ch>:SETup:ADVanced:AUDioverload` on page 401

6.4.4 Setup for current probes

The setup and adjustment of current probes depends on the output connector of the probe: BNC or Rohde & Schwarz probe box.

Current probes R&S RT-ZCxx

The current probes **R&S RT-ZCxx** have BNC connectors. They are known to the R&S MXO 4 as predefined probes. Demagnetizing and zero adjustment is done on the probe, see the probe's User Manual for details. Make sure to demagnetize and adjust the probe before taking measurements.

Current probes R&S RT-ZCxxB

Current probes **R&S RT-ZCxxB** have a Rohde & Schwarz probe interface; they are powered and remotely controlled by the oscilloscope.

When the probe is connected, demagnetization is performed automatically.

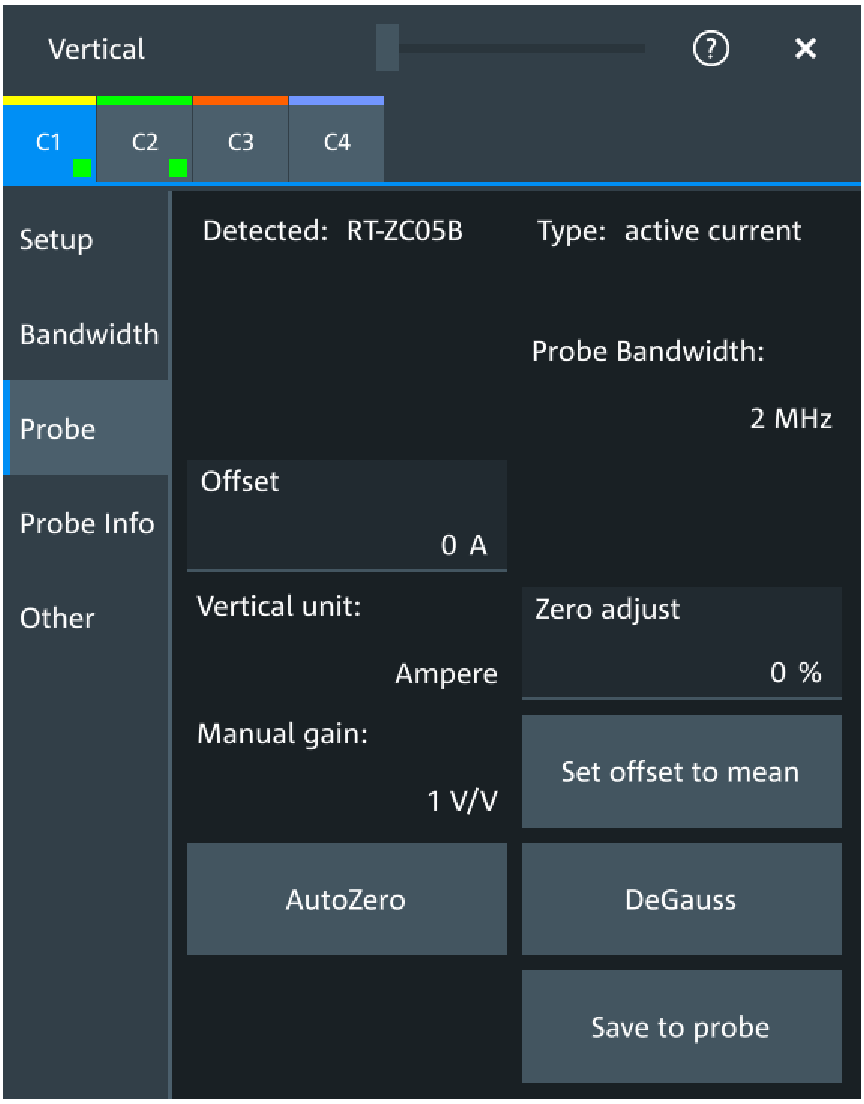


Figure 6-7: Setup for current probe R&S RT-ZC05B

Most settings are common settings, which are available for all probe types. See Chapter 6.4.1, "Common probe settings", on page 111 for description of these settings.

Current probes are adjusted by the following functions.

Manual gain

Shows the gain of the connected probe if the probe is detected or predefined. For unknown current probes, set the correct gain of the probe.

The vertical scaling and measured values are multiplied by this factor so that the displayed values are equal to the actual measured signal values.

Remote command:

`PROBe<ch>:SETup:GAIN:AUTO?` on page 402

`PROBe<ch>:SETup:GAIN:MANual` on page 402

DeGauss
Demagnetizes the core if it has been magnetized by switching the power on and off, or by an excessive input. Always carry out demagnetizing before measurement.

The demagnetizing process takes about one second. During demagnetizing, a demagnetizing waveform is displayed.

Demagnetizing is done automatically when R&S RT-ZCxxB is connected to the oscilloscope, or when "AutoZero" is performed.

Remote command:
`PROBe<ch>:SETup:DEGauss` on page 403

Zero adjust
Zero adjust corrects the effect of an offset caused by temperature drift, and compensates for the remanence. The setting is only available if DC coupling is set.

To set the waveform to zero level by the instrument, use "AutoZero". The detected value is displayed.

Alternatively, you can adjust the value manually until the waveform is set to zero level. Make sure to demagnetize the probe before zero adjustment.

The value is given in percent of the maximum range, which is internally defined. The actual setup range depends on the temperature drift, the measured current and other variables, and it can change over time. If you measure high currents, the probe core magnetizes, which impairs the measurement results. Therefore, repeat "AutoZero" before the measurement.

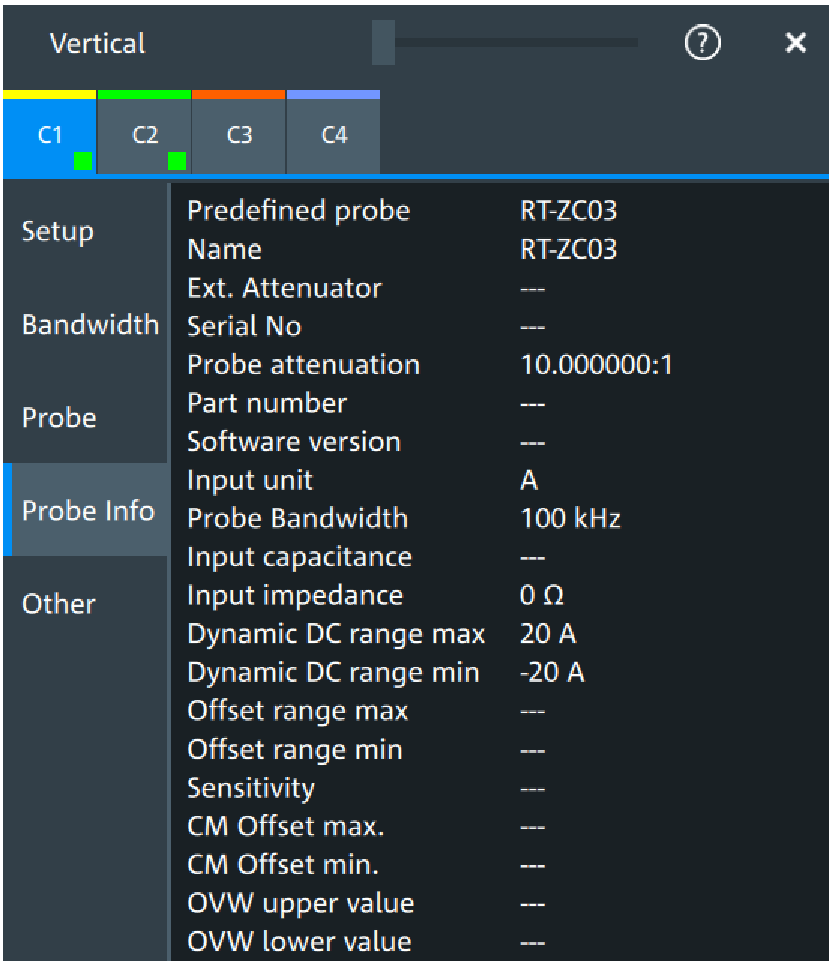
Remote command:
`PROBe<ch>:SETup:OFFSet:ZADJust` on page 403

Save to probe
Saves the zero adjust value in the probe box. If you connect the probe to another channel or to another Rohde & Schwarz oscilloscope, the value is read out again, and you can use the probe without further adjustment.

Remote command:
`PROBe<ch>:SETup:OFFSet:STPRobe` on page 403

6.4.5 Probe info

In this dialog you can check the attributes of the connected probes. For a specification of the probe parameters, refer to the data sheet.



Remote commands: Chapter 17.8.7.4, "Probe attributes", on page 404.

6.4.6 Adjusting passive probes

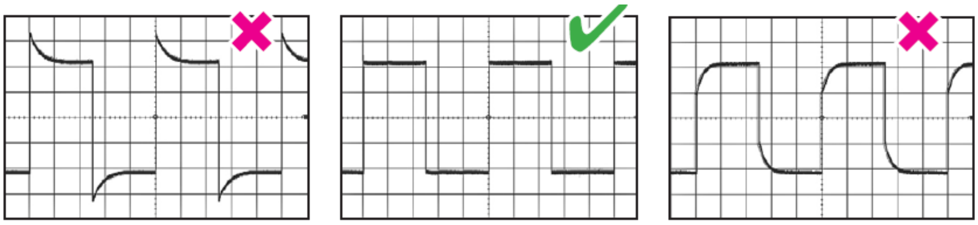
When using a passive probe, you have to compensate it when you connect it to the instrument the first time. Compensation matches the probe cable capacitance to the oscilloscope input capacitance to assure good amplitude accuracy from DC to upper bandwidth limit frequencies. A poorly compensated probe reduces the performance of the probe-oscilloscope system and introduces measurement errors resulting in distorted waveforms and inaccurate results.

Two connector pins are located on the front panel. The ⊥ pin is on ground level. The ⎍ pin supplies a square wave signal with 1 kHz for low frequency probe compensation.

1. Connect the BNC connector of the probe to one of the channel inputs.
2. Connect the probe's ground connector to the ground compensation pin, and the probe tip to the signal pin.
3. Press [Autoset].

A square wave appears on the display.

4. Adjust the compensation trimmer of the probe to optimum square wave response. For details, refer to the documentation of your probe.



7 Trigger

7.1 Basics of triggering

Triggering means to capture the interesting part of the relevant waveforms, and the trigger point is the determining point in the waveform record. Choosing the right trigger type and configuring all trigger settings correctly allows you to detect various incidents in analog, digital, and protocol signals.

How the instrument triggers

A trigger occurs if the complete set of trigger conditions is fulfilled. The instrument acquires continuously and keeps the sample points to fill the pre-trigger part of the waveform record. When the trigger occurs, the instrument continues acquisition until the post-trigger part of the waveform record is filled. Then it stops acquiring and waits for the next trigger. When a trigger is recognized, the instrument does not accept another trigger until the acquisition is complete and the holdoff time has expired.

Trigger setup

A simple trigger setup includes:

- Source of the trigger signal
- Trigger type selection and setup
- Horizontal position of the trigger: see: Chapter 6.1.1, "About the horizontal system", on page 94
- Trigger mode

The R&S MXO 4 provides various trigger types for troubleshooting and signal analysis, for example, edge trigger, glitch trigger, interval trigger, pattern trigger, and much more.

For complex tasks like verifying and debugging designs, advanced trigger settings are available:

- Filter to remove high or low frequencies from the trigger signal
- Hysteresis to avoid unwanted trigger events caused by noise
- Holdoff to define exactly which trigger event causes the trigger
- Trigger sequences to combine several event conditions

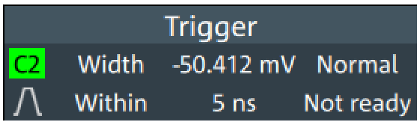
Trigger sequence

A trigger sequence joins two or more separate trigger conditions with an optional delay time and an optional reset time or reset condition. Similar setups are also known as multi-step trigger or A/B trigger.

7.1.1 Trigger information

Information on the most important trigger settings is shown in the trigger label above the diagram. If you tap the trigger label, the "Trigger" dialog opens.

If you trigger on a single event, the trigger label shows:
- Trigger source
- Trigger type
- Trigger level
- Trigger mode
- Edge or polarity, and important trigger-type specific settings
- Trigger state



If you trigger on a sequence, the trigger label shows:
- Sequence type
- Trigger mode
- Trigger state

7.2 Common trigger settings

Access: "Menu" > "Trigger" > "Setup" tab

The common trigger settings are the trigger source and the trigger type, including the trigger level. These settings are specific for each condition in a trigger sequence. To set the trigger level automatically, use "Find level".

Depending on the trigger type, additional settings are available. They are explained in the trigger-type specific sections.

Trigger on
Selects, if you want to trigger on a single event, or on a series of events.

Remote command:
`TRIGger:MEVents:MODE` on page 408

Source

Selects the source of the trigger signal for the selected trigger event. The trigger source works even if it is not displayed in a diagram.

Available sources depend on the trigger sequence setting. If you trigger on a single event, all inputs can be used as trigger source. If you trigger on a sequence, only analog channels can be set as trigger source.

The trigger source can be:
- Channel <n>: an analog input channel
- Extern: external analog signal connected to the external trigger input. For the external trigger source, the analog edge trigger is available.
- Line: The instrument generates the trigger from the AC power input and synchronizes the signal to the AC power frequency. Use this source if you want to analyze signals related to the power line frequency, such as lighting equipment and power supply devices. For the line trigger source, the edge trigger type is available.
- Digital channels D0 to D15, serial bus,
  If options with trigger functionality are installed, the variety of trigger sources is enhanced with specific trigger sources. These specific trigger sources are only available for triggering on single event.

For the state trigger, this source is the "Clock source", the clock signal.

For the setup & hold trigger, this source is the "Data Source", the data signal.

Remote command:
`TRIGger:EVENt<m>:SOURce` on page 409

Type

Selects the trigger type specific for each condition in a trigger sequence.

The current trigger type is shown on the button and in the trigger label above the diagram.

The following trigger types are available:
- Edge trigger, see page 132
- Glitch trigger, see page 135
- Width trigger, see page 137
- Runt trigger, see page 138
- Window trigger, see page 140
- Timeout trigger, see page 142
- Interval trigger, see page 143
- Slew rate trigger, see page 145
- Setup & Hold, see page 147
- State trigger, see page 149
- Pattern trigger, see page 150

If the external trigger input is used as trigger source, the analog edge trigger is the only available trigger type.

For digital channels, the edge, width, timeout, state and pattern trigger are available.

Remote command:
`TRIGger:EVENt<m>:TYPE` on page 408

Level

Sets the voltage level or threshold for the trigger.

You can also drag the trigger level marker on the display, or turn the [Level] knob. To set the trigger level to 50% of the signal amplitude, press the [Level] knob.

For the setup & hold trigger, this level sets the voltage level for the data signal. At this level, the setup and hold time are measured.

For the timeout trigger, the trigger level is the threshold for the high and low signal states.

Runt, window and slew rate triggers require two trigger levels (upper and lower), which are defined as specific settings.

Remote command:
`TRIGger:EVENt<m>:LEVel<n>[:VALue]` on page 408
`TRIGger:ANEDge:LEVel` on page 412 (for external trigger source)

Find level
Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*.

The function is not available for trigger sources "Extern" and "Line".

Remote command:
`TRIGger:FINDlevel` on page 409

7.3 Trigger sequence

With R&S MXO 4, you can trigger on a single trigger event, or on a sequence of events. A trigger sequence consists of at least two event conditions and additional conditions defining when the trigger occurs.

The trigger sequence "A → B → R", for example, consists of two subsequent events: A-trigger and B-trigger with optional B-trigger delay and count. In addition, an optional reset condition R can be configured: timeout or R-trigger condition. A-, B-, and R-triggers are configured in the same way.

After the A-trigger conditions have been met, and an optional delay has passed, the B-trigger with independent conditions is enabled. The instrument waits until one or a specified number of B-trigger conditions occur. If the reset condition is not fulfilled, the latest B-trigger causes the trigger event, and then the sequence starts again. The B-trigger can only cause the trigger event if it occurs after the A-trigger and after the delay time.

If you expect, for example, an irregular B-trigger, you can configure a reset condition to restart the sequence. The reset condition can be a simple timeout, and/or a reset event that is defined in the same way as the A- and B-trigger conditions.

All trigger sequences require that analog input channels C<n> are set as trigger sources for all events. The instrument checks all trigger settings for compatibility and adjusts them if they do not fit.

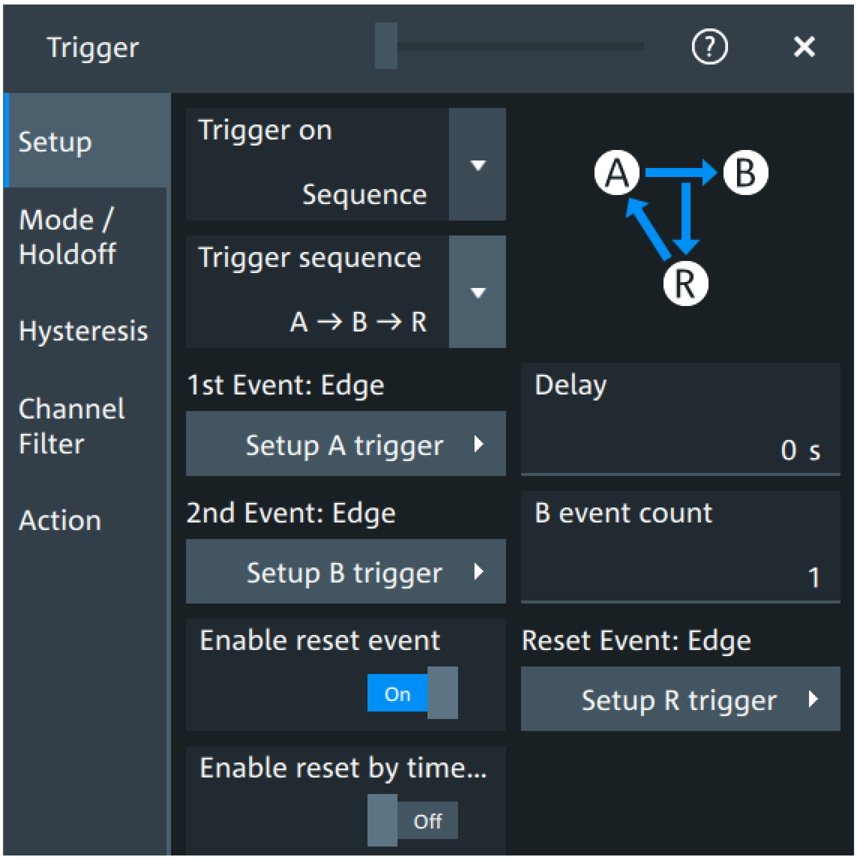
The following trigger types are only available for triggering on single event:

- Setup & Hold
- State

- Pattern

7.3.1 Sequence setup

Access: "Menu" > "Trigger" > "Setup" tab > "Trigger on" = "Sequence"



B-trigger and R-trigger are configured in the same way as the A-trigger. You can configure a delay between the A- and B-trigger, and define a number of fulfilled B-trigger conditions to be ignored. The reset condition R can be a timeout or a trigger condition, or a combination of both.

Trigger sequence
Selects the type of the trigger sequence.

"A → B → R" Triggers if all conditions of A- and B-events, as well as additional delay and count, and optional reset timeout and/or R-event conditions are fulfilled.

Remote command:
`TRIGger:MEVents:AEVents` on page 410

Delay
Sets the time that the instrument waits after an A-trigger until it recognizes B-triggers.

Remote command:
TRIGger:MEVents:SEQuence<se>:DELay on page 410

B event count

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

Remote command:
TRIGger:MEVents:SEQuence<se>:COUNt on page 410

Enable reset event

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

Remote command:
TRIGger:MEVents:SEQuence<se>:RESet:EVENt on page 411

Enable reset by time, Reset timeout

If reset timeout is enabled, the instrument waits for the "Reset timeout" time for the specified number of B-triggers. If no trigger occurs during that time, the sequence is restarted with the A-trigger.

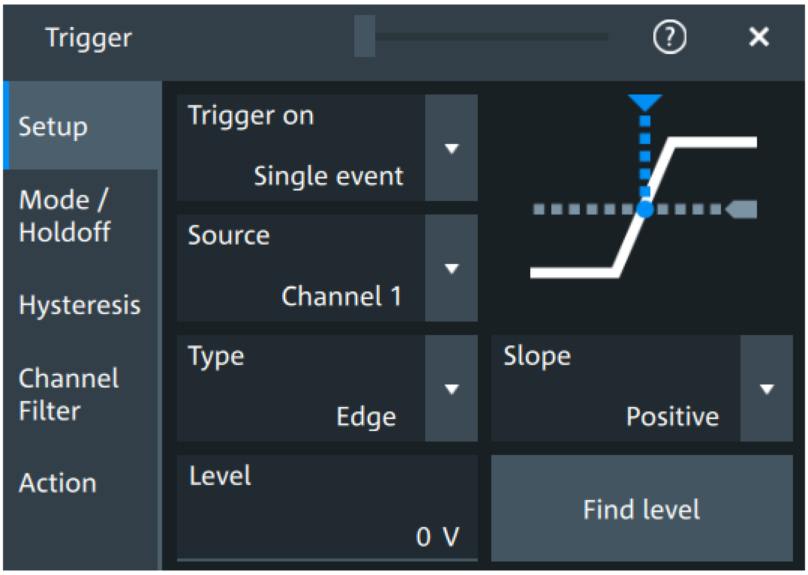
Remote command:
TRIGger:MEVents:SEQuence<se>:RESet:TIMeout[:ENABle] on page 411
TRIGger:MEVents:SEQuence<se>:RESet:TIMeout:TIME on page 411

7.4 Trigger types

7.4.1 Edge trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Edge"

The edge trigger is the most common trigger type. The trigger occurs when the signal from the trigger source passes the trigger level in the specified direction (slope).



Level

See "Level" on page 129.

Remote command:

TRIGger:EVENt<m>:LEVel<n>[:VALue] on page 408

Slope

Sets the edge direction for the trigger.

"Positive" Selects the rising edge, which is a positive voltage change.

"Negative" Selects the falling edge, which is a negative voltage change.

"Either" Selects the rising and falling edge. After starting an acquisition, the instrument triggers on the first identified edge.

Remote command:

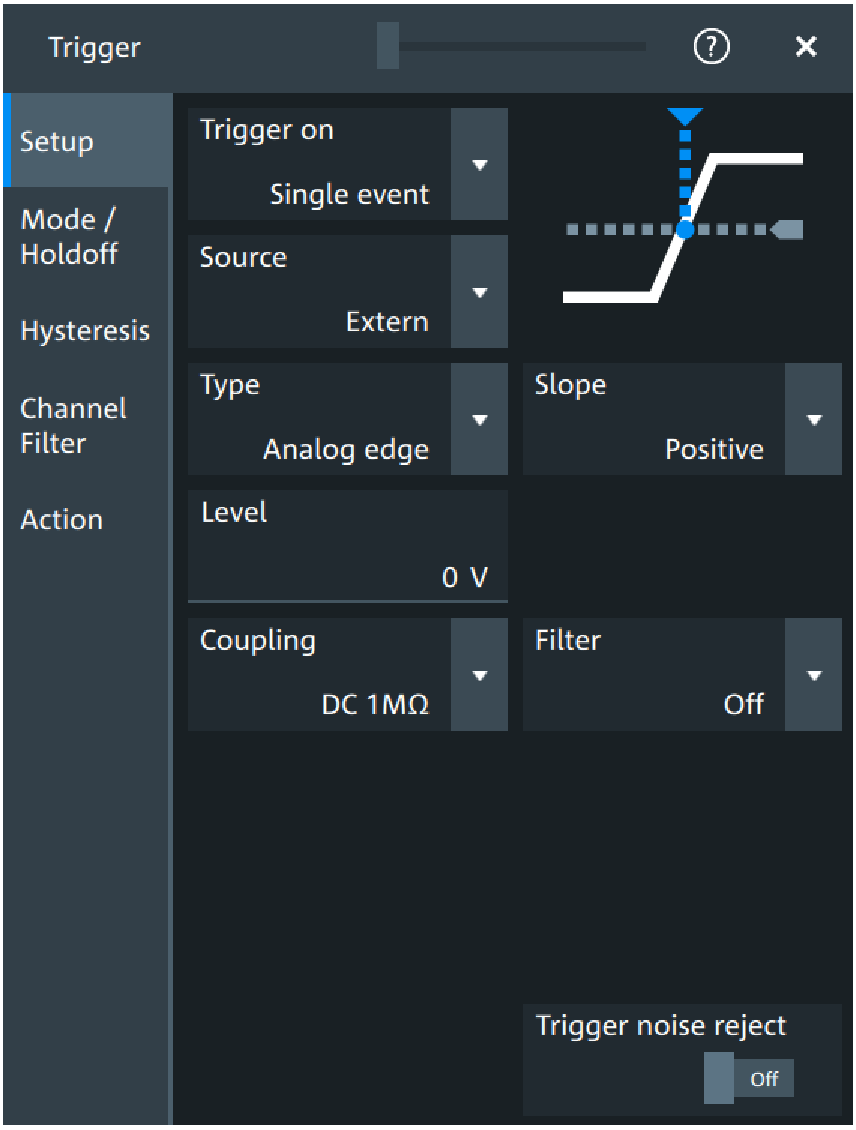
TRIGger:EVENt<m>:EDGE:SLOPe on page 412

TRIGger:EVENt<m>:SLEW:SLOPe on page 426

7.4.2 Edge trigger on external trigger source

Access: "Menu" > "Trigger" > "Setup" tab > "Source" = "Extern" > "Type = Analog Edge"

If an external trigger signal is connected to the Trigger In, and the trigger source is set to "Extern", the analog edge trigger is available. Triggering on an external source is only possible if you trigger on a single event but not for sequences.



The "Slope" and "Level" are the same settings as for the edge trigger, see:

- "Level" on page 129
- "Slope" on page 133

Specific settings for the analog edge trigger are the following:

Coupling
Sets the connection of the external trigger signal, i.e. the input impedance and a termination. The coupling determines what part of the signal is used for triggering.

"DC 50 Ω"	Connection with 50 Ω termination, passes both DC and AC components of the signal.
"DC 1 MΩ"	Connection with 1 MΩ termination, passes both DC and AC components of the signal.

"AC 1 MΩ" Connection with 1 MΩ termination through DC capacitor, removes DC and very low-frequency components. The waveform is centered on zero volts.

Remote command:
`TRIGger:ANEDge:COUPling` on page 412

Filter, Cut-off
Selects the filter mode for the external trigger signal, and sets the cut-off frequency.

"Off" The trigger signal is not filtered.

"LF reject" Frequencies lower than the "Cut-off" frequency are rejected, higher frequencies pass the filter.

"RF reject" Frequencies higher than the "Cut-off" frequency are rejected, lower frequencies pass the filter.

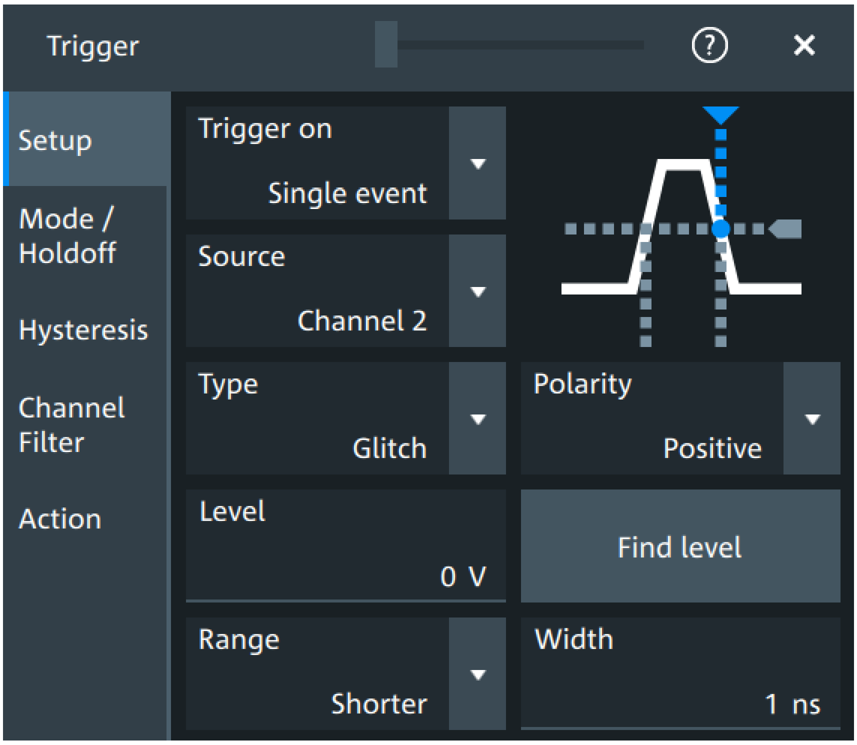
Remote command:
`TRIGger:ANEDge:FILTer` on page 413
`TRIGger:ANEDge:CUToff:HIGHpass` on page 413
`TRIGger:ANEDge:CUToff:LOWPass` on page 413

Trigger noise reject
Enables an automatic hysteresis on the trigger level to avoid unwanted trigger events caused by noise.

Remote command:
`TRIGger:ANEDge:NREJect` on page 414

7.4.3 Glitch trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Glitch"



Level
See "Level" on page 129.

Remote command:
`TRIGger:EVENt<m>:LEVel<n>[:VALue]` on page 408

Polarity
Sets the polarity of a pulse, which is the direction of the first pulse slope.

"Positive" Selects positive going pulses, the width is defined from the rising to the falling slopes.

"Negative" Selects negative going pulses, the width is defined from the falling to the rising slopes.

"Either" Selects both positive and negative going pulses.

Remote command:
`TRIGger:EVENt<m>:GLITch:POLarity` on page 414
`TRIGger:EVENt<m>:RUNT:POLarity` on page 418

Range
Selects how the time limit of the runt pulse is defined.

Remote command:
`TRIGger:EVENt<m>:GLITch:RANGe` on page 414

Width
Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value, depending on the value set with "Range".

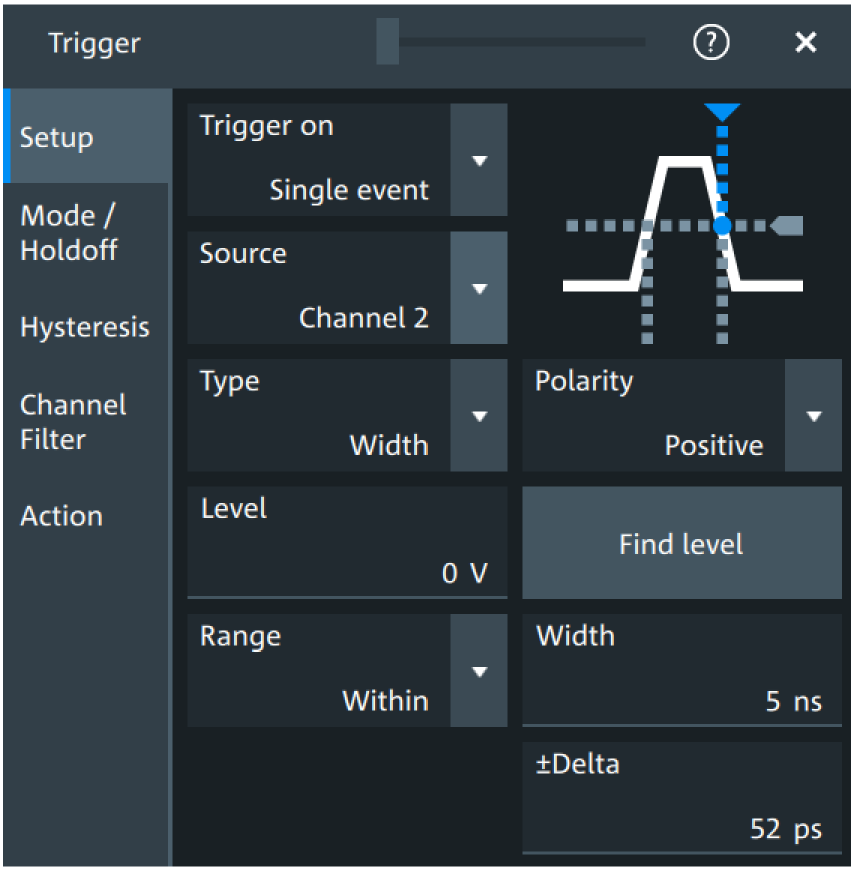
You need to know the expected pulse widths of the circuit to set the glitch width correctly.

Remote command:
`TRIGger:EVENt<m>:GLITch:WIDTh` on page 415

7.4.4 Width trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Width"

The width trigger compares the pulse width (duration) with given time limits. It detects pulses with an exact pulse width, pulses shorter or longer than a given time, and also pulses inside or outside the allowable time range. The pulse width is measured at the trigger level.



Level
See "Level" on page 129.

Remote command:
`TRIGger:EVENt<m>:LEVel<n>[:VALue]` on page 408

Polarity
Sets the polarity of a pulse, which is the direction of the first pulse slope.

"Positive" Selects positive going pulses, the width is defined from the rising to the falling slopes.

"Negative" Selects negative going pulses, the width is defined from the falling to the rising slopes.

"Either" Selects both positive and negative going pulses.

Remote command:
TRIGger:EVENt<m>:WIDTh:POLarity on page 415

Range

Selects how the range of a pulse width is defined.

"Longer" Triggers on pulses longer than the given "Width".

"Shorter" Triggers on pulses shorter than the given "Width".

"Within" Triggers on pulses inside a given range. The range of the pulse width is defined by "±Delta" related to "Width".

"Outside" Triggers on pulses outside a given range. The range definition is the same as for "Within" range.

Remote command:
TRIGger:EVENt<m>:WIDTh:RANGe on page 416

Width

For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Remote command:
TRIGger:EVENt<m>:WIDTh:WIDTh on page 416

±Delta

Defines a range around the width value.

The combination "Range" = "Within" and "±Delta" = 0 triggers on pulses with a pulse width that equals "Width".

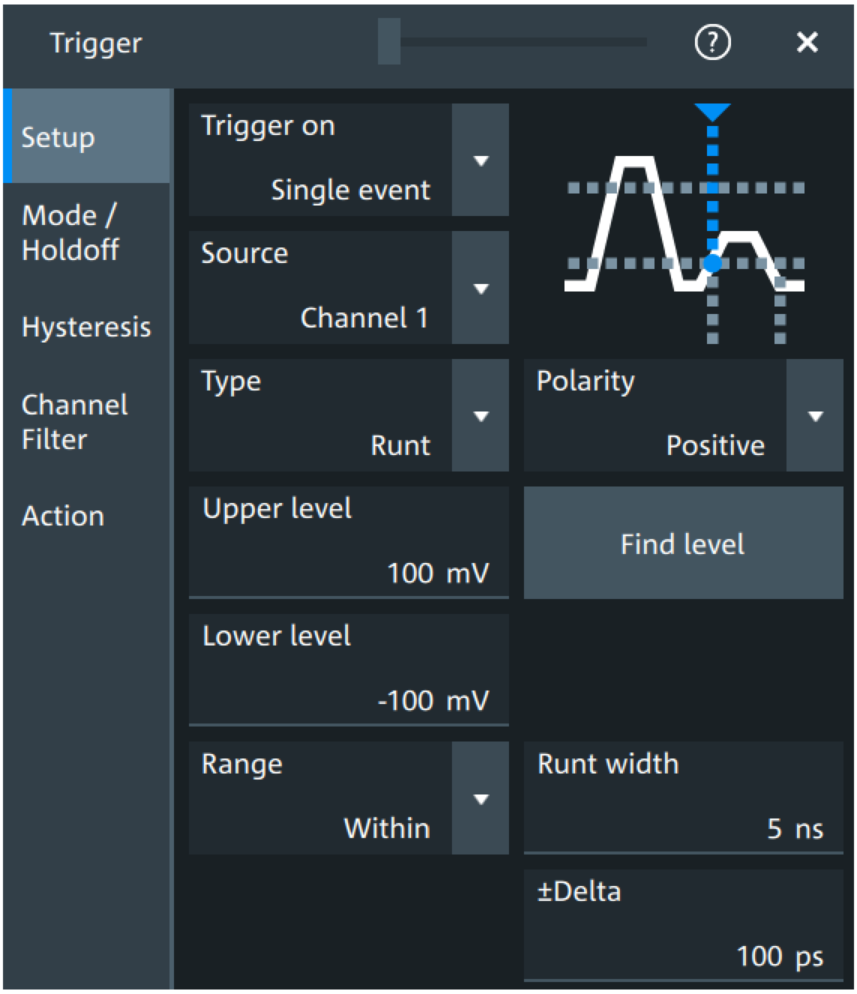
The combination "Range" = "Outside" and "±Delta" = 0 means to trigger on pulse widths ≠ "Width".

Remote command:
TRIGger:EVENt<m>:WIDTh:DELTa on page 415

7.4.5 Runt trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Runt"

A runt is a pulse lower than normal in amplitude. The amplitude crosses the first threshold twice in succession without crossing the second one. For example, this trigger can detect logic, digital, and analog signals remaining below a specified threshold amplitude because I/O ports are in undefined state.



Polarity
Sets the polarity of a pulse, which is the direction of the first pulse slope.

"Positive" Selects positive going pulses, the width is defined from the rising to the falling slopes.

"Negative" Selects negative going pulses, the width is defined from the falling to the rising slopes.

"Either" Selects both positive and negative going pulses.

Remote command:
`TRIGger:EVENt<m>:GLITch:POLarity` on page 414
`TRIGger:EVENt<m>:RUNT:POLarity` on page 418

Upper limit
Sets the upper voltage limit.

Remote command:
`TRIGger:EVENt<m>:LEVel<n>:RUNT:UPPer` on page 417

Lower limit
Sets the lower voltage limit.

Remote command:
`TRIGger:EVENt<m>:LEVel<n>:RUNT:LOWer` on page 416

Range
Selects how the time limit of the runt pulse is defined.

"Any runt"	Triggers on all runts fulfilling the level condition, without time limitation.
"Longer"	Triggers on runts longer than the given "Runt width".
"Shorter"	Triggers on runts shorter than the given "Runt width".
"Within"	Triggers if the runt length is inside a given time range. The range is defined by "Runt width" and "±Delta".
"Outside"	Triggers if the runt length is outside a given time range. The range definition is the same as for "Within" range.

Remote command:
`TRIGger:EVENt<m>:RUNT:RANGe` on page 418

Runt width
For the ranges "Shorter" and "Longer", the runt width defines the maximum and minimum pulse width, respectively.

For the ranges "Within" and "Outside", the runt width defines the center of a range which is defined by "±Delta".

Remote command:
`TRIGger:EVENt<m>:RUNT:WIDTh` on page 418

±Delta
Defines a range around the runt width value.

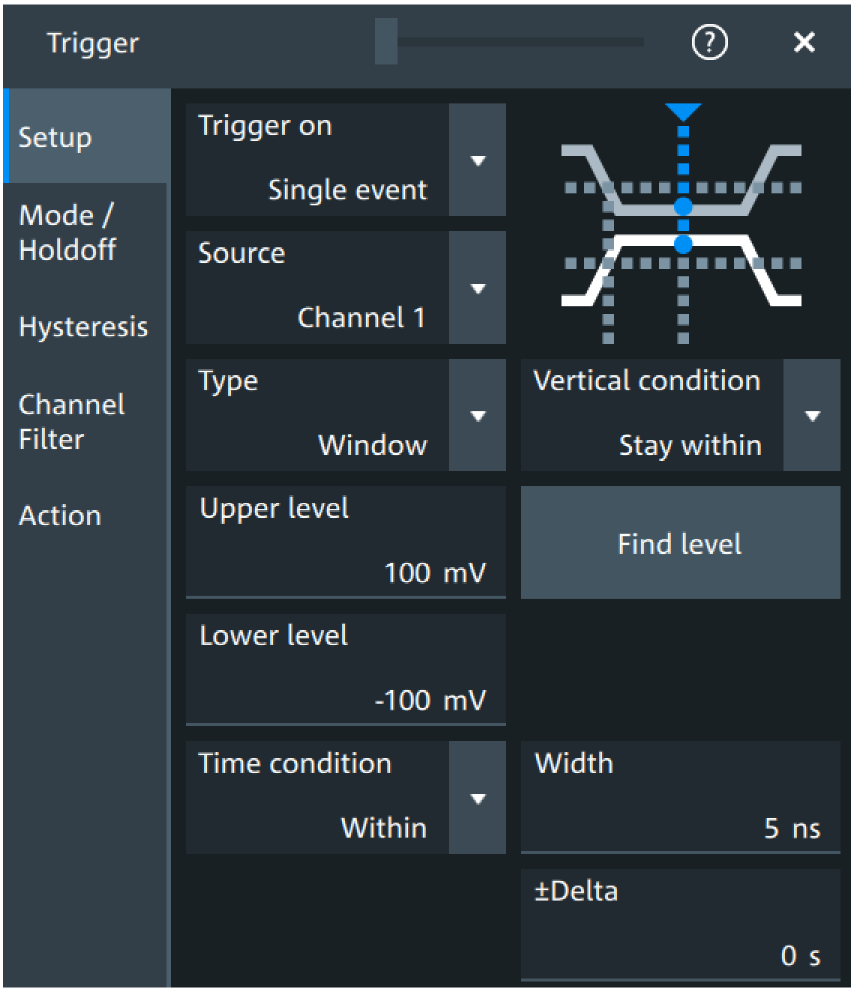
Remote command:
`TRIGger:EVENt<m>:RUNT:DELTa` on page 417

7.4.6 Window trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Window"

The window trigger checks the signal run in relation to a "window". The window is formed by the upper and lower voltage levels. The trigger condition is fulfilled, if the waveform enters or leaves the window, or if the waveform stays inside or outside for a time longer or shorter than specified.

With the window trigger, you can display longer transient effects.



Vertical condition

Selects how the signal run is compared with the window.

"Enter" Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.

"Exit" Triggers when the signal leaves the window.

"Stay within" Triggers if the signal stays between the upper and lower level for a specified time. The time is defined in various ways by the "Time condition".

"Stay outside" Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is also defined by the "Time condition".

Remote command:

`TRIGger:EVENt<m>:WINDow:RANGe` on page 420

Upper limit

Sets the upper voltage limit.

Remote command:

`TRIGger:EVENt<m>:LEVel<n>:WINDow:UPPer` on page 419

Lower limit
Sets the lower voltage limit.

Remote command:
`TRIGger:EVENt<m>:LEVel<n>:WINDow:LOWer` on page 419

Time condition
Available for "Vertical condition" = "Stay within"/"Stay outside".

Selects how the time limit of the window is defined.

"Within" Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width* - *Delta* and for *Width* + *Delta* at the most.

"Outside" "Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width* - *Delta* or longer than *Width* + *Delta*.

"Shorter" Triggers if the signal crosses vertical limits before the specified "Width" time is reached.

"Longer" Triggers if the signal crosses vertical limits after the specified "Width" time is reached.

Remote command:
`TRIGger:EVENt<m>:WINDow:TIME` on page 420

Width
For the ranges "Within" and "Outside", the width defines the center of a time range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

Remote command:
`TRIGger:EVENt<m>:WINDow:WIDTh` on page 421

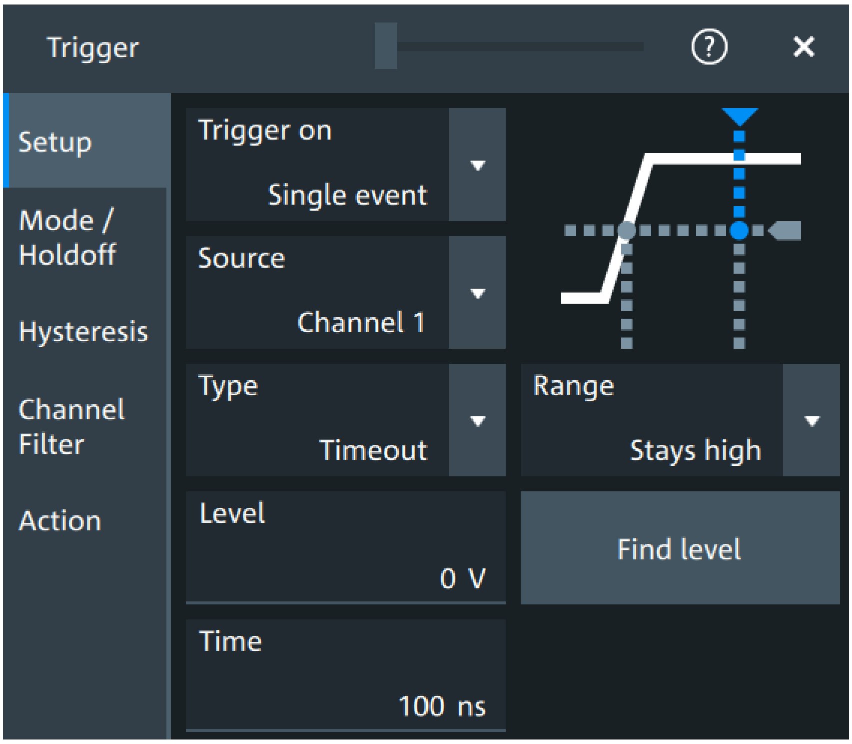
±Delta
Defines a range around the width value.

Remote command:
`TRIGger:EVENt<m>:WINDow:DELTa` on page 420

7.4.7 Timeout trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Timeout"

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



Level
Sets the threshold for the high and low signal states.

Remote command:
TRIGger:EVENt<m>:LEVel<n>[:VALue] on page 408

Range
Sets the relation of the signal level to the trigger level for the timeout trigger.

"Stays high"	The signal level stays above the trigger level.
"Stays low"	The signal level stays below the trigger level.
"High or low"	The signal level stays above or below the trigger level.

Remote command:
TRIGger:EVENt<m>:TIMeout:RANGe on page 422

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

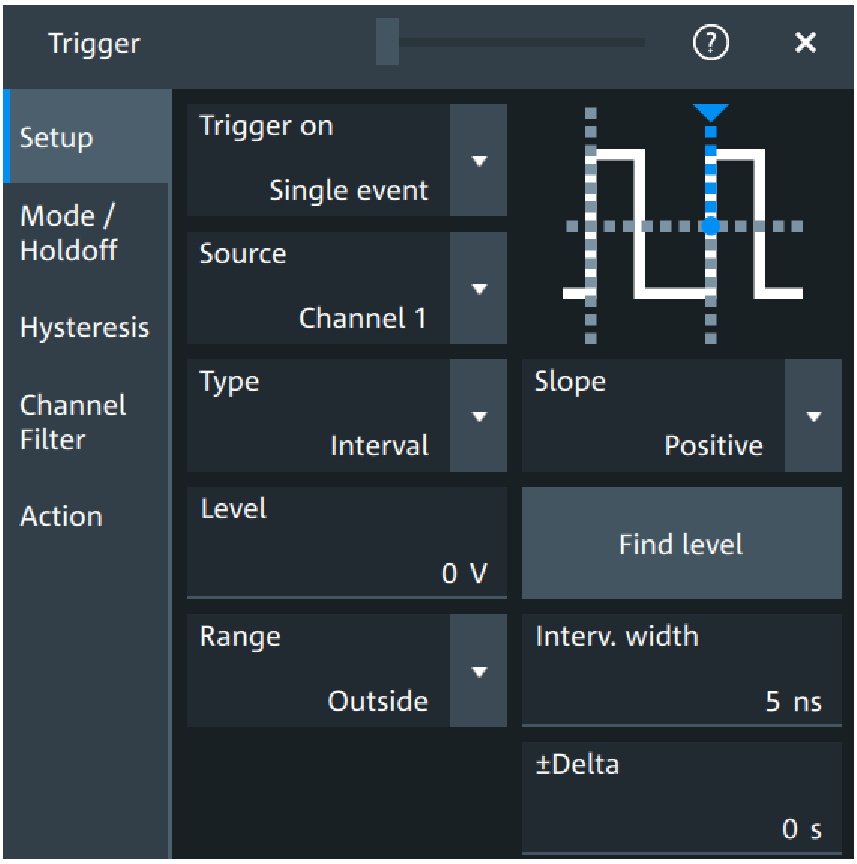
Remote command:
TRIGger:EVENt<m>:TIMeout:TIME on page 422

7.4.8 Interval trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Interval"

The interval trigger analyzes the time between two pulses.

The interval trigger can analyze either rising or falling edges, but searching for an interval is also possible for both edges at the same time ("Either").



Level

See "Level" on page 129.

Remote command:

`TRIGger:EVENt<m>:LEVel<n>[:VALue]` on page 408

Slope

Sets the edge for the trigger. You can analyze the interval between positive edges or between negative edges.

Remote command:

`TRIGger:EVENt<m>:INTerval:SLOPe` on page 423

Range

Selects how the range of an interval is defined:

"Within"	Triggers on pulse intervals inside a given range. The range is defined by "Interv. width" and "±Delta".
"Outside"	Triggers on intervals outside a given range. The range definition is the same as for "Within" range.
"Shorter"	Triggers on intervals shorter than the given "Interv. width".
"Longer"	Triggers on intervals longer than the given "Interv. width".

Remote command:
`TRIGger:EVENt<m>:INTerval:RANGe` on page 423

Interv. width
Sets the time between two pulses for the interval trigger.

Remote command:
`TRIGger:EVENt<m>:INTerval:WIDTh` on page 424

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

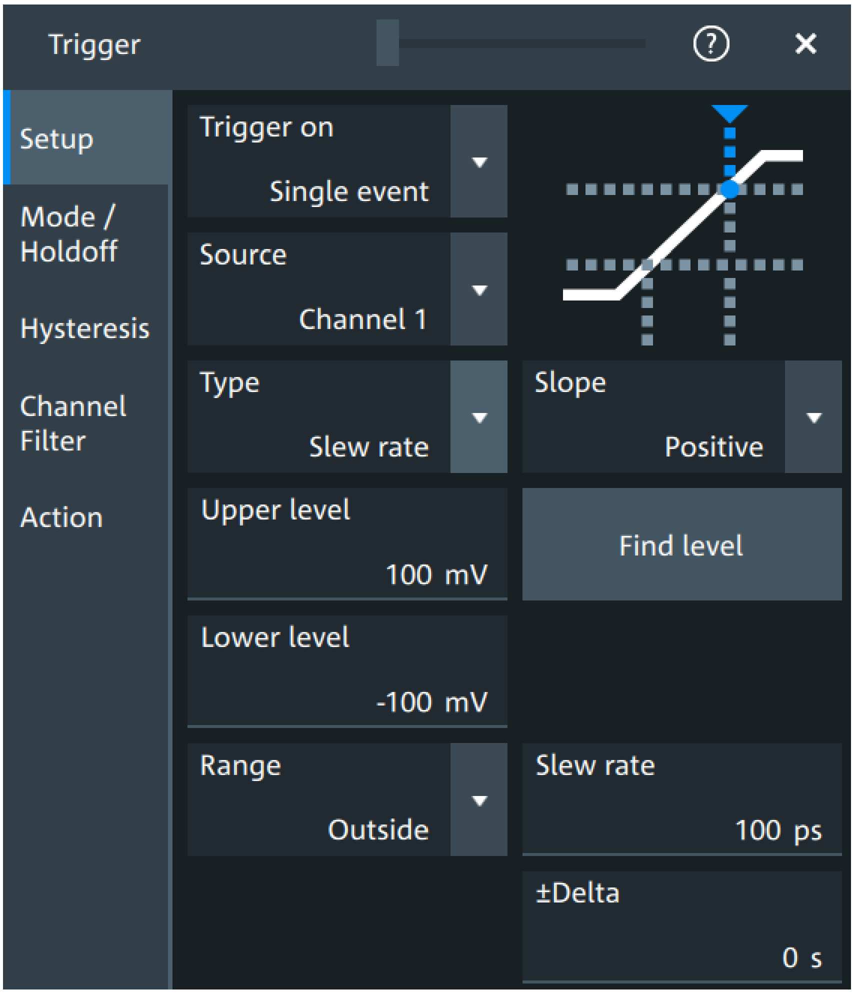
Remote command:
`TRIGger:EVENt<m>:INTerval:DELTa` on page 422

7.4.9 Slew rate trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Slew rate"

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

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



Slope

Sets the edge direction for the trigger.

"Positive" Selects the rising edge, which is a positive voltage change.

"Negative" Selects the falling edge, which is a negative voltage change.

"Either" Selects the rising and falling edge. After starting an acquisition, the instrument triggers on the first identified edge.

Remote command:

`TRIGger:EVENt<m>:EDGE:SLOPe` on page 412

`TRIGger:EVENt<m>:SLEW:SLOPe` on page 426

Upper limit

Sets the upper voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:

`TRIGger:EVENt<m>:LEVel<n>:SLEW:UPPer` on page 425

Lower limit

Sets the lower voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:

TRIGger:EVENt<m>:LEVel<n>:SLEW:LOWer on page 424

Range

Selects how the time limit for the slew rate is defined. The time measurement starts when the signal crosses the first trigger level - the upper or lower limit depending on the selected slope. The measurement stops when the signal crosses the second level.

"Within" Triggers on slew rates inside a given time range. The range is defined by "Slew rate" and "±Delta".

"Outside" Triggers on slew rates outside a given time range. The range definition is the same as for "Within" range.

"Shorter" Triggers on slew rates shorter than the given "Slew rate" limit.

"Longer" Triggers on slew rates longer than the given "Slew rate" limit.

Remote command:

TRIGger:EVENt<m>:SLEW:RANGe on page 425

Slew rate

For the ranges "Within" and "Outside", the slew rate defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the slew rate defines the maximum and minimum slew rate limits, respectively.

Remote command:

TRIGger:EVENt<m>:SLEW:RATE on page 426

±Delta

Defines a time range around the given slew rate.

Remote command:

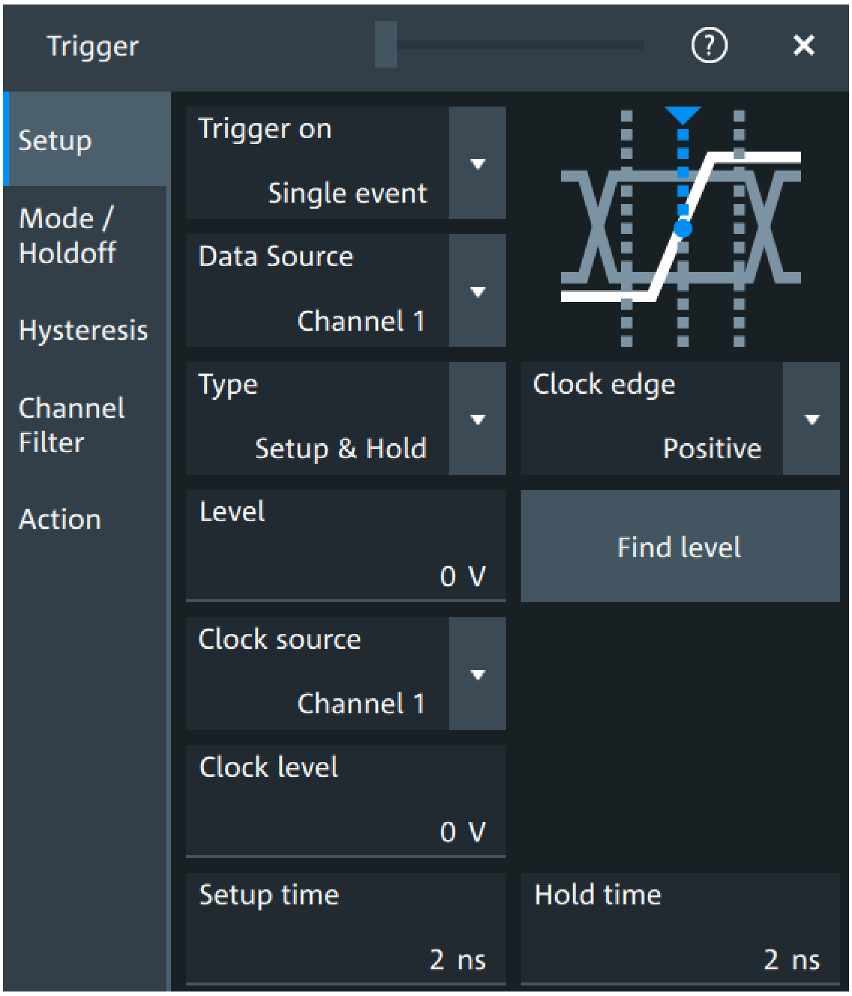
TRIGger:EVENt<m>:SLEW:DELTa on page 425

7.4.10 Setup & Hold

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Setup & Hold"

The setup & hold trigger analyzes the relative timing between two signals: a data signal and the synchronous clock signal. Many systems require, that the data signal must be steady for some time before and after the clock edge, for example, the data transmission on parallel interfaces. With this trigger type, you can also test the time correlation of sideband and in-band signals.

The setup & hold trigger is also known as Data2Clock trigger.



Data Source
Selects the input channel of the data signal.

Remote command:
`TRIGger:EVENt<m>:SOURce` on page 409

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

Remote command:
`TRIGger:EVENt<m>:LEVel<n>[:VALue]` on page 408

Clock source
Selects the input channel of the clock signal.

Remote command:
`TRIGger:EVENt<m>:SETHold:CSOurce[:VALue]` on page 427

Clock edge
Sets the edge of the clock signal. Edge and level define the time reference point.

"Positive" Rising edge, a positive voltage change.

"Negative" Falling edge, a negative voltage change.

"Both" Both the rising and the falling edge.

Remote command:
TRIGger:EVENt<m>:SETHold:CSOurce:EDGE on page 427

Clock level
Sets the voltage level for the clock signal.

Both the clock level and the clock edge define the starting point for calculation of the setup and hold time.

Remote command:
TRIGger:EVENt<m>:SETHold:CSOurce:LEVel on page 427

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

Remote command:
TRIGger:EVENt<m>:SETHold:STIMe on page 428

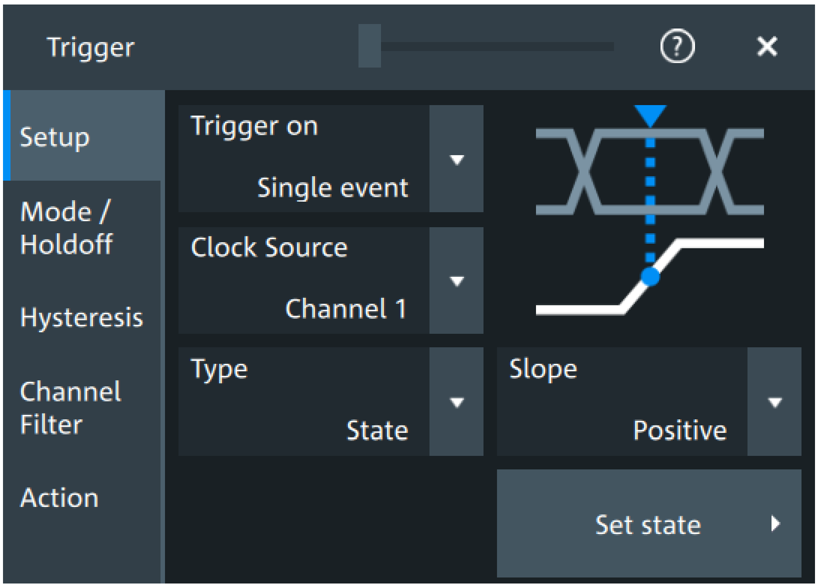
Hold time
Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

Remote command:
TRIGger:EVENt<m>:SETHold:HTIMe on page 428

7.4.11 State trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = State"

The state trigger verifies if the channel states match the defined pattern at the clock edge. The trigger occurs if the logical combination of the input channels is true at the crossing point of the selected clock edge and the trigger level.



1. Select the "Clock Source" and the "Slope".
2. Tap "Set state".
   See Chapter 7.4.12.1, "Set state for state and pattern trigger", on page 151 for setting details.

Slope
Sets the edge direction for the trigger.

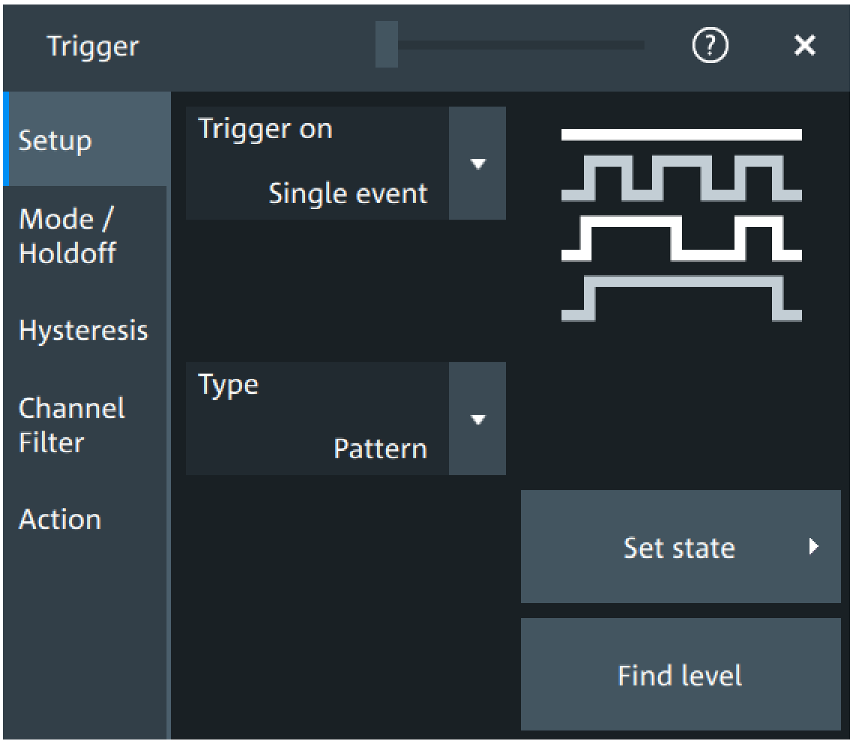
"Positive"	Selects the rising edge, which is a positive voltage change.
"Negative"	Selects the falling edge, which is a negative voltage change.
"Either"	Selects the rising and falling edge. After starting an acquisition, the instrument triggers on the first identified edge.

Remote command:
`TRIGger:EVENt<m>:STATe:SLOPe` on page 429

7.4.12 Pattern trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = Pattern"

The pattern trigger works like a logic trigger. It provides logical combinations of the input channels and can be used for verifying the operation of digital logic. If the channel states match the desired pattern, the pattern trigger occurs.



► Tap "Set state".
See Chapter 7.4.12.1, "Set state for state and pattern trigger", on page 151 for setting details.

7.4.12.1 Set state for state and pattern trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Type = State" or "Type = Pattern" > "Set state"

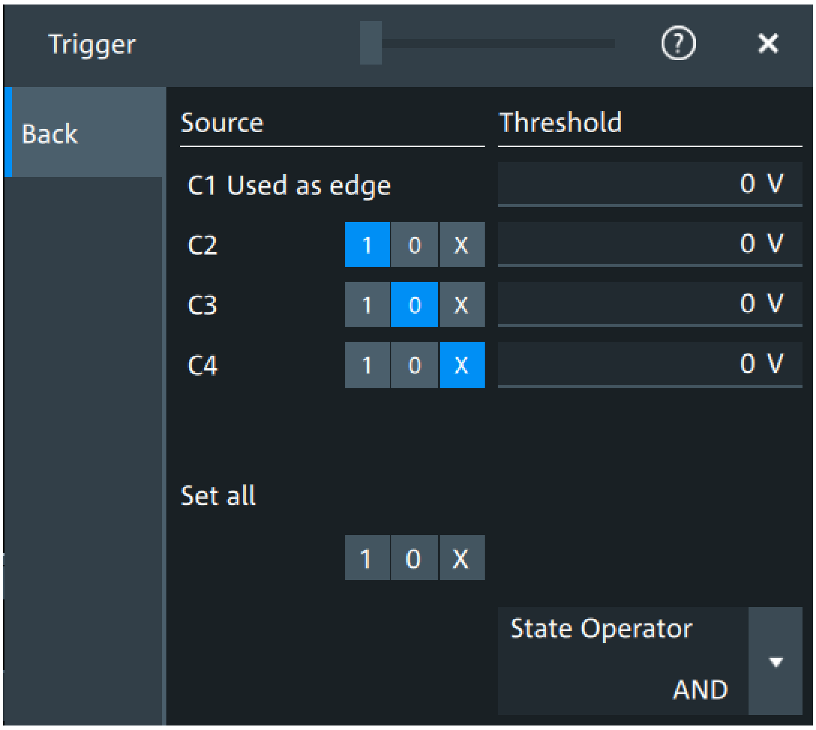


Figure 7-1: Set state for state trigger

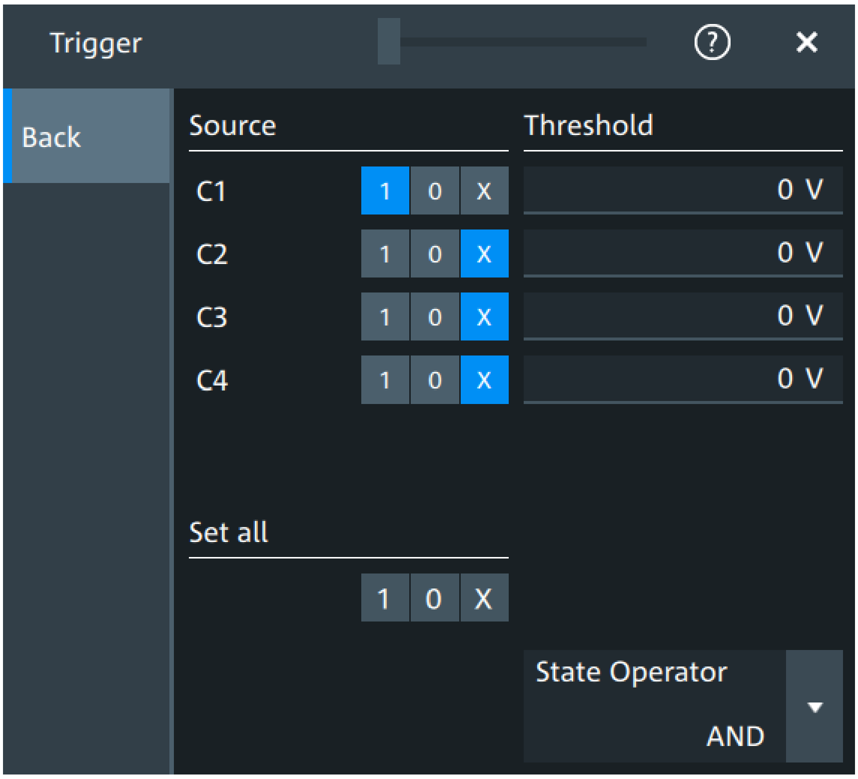


Figure 7-2: Set state for pattern trigger

Source: channel states
Set the state for each channel. For the state trigger, the clock source is indicated and does not get a state.

Remote command:
`TRIGger:EVENt<m>:STATe:QUALify:ANALog:CHAN<n>:HLX` on page 429
`TRIGger:EVENt<m>:PATTern:QUALify:ANALog:CHAN<n>:HLX` on page 430

Threshold
Set the threshold for each channel.

Remote command:
`TRIGger:EVENt<m>:LEVel<n>[:VALue]` on page 408

Set all
Sets all channels to the selected state.

State Operator
Defines the logic combination of the channels and their states.

- "AND": logical AND, conjunctive combination
- "OR": logical OR, disjunctive combination

Remote command:
`TRIGger:EVENt<m>:STATe:QUALify:LOGic` on page 429
`TRIGger:EVENt<m>:PATTern:QUALify:LOGic` on page 430

7.4.13 Line trigger

Access: "Menu" > "Trigger" > "Setup" tab > "Source" = "Line"

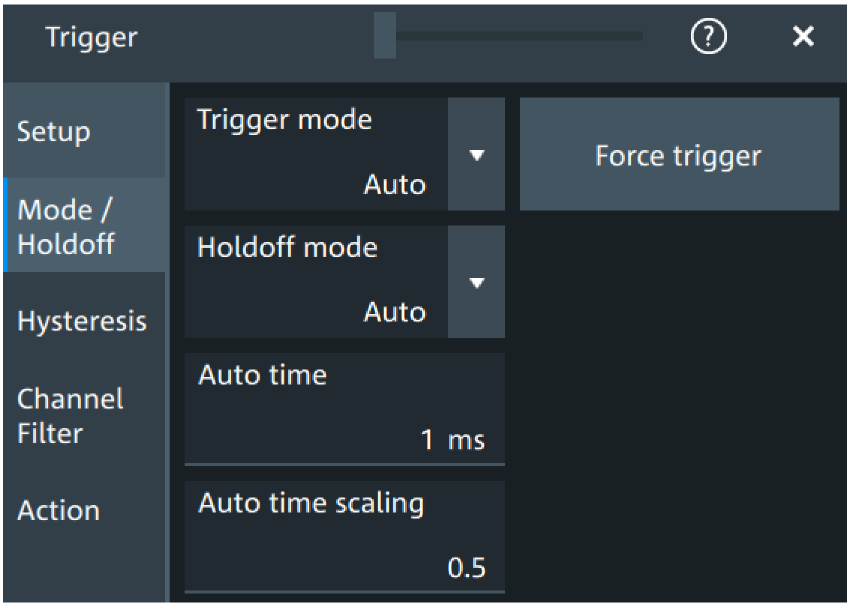
The line trigger is an edge trigger that triggers on the AC power input and synchronizes the signal to the AC power frequency. It is not a trigger type but rather a special trigger source. Use the line source if you want to analyze signals related to the power line frequency, such as lighting equipment and power supply devices.

Slope
Selects the rising or falling edges of the AC power input.

7.5 Trigger mode / holdoff

Access: "Trigger" menu > "Mode / Holdoff" tab

Holdoff conditions define a waiting time after the current trigger until the next trigger can be recognized.



Trigger mode

Sets the trigger mode which determines the behavior of the instrument if no trigger occurs. The current setting is shown on the trigger label.

To toggle quickly between "Auto" and "Normal" mode, use the [Auto Norm] key on the front panel (in "Trigger" section).

"Auto" The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. This mode helps to see the waveform even before the trigger conditions are set correctly. The waveform on the screen is not synchronized, and successive waveforms are not triggered at the same point of the waveform. The time interval depends on the time base settings.

"Normal" The instrument acquires a waveform only if a trigger occurs, that is, if all trigger conditions are fulfilled. If no trigger occurs, no waveform is acquired and the last acquired waveform is displayed. If no waveform was captured before, none is displayed.
When no trigger has been found for longer than one second, a message box appears that shows the time elapsed since the last trigger.

"Free run" The instrument starts acquisition immediately and triggers after a short time interval independent of the time base settings and faster than in "Auto" mode. Real triggers are ignored. Use this mode if the "Auto" mode is too slow.

Remote command:
`TRIGger:MODE` on page 431

Force trigger

Provokes an immediate single acquisition. Force the trigger if the acquisition is running in normal mode and no valid trigger occurs. Thus, you can confirm that a signal is available and use the waveform display to determine how to trigger on it.

Remote command:
`TRIGger:FORCe` on page 431

Holdoff mode
Selects the method to define the holdoff condition.

The trigger holdoff defines when the next trigger after the current will be recognized. Thus, it affects the next trigger to occur after the current one. Holdoff helps to obtain stable triggering when the oscilloscope is triggering on undesired events.

Holdoff settings are not available if the trigger source is an external trigger input or serial bus, and if you trigger on a sequence of events.

Example:

For example, you want to analyze the first pulse in a burst of several pulses. At first, you select a sufficiently slow time base to display the entire burst. Then, you set the holdoff time a little longer than the length of the burst. Now, each trigger corresponds to the first pulse in successive bursts, and you can change the time base to display the waveform in more detail.

The following methods are available:

"Time" Defines the holdoff directly as a time period. The next trigger occurs only after the "Holdoff time" has passed.

"Events" Defines the holdoff as a number of trigger events. The next trigger only occurs when this number of events is reached. The number of triggers to be skipped is defined in "Holdoff events".

"Random" Defines the holdoff as a random time limited by "Minimum time" and "Maximum time". For each acquisition cycle, the instrument selects a new random holdoff time from the specified range.
Random holdoff prevents synchronization to discover effects invisible with synchronized triggering, for example, the features of a pulse train.

"Auto" The holdoff time is calculated automatically based on the current horizontal scale.
"Auto time scaling" defines the factor that the horizontal scale is multiplied with.
"Auto time" shows the resulting holdoff time: *Auto time = Auto time scaling * Horizontal scale*.

"Off" No holdoff

Remote command:
`TRIGger:HOLDoff:MODE` on page 431
`TRIGger:HOLDoff:TIME` on page 434
`TRIGger:HOLDoff:EVENts` on page 433
`TRIGger:HOLDoff:MAX` on page 433
`TRIGger:HOLDoff:MIN` on page 433
`TRIGger:HOLDoff:AUTotime?` on page 432
`TRIGger:HOLDoff:SCALing` on page 432

7.6 Hysteresis

Access: "Menu">"Trigger" > "Hysteresis"

The rejection of noise by setting a hysteresis avoids unwanted trigger events caused by noise oscillation around the trigger level.

HW hysteresis
Displays the hysteresis that is set by the instrument in automatic hysteresis mode.

Remote command:
TRIGger:NOISe<m>:EFFective? on page 434

Hysteresis mode
Selects how the hysteresis is set.

"Auto"	Automatic mode is the recommended mode. The hysteresis is set by the instrument to reject the internal noise of the instrument.
"Manual"	The hysteresis is defined directly in absolute or relative values.

Remote command:
TRIGger:NOISe<m>:MODE on page 435

Size mode
Selects whether the hysteresis is defined in absolute or relative values. The setting is available only in manual hysteresis mode.

Remote command:
TRIGger:NOISe<m>:MODE on page 435

Absolute hysteresis
Defines a range in absolute values around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs.

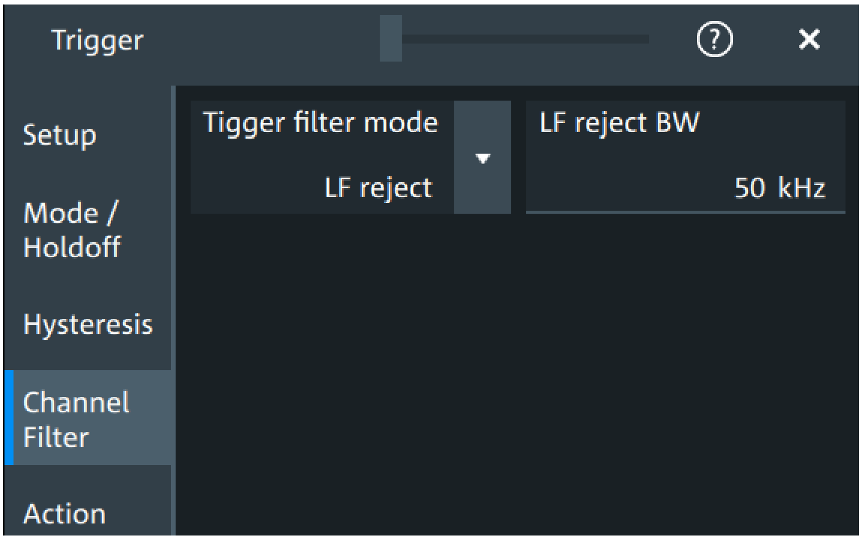
Remote command:
TRIGger:NOISe<m>:ABSolute on page 434

Relative hysteresis
Defines a range in divisions around the trigger level in division or as percentage. If the signal oscillates inside this range and crosses the trigger level thereby, no trigger event occurs.

Remote command:
TRIGger:NOISe<m>:PERDivision on page 435
TRIGger:NOISe<m>:RELative on page 435

7.7 Channel filter

Access: "Menu">"Trigger" > "Channel Filter"



Trigger filter mode
Selects the filter mode for the trigger channel.

"Off"	The trigger signal is not filtered.
"LF reject"	Frequencies lower than the "LF reject BW" are rejected, higher frequencies pass the filter.
"RF reject"	Frequencies higher than the "RF reject BW" are rejected, lower frequencies pass the filter.

Remote command:
`TRIGger:FILTermode` on page 436

LF reject BW
Sets the limit frequency limit for the high-pass filter of the trigger signal. Frequencies lower than this value are rejected, higher frequencies pass the filter.

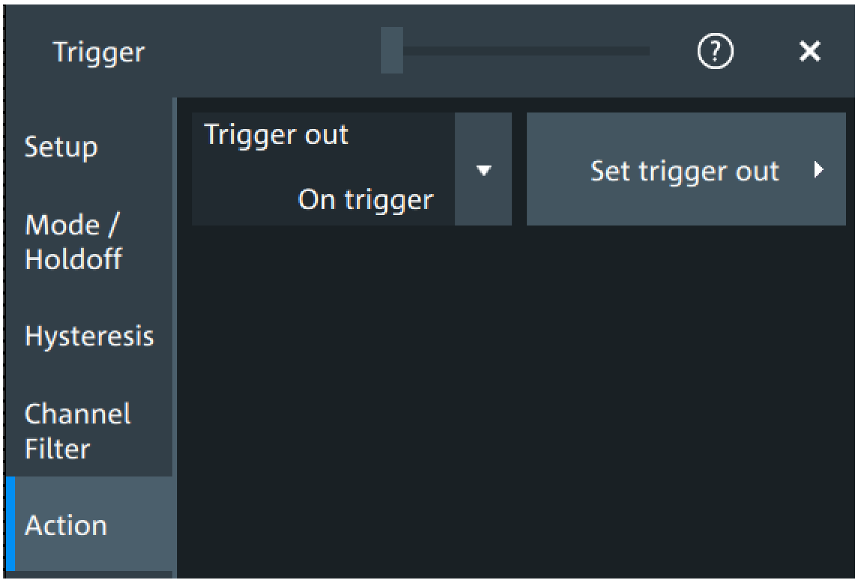
Remote command:
`TRIGger:LFReject` on page 437

RF reject BW
Sets the limit frequency limit for the low-pass filter of the trigger signal. Frequencies higher than this value are rejected, lower frequencies pass the filter.

Remote command:
`TRIGger:RFReject` on page 437

7.8 Actions on trigger

Access: "Menu" > "Trigger" > "Action" tab



The action settings define what happens when a trigger occurs. All available actions can be initiated at the same time.

Trigger out

Selects, if a pulse is provided to the [Aux Out] connector on the rear panel. The trigger-out signal is used to synchronize the measurements of other instruments.

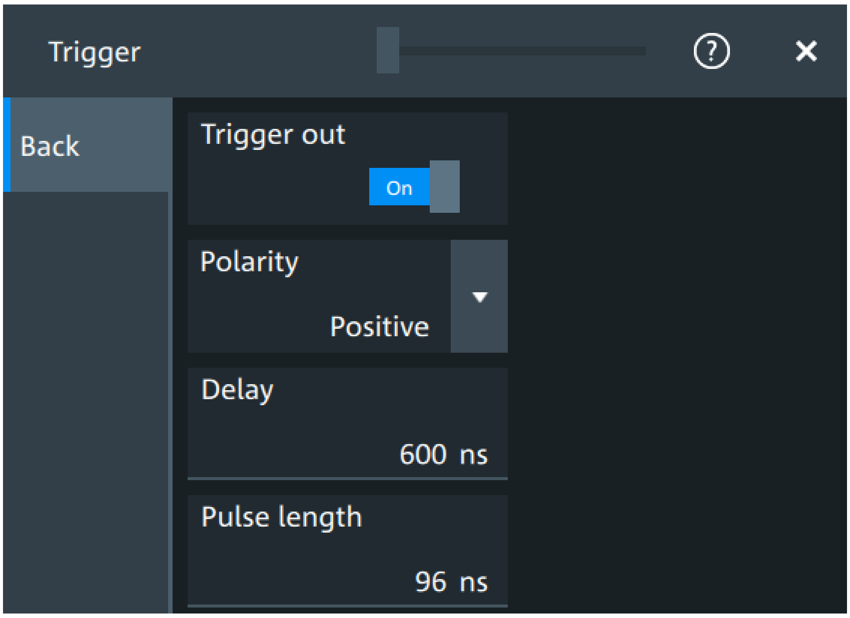
To adjust the outgoing signal, tap "Set trigger out"

Remote command:

`TRIGger:ACTions:OUT:STATe` on page 437

Set trigger out

Opens a dialog to adjust the trigger out pulse.



Trigger out ← Set trigger out
Activates the outgoing pulse on the [Aux Out] connector on the rear panel.

Remote command:
`TRIGger:ACTions:OUT:STATe` on page 437

Polarity ← Set trigger out
Sets the polarity of the trigger out pulse, which is the direction of the first pulse edge.

Remote command:
`TRIGger:ACTions:OUT:POLarity` on page 438

Delay ← Set trigger out
Defines the delay of the first pulse edge to the trigger point. The minimum delay is 600 ns.

Remote command:
`TRIGger:ACTions:OUT:DELay` on page 438

Pulse length ← Set trigger out
Sets the length of the trigger out pulse.

Remote command:
`TRIGger:ACTions:OUT:PLENgth` on page 438

8 Waveform analysis

This chapter describes general methods to check and analyze waveforms. These are:

8.1 Zoom

The zoom magnifies a part of the waveform to view more details. The zoom is applied to all waveforms that are visible in a diagram.

For each diagram, you can define one zoom area.

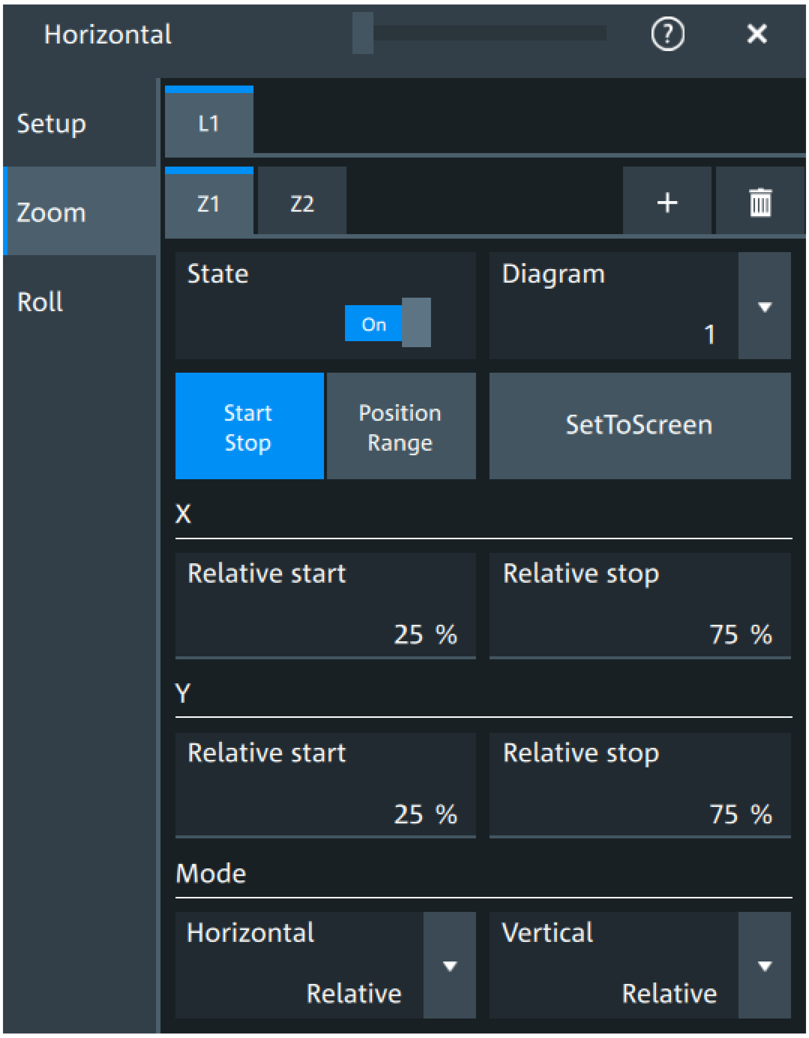
- You can define the zoom by drawing, moving and adjusting the zoom area on the touchscreen.
- You can precisely define the size of the zoom area by entering start and stop values in a dialog box.

Zoom areas can be used for gating, for example, to define a measurement gate. You can set the gate exactly to the limits of the zoom.

8.1.1 Zoom settings

Access: "Menu" > "Horizontal" > "Zoom" tab.

The "Zoom" tab allows you to specify start and stop values for the x- and y-axes. The acquired data within these ranges is zoomed.



Lx

Selects one of the enabled SmartGrid layouts.

Zx

Selects the zoom window. You can add up to 4 different zooms.

State

Enables the zoom.

Remote command:

`LAYout<m>:ZOOM<n>[:ENABle]` on page 439

Diagram

Indicates which of the waveform diagrams is selected for zooming. The number is displayed on the screen in the middle of each diagram.

Remote command:

`LAYout<m>:ZOOM<n>:SOURce` on page 444

Start Stop, Position Range
Selects how the window for the zoom diagram is defined. You can select between defining "Start Stop" values or "Position Range".

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

According to the selected "Mode", absolute or relative values are used.

"Start", "Relative start"
Defines the lower limit of the zoom area on the axis.

"Stop", "Relative stop"
Defines the upper limit of the zoom area on the axis.

Remote command:
`LAYout<m>:ZOOM<n>:HORizontal:ABSolute:STARt` on page 441
`LAYout<m>:ZOOM<n>:HORizontal:RELative:STARt` on page 443
`LAYout<m>:ZOOM<n>:HORizontal:ABSolute:STOP` on page 441
`LAYout<m>:ZOOM<n>:HORizontal:RELative:STOP` on page 443
`LAYout<m>:ZOOM<n>:VERTical:RELative:STARt` on page 446
`LAYout<m>:ZOOM<n>:VERTical:ABSolute:STARt` on page 445
`LAYout<m>:ZOOM<n>:VERTical:RELative:STOP` on page 446
`LAYout<m>:ZOOM<n>:VERTical:ABSolute:STOP` on page 445

Position Range
If "Position Range" is selected, you specify the x and y position of center point of the zoom area plus a range for the x- and y-axes. The area defined by that point and the ranges is zoomed. You can set absolute values or relative values (in percent of the screen, depending on the "Mode" selection.

"Range" Defines the width or height of the zoom area.

"Position" Defines the x or y value of the centerpoint of the zoom area.

Remote command:
`LAYout<m>:ZOOM<n>:HORizontal:ABSolute:POSition` on page 440
`LAYout<m>:ZOOM<n>:HORizontal:RELative:POSition` on page 442
`LAYout<m>:ZOOM<n>:HORizontal:ABSolute:SPAN` on page 440
`LAYout<m>:ZOOM<n>:HORizontal:RELative:SPAN` on page 442
`LAYout<m>:ZOOM<n>:VERTical:ABSolute:POSition` on page 444
`LAYout<m>:ZOOM<n>:VERTical:RELative:POSition` on page 446
`LAYout<m>:ZOOM<n>:VERTical:ABSolute:SPAN` on page 444
`LAYout<m>:ZOOM<n>:VERTical:RELative:SPAN` on page 447

Mode
Defines if absolute or relative values are used to specify the "Horizontal" (x-axis) and the "Vertical" (y-axis) values.

Remote command:
`LAYout<m>:ZOOM<n>:HORizontal:MODE` on page 442
`LAYout<m>:ZOOM<n>:VERTical:MODE` on page 445

8.1.2 Zooming for details

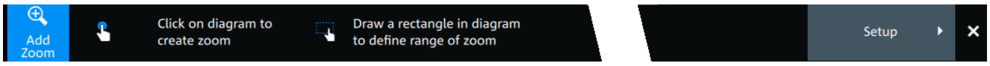
To define the zoom area on the touchscreen

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

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

   The zoom overlay menu opens.

2. Draw a rectangle in the diagram that defines the zoomed area.
   While you drag your finger on the touchscreen, a dotted rectangle indicates the current zoom area.

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

3. If the position of the zoom area is not correct, drag the rectangle in the overview to the correct position.

4. If the size of the zoom area is not yet ideal, tap the rectangle in the overview diagram.
   Now, 4 white lines indicate the edges of the zoom area. A dashed white line indicates the selected edge, which you can adjust.

5. Touch the edge that you want to move. Drag it to the required position.

To create a zoom using the zoom dialog box

► If you want to create a new, unconfigured zoom, tap the "Add" icon.

To define the zoom area numerically using start/stop values

1. Open "Menu" > "Horizontal".
2. In the "Zoom" tab, select "Start Stop".
3. Select a value for "Mode" > "Horizontal" to define "Absolute" or "Relative" x-axis values. Relative values cause the zoom area to adapt to the input values dynamically.
4. For "X", define the "Relative start" and "Relative stop" values. They define the lower and upper borders of the zoom area on the x-axis.
5. Select the "Mode" > "Vertical" to define "Absolute" or "Relative" y-axis values.

6. For "Y", define the "Relative start" and "Relative stop" values. They define the lower and upper borders of the zoom area on the y-axis.

   When you close the dialog box, the specified area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle.

To define the zoom area numerically using position and range values

1. Open "Menu" > "Horizontal".
2. In the "Zoom" tab, select "Position Range".
3. Select "Mode" > "Horizontal" to define "Absolute" or "Relative" x-axis values. Relative values cause the zoom area to adapt to the input values dynamically.
4. Under "X" > "Position", define the x-value of the center point of the zoom area.
5. Under "X" > "Range", define the width of the zoom area.
6. Select the "Mode" > "Vertical" to define "Absolute" or "Relative" y-axis values.
7. Under "Y" >"Position", define the y-value of the center point of the zoom area.
8. Under "Y" > "Range", define the height of the zoom area.

   When you close the dialog box, the specified area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle.

8.2 Mathematics

Math waveforms are calculated waveforms. You can define up to 5 math waveforms and display them on the screen, and use it as source for further analysis.

It is calculated out of one or two analog channels, or another math waveform using several predefined operations. You can define up to 5 equations. The complete configuration is called equation set and can be saved for later use.

You can analyze math waveforms in the same way as channel waveforms: use zoom, perform automatic and cursor measurements, and save as reference waveform.

You can store a math waveform as a reference waveform and restore it later .

8.2.1 Displaying math waveforms

Math waveforms can be displayed in addition to the channel and other waveforms. They also can be used for analysis, e.g. measurements, even if the math waveform is not active.

1. Open "Menu" > "Math" >"Setup".
   Alternatively, press the [Math] key.

2. Select the math "Operator".
3. If necessary, define the settings for the operator.
4. Tap "Display".

   The math waveform is displayed on the screen. Also a green dot appears in the enabled math tab.

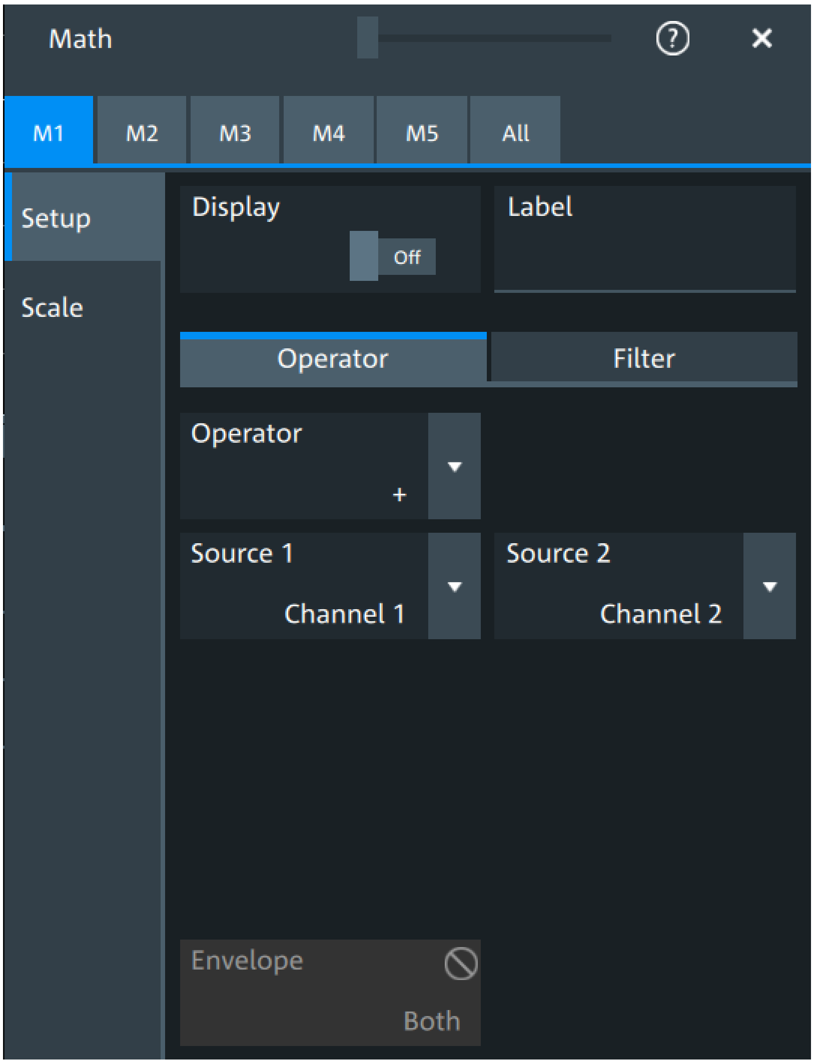
   

5. To change the vertical scaling of the math waveform, open the "Scale" tab.
6. Set the "Scale mode" to "Manual".
7. Enter the "Vertical scale" factor (per division). If necessary, add a "Vertical offset". By default the instrument performs an automatic scaling.
8. Close the "Math" dialog box.

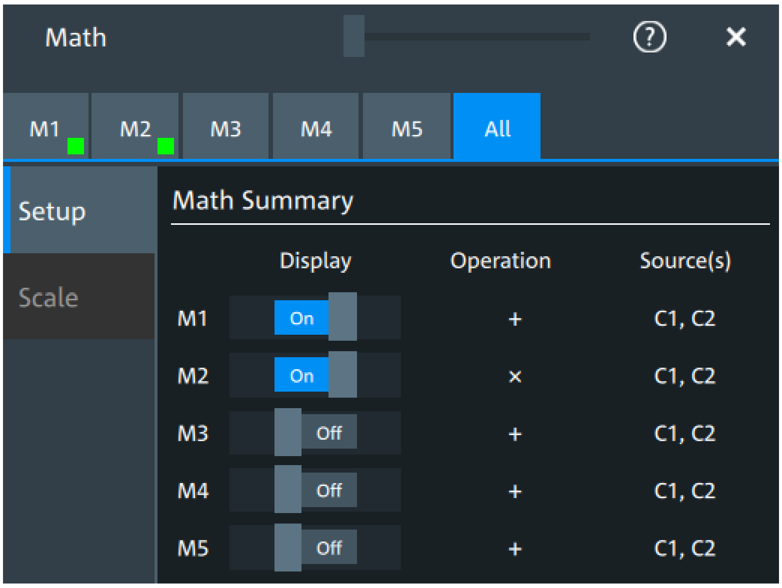
8.2.2 Math waveforms settings

Access: [Math] > "Setup" tab

You can define up to five different math waveforms. Each waveform is defined in a separate tab in the "Math" dialog box ("M1" to "M5").



You can also find a summary of the state of all math channels in the "All" tab.



Display
Activates the selected Math channel and displays the defined math waveforms.

Remote command:
`CALCulate:MATH<m>:STATe` on page 447

Label
Adds a label to the math waveform.

Operator
Defines the type of operation to be performed on the selected signal sources.

The following functions are available:

"+"	Adds the values of 2 sources (channel or math waveform).
"-"	Subtracts source 2 from source 1.
"x"	Multiplies the two sources.
"/"	Divides source 1 by source 2.
"|x|"	Determines the absolute value of the source.
"dx/dt"	Differentiates the source value relating to the time value. Not possible on envelope waveforms and waveforms with "Peak detect" decimation.
"Integral"	Calculates the definite integral of the source.
"log(x)"	Calculates the logarithm of the source value based on 10.
"ln(x)"	Calculates the natural logarithm of the source value (based on e).
"ld(x)"	Calculates the binary logarithm of the source value (binary logarithm, based on 2).
"x^2"	Squares the source. If the source contains negative values that have been clipped, then the result contains positive clipping.

"√x"	Calculates the square root of the source. Note that the square root of a negative number is undefined and the result is clipped.
"ax+b"	Rescaling of x.

Remote command:
`CALCulate:MATH<m>[:EXPRession][:DEFine]` on page 448

Source 1, Source 2
Defines the signal source to be evaluated by the math function.

a, b
Defines the values for the rescale function, if "Operator" = "ax+b"

"a"	Multiplication factor
"b"	Offset of the signal source on the y-axis.

Noise reject
Only available for "Operator" = "dx/dt".

Sets the number of neighboring samples that are skipped for differentiation.

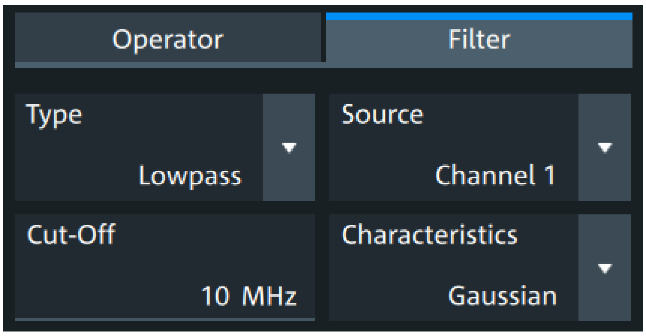
To suppress noise effects during differentiation, it can be useful not to consider two directly neighboring points to calculate *dx* (x_n-x_{n-1}). Instead, some samples in-between are skipped and a point a few samples further is used (e.g. x_n-x_{n-3}).

Envelope wfm selection
Selects the upper or lower part of the input waveform for mathematic calculation, or a combination of both.

Remote command:
`CALCulate:MATH<m>:ENVSelection` on page 449

8.2.3 Math filter

Access:[Math] > "Filter" tab



The finite impulse response filter is a filter to create filtered math waveforms with low-pass or highpass. The filter requires additional settings.

Type
Selects, if the filter is highpass or lowpass.

Source 1
Selects the input channel of the signal.

Cut-off
Sets the limit frequency for the filter.

Cut-off frequency for lowpass filter

The cut-off frequency depends on the horizontal resolution and the filter characteristics. The frequency for the lowpass filter can only be set in this range:

f_g_3dB = (0.001 ... 0.2) f_a_in* for Gaussian FIR filter

f_g_3dB = (0,001 ... 0.4) f_a_in* for rectangular FIR filter

Where: *f_g_3dB* = cut-off frequency to be set for the lowpass filter, and *f_a_in* = reciprocal of the resolution, or sample rate.

Cut-off frequency for highpass filter

To check limit frequency for the highpass filter, convert it to an equivalent lowpass frequency:

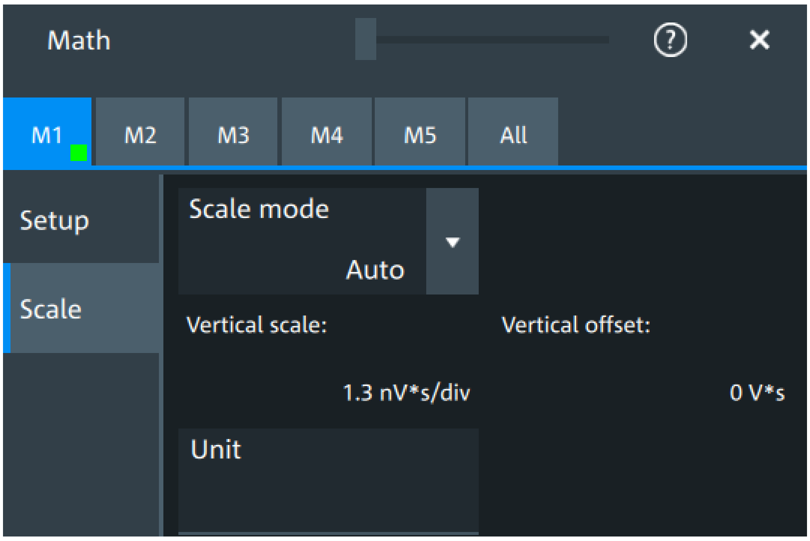
f_LP = f_a_in/2 - f_HP

Where f_HP is the requested highpass limit frequency and f_LP the equivalent lowpass frequency that has to comply with the limits given above.

Characteristics
Selects if a Gaussian or a rectangular shape is used for the lowpass filter. The highpass filter is always Gaussian.

8.2.4 Math scale settings

Access:[Math] > "Scale" tab



Scale mode
By default, the vertical scale is adapted to the current measurement results automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

"Manual"	Enter the required values for "Vertical scale" and "Vertical offset".
"Auto"	"Vertical scale" and "Vertical offset" are read-only.

Remote command:
`CALCulate:MATH<m>:VERTical:SCALe:MODE` on page 449

Vertical scale
Sets the scale of the y-axis in the math function diagram. The value is defined as "<unit> per division", e.g. *50 mV/div*. In this case, the horizontal grid lines are displayed in intervals of 50 mV.

If Scale mode is set to "Auto", this setting is read-only.

Remote command:
`CALCulate:MATH<m>:VERTical:SCALe[:VALue]` on page 448

Vertical offset
Sets a voltage offset to adjust the vertical position of the math function on the screen. Negative values move the waveform, positive values move it down.

If Scale mode is set to "Auto", this setting is read-only.

Remote command:
`CALCulate:MATH<m>:VERTical:OFFSet` on page 448

Unit
Sets a user-defined unit for the math operation.

8.3 History

The history accesses the data of previous acquisitions and provides them for further analysis.

8.3.1 About history

If a continuous acquisition runs, the captured data is stored in the sample memory and the current acquisition is processed and shown on the display. After the acquisition is stopped, the history accesses the captured samples that were stored, displays these samples as history waveforms, and makes them available for further analysis. It considers all channels that were enabled during the running acquisition. When a new acquisition is started with [Run / Stop] or [Single], the memory is cleared and written anew.

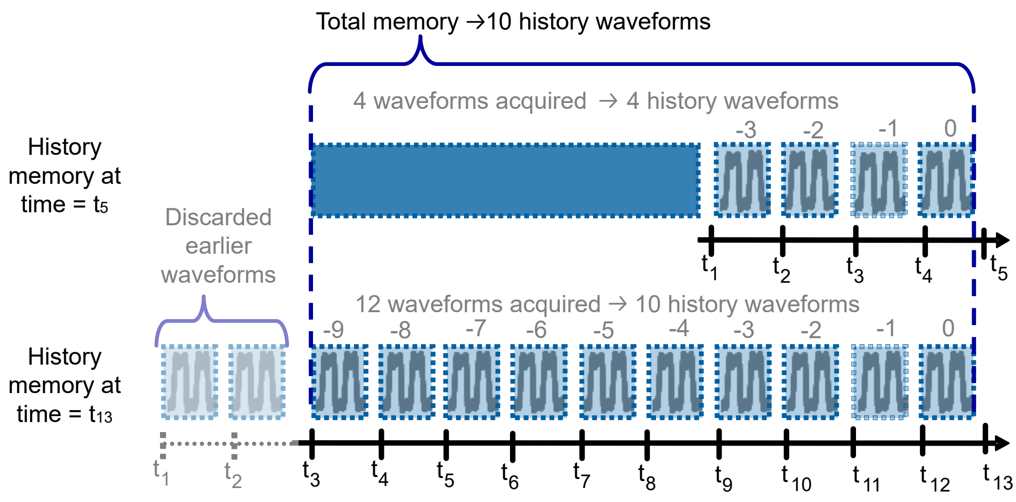


Figure 8-1: History memory. In this example, the memory can store 10 waveforms.

You can work with history waveforms in the same way as with the waveform of the latest acquisition: use zoom, cursors, measurements, create math waveforms and so on. Saving the history data is also possible, either completely or a part of the data.

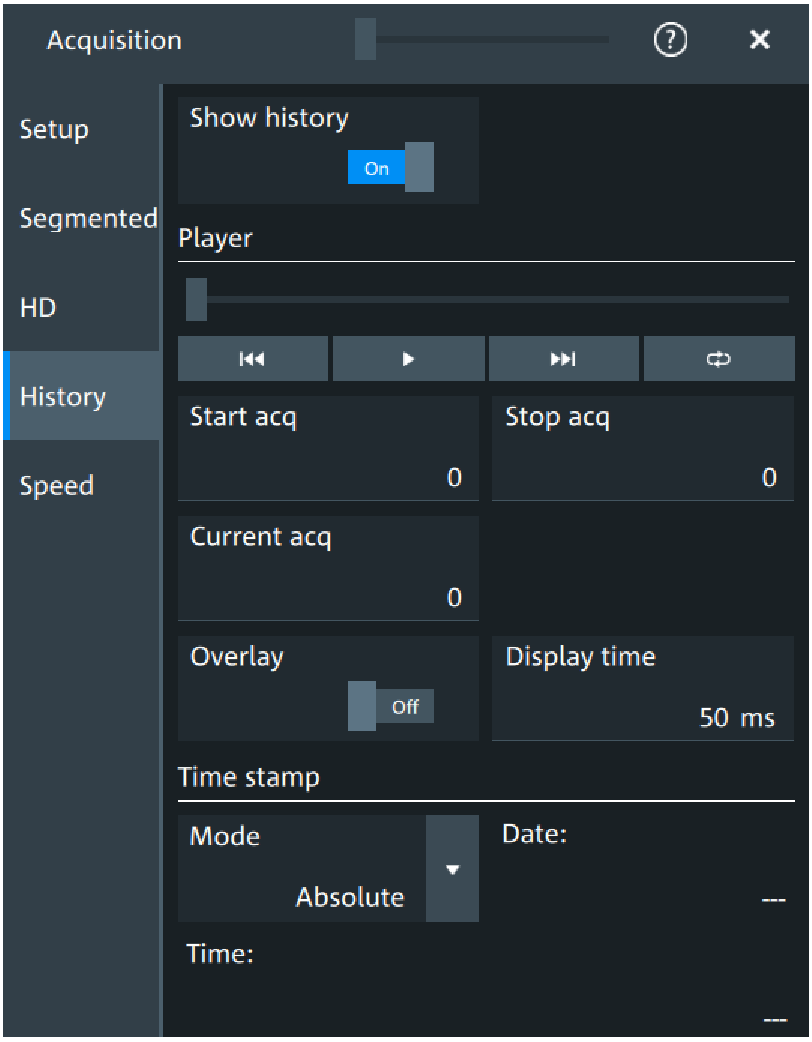
The number of stored history waveforms depends on the memory size, the number of enabled channels, and the record length. The shorter the record length, the less the number of channels, and the larger the memory, the more history waveforms are saved.

8.3.2 History setup

The "History" dialog contains the complete functionality on history viewing and information.

The most important information and functions are also provided in the quick-access history dialog box.

Access: "Menu" > "Acquisition" > "History" tab.



Show history

Enables the history mode and allows you to save history waveforms to file.

The history display is enabled automatically when you press the [History] button. It is disabled when you close the quick-access "History" dialog box.

Remote command:

`ACQuire:HISTory[:STATe]` on page 453

Player

The player can be used to control the playback of the history waveforms.

Sets the oldest acquisition in the sample memory as "Start acq" and "Current acq".

Starts and stops the replay of the history waveforms from "Start acq" to "Stop acq".

Sets the newest acquisition in the sample memory as "Stop acq" and "Current acq". This acquisition always has the index "0".

"Auto repeat": If selected, the playback of the selected history segments repeats automatically. See also: "Auto repeat" on page 174.

Remote command:
`ACQuire:HISTory:PLAY` on page 451

Start acq
Sets the index of the first (oldest) acquisition to be displayed or exported. The index is always negative.

Remote command:
`ACQuire:HISTory:STARt` on page 452

Stop acq
Sets the index of the last (newest) acquisition to be displayed or exported. The newest acquisition of the complete acquisition series always has the index "0".

Remote command:
`ACQuire:HISTory:STOP` on page 452

Current acq
Accesses a particular acquisition in the memory to display it, or to save it. The newest acquisition always has the index "0". Older acquisitions have a negative index.

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

Remote command:
`ACQuire:HISTory:CURRent` on page 451

Overlay
Displays the segments with infinite persistence. Thus, you can see all data points of all displayed segments of a player cycle. Same setting as "Infinite persistence" on page 80.

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

The setting takes effect for usual history replay and the display of a fast segmentation series via the history.

Remote command:
`ACQuire:HISTory:TPACq` on page 452

Time stamp
The time stamp shows the time of the currently displayed history acquisition. Thus, the time relation between acquisitions is always available.

The time stamp "Mode" can be absolute or relative:
- In "Absolute" mode, the instrument shows the date and the daytime of the current acquisition.
- In "Relative" mode, the time difference to the newest acquisition (index = 0) is shown.

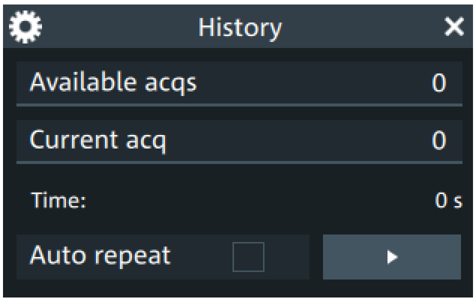
During history replay, the time value is displayed and updated if the replay speed ("Display time") is slow enough, that is 40 ms or slower.

The quick-access history dialog box always shows the time according to the "Mode" that is selected in the "Acquisition" > "History" tab.

Remote command:
`ACQuire:HISTory:TSDate?` on page 453
`ACQuire:HISTory:TSABsolute?` on page 452
`ACQuire:HISTory:TSRelative?` on page 453
`ACQuire:HISTory:TSRReference?` on page 453

8.3.3 Quick access history dialog

The quick access history dialog is visible when the history is active. Closing the dialog disables the history display ("Show history" = "Off")



Available acqs
Number of acquisitions that is saved in the memory and available for history viewing. It is also the number of acquisitions in a fast segmentation acquisition series.

Remote command:
`ACQuire:AVAilable?` on page 387

Current acq
Index of the current acquisition, same as Current acq in the history setup.

Time
Shows the timestamp of the current acquisition. See "Time stamp" on page 173.

Auto repeat
If selected, the playback of the selected history segments repeats automatically.

Remote command:
`ACQuire:HISTory:REPLay` on page 451

Play
Starts and stops the replay of the history waveforms. See also: "Player" on page 172.

8.3.4 Using history

You can access the history waveforms in two ways:

- Display a particular acquisition.

- Replay all or a part of the saved waveforms to track the signal run.

To open the history and get information

1. Press the [History] key on the front panel.

   A running acquisition is stopped, the history mode is enabled and the quick-access "History" dialog box is displayed. The [History] key lights up as long as the history mode is active.

2. Open the full configuration dialog box:
   - Tap the icon.
   - Open "Menu" > "Acquisition" dialog > "History" tab.

To display a particular acquisition

1. In the quick-access "History" dialog box, enter the number of the required acquisition in the "Current acq" field. The newest acquisition always has the index "0", older acquisitions have a negative index.

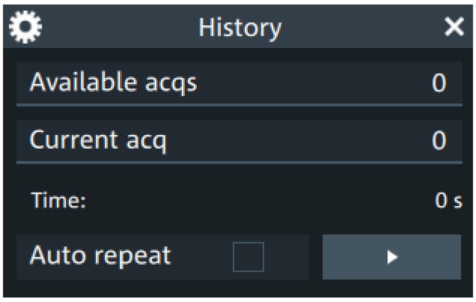
2. Tap "Play" to start.

Alternatively, you can configure and start the history display from the "History" configuration dialog box:

1. Open the "History" configuration tab.

2. If the history mode is off (the [History] key is not illuminated), select "Show history".

   The quick-access dialog box is displayed.



3. Drag the slider to the required acquisition. The current number is shown in the "Current acq" field.
   Alternatively, enter the number of the required acquisition in the "Current acq" field.

4. Tap "Play" to start.

To replay history waveforms

If you want to see the complete acquisition series without any setup, simply tap in the quick-access "History" dialog box. For specific analysis of history data, use the history "Viewer" setup.

1. Open the "History" configuration dialog tab.

2. If the history mode is off (the [History] key is not illuminated), enable "Show history".
3. Tap to start.

To exit the history

► Choose one of the following ways:
   - Close the quick-access "History" dialog box.
   - In the "History" configuration tab, disable "Show history".
   - Start the acquisition.

8.4 Reference waveforms

You can configure up to four reference waveforms to display stored waveforms. Any active signal, mathematical waveform or spectrum can be stored as a reference waveform. It can then be loaded again later to restore the waveform on the screen.

8.4.1 Working with reference waveforms

Reference waveforms can be displayed in addition to the signal waveforms.

To display a reference waveform

1. In the "Menu" > "Apps" > "General" tab, select "Reference".
   Alternatively, press the [Ref] key.
2. Select the tab for the reference waveform that you want to display ("R1/2/3/4").
3. Load a stored reference waveform as described in To load a reference waveform.
   Alternatively, select a source to be displayed as a reference:
   a) In the "Setup" tab, select "Source".
   b) Select the "Source" from the selection list. The list shows all active waveforms that can be saved as references.
   c) Tap the "Create/Update" button to update the current reference waveform with the source data.
4. Tap the "Show" button.

   The reference waveform is displayed on the screen.
5. A reference waveform can have its own scaling settings or it can be scaled according to the source settings. By default, the scaling of the reference waveform is coupled to the source settings. Also, it can be stretched or compressed in vertical and horizontal direction.
   If necessary, change the settings on the "Vertical" and "Rescale" tabs of the "Reference Waveform" dialog.
   To restore the original settings, tap the "Set to original" in the "Vertical" tab.

For a description of the scaling settings, see Chapter 8.4.2.4, "Reference waveform rescale", on page 182.

To load a reference waveform

1. Press the [Ref] key.
2. Select the tab for the reference waveform that you want to load ("R1/2/3/4").
3. In the "Setup" tab, select "Recall".
4. Select the file from the file selection dialog box.
5. To load the waveform from the specified file, tap "Open".

   The selected waveform is loaded as the specified reference waveform.

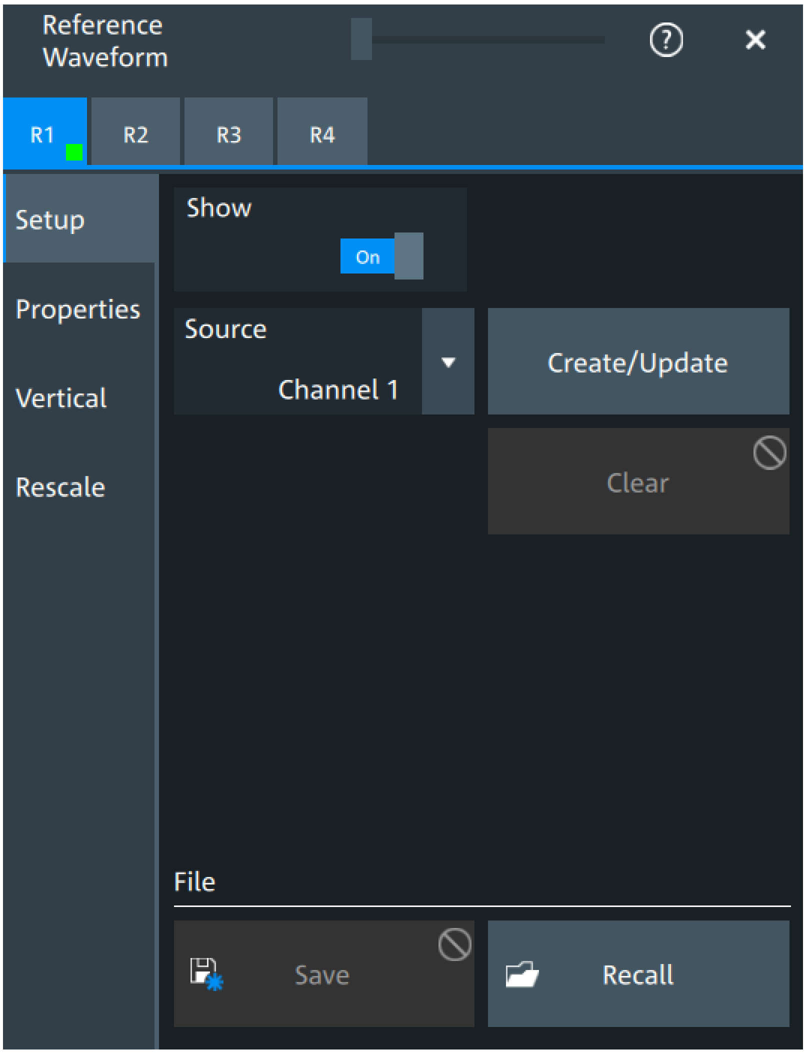
8.4.2 Settings for reference waveforms

To compare waveforms and analyze differences between waveforms, you can use up to four reference waveforms R1 to R4. Each reference waveform has its own memory on the instrument. You can also save an unlimited number of reference waveforms and load them for further use.

The display of a reference waveform is independent from the display of the source waveform; you can move, stretch and compress the curve vertically and horizontally.

8.4.2.1 Reference waveform setup

Access: [Ref] key > "Setup" tab



In the "Setup" tab, you select the target reference waveform and its source.

R1/2/3/4

Each tab contains the settings for one of the four available reference waveforms.

Show

Enables the display of the reference waveform in the diagram.

Remote command:

`REFCurve<rc>:STATe` on page 455

Source

Selects the source waveform from the active waveforms, e.g. input channels, math waveforms, or spectrum.

Remote command:

`REFCurve<rc>:SOURce` on page 455

Create/Update
Copies/updates the selected source waveform with all its settings to the memory of the reference waveform. If the acquisition is running, the reference waveform is a snapshot.

Remote command:
`REFCurve<rc>:UPDate` on page 456

Clear
The selected reference waveform disappears, its memory is deleted.

Remote command:
`REFCurve<rc>:CLEar` on page 454

Save
Saves the reference waveform. The complete reference waveform is stored in a REF file and can be reloaded later. If you want to save only a part of the waveform, or need CSV format, use "Menu" key >"Save/Recall" key > "Save" tab > "Waveform".

See also:
- Chapter 12.2, "Save and recall waveform data", on page 236
- Chapter 12.2.3, "Waveform export files", on page 239

Remote command:
`REFCurve<rc>:SAVE` on page 455

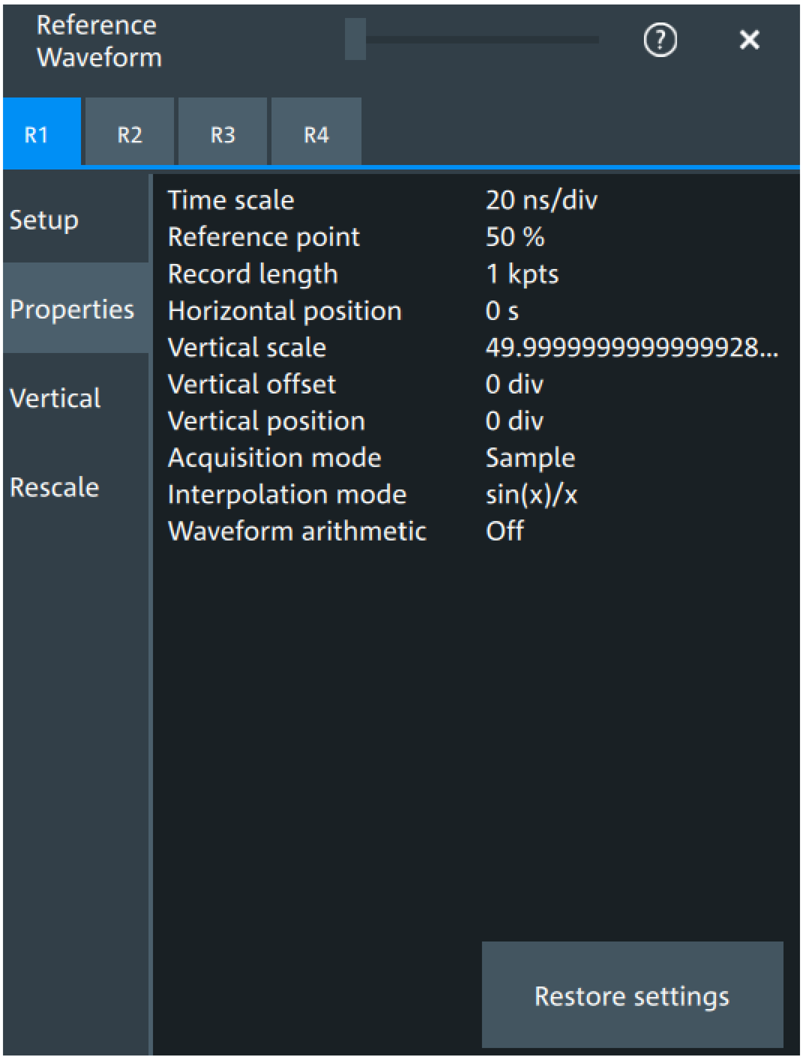
Recall
Opens a file selection dialog box and loads the selected reference waveform file.

Note that reference waveforms can be loaded only from `.ref` files. Other formats are meant for further processing in other applications.

Remote command:
`REFCurve<rc>:OPEN` on page 454

8.4.2.2 Reference waveform properties

Access: [Ref] key > "Properties" tab



A reference waveform can be scaled, stretched and positioned in the diagram. The "Properties" tab shows the original settings of the reference waveform, which are stored together with the waveform data.

Restore settings

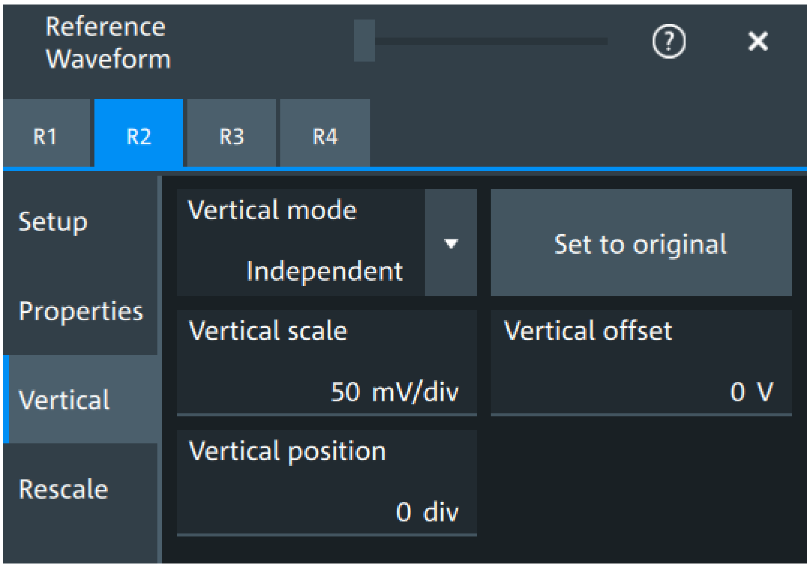
Resets the time scale and the reference point to the original values of the reference waveform.

Remote command:

`REFCurve<rc>:RESTore` on page 455

8.4.2.3 Reference waveform vertical

Access: [Ref] key > "Vertical" tab



Mode

Selects the type of vertical settings:

"Coupled to source" Vertical position and scale of the source are used.

"Independent" Scaling and position can be set specific to the reference waveform.

Remote command:
REFCurve<rc>:VMODe on page 460

Set to original

Available, if "Mode" = "Independent".

Restores the original vertical settings of the reference waveform (vertical scale, position, and offset).

Remote command:
REFCurve<rc>:TOORiginal on page 460

Vertical scale

Available, if "Mode" = "Independent".

Sets the vertical scale in Volts per division. The vertical scale defines the displayed amplitude of the selected waveform.

Remote command:
REFCurve<rc>:SCALe on page 457

Vertical offset

The vertical offset moves the reference waveform vertically. Enter a value with the unit of the waveform.

Remote command:
REFCurve<rc>:OFFSet on page 456

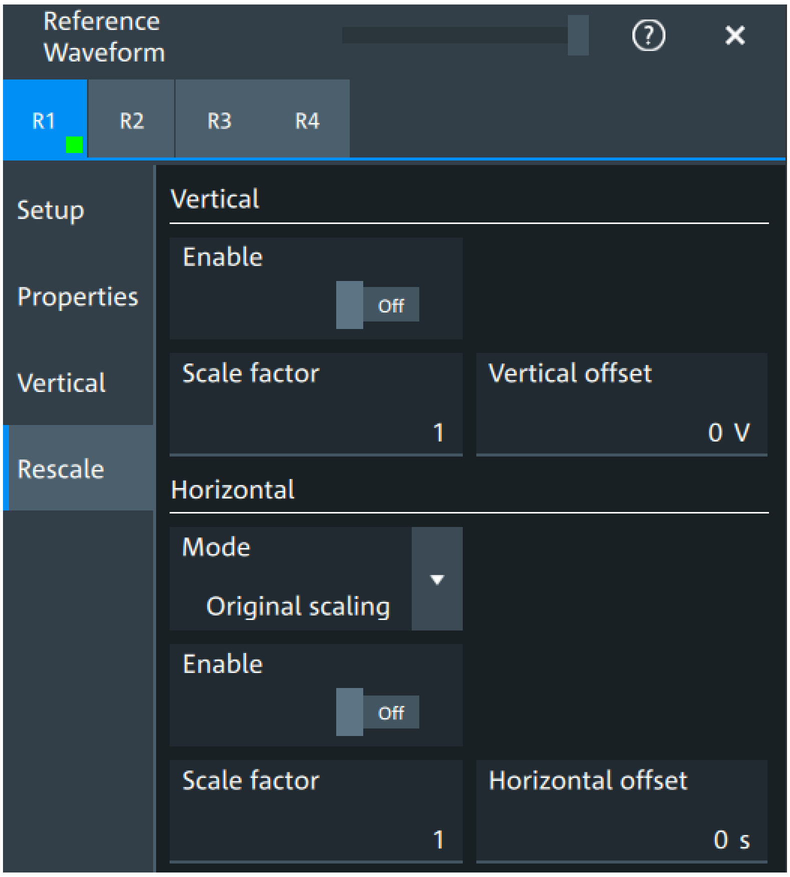
Vertical position
Available, if "Mode" = "Independent".

Moves the reference waveform up or down in the diagram.

Remote command:
REFCurve<rc>:POSition on page 457

8.4.2.4 Reference waveform rescale

Access: [Ref] key > "Rescale" tab



In the "Rescale" tab you can adjust the vertical and horizontal scaling of the reference waveform.

Vertical
Stretching and offset change the display of the waveform independent of the vertical scale and position.

Enable ← Vertical
If enabled, the vertical offset and factor are applied to the reference waveform.

Remote command:
REFCurve<rc>:RESCale:VERTical:STATe on page 459

Scale factor ← Vertical
Sets the vertical scale factor. A factor greater than 1 stretches the waveform vertically, a factor lower than 1 compresses the curve.

Remote command:
`REFCurve<rc>:RESCale:VERTical:FACTor` on page 459

Vertical offset ← Vertical
The vertical offset moves the reference waveform vertically. Enter a value with the unit of the waveform.

Like vertical offset of a channel waveform, the offset of a reference waveform is subtracted from the measured value. Negative values shift the waveform up, positive values shift it down.

Remote command:
`REFCurve<rc>:RESCale:VERTical:OFFSet` on page 459

Horizontal
Stretching and offset change the display of the waveform independent of the horizontal settings of the source waveform and of the horizontal diagram settings.

Mode ← Horizontal
Selects the type of horizontal settings:

"Original scaling"	Horizontal scaling and reference point of the source waveform are used.
"Adjust to X Axis"	The current horizontal settings of the diagram are used.

Remote command:
`REFCurve<rc>:HMODe` on page 457

Enable ← Horizontal
If enabled, the horizontal offset and factor are applied to the reference waveform.

Remote command:
`REFCurve<rc>:RESCale:HORizontal:STATe` on page 458

Scale factor ← Horizontal
Sets the horizontal scale factor. A factor greater than 1 stretches the waveform horizontally, a factor lower than 1 compresses the curve.

Remote command:
`REFCurve<rc>:RESCale:HORizontal:FACTor` on page 458

Horizontal offset ← Horizontal
Moves the waveform horizontally. Enter a value with a time unit suitable for the time scale of the diagram.

Positive values shift the waveform to the right, negative values shift it to the left.

Remote command:
`REFCurve<rc>:RESCale:HORizontal:OFFSet` on page 458

9 Measurements

Using the R&S MXO 4 you can perform and display different measurements simultaneously, based on the active signal or math waveforms. The color of the results in the result table corresponds with the source waveform color.

9.1 Cursor measurements

9.1.1 Cursors and results of cursor measurements

Cursor measurements determine the results at the current cursor positions. The cursors can be positioned manually, or can be configured to follow the waveform. You can measure on one waveform, or on two different waveforms (sources).

Up to 2 cursor sets can be configured and displayed. Each cursor set consists of a pair of horizontal or vertical cursors, or both. Cursor lines can be coupled so that the initially defined distance is always maintained.

The cursors are displayed in the diagrams of the source waveform only, or in all diagrams. For each measurement, labels can be defined for the cursors. By default, the cursors are labeled as Cu1.1, Cu1.2, Cu2.1, Cu2.2.

How to set up cursor measurements is described in Chapter 9.1.2, "Using cursors", on page 185. The Chapter 9.1.3, "Settings for cursor measurements", on page 187 provides a detailed description of all settings.

For details on using the result box, see Chapter 4.7, "Displaying results", on page 57.

9.1.1.1 Cursor measurements on time-based waveforms

The cursor for measurement on time-based waveforms returns the following results. The results are displayed automatically when a cursor measurement is enabled.

Label	Description
"X1, X2"	Time at the position of the vertical cursors.
"Y1, Y2"	Vertical values of the waveform at the position of the horizontal cursors in V or A.
"dx"	Difference between the vertical cursor (time) values

Label	Description
"1/dx"	Inverse time difference
"dy"	Difference between the horizontal cursor values
"dy/dx"	Slope of the waveform between the cursors (if measured on one source)

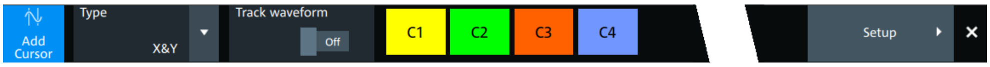
9.1.2 Using cursors

You can start cursor measurements by using the toolbar, or using the [Cursor] key. For detailed configuration, use the "Cursor" dialog box.

9.1.2.1 Starting a simple cursor measurement

To add cursors using the toolbar

1. Tap the "Add Cursor" icon on the toolbar.



2. Select the channel that you want to apply the cursor to.
   Tap the waveform that you want to measure. Alternatively, you can draw a rectangle in the diagram to position the cursor lines.

   The cursor lines appear and the cursor results are displayed in a table or result box.

To display cursors using the [Cursor] key

1. Select the waveform that you want to measure.
2. Press the [Cursor] key.

   The cursor lines and the measurement results are displayed.

9.1.2.2 Configuring a cursor measurement

To modify the position of the cursor lines, you can drag the lines on the screen. In addition, various settings are possible to refine the measurement.

The complete configuration of cursor measurements is provided in the "Cursor" dialog.

1. To open the "Cursor" dialog, use one of these ways:
   - Open the "Menu" > "Cursor".
   - Press the [Cursor] key.
   - Double-tap in the results table (but not on a result).
2. Select the "Setup" tab.
3. Select the subtab for the cursor set that you want to use.

4. Select the "Source" - the measured waveform. You can select any input channel, or various other active waveforms. Available sources are shown in the source list.
5. If necessary, enable the "Second source". Select a waveform for "Source 2".
6. Select the "Type": X (vertical), Y (horizontal), or XY (both).
7. Define the position of the cursors:
   a) To define exact positions of the cursor lines, enter the X-position for each vertical cursor and the Y-position for each horizontal cursor.
   If it is not possible to set horizontal cursors, disable "Track waveform".
   b) To position the horizontal cursors automatically, select "Track waveform".
   In this case, Cu 1.1 indicates the current maximum, Cu 1.2 indicates the current minimum. If both horizontal and vertical cursors are displayed, the horizontal cursors are placed at the crossing points of the vertical cursors with the waveform. Adjust the vertical cursors manually, and the horizontal cursors follow.
8. To display the cursor in all diagrams that are in the same domain as the selected source (time or spectrum), enable "Show in all diagrams" in the "Advanced" tab.
9. To set the cursors for a spectrum measurement to peak values, select the "Peak search" tab.
   Tap one of the buttons to place the cursors on the selected peak value. For details, see Chapter 9.1.3.3, "Peak search tab", on page 192.
10. Tap the "Type" button in the "Setup" tab to activate the cursor measurement.

    The cursors lines and the results are displayed. For details on cursor measurement results, see Chapter 9.1.1, "Cursors and results of cursor measurements", on page 184.

9.1.2.3 Configuring the cursor display

By default, the cursors are displayed as lines in the diagrams and labeled according to the syntax: Cu<cursor set number>.<1|2>

For example, the cursors for the cursor set 2 are labeled 2.1 and 2.2. The horizontal and the vertical cursors lines have the same labels.

You can change the default cursor display and labels.

To set the cursor style

1. Press the [Cursor] key.
2. Select the subtab for the cursor set you want to configure.
3. Select the "Setup" tab.
4. Select the "Cursor style". See also: "Cursor style" on page 188.

To add labels to cursor lines

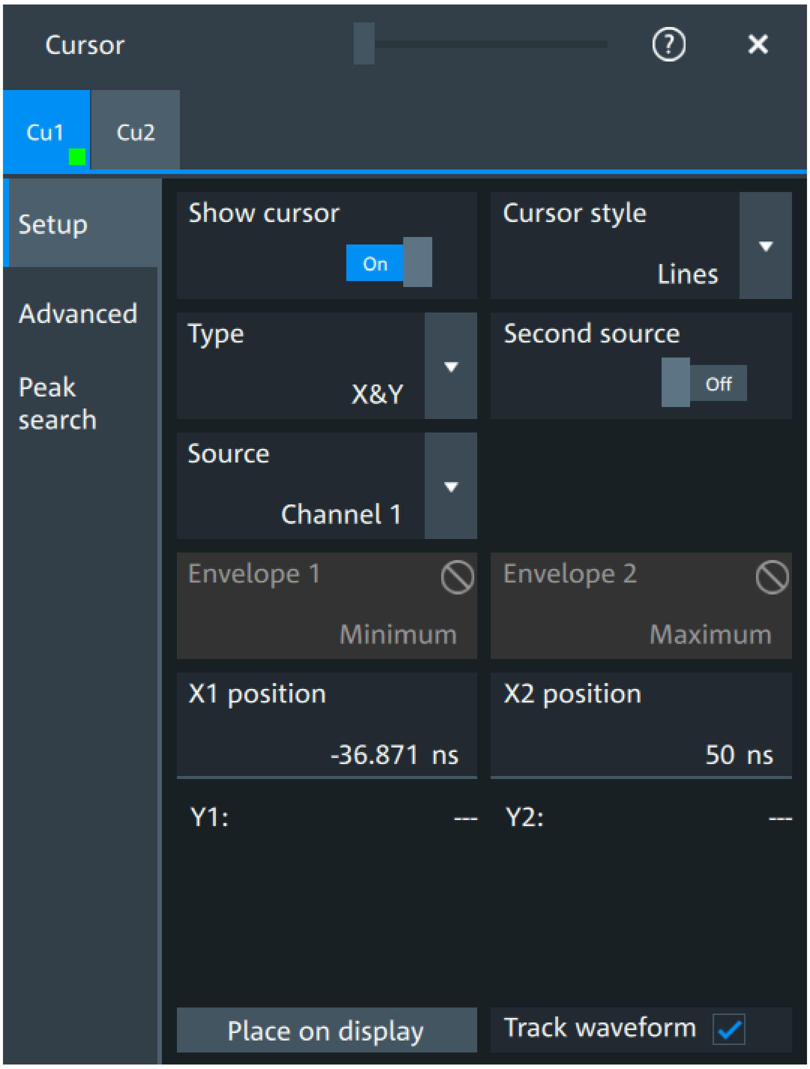
1. Press the [Cursor] key.
2. Select the subtab for the cursor set you want to configure.
3. Select the "Advanced" tab.
4. Enter a label for "Vertical cursor 1", "Vertical cursor 2", "Horizontal cursor 1", "Horizontal cursor 2".
5. Enable "Show label".

9.1.3 Settings for cursor measurements

Cursor measurements are configured in the "Cursor" dialog box.

9.1.3.1 Setup tab

The "Setup" tab contains the settings for cursor measurements.



Cu1/Cu2
The settings for each cursor measurement (or cursor set) are configured on separate tabs. For each cursor set, a horizontal pair of cursors, a vertical pair of cursors, or both can be displayed.

Show cursor
Enables the selected cursor measurement.

Remote command:
`CURSor<cu>:STATe` on page 493

Cursor style
Defines how the cursor is displayed in the diagram.

"Lines" The cursors are displayed as lines.

"Line & Rhombus"
The cursors are displayed as lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

"VLine & Rhombus"
Vertical line and rhombus: the cursors are displayed as vertical lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

"Rhombus" The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

Remote command:
`CURSor<cu>:STYLe` on page 501

Type
Defines the cursor type to be used for the measurement.

"X" (vertical cursors)
Both vertical cursor lines are set automatically to the trigger position, and you can reposition them manually.

"Y" (horizontal cursors)
Horizontal cursors are positioned automatically along the waveform and can be adjusted manually.

"X&Y" (both vertical and horizontal cursors)
Horizontal cursors are positioned automatically along the waveform and vertical cursors are set to the trigger position. You can reposition all cursor lines manually.

Remote command:
`CURSor<cu>:FUNCtion` on page 493

Second source, Source 2
Enables and selects a second source for the cursor measurements. If enabled, the second cursor lines Cu2 measure on the second source. Using a second source, you can measure differences between two channels with cursors.

Remote command:
`CURSor<cu>:USSource` on page 494
`CURSor<cu>:SSOurce` on page 494

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

Remote command:
`CURSor<cu>:SOURce` on page 493

Envelope, Envelope 2
Envelope selection is effective under the following conditions:
- The acquisition mode of the cursor source waveform is set to envelope, see Acquisition mode.
- Track waveform is enabled.
- Both horizontal and vertical cursors are enabled (Type = "X&Y").

The setting defines which horizontal cursor is positioned to the maximum and which to the minimum envelope values.

"Minimum" — The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope.

"Maximum" — The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope.

Remote command:
`CURSor<cu>:X1ENvelope` on page 497
`CURSor<cu>:X2ENvelope` on page 497

X1 position, X2 position
Define the left and right position of the vertical cursors.

Remote command:
`CURSor<cu>:X1Position` on page 494
`CURSor<cu>:X2Position` on page 495

Y1 position, Y2 position
Define the upper and lower position of the horizontal cursor lines.

If Track waveform is enabled, the user setting is disabled and the measurement results are displayed in the result table.

Remote command:
`CURSor<cu>:Y1Position` on page 495
`CURSor<cu>:Y2Position` on page 495

Track waveform
The horizontal cursors track the waveform. The first cursor line indicates the current vertical minimum, and the second cursor line indicates the maximum. If the waveform changes, e.g. during a running measurement, the cursors move along with it.

If both horizontal and vertical cursors are displayed, the horizontal cursors are positioned to the crossing points of the vertical cursors with the waveform. The measurement results are displayed in the cursor result box.

Remote command:
`CURSor<cu>:TRACking[:STATe]` on page 496

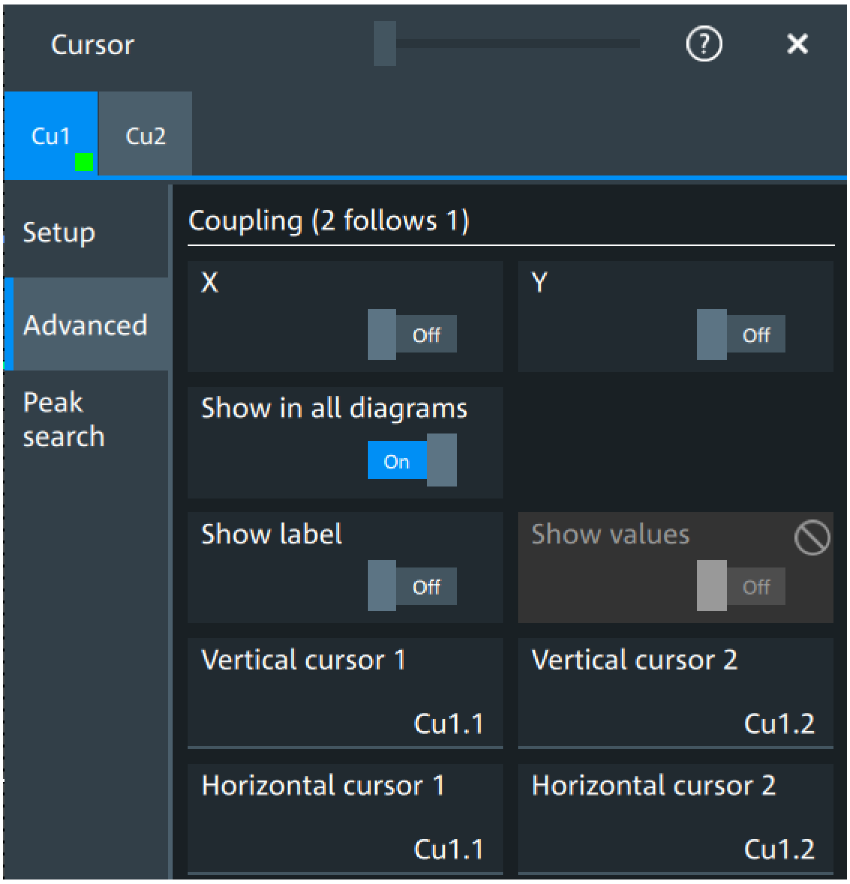
Place on display
Resets the cursors to their initial positions. Reset is helpful if the cursors have disappeared from the display or need to be moved for a larger distance.

9.1.3.2 Advanced settings

Access: Cursor key > "Advanced" tab

The settings in the "Advanced" cursor tab configure the behavior and display of cursor lines, and labels for the lines.

The cursor style and position of the measurement results is defined in the "Settings" > "Appearance" > "Cursor" dialog box.



X, Y

Couple the horizontal or vertical cursor lines so that the distance between the two lines remains the same if one cursor is moved.

Remote command:

`CURSor<cu>:XCOupling` on page 497
`CURSor<cu>:YCOupling` on page 497

Show in all diagrams

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

Remote command:

`CURSor<cu>:SIAD` on page 496

Show label

Shows the cursor labels in the diagram.

Remote command:

`CURSor<cu>:LABel` on page 496

Show values

Displays the values of the labels.

Vertical cursor 1, Vertical cursor 2
Defines a label to be displayed with the vertical cursors.

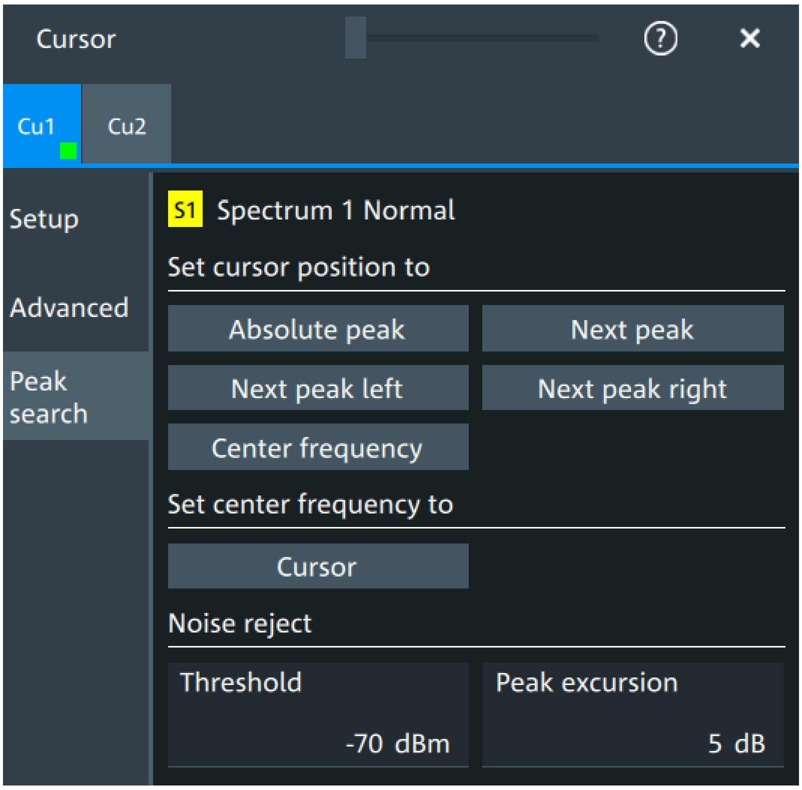
By default, the cursors are labeled as Cu1.1, Cu1.2, Cu2.1, Cu2.2.

Horizontal cursor 1, Horizontal cursor 2
Defines a label to be displayed with the horizontal cursors.

9.1.3.3 Peak search tab

Access: [Cursor] key > "Peak search" tab

The settings on this tab are only available in spectrum mode, i.e. the source of the cursor measurement is a spectrum. In this case, the cursors can indicate the results of a peak search on the waveform. You can define which peaks the instrument determines by defining the noise reject settings.



Absolute peak
Sets both cursors to the absolute peak value.

Remote command:
`CURSor<cu>:MAXimum[:PEAK]` on page 500

Next peak
Cursor 2 is set to the next smaller absolute peak from the current position.

Remote command:
`CURSor<cu>:MAXimum:NEXT` on page 501

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

Remote command:
`CURSor<cu>:MAXimum:LEFT` on page 500

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

Remote command:
`CURSor<cu>:MAXimum:RIGHt` on page 500

Center frequency
Sets the vertical cursor line Cu1 to the center frequency.

Remote command:
`CURSor<cu>:FFT:TOCenter` on page 500

Set center frequency to
Sets the center frequency to the frequency value that is measured at cursor line Cu1.

Remote command:
`CURSor<cu>:FFT:SETCenter` on page 499

Threshold
Sets an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Remote command:
`CALCulate:SPECtrum<sp>:THReshold` on page 508
`CURSor<cu>:THReshold` on page 501

Peak excursion
Defines a relative threshold, the minimum level value by which the waveform must rise by to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Remote command:
`CALCulate:SPECtrum<sp>:PEXCursion` on page 508
`CURSor<cu>:PEXCursion` on page 501

9.2 Automatic measurements

You can perform up to 16 different measurements simultaneously.

There are two methods to start a measurement, each with slightly different effects:

- Using the "Measure" icon on the toolbar:

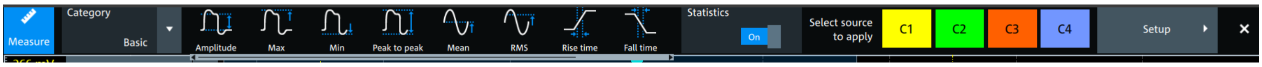
See: "To start a measurement using the toolbar icon" on page 194.
- Pressing the [Measure] key on the front panel, or using the "Measurement" menu.
  See: "To configure measurements in the Measurement dialog" on page 194.

To start a measurement using the toolbar icon

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

   The measurement overlay menu opens.



2. Select the "Category".
3. Tap on the measurements that you want to perform. You can scroll left and right through the measurement list, to view all available measurements for the selected "Category".
4. Select the source that you want to apply the measurement on.
5. If needed, click on "Setup" to configure further measurements.

   The measurement results are displayed.

To configure measurements in the Measurement dialog

1. Select the waveform on the screen.
2. Press the [Measure] key.

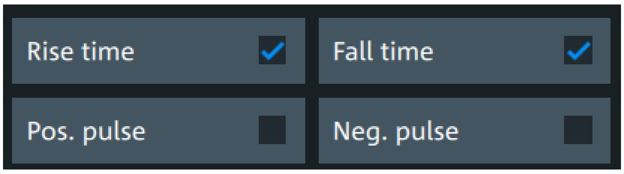
   The measurement for the selected waveform is enabled using the next available measurement configuration. The measurement results are displayed.

To add a new measurement

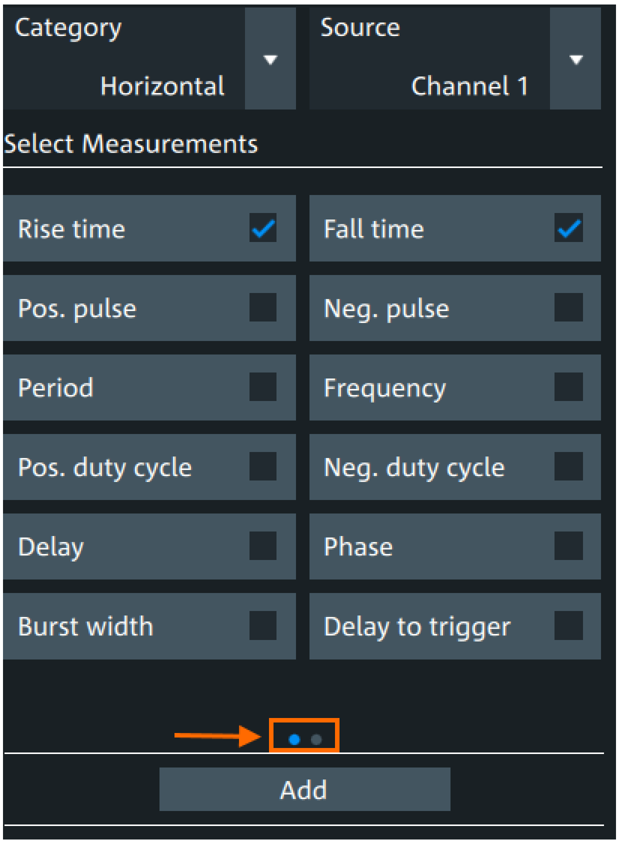
1. Press the [Measure] key, to open the measurement dialog.
2. In the "Setup" tab, press "Add".

   A dialog opens to select the measurements.
3. Select the "Source" for the measurement.
4. Select the "Category" of the measurement that you want to add, e.g. "Horizontal".

   All available measurements for this category are displayed. For more details on the available measurement types, see Chapter 9.2.4, "Measurement types", on page 202.
5. Tap on a measurement from the list to enable it.
   Selected measurements are marked with a blue check mark in their checkbox.

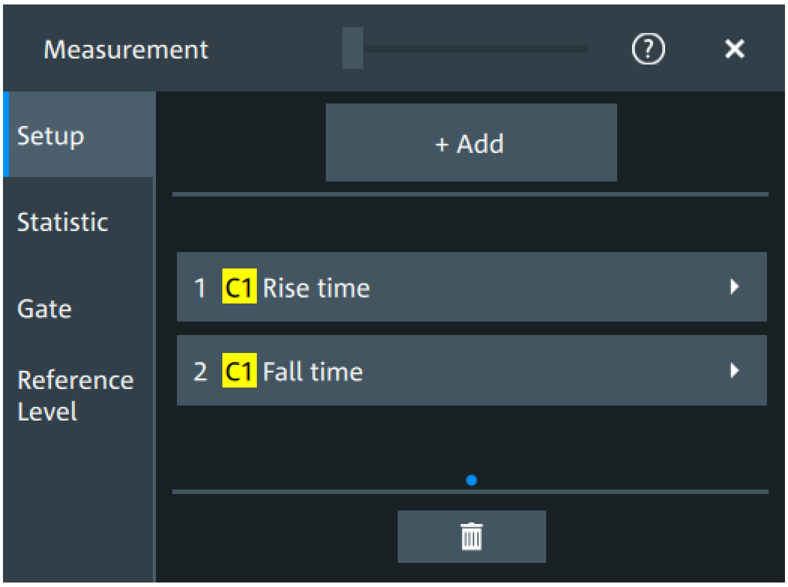


6. The measurements of some categories are listed on several tabs. To switch between the tabs, press the points at the bottom of the list.



7. Tap "Add" to add the selected measurements.

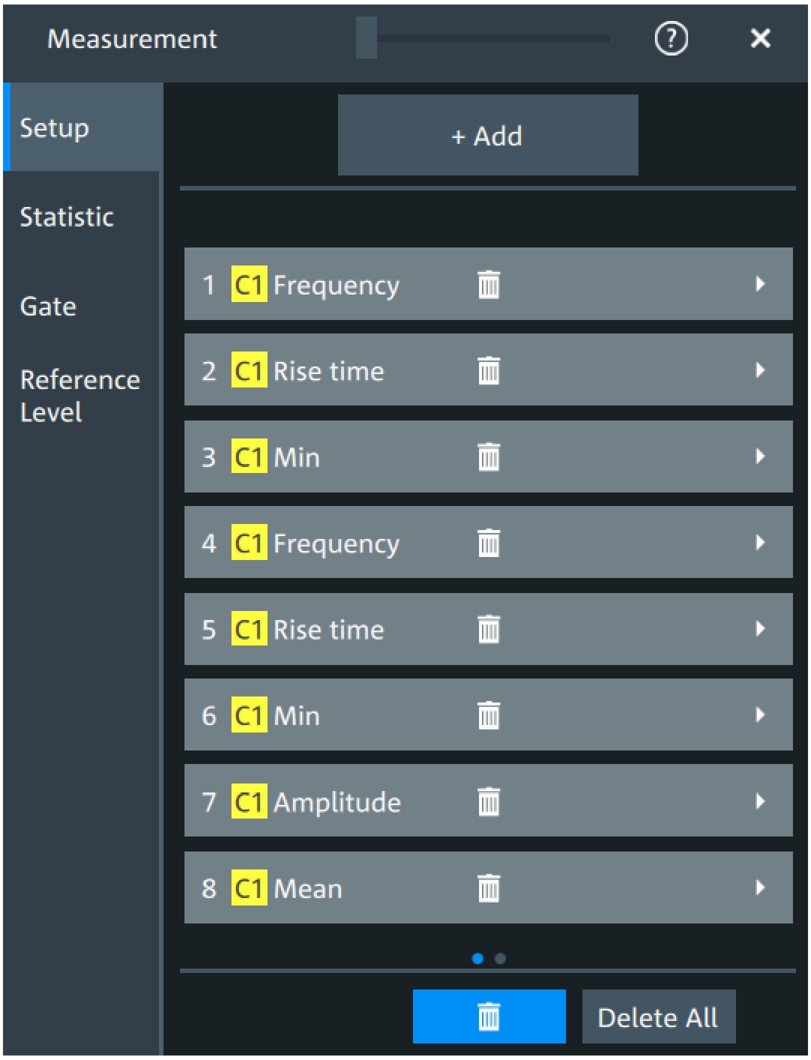
   All selected measurements are enabled.



To delete a measurement

1. Press the [Measure] key, to open the measurement dialog.
2. In the "Setup" tab, press .

   A delete icon appears in the selection button of each measurement.



3. Tap on the button of the measurement that you want to delete. Alternatively, tap "Delete All" to delete all measurements.

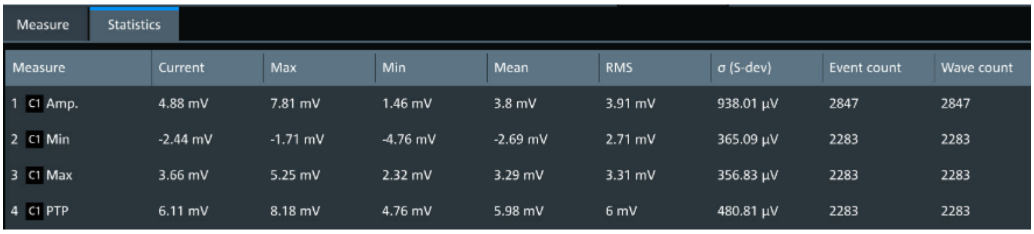
9.2.1 Measurement results

The measurement results are shown in a table below the grid.

-	No valid waveform is available, for example, if the source waveform is off.

Statistics

In addition to the current measurement results, you can enable a statistic evaluation. It returns the current, minimum and maximum measurement values, the average and standard deviation, and the number of measured waveforms. The results are shown in a separate tab below the grid. If the cursor measurement is active simultaneously, its results are shown beside the statistics results.



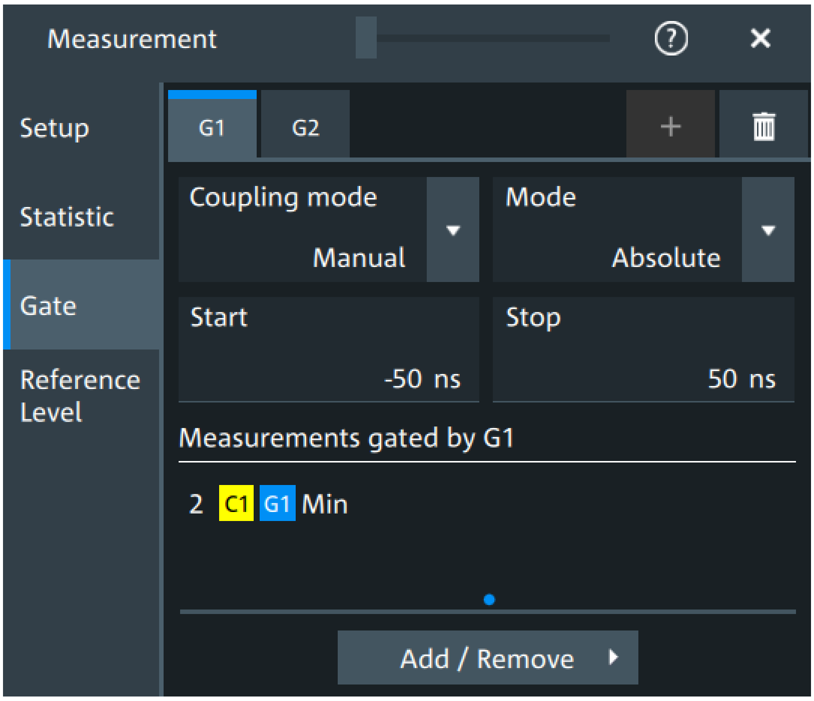
Measure	Current	Max	Min	Mean	RMS	σ (S-dev)	Event count	Wave count
1 C1 Amp.	4.88 mV	7.81 mV	1.46 mV	3.8 mV	3.91 mV	938.01 µV	2847	2847
2 C1 Min	-2.44 mV	-1.71 mV	-4.76 mV	-2.69 mV	2.71 mV	365.09 µV	2283	2283
3 C1 Max	3.66 mV	5.25 mV	2.32 mV	3.29 mV	3.31 mV	356.83 µV	2283	2283
4 C1 PTP	6.11 mV	8.18 mV	4.76 mV	5.98 mV	6 mV	480.81 µV	2283	2283

9.2.2 Gate settings for measurements

Gate areas limit the measurement to a user-defined range of the waveform. The gate settings are defined on the "Gate" tab.

You can define two separate gates for the measurement analysis. You can then add a selection from all enabled measurements to one of the enabled gates.

Access: [Measure] > "Gate" tab



Add +

Enables a new gate for the measurement.

Remote command:

GATE<m>:ENABle on page 485

Coupling mode

The gate coupling mode selects how the gate area is defined.

"Manual"	Manually define the gate with a user-defined start and stop values.
"Cursor"	Cursor coupling is available if a cursor is defined. The gate area is defined by the cursor lines of an active cursor measurement. If several cursor measurements are enabled, select the "Cursor" to be used for gating. The start and stop values of the gate are adjusted to the values of the cursor line positions. The measurement is limited to the part of the waveform between the cursor lines.
"Zoom"	Zoom coupling is available if a zoom is defined. The gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well. If several zoom diagrams are defined, select the "Zoom" diagram to be used for gating. The start and stop values of the gate are adjusted to the values of the zoom positions.
"Spectrum"	Spectrum coupling is available if a spectrum is enabled.

Remote command:
`GATE<m>:GCOupling` on page 485
`GATE<m>:CURSor` on page 485
`GATE<m>:ZDIagram` on page 486

Mode
Selects if the gate settings are configured using absolute or relative values.

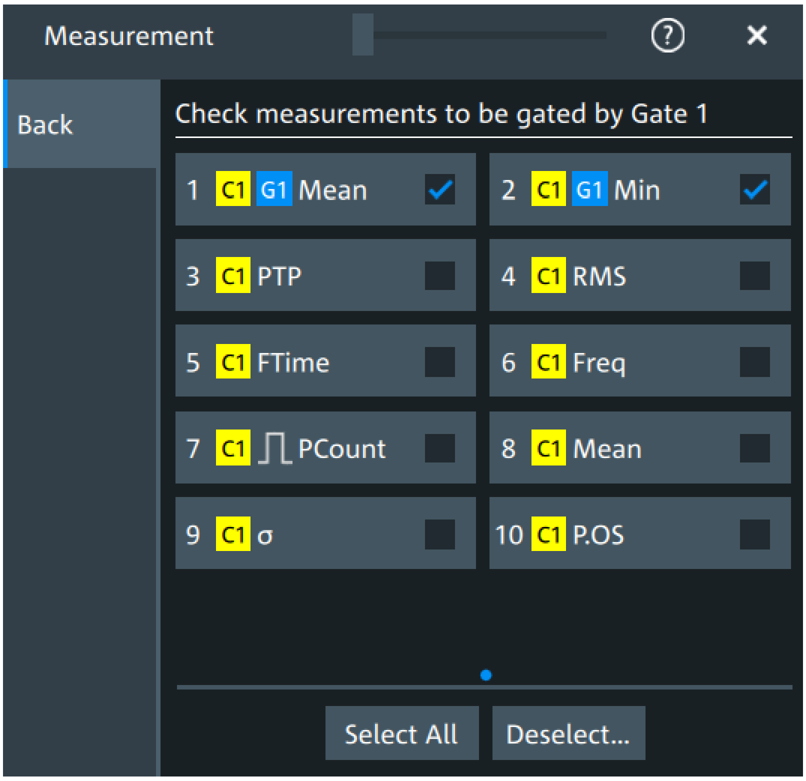
"Absolute"	The gate is defined by absolute start and stop values with "Start" and "Stop".
"Relative"	The gate's start and stop values are defined by a percentage of the value range with "Relative start" and "Relative stop".

Remote command:
`GATE<m>:MODE` on page 486
`GATE<m>:ABSolute:STARt` on page 486
`GATE<m>:ABSolute:STOP` on page 486
`GATE<m>:RELative:STARt` on page 487
`GATE<m>:RELative:STOP` on page 487

Measurements gated by G1/G2
Displays all active measurements that are limited by the gate.

Remote command:
`MEASurement<mg>:GATE` on page 487

Add
Opens a dialog to select the measurements to be gated by the active gate. You can select from the list of all enabled measurements.



9.2.3 Reference level

Some measurements require reference levels to obtain the measurement points, e.g. time measurements or pulse count. You can define 2 sets of reference levels. During configuration of the measurement, you select which set of reference levels is used.

Access: [Measure] > "Reference level" tab

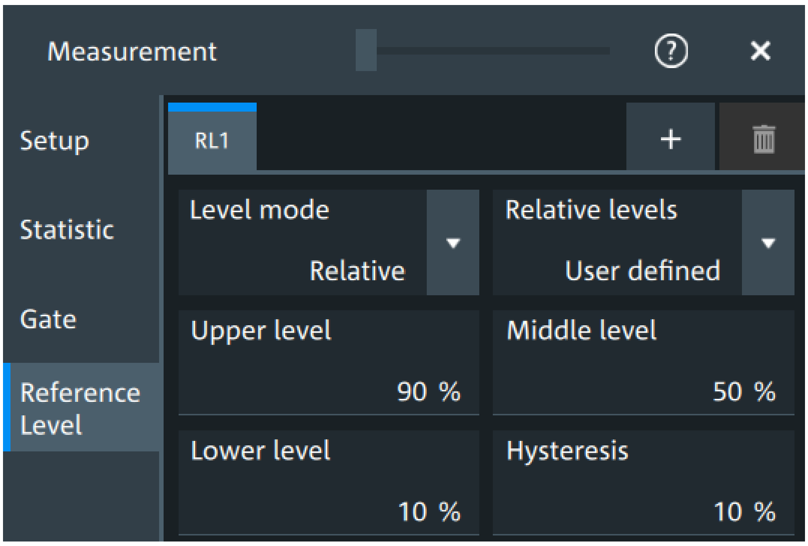


Figure 9-1: Relative reference level

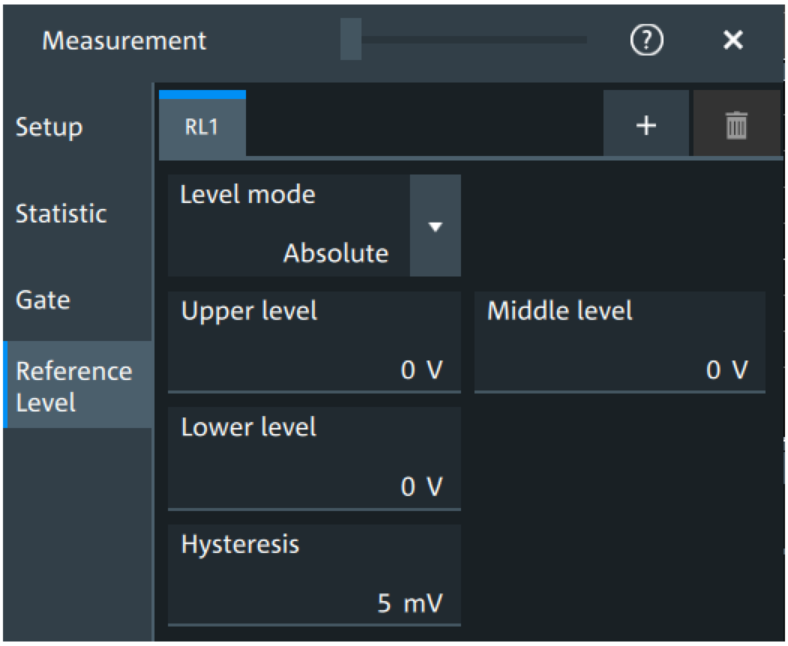


Figure 9-2: Absolute reference level

Level mode

Defines if the reference level is set in absolute or relative values.

Remote command:

`REFLevel<rl>:LMODe` on page 488

Absolute Level mode

In the absolute mode, the reference values are set as voltages, in absolute values.

Upper level, Middle level, Lower level ← Absolute Level mode

Sets the low, middle and upper reference signal levels.

Remote command:

`REFLevel<rl>:ABSolute:LLEVel` on page 489

`REFLevel<rl>:ABSolute:MLEVel` on page 489

`REFLevel<rl>:ABSolute:ULEVel` on page 489

Relative Level mode

In the relative mode, the reference values are set as percentages of the signal amplitude.

Relative levels ← Relative Level mode

Selects the lower, middle and upper reference levels, defined as percentages of the signal amplitude.

Available relative levels:

- 5/50/95
- 10/50/90
- 20/50/80
- User defined: Enter "Upper level", "Middle level", and "Lower level".

For example, for "5/50/95" the levels are set to the following values:

- Lower level = 5% of the signal amplitude
- Middle level = 50% of the signal amplitude
- Upper level = 95% of the signal amplitude

Remote command:
REFLevel<rl>:RELative:MODE on page 491

Upper level, Middle level,Lower level ← Relative Level mode
Define the reference levels in percent, if "Level mode" is set to "User-defined".

Remote command:
REFLevel<rl>:RELative:LOWer on page 490
REFLevel<rl>:RELative:MIDDle on page 490
REFLevel<rl>:RELative:UPPer on page 491

Hysteresis
Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Remote command:
REFLevel<rl>:ABSolute:HYSTeresis on page 488
REFLevel<rl>:RELative:HYSTeresis on page 490

9.2.4 Measurement types

The R&S MXO 4 provides many measurement types to measure time and amplitude characteristics, and to count pulses and edges.

9.2.4.1 Horizontal measurements (time)

Meas. type	Symbol	Description/result
Rise Time	RTime	Rise time of the first rising edge, the time it takes the signal to rise from the lower reference level to the upper reference level.
Fall Time	FTime	Fall time of the first falling edge, the time it takes the signal to fall from the upper reference level to the lower reference level.
Pos. pulse	PPuls	Duration of the first positive pulse: time between a rising edge and the following falling edge measured on the middle reference level.
Neg. pulse	NPuls	Duration of the first negative pulse: time between a falling edge and the following rising edge measured on the middle reference level.
Period	T in s	Time of the first period, measured on the middle reference level. The measurement requires at least one complete period of the signal.
Frequency	Freq	Frequency of the signal, reciprocal value of the measured first period.
Delay	Delay	Time difference between two slopes of the same or different waveforms, measured on the middle reference level. A negative result indicates that the slope of the second source comes before the slope of the first source.

Meas. type	Symbol	Description/result
Phase	Phs in °	Phase difference between two waveforms, measured on the middle reference level.
Burst width	Bst	Duration of one burst, measured on the middle reference level from the first edge to the last edge.
Setup Hold Setup/Hold time	Setup Hold SHT	Setup and Hold time measurements with positive and/or negative clock edge, measured on the middle reference level.
Setup/Hold ratio	SHR	Setup/Hold ratio measurement with positive and/or negative clock edge.
Delay to trigger	Dly Trg in s	Time between the trigger point and a selectable edge, measured on the middle reference level. If the edge is to the left of the trigger (before trigger), the result is negative.
Slew rate rising	SrateRis-ing	Steepness of the first rising edge, measured between the lower and the upper reference levels. Slewrt = ΔV / Δt
Slew rate falling	SrateFal-ling	Steepness of the first falling edge, measured between the upper and the lower reference levels. Slewrt = ΔV / Δt

9.2.4.2 Vertical measurements (amplitude)

The unit of most amplitude measurement results depends on the measured source.

Meas. type	Symbol	Description/result
High	High	High level of the displayed waveform - the upper maximum of the sample distribution, or the mean value of the high level of a square wave without overshoot. The measurement requires at least one complete period of the signal.
Low	Low	Low level of the displayed waveform - the lower maximum of the sample distribution, or the mean value of the low level of a square wave without overshoot. The measurement requires at least one complete period of the signal.
Amplitude	Amp	Difference between the top level and the base level of the signal. The measurement requires at least one complete period of the signal.
Max	Max	Maximum value within the displayed waveform.
Min	Min	Minimum value within the displayed waveform.
Peak to peak	PTP	Difference of maximum and minimum values.
Mean	Mean	Arithmetic average of the complete displayed waveform. $\text{Mean} = \frac{1}{N}\sum_{k=1}^{N} x_k$
RMS	RMS	RMS (root mean square) value of the voltage of the complete displayed waveform. $\text{RMS} = \sqrt{\frac{1}{N}\sum_{k=1}^{N} x_k^2}$
σ (S-dev/AC-RMS)	σ (S-dev/AC-RMS)	Standard deviation of one cycle, usually of the first, left-most signal period.

Meas. type	Symbol	Description/result
Crest factor	Crest	The crest factor is also known as peak-to-average ratio. It is the maximum value divided by the RMS value of the displayed waveform. $$\text{Crest} = \frac{\text{Max}\,\lvert x_k \rvert}{\text{RMS}}$$
Pos. Overshoot Neg. Overshoot	P.OS N.OS	Overshoot of a square wave after a rising or falling edge. It is calculated from measurement values top level, base level, local maximum, local minimum, and amplitude. $$\text{Over+} = \frac{\text{Max}_{\text{local}} - \text{Top}}{\text{Amplitude}} \cdot 100\%$$ $$\text{Over-} = \frac{\text{Base} - \text{Min}_{\text{local}}}{\text{Amplitude}} \cdot 100\%$$

9.2.4.3 Area and cycle measurements

All cycle measurements require that at least one complete period of the signal is acquired.

Meas. type	Symbol	Description/result
Area	Area	Area between the waveform and a reference level (X_{Ref}). $$A_{Ref} = \frac{T_{Eval}}{N_{Eval}} \cdot \sum_{i=1}^{N_{Eval}} \left(x(i) - X_{Ref} \right)$$ T_{Eval}: Evaluation time, time of a full waveform or limited by a gate
Cycle area	CArea	Area between the waveform and a reference level measured for one period, see also "Area" measurement.
Pos duty cycle	PDCyc	Width of the first positive pulse in relation to the period in %. $$R_{PosCyc} = \frac{T_{PosPulse}}{T_{Period}} \cdot 100\%$$
Neg duty cycle	NDCyc	Width of the first negative pulse in relation to the period in %. $$R_{NegCyc} = \frac{T_{NegPulse}}{T_{Period}} \cdot 100\%$$
Cycle mean	CMean	Mean value of one cycle
Cycle RMS	CRMS	RMS (root mean square) value of one cycle
Cycle σ(S-dev)	Cycσ	Standard deviation of one cycle
Cycle max	CMax	Maximum value of one cycle
Cycle min	CMin	Minimum value of one cycle
Cycle peak to peak	CPTP	Peak-to-peak value of one cycle: the difference of CMax and CMin

9.2.4.4 Counting

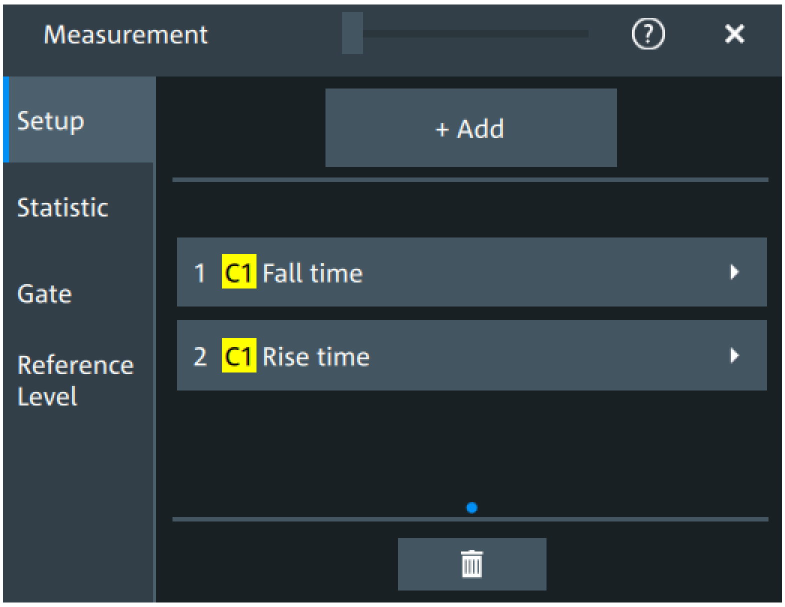
Meas. type	Symbol	Description/result
Pulse count	PCount	The number of positive or negative pulses of the waveform, or of both positive and negative pulses. The mean value of the signal is determined. If the signal passes the mean value, an edge is counted. A positive pulse is counted if a rising edge and a following falling edge are detected. A negative pulse is counted if a falling edge and a following rising edge are detected.
Edge count	EdCo	The number of positive or negative edges, or of both positive and negative edges. The instrument determines the mean value of the signal and counts an edge every time the signal passes the mean value.

9.2.5 Settings for measurements

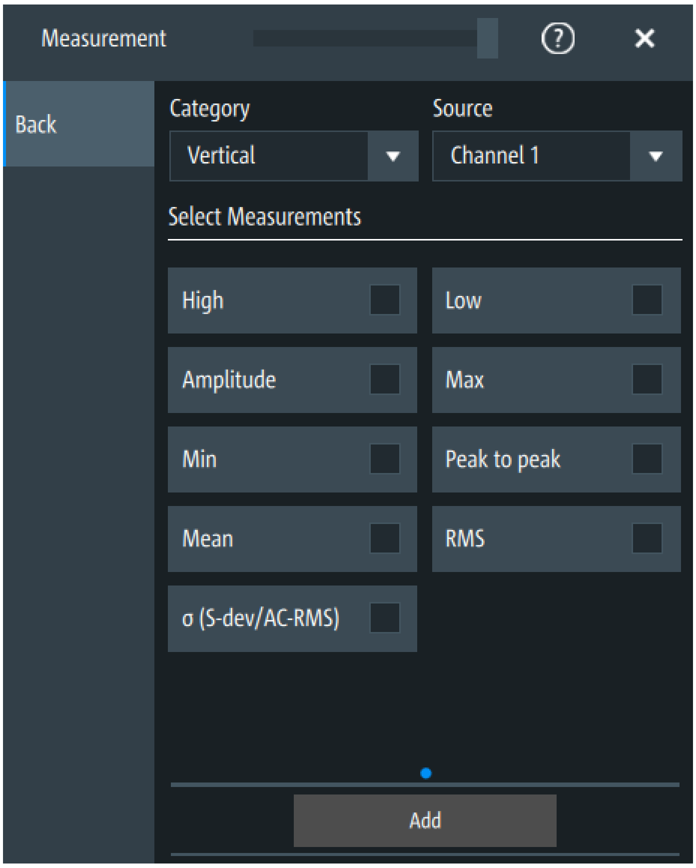
In the "Measurement" dialog, you can enable measurement and define their settings.

9.2.5.1 Setup tab

Access: "Menu" > "Measurement" > "Setup" tab.



Add
Opens a dialog to select the measurements.



Category ← Add
Selects the measurement category. Some measurements are listed in more than one category.

For an overview of the available categories and measurements see Chapter 9.2.4, "Measurement types", on page 202.

Source ← Add
Sets the source of the measurement.

Remote command:
`MEASurement<mg>:SOURce` on page 476

Specific type
Enables the removal of measurements. You can delete a single measurement by tapping on the delete icon next to it.

You can also delete all current measurements with "Delete All".

Envelope
This setting is only available for measurements on envelope waveforms, see Acquisition mode.

"Both"	The upper and the lower envelope are used in measurements. For time measurements, the averages of min and max values are used, that is, the measurement is performed on the average waveform built from the upper and lower envelope.
"Maximum"	Measurements are performed on the upper envelope.
"Minimum"	Measurements are performed on the lower envelope.

Remote command:
`MEASurement<mg>:ENVSelect` on page 477

9.2.5.2 Measurement type specific settings

You can define additional parameters for some measurements.

Specific type
Selects the type of measurement that you want to define the settings for.

Source
Sets the source of the measurement.

Remote command:
`MEASurement<mg>:SOURce` on page 476

Reference levels
Selects the set of reference levels that is used for the measurement. Define the reference level set before you select it, see Chapter 9.2.3, "Reference level", on page 200.

Gate
Selects the gate that is used for limiting the measurement range. Define a gate before you select it, see Chapter 9.2.2, "Gate settings for measurements", on page 198.

Label
Adds a user-defined label to the measurement.

Pulse count
Available, if "Specific type" is set to "Pulse train".

Sets the number N of positive pulses for the "Pulse train" measurement. This measurement measures the duration of N positive pulses from the rising edge of the first pulse to the falling edge of the N-th pulse.

Remote command:
`MEASurement<mg>:AMPTime:PTCount` on page 478

Pulse slope
Available, if "Specific type" is set to "Pulse count".

Sets the first slope of the pulses to be counted.

"Positive"	Positive pulses are counted.
"Negative"	Negative pulses are counted.
"Either"	Both positive and negative pulses are counted.

Remote command:
`MEASurement<mg>:AMPTime:PSLope` on page 479

Edges slope
Available, if "Specific type" is set to "Edge count" or "Delay to trigger".

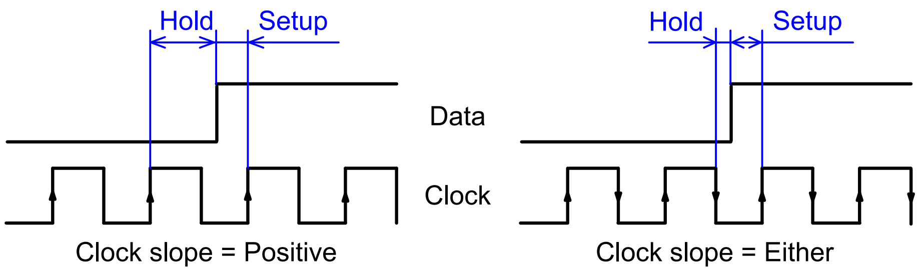
Sets the edge direction to be used for delay measurement: positive, negative, or either edge.

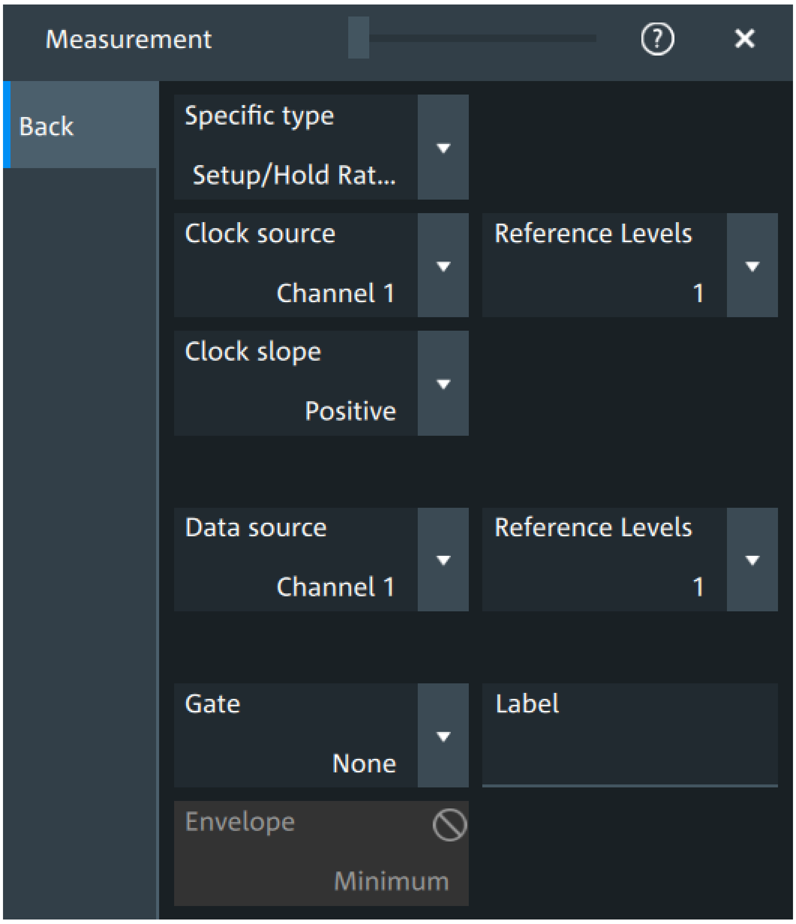
Remote command:
`MEASurement<mg>:AMPTime:ESLope` on page 478

Setup/Hold time measurement
Setup/Hold measurements analyze the relative timing between two signals: a data signal and the synchronous clock signal. Setup time is the time that the data signal is steady before clock edge - the time between a data transition and the next specified clock edge. Hold time is the time that the data signal is steady after clock edge - the time between a data transition and the previous specified clock edge.

"Setup/Hold time" measures and displays the setup and hold durations. "Setup/Hold ratio" measurements return the ratio of the setup time to the sum of hold and setup time: $T_{Setup} / (T_{Setup} + T_{Hold})$.

The clock edge can be defined, the polarity of the data signal does not matter.





Clock source ← Setup/Hold time measurement
Sets the waveform used as clock in the setup/hold measurement.

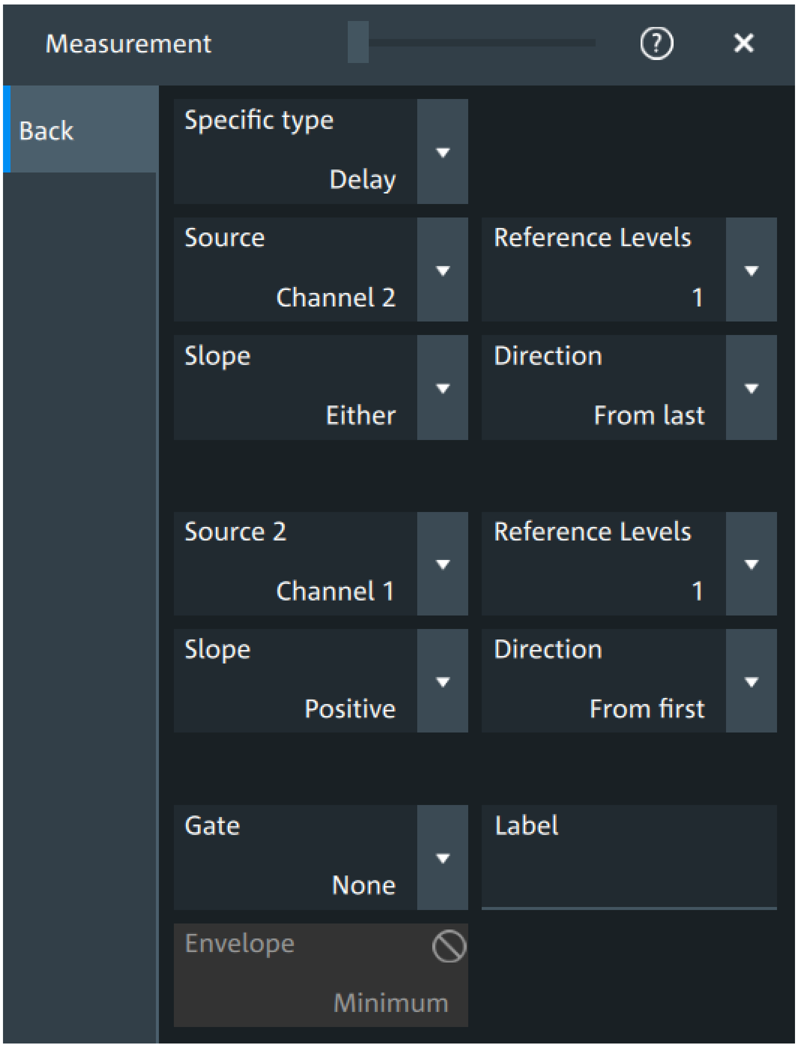
Remote command:
`MEASurement<mg>:SSRC` on page 476

Clock slope ← Setup/Hold time measurement
Sets the edge of the clock from which the setup and hold times are measured: positive, negative, or either of them. If "Either" is selected, the clock edges next to the data edge are considered regardless of the clock slope.

Remote command:
`MEASurement<mg>:AMPTime:CSLope` on page 478

Data source ← Setup/Hold time measurement
Sets the source for the data signal.

Delay measurement
The specific settings for delay measurement allow you to measure the time between any two slopes at any reference level. Therefore, the reference levels and the slopes must be defined for each source individually. The measurement result is negative if the edge of the second source comes before the edge of the first source.



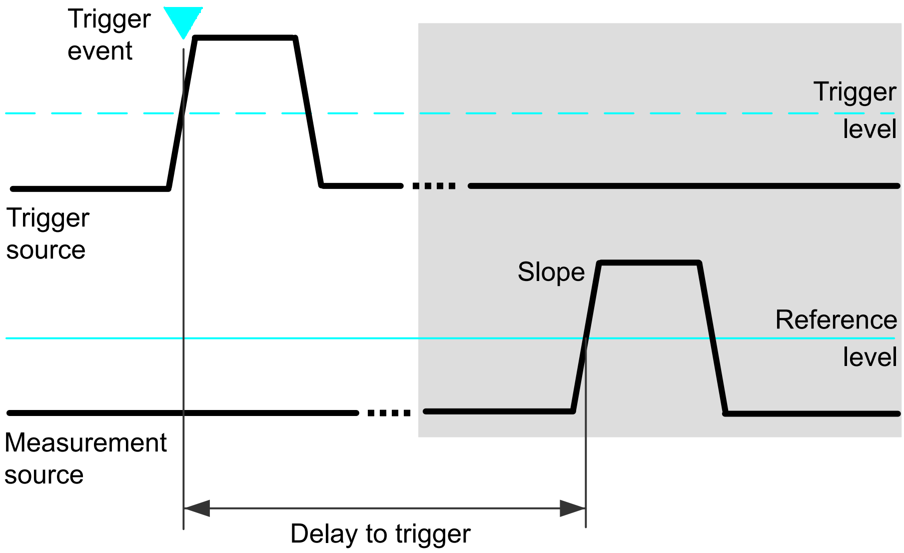
Slope ← Delay measurement
Sets the edge of each source, between which the delay is measured: positive, negative, or either of them.

Remote command:
MEASurement<mg>:AMPTime:DELay<n>:SLOPe on page 480

Direction ← Delay measurement
Selects the direction for counting slopes for each source: from the beginning of the waveform, or from the end.

Remote command:
MEASurement<mg>:AMPTime:DELay<n>:DIRection on page 479

Delay to trigger measurement settings
Delay to trigger measures the time between the trigger point and the following slope of a waveform. The delay between the trigger and the slope can be high compared to the accuracy of the acquisition, and the trigger point can even be outside of the current acquisition.



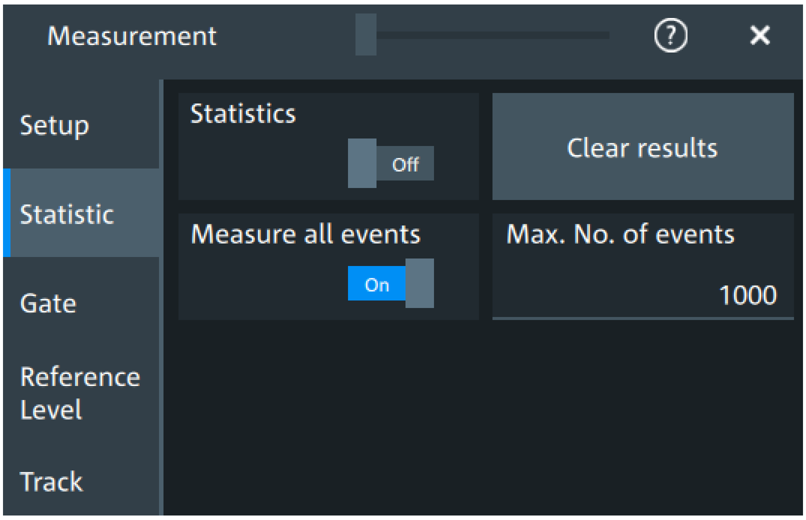
To configure the trigger conditions, use the trigger setup.

"Edges slope" Sets the edge direction to be used for delay measurement: positive, negative, or either edge.

Remote command:
`MEASurement<mg>:AMPTime:DTOTrigger<n>:SLOPe` on page 479

9.2.6 Statistics

Access: "Menu" > "Measurement" > "Statistic" tab.



In addition to the current measurement results, you can enable a statistical evaluation. It returns the current, minimum and maximum measurement values, the average and standard deviation, and the number of measured waveforms. The results are shown in a separate tab below the grid. If the cursor measurement is active simultaneously, its results are shown beside the statistics results.

Statistics
Activates or deactivates the statistical evaluation for the measurement.

Remote command:
`MEASurement<mg>:STATistics[:ENABle]` on page 483

Clear results
Deletes the statistical results for all measurements, and starts a new statistical evaluation if the acquisition is running.

Remote command:
`MEASurement<mg>:STATistics:RESet` on page 484

Measure all events
Normally, only one measurement is performed for each acquired waveform to get best performance. If "Measure all events" is enabled, more than one result is taken from one acquired waveform and the results are included in evaluation. For example, the rise time is measured on all pulses in the waveform, not only on the first.

The result table shows only the first result of the waveform, the following results are used only for evaluation. The setting affects all measurements, it is a global setting.

Measuring all events is useful when calculating statistics.

The number of considered results can be restricted: See Max. No. of events.

Remote command:
`MEASurement<mg>:MULTiple` on page 484

Max. No. of events
Sets the maximum number of measured events per acquisition.

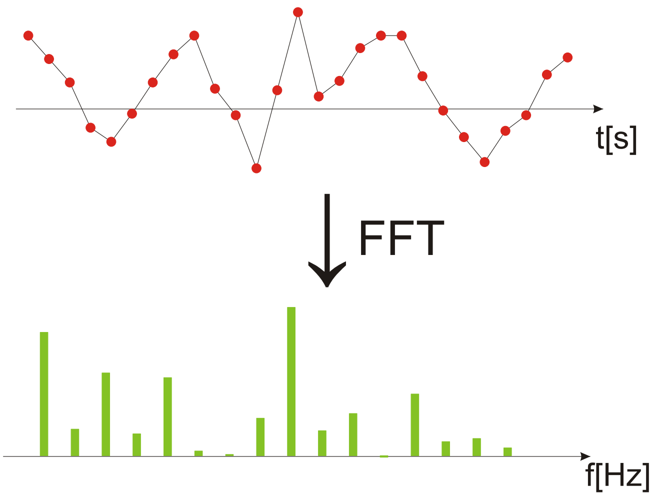
Remote command:
`MEASurement<mg>:MNOMeas` on page 484

10 Spectrum analysis

The R&S MXO 4 provides an easy way to set up a spectrum analysis. The spectrum settings are independent of the time domain settings but the time and frequency domains are time-correlated.

10.1 Fundamentals of spectrum analysis

During spectrum analysis, a signal in the time domain is converted to a spectrum of frequencies. As a result, either the magnitude or the phase of the determined frequencies can be displayed. Spectrum analysis can be restricted to an extract of the original time base, and the results display can be restricted to a specified frequency range.



Window functions

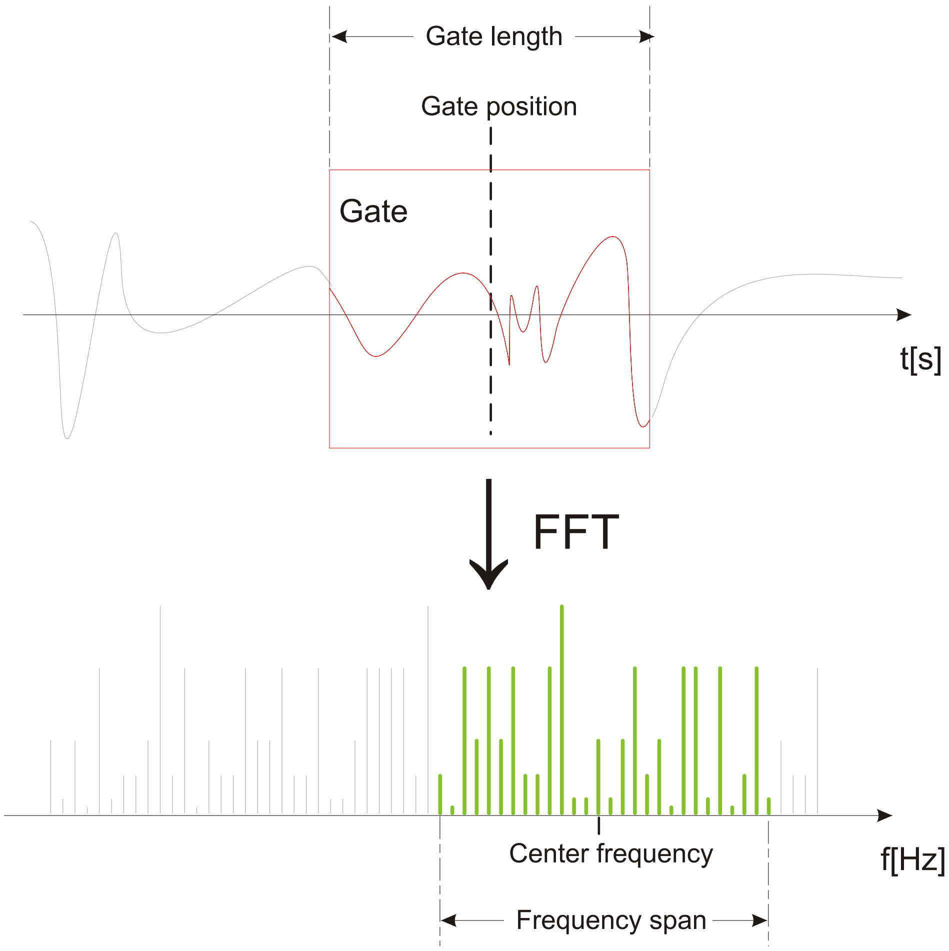
Each frame is multiplied with a specific window function after sampling in the time domain. Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

There are several window functions that can be used in FFT analysis. Each of the window functions has specific characteristics, including some advantages and some trade-offs. Consider these characteristics carefully to find the optimum solution for the measurement task.

For details, see "Window type" on page 219.

Gating functions

You can restrict the time base of the input signal for which spectrum analysis is to be performed. You can define start and stop times for the time base extract.



Restricting the result range

You can restrict the results of the spectrum analysis to a specified frequency range. The frequency range can be defined in two ways:

- Define a center frequency and frequency span
- Define start and stop frequencies

Dependencies between spectrum parameters

Spectrum analysis in the R&S MXO 4 is highly configurable. Several parameters, including the resolution bandwidth, frequency span and center frequency, can be defined according to your requirements. Note, however, that several parameters are correlated and not all can be configured independently of the others.

The **resolution bandwidth** defines the minimum frequency separation at which the individual components of a spectrum can be distinguished. Small values result in high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase measurement speed.

The minimum achievable RBW depends on the integration time which is equivalent to the number of samples available for calculation. If a higher spectral resolution is required, the number of samples must be increased by using a higher sample rate or longer record length. To simplify operation, some parameters are coupled and automatically calculated, such as record length and RBW.

The **frequency span** and **center frequency** define the start and stop frequency of the spectral diagram. By default, a suitable frequency range according to the resolution bandwidth is selected, in respect to performance and precision. Span and RBW settings are coupled, so that the parameters can be adjusted automatically as necessary.

With a **Span/RBW ratio** of 100 and a screen resolution of 1000 pixels, each frequency in the spectrum is displayed by 10 pixels. A span/RBW ratio of 1000 provides the highest resolution. For full flexibility, the span/RBW coupling can also be disabled. Note, however, that a higher span/RBW ratio (i.e. low RBW values and large frequency spans) result in large amounts of data and extend the duration of the calculation.

10.2 Configuring spectrum waveforms

During spectrum analysis, a signal in the time domain is converted to a spectrum of frequencies. A basic spectrum waveform can be displayed quickly. By defining additional parameters, the waveform can be configured in more detail.

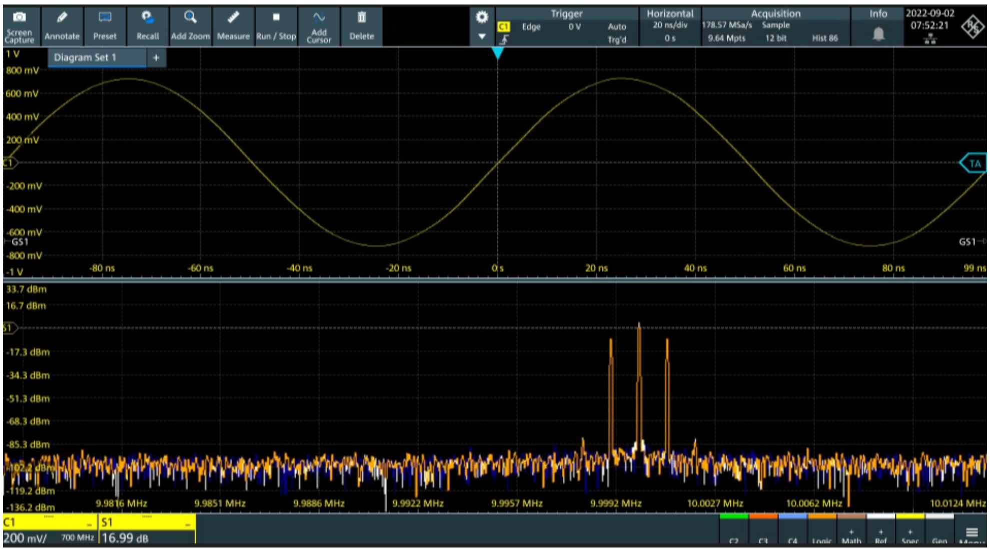
To display a basic spectrum waveform

1. Press the [Spectrum] key.

   The "Setup" tab of the "Spectrum" dialog box opens.

2. Set the "Source" to the input signal.

3. Enable "Display".



4. If necessary, edit the spectrum waveform parameters as described in the following procedures.

To configure the spectrum

By default, a suitable frequency range for the expected horizontal values according to the resolution bandwidth is selected, in respect to performance and precision. Span and RBW settings are coupled. If a more precise evaluation is required, for example for postprocessing in a different application, disable the coupling and change the frequency ranges and resolution bandwidth values as required.

1. Press [Spectrum].

   The "Spectrum" dialog opens.

2. In the "Setup" tab, specify the frequency range you want to display using one of the following methods:
   - Select "CF Span". Enter a "Center" and a "Span" that define the spectrum.
   - Select "Start Stop". Enter a "Start" and "Stop" frequencies that define the spectrum.
   - Tap the "Full span" button to display the complete spectrum resulting from the FFT analysis.

3. Define the resolution bandwidth for the spectrum result.
   The resolution bandwidth defines how precise the results are, i.e. how close together the individual frequencies can be. Small values result in high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase performance.

   You can define the RBW manually, or couple it to other settings. Do one of the following:
   - To couple the RBW to the span, enable "Auto RBW". Define the "Span/RBW" ratio, the smaller the ratio, the higher the RBW becomes to display the same frequency span.
   - Disable "Auto RBW". Enter the "RBW" manually.

4. Tap "Advanced".

5. Select the most suitable "Window type" for your source data. Window functions are multiplied with the input values and thus can improve the spectrum display. For details, see "Window type" on page 219.

To restrict the input values (gating)

You can restrict the time range for which the FFT is calculated, resulting in a restricted spectrum.

1. Open [Spectrum] > "Gate" tab.

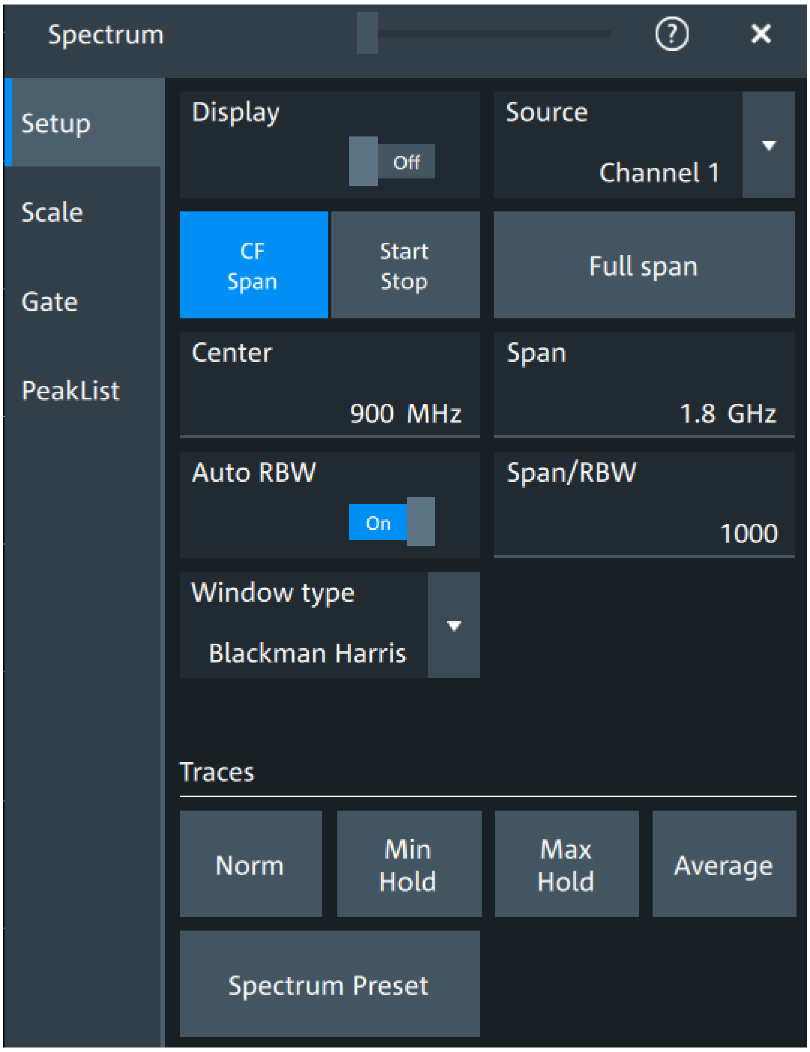
2. Enter the "Start" and the "Stop" times that define the gate area.

3. Set the "Position" and the "Width".

   The spectrum waveform displays the spectrum for the specified time span.

10.3 Spectrum setup

Access: "Menu" > "Spectrum" > "Setup" tab.



Display
Enables the spectrum.

Remote command:
`CALCulate:SPECtrum<sp>:STATe` on page 508

Source
Selects the source for the spectrum.

Remote command:
`CALCulate:SPECtrum<sp>:SOURce` on page 507

Full span
Displays the full frequency span.

CF Span, Start Stop
Selects if the frequency span is defined through a "Center"/"Span" pair or through the "Start"/"Stop".

Center
Defines the position of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The width of the range is defined using the frequency span setting.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:CENTer` on page 504

Span
The span is specified in Hertz and defines the width of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The position of the span is defined using the "Center" setting.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:SPAN` on page 504

Start
Defines the start frequency of the displayed frequency span.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:STARt` on page 505

Stop
Sets the stop frequency of the displayed frequency span.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:STOP` on page 505

Auto RBW
Couples the frequency span to the "RBW" setting.

If span and RBW values are coupled, changing the span also changes the RBW.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution]:AUTO`
on page 503

Span/RBW
Defines the coupling ratio for Span/RBW.

This setting is only available if "Auto RBW" is enabled.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution]:RATio`
on page 503

RBW
Defines the resolution bandwidth. Note that the resolution bandwidth is correlated with the span, record length and acquisition time. If a constant record length is to be used, the RBW can be adapted if the required number of samples cannot be acquired.

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution][:VALue]` on page 503

Window type
Selects the window type. Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

Various different window functions are provided in the R&S MXO 4 to suit different input signals. Each of the window functions has specific characteristics, including some advantages and some trade-offs. Consider these characteristics carefully, to find the optimum solution for the measurement task.

Window type	Frequency resolution	Magnitude resolution	Measurement recommendation
Rectangular	Best	Worst	Separation of two tones with almost equal amplitudes and a small frequency distance
Hamming Hann	Good	Poor	Frequency response measurements, sine waves, periodic signals and narrow-band noise
Blackman Harris (default)	Worst	Best	Mainly for signals with single frequencies to detect harmonics Accurate single-tone measurements
Gaussian	Good	Good	Weak signals and short duration
Flattop2	Poor	Best	Accurate single-tone measurements
Kaiser Bessel	Poor	Good	Separation of two tones with differing amplitudes and a small frequency distance

Remote command:
`CALCulate:SPECtrum<sp>:FREQuency:WINDow:TYPE` on page 505

Traces
Spectrum analysis can only be performed on a maximum number of values at once. If more values must be calculated, the input signal is divided into segments, each of which is calculated separately. The segments need not to be disjunct. In this case, the arithmetic mode defines how the final result is calculated from the individual results.

The following methods are available:

"Norm" The data of only one segment is considered. In effect, no arithmetics are processed.

"Min Hold" Determines the minimum result for each input value from the data of the current acquisition and the acquisitions before.

"Max Hold" Determines the maximum result for each input value from the data of the current acquisition and the acquisitions before.

"Average" The average is calculated over the number of segments set with "Average count".

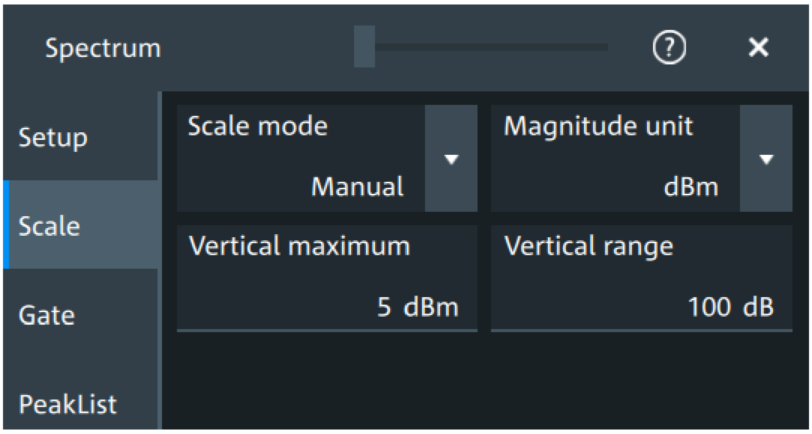
Remote command:
`CALCulate:SPECtrum<sp>:WAVeform:AVERage:ENABle` on page 509
`CALCulate:SPECtrum<sp>:WAVeform:AVERage:COUNt` on page 509
`CALCulate:SPECtrum<sp>:WAVeform:MAXimum:ENABle` on page 509
`CALCulate:SPECtrum<sp>:WAVeform:MINimum:ENABle` on page 510
`CALCulate:SPECtrum<sp>:WAVeform:NORMal[:ENABle]` on page 510

Spectrum preset
Presets the spectrum measurement.

Remote command:
`CALCulate:SPECtrum<sp>:PRESet` on page 507

10.4 Spectrum scale

Access: "Menu" > "Spectrum" > "Scale"



Scale mode
By default, the vertical scale is adapted to the current measurement results automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

Note: When you change the scaling values manually using the [Scale] rotary knob, the scale mode is set to "Manual" temporarily.

"Manual"	Enter the required values for "Vertical maximum" and "Vertical range".
"Auto"	"Vertical maximum" is read-only.

Magnitude unit
Sets the unit for the y-axis.

The display values are valid for 50Ω termination impedance.

Remote command:
`CALCulate:SPECtrum<sp>:MAGNitude:SCALe` on page 507

Vertical maximum
Sets the maximum displayed value on the vertical scale.

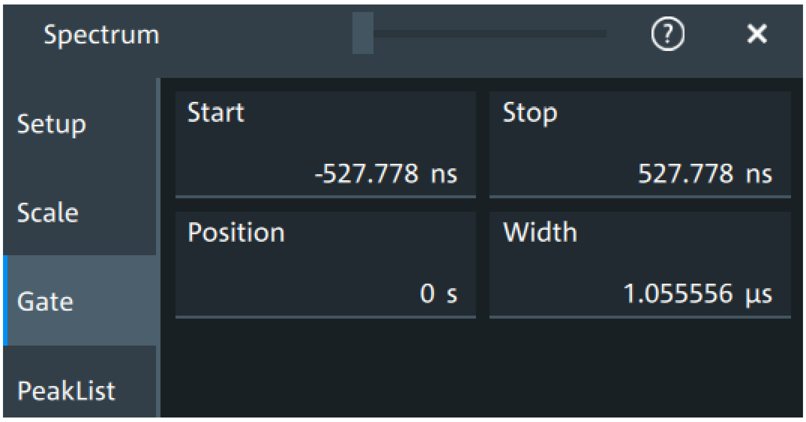
Remote command:
`CALCulate:SPECtrum<sp>:MAGNitude:LEVel` on page 506

Vertical range
Sets the range of the spectrum values to be displayed.

Remote command:
`CALCulate:SPECtrum<sp>:MAGNitude:RANGe` on page 507

10.5 Spectrum gate

Access: "Menu" > "Spectrum" > "Scale"



Spectrum gating restrict the spectrum analysis to a user-defined region of the captured time domain signal.

Start
Sets the starting value for the gate.

Remote command:
`CALCulate:SPECtrum<sp>:GATE:STARt` on page 511

Stop
Sets the end value for the gate.

Remote command:
`CALCulate:SPECtrum<sp>:GATE:STOP` on page 511

Position
Sets the position of the displayed frequency range.

The width of the gate is defined using the "Width" setting.

Remote command:
`CALCulate:SPECtrum<sp>:GATE:POSition` on page 510

Width

Defines the width of the displayed gate.

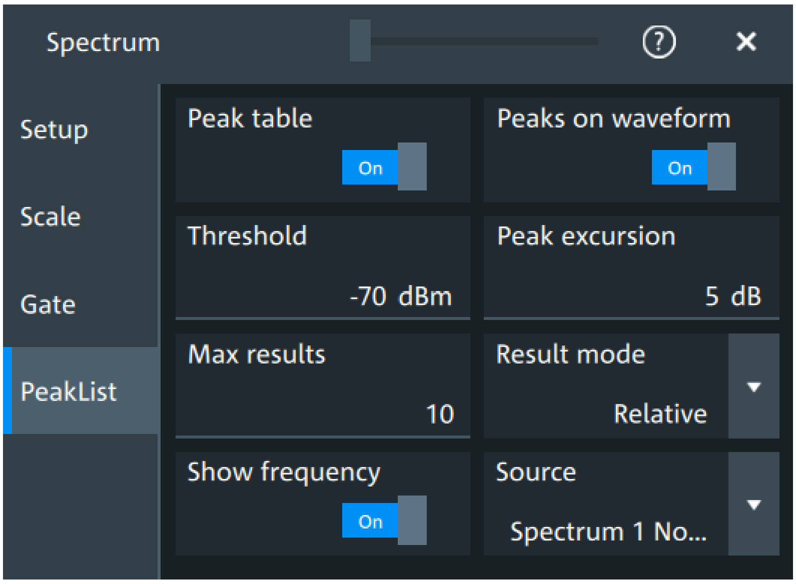
The position of the span is defined using the "Position" setting.

Remote command:

`CALCulate:SPECtrum<sp>:GATE:WIDTh` on page 511

10.6 Spectrum peak list

Access: "Menu" > "Spectrum" > "PeakList"



In the peak list dialog, you can define various criteria for a peak search. The peaks are indicated in the frequency diagram by peak boxes, and the measured peak frequencies and magnitudes are listed in the peak list.

Peak table

Enables the display of the peak table.

Remote command:

`CALCulate:SPECtrum<sp>:PLISt[:STATe]` on page 513

Peak on waveform

Displays the peaks.

Threshold

Sets an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Remote command:

`CALCulate:SPECtrum<sp>:THReshold` on page 508

`CURSor<cu>:THReshold` on page 501

Peak excursion

Defines a relative threshold, the minimum level value by which the waveform must rise by to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Remote command:

`CALCulate:SPECtrum<sp>:PEXCursion` on page 508

`CURSor<cu>:PEXCursion` on page 501

Max results

Sets the maximum number of measurement results that are listed in the result table.

Remote command:
`CALCulate:SPECtrum<sp>:PLISt:MAXCount` on page 512

Result mode

Selects how the measurement results are displayed.

"Absolute" The peaks are shown in absolute value, dBm.

"Relative" The level of the carrier is shown in absolute value dBm. The values of the peaks are shown relatively to the carrier in dBc.

Remote command:
`CALCulate:SPECtrum<sp>:PLISt:MODE` on page 513

Show frequency

Includes the frequency of the detected peak in the diagram labels.

Remote command:
`CALCulate:SPECtrum<sp>:PLISt:LABel:FREQuency[:STATe]` on page 512

Source

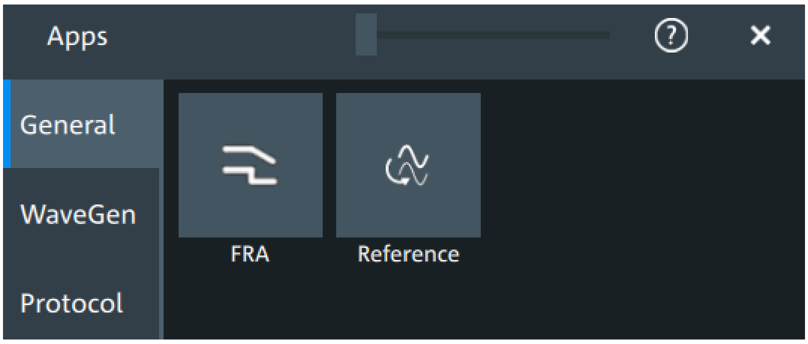
Selects the source of the peak table. You can select one of the traces that is enabled with Traces.

Remote command:
`CALCulate:SPECtrum<sp>:PLISt:SOURce` on page 513

11 Applications

All available applications are provided in the "Apps" dialog.

► To open an application, press the [Apps] key.



Some applications are described in different chapters. See:
- Chapter 8.4, "Reference waveforms", on page 176
- Chapter 15, "Waveform generator (option R&S MXO4-B6)", on page 308
- Chapter 13, "Protocol analysis", on page 251

11.1 Frequency response analysis (option R&S MXO4-K36)

The frequency response analysis (FRA) option lets you perform low-frequency response analysis on your oscilloscope. It characterizes the frequency response of a variety of electronic devices, including passive filters and amplifier circuits. For switched-mode power supplies, it measures the control loop response (CLR) and power supply rejection ratio (PSRR).

The FRA option uses the oscilloscope's built-in waveform generator to create stimulus signals ranging from 10 Hz to 100 MHz. Measuring the ratio of the stimulus signal and the output signal of the DUT at each test frequency, the oscilloscope plots gain and phase logarithmically.

Having both time and frequency domain views allows you to monitor if the injected signal causes distortion that leads to errors in the measurement.

11.1.1 About the frequency response analysis plot

FRA plot display

The FRA plot display is divided into several sections.

Figure 11-1: FRA plot display

1 = Toolbar
2 = Progress bar
3 = FRA result table
4 = Marker value table
5 = Margin value table
6 = Exit app button
7 = Inactive channels
8 = Active channels and plots
9 = FRA plot controls
10 = FRA plot diagram, gain: blue color; phase: red color; amplitude: green color
11 = Channel diagram

Progress bar

Displays the current status of the measurement: how many points have already been displayed and the total set number of points.

FRA plot diagram

The FRA plot diagram has the frequency presented on the x-axis. The gain (blue color waveform) and phase (red color waveform) scales are on the y-axis. The gain plot represents the ratio between input and output. The phase plot shows the phase shift between input and output.

FRA plot result table

In the FRA plot result table, all sample points are displayed with the respective value for the frequency, gain, phase and amplitude. If you select a sample in the table, the respective points in the FRA plot are highlighted by a white line on the gain and the phase curve.

Marker value table

There are two markers available for the FRA plot. They are highlighted on the FRA plot diagram by a white line and the respective marker number 1 or 2. You can move the markers as needed.

In the marker table you can see the frequency, phase and gain values for both of them.

Remote commands:
- `FRANalysis:MARKer<m>:FREQuency` on page 526
- `FRANalysis:MARKer<m>:GAIN?` on page 527
- `FRANalysis:MARKer<m>:PHASe?` on page 527

Margin value table

The margin value displays the gain and the phase margin frequency and value of the system. Higher margin values are an indicator for higher stability of the system.

Remote commands:
- `FRANalysis:MARGin:STATe` on page 525
- `FRANalysis:MARGin:GAIN:FREQuency?` on page 525
- `FRANalysis:MARGin:GAIN:VALue?` on page 526
- `FRANalysis:MARGin:PHASe:FREQuency?` on page 526
- `FRANalysis:MARGin:PHASe:VALue?` on page 526

Vertical position and size of the waveforms

To set the position and the vertical scaling of the gain, phase or amplitude waveforms, select the waveform and use the vertical [Scale] and [Position] (upper knob) knobs.

The remote commands for setting the position and scales of the are described in Chapter 17.15.1.3, "Frequency response analysis diagram settings", on page 522.

11.1.2 Using a frequency response analysis

Connecting the test setup

To avoid measurement uncertainties, make sure that the cables connecting the input and the output of your DUT to the oscilloscope are of similar length.

Starting the FRA

1. Press the [Apps] key.
2. In the "General" tab, tap "FRA".

   The FRA window opens. Only the settings relevant for the FRA setup are visible in the "Menu".

Closing the FRA

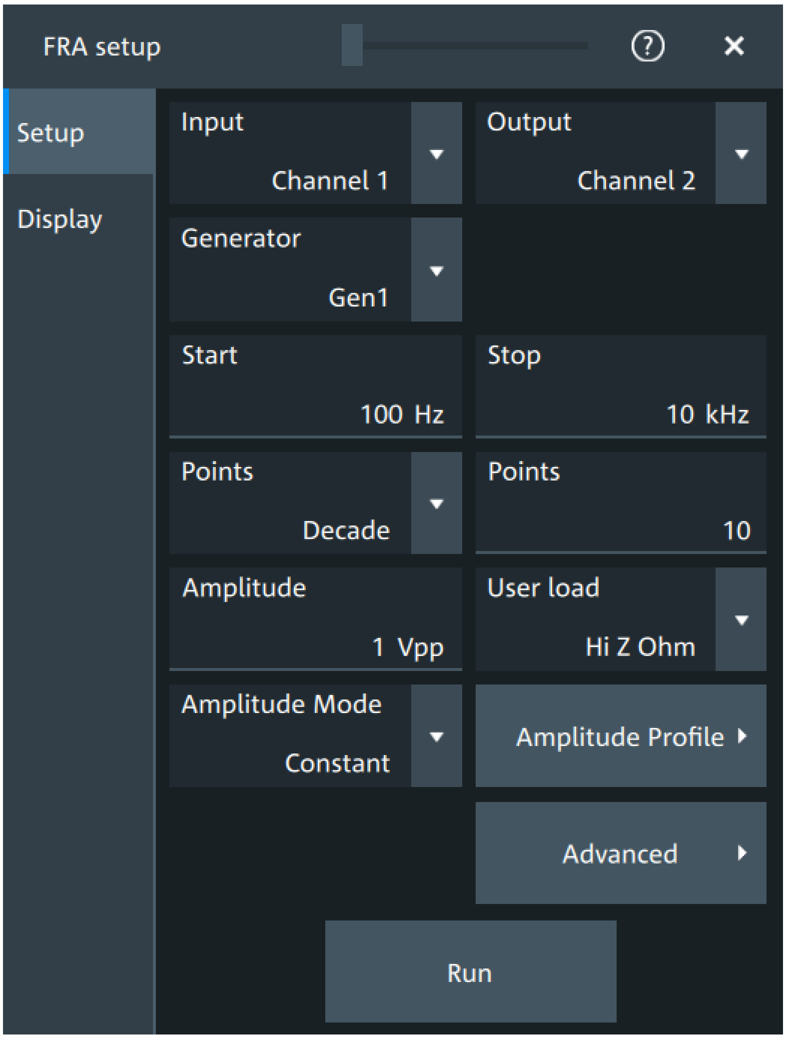
► Tap the "Exit FRA" key at the bottom-right corner of the display.

11.1.3 Settings for frequency response analysis

The following chapters, describes the settings that you can define for the frequency response analysis.

11.1.3.1 Setup

Access: [Apps] > "General" > "FRA" > "Setup".



Input
Sets the channel for the input signal of the DUT.

Remote command:
`FRANalysis:INPut[:SOURce]` on page 517

Output
Sets the channel for the output signal of the DUT.

Remote command:
`FRANalysis:OUTPut[:SOURce]` on page 518

Generator
Selects the built-in generator to start a frequency sweep for a defined frequency range.

Remote command:
`FRANalysis:GENerator[:CHANnel]` on page 517

Start, Stop
Set the start and stop frequency of the sweep.

Remote command:
`FRANalysis:FREQuency:STARt` on page 516
`FRANalysis:FREQuency:STOP` on page 516

Points
Selects, if the number of points are measured as total or per decade and sets the number of points.

Remote command:
`FRANalysis:POINts:TOTal` on page 519
`FRANalysis:POINts:MODE` on page 519
`FRANalysis:POINts:LOGarithmic` on page 519

Amplitude
Sets a fixed amplitude for the frequency response analysis.

Remote command:
`FRANalysis:GENerator:AMPLitude` on page 516

User load
Selects the generator voltage display for 50Ω or high impedance load.

Remote command:
`FRANalysis:GENerator:LOAD` on page 517

Amplitude mode
Selects, if the amplitude is a constant value ("Amplitude") or is defined as an amplitude profile.

Remote command:
`FRANalysis:POINts:MODE` on page 519

Amplitude profile
Opens a dialog to set the amplitude profile. See Chapter 11.1.3.2, "Amplitude profile", on page 230.

You can then define different amplitudes for different frequencies. The amplitude profile is useful when testing sensitive circuits, where the amplitude gets too high. In this case distortion might occur.

If this function is enabled, a green colored diagram of the amplitudes for the different frequencies can be displayed on the screen.

Remote command:
`FRANalysis:AMPLitude:MODE` on page 516
`FRANalysis:AMPLitude:ENABle` on page 524

Run
Starts the frequency response analysis.

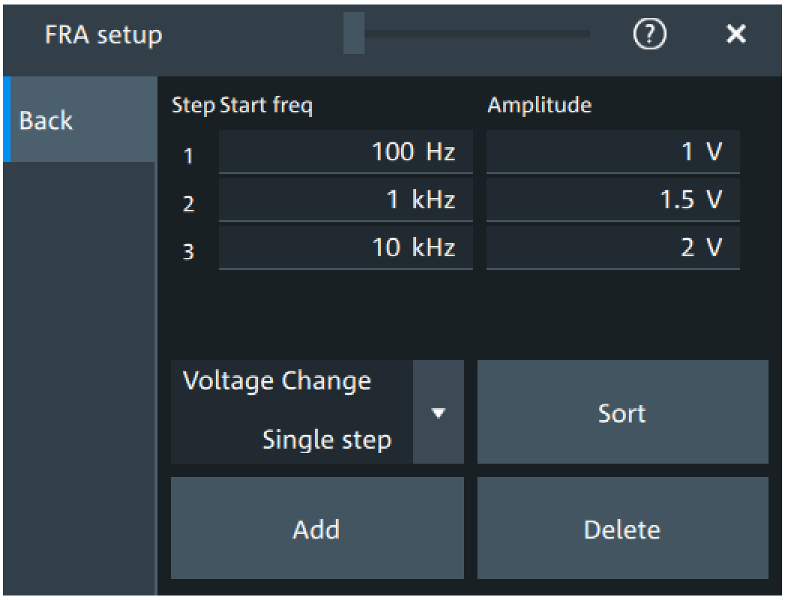
Remote command:
`FRANalysis:STATe` on page 515

Repeat
Repeats the measurement, using the same parameters.

Remote command:
`FRANalysis:REPeat` on page 520

11.1.3.2 Amplitude profile

Access: [Apps] > "General" > "FRA" > "Setup" > "Amplitude profile".



Opens a dialog to set the amplitude profile. You can then define different amplitudes for different frequency. The amplitude profile is useful when testing sensitive circuits, where the amplitude gets too high. In this case distortion can occur.

Step start freq, Amplitude
Set the frequency and amplitude values for the selected point.

Remote command:
`FRANalysis:AMPLitude:PROFile:POINt<m>:AMPLitude` on page 522
`FRANalysis:AMPLitude:PROFile:POINt<m>:FREQuency` on page 522
`FRANalysis:AMPLitude:PROFile:COUNt` on page 520

Voltage change
Selects if the voltage change is done as a single step or as a ramp.

Remote command:
`FRANalysis:AMPLitude:PROFile:MODE` on page 521

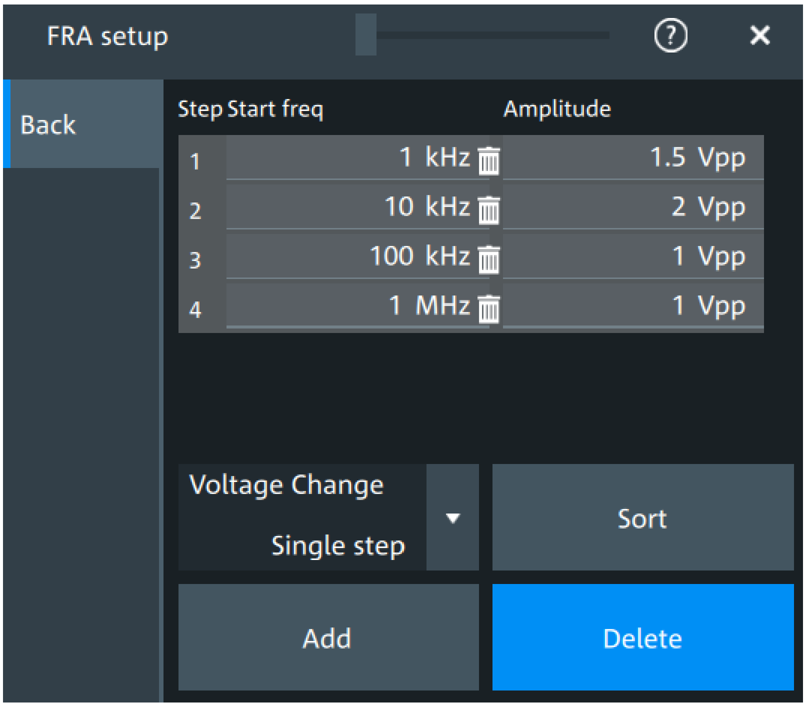
Add
Adds a new point to the amplitude profile.

Remote command:
`FRANalysis:AMPLitude:PROFile:APOint` on page 521

Sort
Sorts the points in the amplitude table by frequency, starting with the lowest frequency.

Remote command:
`FRANalysis:AMPLitude:PROFile:SORT` on page 521

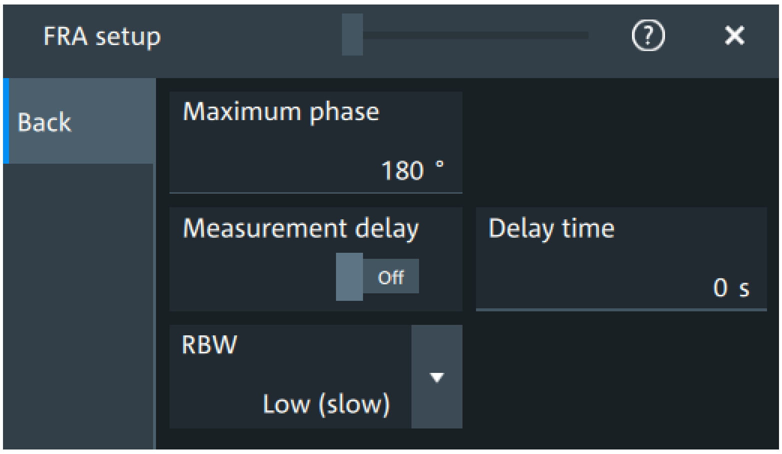
Delete
If enabled a delete icon appears next to each point in the amplitude profile table. You can tap on it to delete the amplitude point.



Remote command:
`FRANalysis:AMPLitude:PROFile:POINt<m>:REMove` on page 521

11.1.3.3 Advanced

Access: [Apps] > "General" > "FRA" > "Setup" > "Advanced".



Maximum phase
Sets the upper boundary of the vertical phase window.

The lower boundary is given by "Maximum phase" - 360°.

By default, the "Maximum phase" is set to 180° for a phase window ranging from -180° to 180° accordingly.

Remote command:
`FRANalysis:PHASe:MAXimum` on page 520

Measurement delay, Delay time
Sets a time delay, that the system waits before measuring the next point of the plot. Time delay is helpful in systems that need more time to adapt to the new frequency, for example if filters with significant time group delays are present.

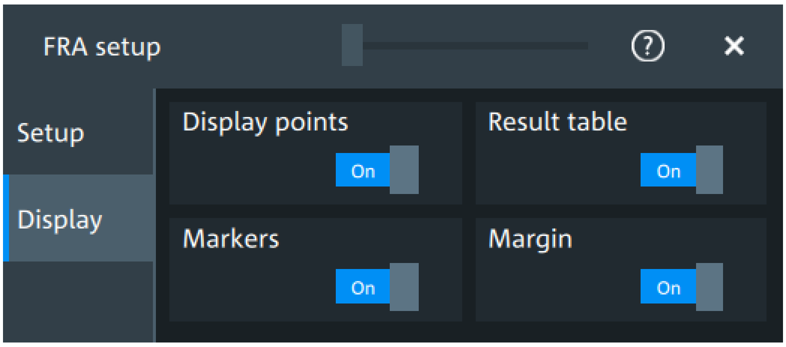
Remote command:
`FRANalysis:MEASurement:DELay:STATe` on page 517
`FRANalysis:MEASurement:DELay[:TIME]` on page 518

RBW
Sets the resolution bandwidth.

Remote command:
`FRANalysis:MEASurement:RBW` on page 518

11.1.3.4 Display

Access: [Apps] > "General" > "FRA" > "Display".



In this dialog, you can select which elements are displayed in the FRA diagram.

Display points
Enables the display of the measurement points for the frequency response analysis.

Remote command:
`FRANalysis:MEASurement:POINt[:DISPlay]` on page 518

Result table
Enables the display of the result table for the FRA.

Remote command:
`FRANalysis:RESult:STATe` on page 525

Markers
Enables the display of the marker table for the FRA.

Remote command:
`FRANalysis:MARKer<m>:STATe` on page 526

Margin
Enables the display of the margin table for the FRA.

Remote command:
`FRANalysis:MARGin:STATe` on page 525

12 Data and file management

This chapter describes how to manage instrument settings, waveform data, measurement results, and screenshots.

The "Save/Recall" dialog provides functions for saving and restoring data on the instrument. A naming pattern is available and can be adjusted to simplify a clear data storage.

The [Camera] key can be configured to save or set up screenshots.

12.1 Save and recall user settings

To repeat measurements at different times or perform similar measurements with different test data, you can save the used instrument settings and load them again later. Furthermore, you can refer to the instrument settings of a particular measurement when analyzing the results. Optionally, the current toolbar and dialog configuration can be included into the saveset.

Access: "Menu" key > "Save/Recall" key > "Save" tab > "User settings".

12.1.1 Using savesets

Savesets contain the complete instrument and measurement configuration. You can save an unlimited number of setting files.

You can assign a saveset to the [Preset] and the "Preset" function on the toolbar, see Chapter 5.6, "Preset setup", on page 83.

To save settings to a saveset file

1. Open "Menu" > "Save/Recall".
2. In the "Save" tab, tap the "Saveset" button.
   The save "Saveset" dialog opens.

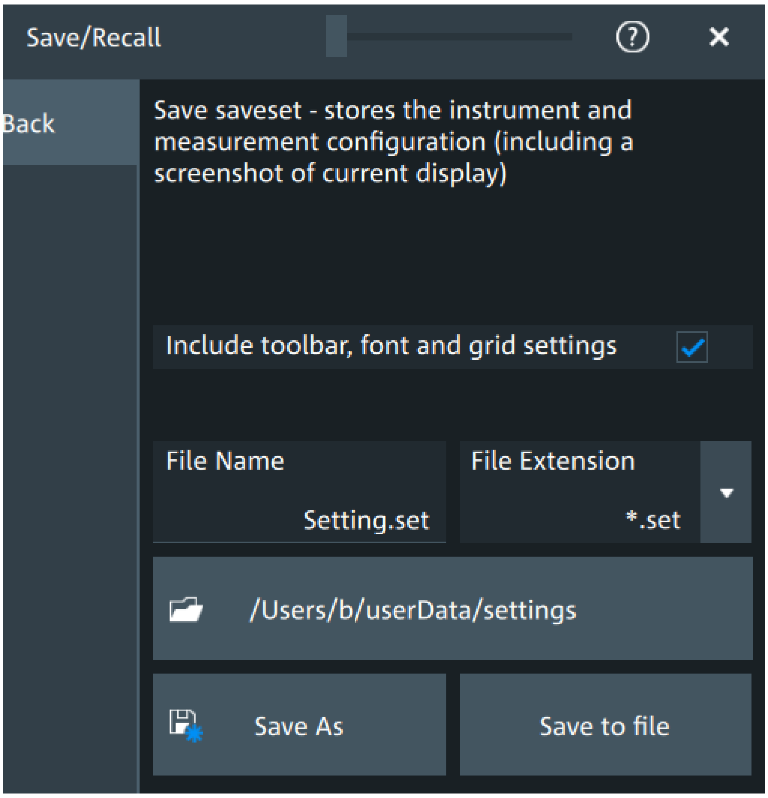


Figure 12-1: Save saveset dialog

3. Enable "Include toolbar, font and grid settings" to include toolbar, font and grid settings.
4. Tap the "Directory". Navigate to the folder, where you want to save the settings file.
5. Tap "Save to file".

   The current settings are saved to the selected file.

To load settings from a saveset file

1. Open "Menu" > "Save/Recall".
2. In the "Recall" tab, press the "Saveset" button.

   The recall "Saveset" dialog opens.

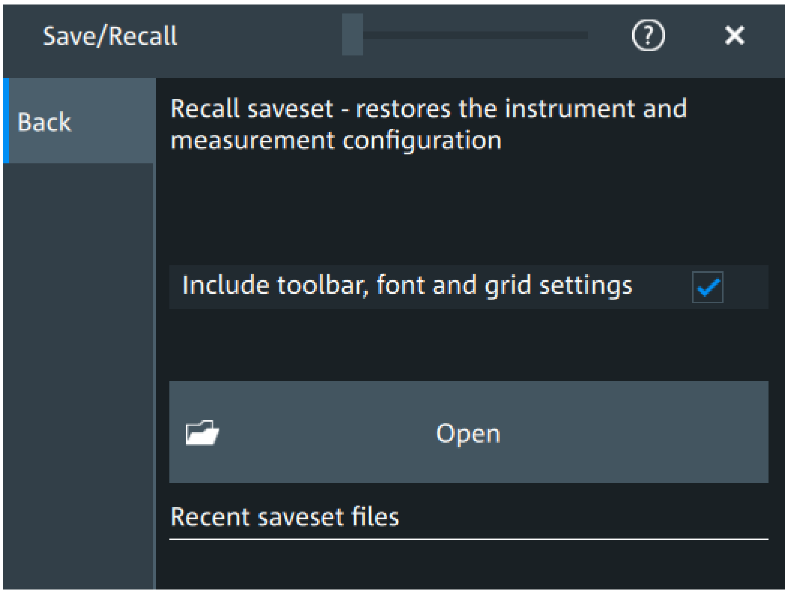


Figure 12-2: Recall saveset dialog

3. Tap "Open".
4. Navigate to the saveset.

   The saved settings are loaded to the R&S MXO 4.

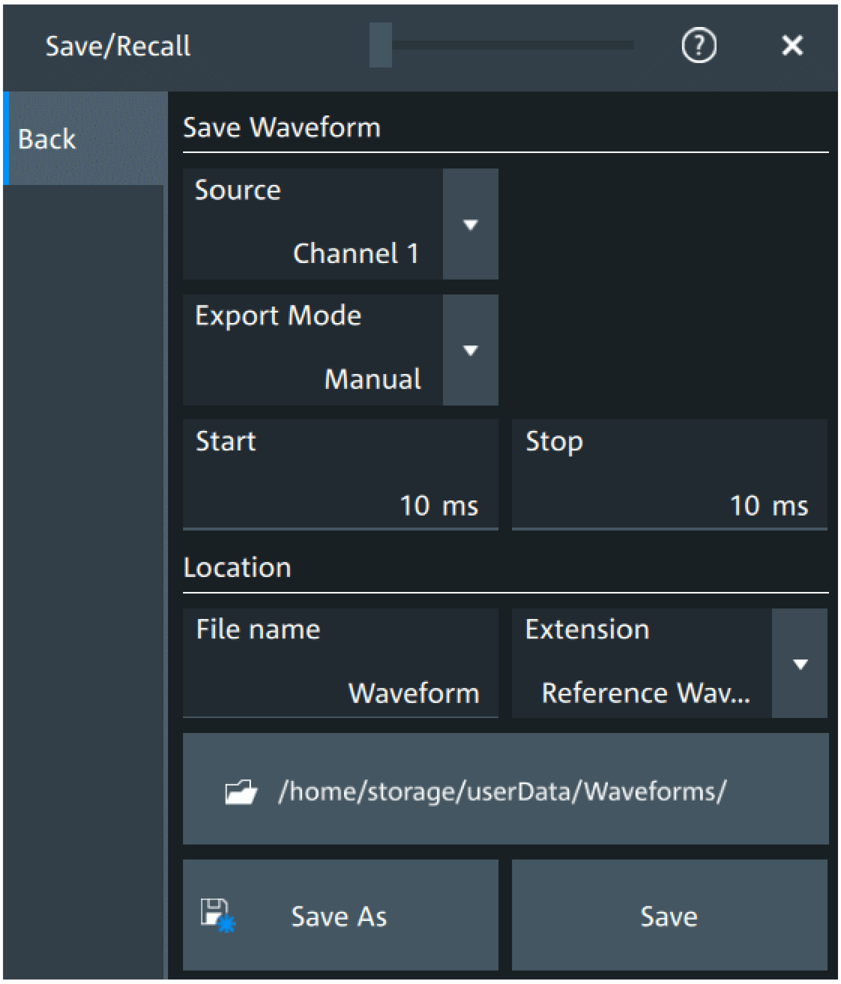
12.2 Save and recall waveform data

You can save waveform data to file, and reload the data of REF files as reference waveforms.

12.2.1 Waveform settings

Access: "Menu" key >"Save/Recall" key > "Save" tab > "Waveform".

In this dialog, you define the storage settings for waveform data.



Source
Selects the waveform to be exported. The list shows all active waveform that can be exported.

Remote command:
EXPort:WAVeform:SOURce on page 470

Export mode
Defines the part of the waveform record that has to be stored.

"DISPLAY"	Saves the waveform data that is displayed in the diagram.
"All data"	Saves the complete waveform record.
"Cursor"	Saves the data between the cursor lines if at least one cursor measurement is defined for the source waveform. If several cursor sets are defined, select the "Cursor set" to be used for export.
"Gate"	Saves the data included in the measurement gate if a gated measurement is defined for the source waveform. Select the "Gate" to be used for export.
"Manual"	Saves the data between user-defined "Start" and "Stop" values.

Remote command:
EXPort:WAVeform:SCOPe on page 469
EXPort:WAVeform:CURSorset on page 471
EXPort:WAVeform:GATE on page 471
EXPort:WAVeform:STARt on page 470
EXPort:WAVeform:STOP on page 470

Location
Defines the details of the file name, extension and directory.

"File name" Sets a name for the file, without extension.

"Extension" Selects the format of the exported file.
You can select between "Excel-CSV-File (*.csv)" and a "Reference Waveform Format (*.ref)". REF files can be reloaded as reference waveforms. See also: Chapter 12.2.3, "Waveform export files", on page 239.

"Directory" Opens a file explorer where you can select the directory where the file is saved.

"Save as" Opens a file explorer where you can select the directory and enter the filename.

"Save" Saves the file in the defined "Directory" using the defined "File name". If the specified file already exists, it is overwritten with the new data.

Remote command:
EXPort:WAVeform:NAME on page 469
EXPort:WAVeform:SAVE on page 469

12.2.2 Saving waveforms

To save a waveform

1. Open "Menu" > "Save/Recall".
2. In the "Save" tab, press the "Waveform" button.
   The save "Waveform" dialog opens.

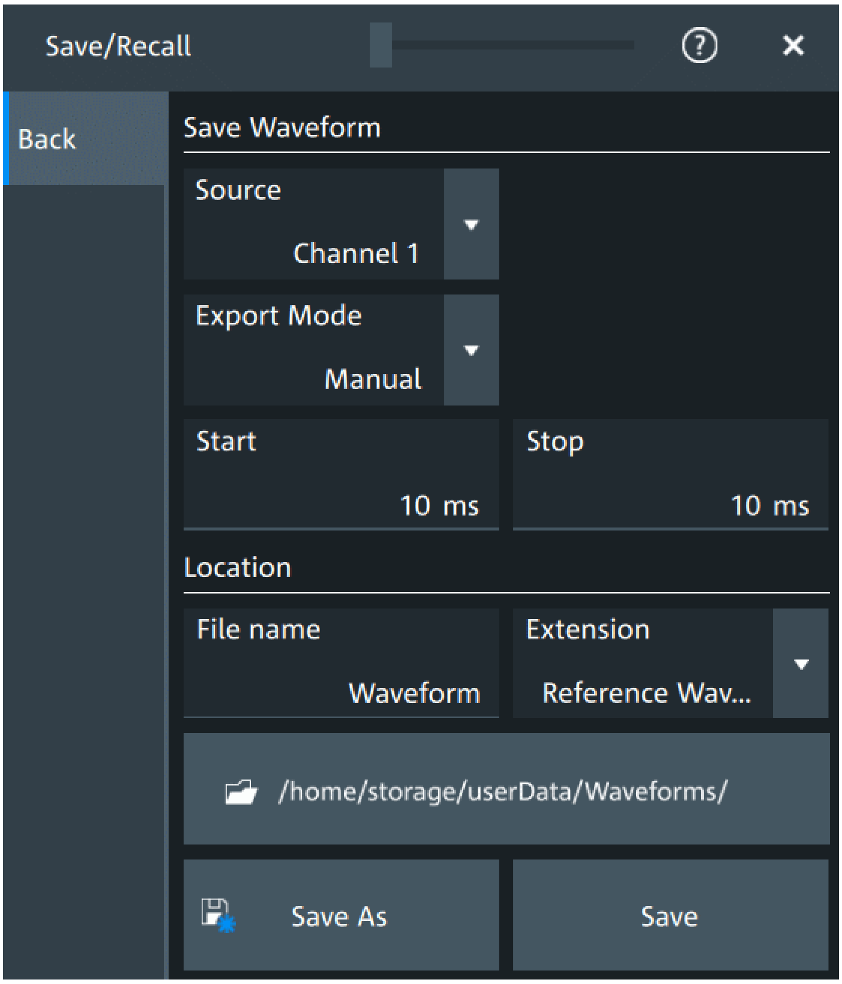


Figure 12-3: Save waveform dialog

3. Select the "Source".
4. Set the "Gate".
5. Tap "Browse".

   The current waveform is saved to the selected file.

12.2.3 Waveform export files

Waveform data is stored in excel `*csv` format, or in a specific `*.ref` format. Files in `*.ref` format can be reloaded as reference waveforms.

12.2.3.1 CSV files

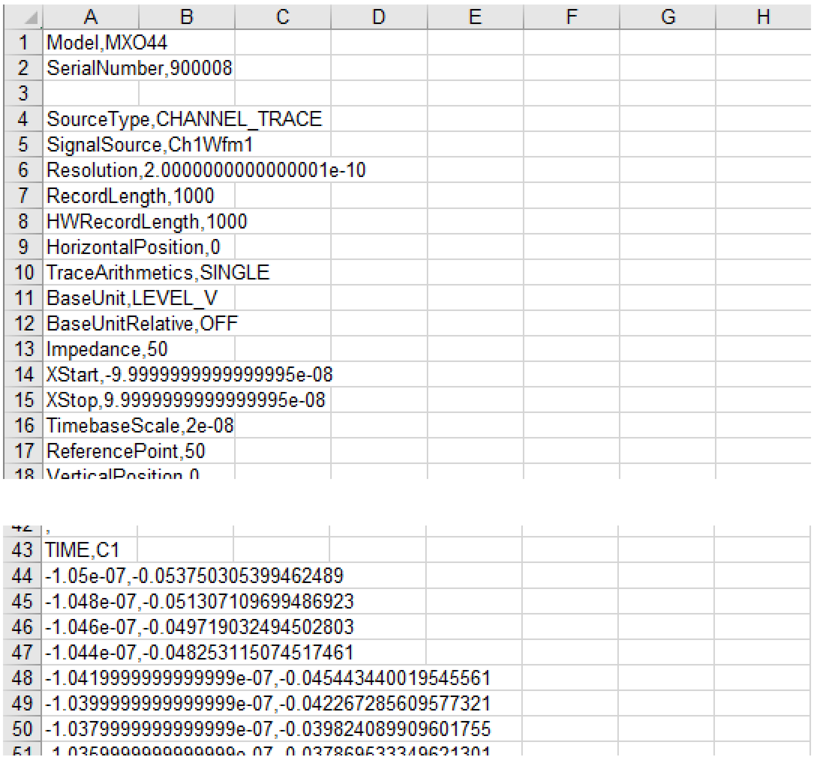
A `*csv` file is a comma-separated values (CSV) text file, the waveform is stored in a table. The columns are separated by commas. For each sample, one line is written.

Values are listed in scientific notation. You can convert the comma-separated text to columns.

Content of waveform files

The first lines of the file contain header data, for example, time scale, vertical scale, vertical and horizontal positions. Header data is required to interpret the waveform data, and to analyze the data values of the data file.

Below the header, the waveform data follows. For each sample, one line is written. The first value is the X-value (time or frequency), the next is the Y-value in the unit indicated in the header data. For envelope or peak detect waveforms, two Y-values (minimum and maximum) are written for each sample.



	A
1	Model,MXO44
2	SerialNumber,900008
3	
4	SourceType,CHANNEL_TRACE
5	SignalSource,Ch1Wfm1
6	Resolution,2.0000000000000001e-10
7	RecordLength,1000
8	HWRecordLength,1000
9	HorizontalPosition,0
10	TraceArithmetics,SINGLE
11	BaseUnit,LEVEL_V
12	BaseUnitRelative,OFF
13	Impedance,50
14	XStart,-9.9999999999999995e-08
15	XStop,9.9999999999999995e-08
16	TimebaseScale,2e-08
17	ReferencePoint,50
18	VerticalPosition,0
43	TIME,C1
44	-1.05e-07,-0.053750305399462489
45	-1.048e-07,-0.051307109699486923
46	-1.046e-07,-0.049719032494502803
47	-1.044e-07,-0.048253115074517461
48	-1.0419999999999999e-07,-0.045443440019545561
49	-1.0399999999999999e-07,-0.042267285609577321
50	-1.0379999999999999e-07,-0.039824089909601755

Figure 12-4: CSV file, opened in Excel

Header data

The header lines contain the following properties:

Table 12-1: Header file properties in CSV files

Value	Description
Model	Model of the instrument
SerialNumber	Serial number of the instrument
SourceType	Type of the exported waveform
SignalSource	Source of the exported waveform

Value	Description
Resolution	Time between two samples *Resolution = 1 / Sample Rate*
RecordLength	Number of samples in a waveform record of one acquisition
HWRecordLength	Equivalent to the RecordLength
HorizontalPosition	Horizontal position of the waveform in divisions
TraceArithmetics	Waveform arithmetic of the waveform: off, envelope, or average
BaseUnit	Base unit of a mathematic waveform, for example, linear unit
BaseUnitRelative	Base unit, if a relative unit (e.g. dB) is enabled
Impedance	Input impedance, used for power calculation
XStart	Horizontal start value of the waveform (time or frequency), as defined in the export settings
XStop	Horizontal stop value of the waveform (time or frequency), as defined in the export settings
TimebaseScale	Horizontal scale in seconds per division
ReferencePoint	Position of the zero point in % of the screen
VerticalPosition	Vertical position of the waveform in divisions
VerticalScale	Vertical scale of the waveform
VerticalOffset	Vertical offset of the waveform in Volts, or other unit
BaseYStart	Vertical start value of the waveform
BaseYStop	Vertical stop value of the waveform
ViewUnit	User-selected unit of a mathematic waveform, for example, logarithmic unit for a spectrum. The value is only valid if the exported waveform is a math waveform.
ViewUnitRelative	Indication of a relative unit. It is true if the math waveform has the ViewUnit "dB", for example. The value is only valid if the exported waveform is a math waveform.
ViewReferenceLevel	Reference level for a relative unit. The value is only valid if the exported waveform is a math waveform, and the unit is relative.
NumericFormat	Number format of bus values and digital channel data (bit pattern format)
EnhancementMode	Method to increase the sample rate if the required sample rate is higher than the ADC sample rate.
InterpolationMode	Interpolation method. The value is relevant when the enhancement mode is interpolated time.
CenterFreq	Center frequency of the spectrum
FreqSpan	Frequency span of the spectrum
ResolutionBW	Resolution bandwidth of the spectrum
FrequencyStart	Start frequency of the spectrum
FrequencyStop	Stop frequency of the spectrum

Value	Description
WindowType	Window used for the spectrum computation
GateRBWCoupling	Indication whether the record length or the resolution bandwidth is a constant for the spectrum computation
HorizontalDivisionCount	Number of horizontal divisions
VerticalDivisionCount	Number of vertical divisions
FirmwareVersion	Firmware version that is installed on the R&S MXO 4
XAxisMode	Indicates a linear or logarithmic x-axis

12.2.3.2 Reference waveforms

The REF format is a specific format, which alllows you to reload the waveform data as reference waveform. The data is saved in a zipped file, that contains two files. One file is a binary file (BIN file) and contains the waveform data values. The second file is an XML file and contains the header data in several data groups. Header data is required to reload the waveform from data, or to analyze the data values of the data file.

```
<?xml version="1.0" encoding="UTF-8"?>
<Group Name="SignalExportBase">
  <Group Name="SignalAttributes">
    <Prop Name="SourceType" Value="CHANNEL_TRACE" UserValue="NONE" />
    <Prop Name="SignalSource" Value="Ch1Wfm1" />
    <Prop Name="Resolution" Value="2.0000000000000001e-10" />
    <Prop Name="RecordLength" Value="1000" />
    <Prop Name="HWRecordLength" Value="1000" />
    <Prop Name="HorizontalPosition" Value="0" />
    <Prop Name="TraceArithmetics" Value="SINGLE" UserValue="SINGLE" />
    <Prop Name="BaseUnit" Value="LEVEL_V" UserValue="LEVEL_V" />
    <Prop Name="BaseUnitRelative" Value="OFF" UserValue="OFF" />
                :
    <Group Name="PostProcessingBufferSampleCounts">
      <Prop Name="DeltaPreSamples" Value="25" />
      <Prop Name="PreSamples" Value="500" />
      <Prop Name="PostSamples" Value="500" />
      <Prop Name="DeltaPostSamples" Value="29" />
    </Group>
  </Group>
</Group>
```

Figure 12-5: Header file in XML format, part of the REF file container

Table 12-2: Header file properties in REF files

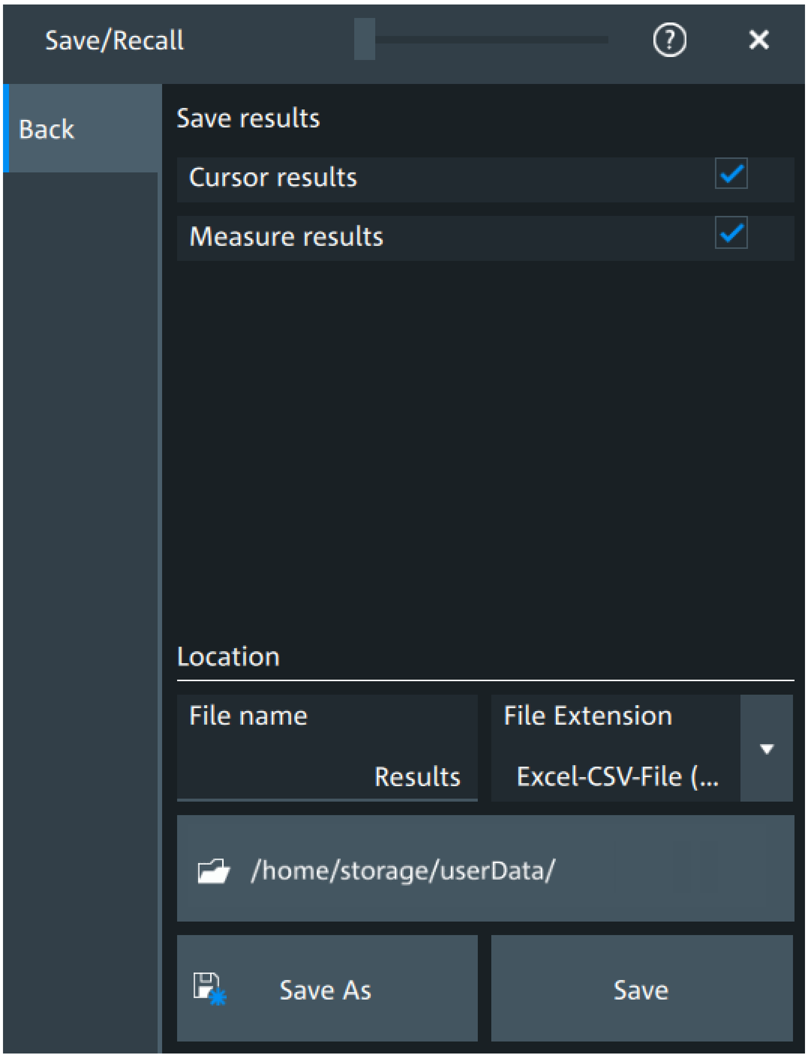
Value	Description
SignalAttributes Same values as in CSV files, except for Model and SerialNumber. See Table 12-1.	
SignalAttributesPostProcessing	
SignalFormat	Format of the data values in the BIN file: INT8BIT, INT16BIT, INT32BIT, FLOAT, DOUBLE
Origin	WFM_EXPORT: export of one acquisition

Value	Description
ByteOrder	Byte order of the values in the BIN file • LSB first: little endian, least significant byte first • MSB first: big endian, most significant byte first
NumberOfWaveforms	Number of waveforms, = 1
TimestampState	OFF
Timestamp	Absolute time of the waveform recording in ISO 8601 format
DecimationMode	Method to reduce the number of data samples to achieve the required sample rate
IsMinMax	If ON, then min and max values are saved for each sample. For envelope and peak detect waveforms.
IsComplex	If ON, then two values are saved for each sample (I and Q value).
TriggerOffsetToPostSampleInSeconds	Offset between the exact trigger position and the first sample after the trigger
SignalRecordLength	Number of samples in the BIN file. If the signal is a spectrum, the value indicates the number of FFT bins.
SignalXStart	Time of the first sample in the acquired data. Different from XStart if only part of the data is exported.
SignalXStop	Time of the last sample in the acquired data. Different from XStop if only part of the data is exported.
AdjustedResolutionBW	Actual resolution bandwidth of a spectrum waveform. Only valid if the exported waveform is a spectrum.
NoiseBandwidth	Noise bandwidth of a spectrum waveform, required for power calculation. Only valid if the exported waveform is a spectrum.
ValuesPerSample	Number of y-values saved at each sampling time. The value is usually 1. The value is 2, if min and max values are saved for each sample, for example, for envelope waveforms.
NofQuantisationLevels	Number of quantization levels of y values
TOADone	If ON, then TriggerOffsetToPostSampleInSeconds is compensated.
SignalResolution	Time between two samples in this waveform. The value can differ from Resolution if the source is, for example, a spectrum. The value is determined automatically considering the waveform parameters and their dependencies. If the signal is a spectrum, the value indicates the frequency range of FFT bins.
HorizontalDomain	Domain of the x-axis (TIME or FREQUENCY)
PostProcessingVerticalAxisAttributes	
Range	Range of the signal in y-direction
Offset	Center of the y-range
Resolution	Resolution of the y-axis
IsLogarithmic	Indicates if the y-axis is logarithmic (ON or OFF)
PostProcessingSampleFormatAttributes	
ValueStorage	Interpretation of the data: is INTEGER or FLOAT (floating point data)

Value	Description
ValueInterpretation	Indicates if the data is saved as binary ADC values (BINARY), or physical values (PHYSICAL)
SampleBitSize	Value size in bit, as used in processing
ValueBitSize	Value size of ADC data in bit
`LsbExtensionBits`	Number of bits...
FractionalBits	Number of decimale places in bit, for fixed point values
IsSigned	Signed values (ON) or unsigned values (OFF)
PostProcessingBufferSampleCounts	
[DeltaPreSamples | PreSamples || PostSamples | DeltaPostSamples]	Indicates the distribution of the samples. || marks the trigger time. The sum of PreSamples and PostSamples matches the requested record length. DeltaSamples are additional samples that needed for computation but they are not measured or displayed.

12.3 Saving results

In this tab, you can select the result tables to be saved, and define the storage settings.



To save results

1. Open "Menu" > "Save/Recall".
2. In the "Save" tab, press the "Results" button.
   The save "Results" dialog opens.
3. Select the results to be saved. The "Save results" results list shows all result tables that are currently open. All results are written into one file.
4. Under "Location", enter a "File name" and select "Save". Alternatively, select "Save As" and define the target directory and file name in the file selection dialog.

   The current results are saved to the selected file.

Remote commands:

- `EXPort:RESult:SELect:CURSor` on page 472
- `EXPort:RESult:SELect:MEASurement` on page 472
- `EXPort:RESult:NAME` on page 471

- EXPort:RESult:SAVE on page 472

12.4 Screenshots

To store the graphical results of the measurement, you can save a screenshot of the graphic area. To document current settings, the open dialog box can be included in the screenshot.

The "Screen Capture" toolbar icon saves the current display to a file according to the settings in "Menu" > "Save/Recall" > "Save" tab > "Screenshot".

You can configure the [Camera] key to save screenshots by a single keypress.

See also "Camera hardkey action" on page 82.

If a USB flash drive is connected to the instrument, the default path of the user data directory is set to the drive letter of the USB flash drive. Thus, you save data to USB flash drive automatically, and you can change the directory in the file explorer at any time.

Screenshots on a computer using the Web interface

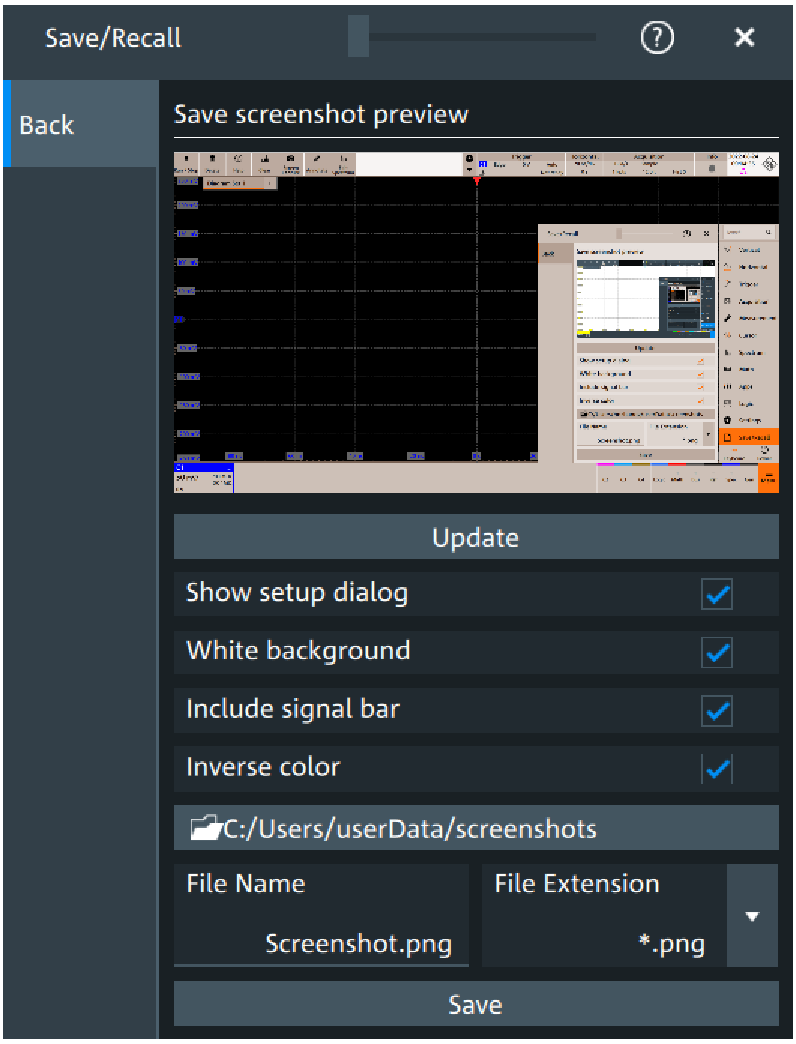
If the R&S MXO 4 is connected to a LAN, you can create and save screenshots of the instrument's display on a computer.

Meta information in screenshots

The meta data of the screenshot also contains instrument information. In PNG and JPEG files, meta information is saved as EXIF information and can be read, for example, using the ExifTool.

12.4.1 Screenshot settings

Access: "Menu" > "Save/Recall" > "Save" tab > "Screenshot"



In the "Screenshot" dialog box, you configure the image to be saved or included in a report. You select the storage location for screenshot files. The image is created when you open the dialog box, and can be updated at any time.

You can also edit the colors of the image before saving it, and include an open dialog box or the sidebar in the image.

You can save the image in the dialog box. To save screenshots quickly, use the "Screen Capture" toolbar icon, or configure and use the [Camera] key.

Preview
Shows a preview of the screenshot. The image is created when the dialog box opens.

Update
Updates the preview of the screenshot with the current display view, e.g. after changes to the settings have been made, or an additional channel has been activated.

Show setup dialog
If enabled, the currently open dialog box is included in the screenshot.

Remote command:
`HCOPy:SSD` on page 474

White background
Inverts the background color, so you can picture waveforms with normal waveform colors on white background.

If both "White background" and "Inverse color" are enabled, the instrument inverts the background twice, and it appears black.

"White background"	"Inverse color"	Background	Waveform and results
On	Off	White	Screen colors
Off	On	White	Inverted colors
On	On	Black	Inverted colors
Off	Off	Black	Screen colors

Remote command:
`HCOPy:WBKG` on page 474

Include signal bar
If enabled, the screenshot shows the signal bar below the diagram area.

Remote command:
`HCOPy:ISBA` on page 474

Inverse color
Inverts the colors of the output, i.e. a dark waveform is shown on a white background.

Remote command:
`HCOPy:DEVice<m>:INVerse` on page 473

Directory
Opens the file selection dialog box. Here you can adjust the target directory where the screenshot is saved. The symbols of important target folders are listed on the left of the file explorer.

Remote command:
`HCOPy:DESTination<m>` on page 473

File name, Extension
Sets a file name for the screenshot, and the extension of the file. You can save the screenshot as `*.jpg` or `*.png` file.

Save
Saves the current screenshot to the specified file.

12.4.2 Configuring and saving screenshots

You can select which elements are shown in the screenshot, invert the colors and the background color. A preview of the current image is shown for reference.

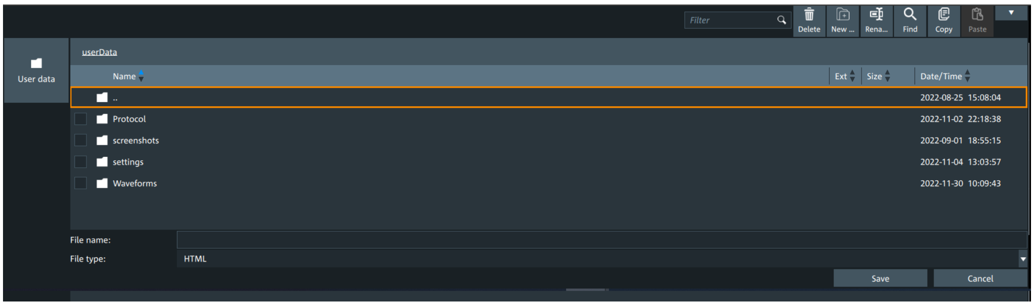
1. Open the "Menu" > "Save/Recall" > "Save" tab > "Screenshot".
2. To enhance the images for later print on white paper, enable "White background" or "Inverse color". If you print this image later on a monochrome printer, you get a grayscaled picture. The contrast of the gray lines depends on waveform colors and the used printer.
3. To change the directory, tap "Browse" and configure the path.

   The symbols of often used target folders are listed on the left of the file explorer. By default, screenshots are saved in the `home/storage/userData/ScreenShots` directory.
4. Tap "Save".

   The file is saved.
5. Check if the screenshot is saved to the desired directory.
6. To save further screenshots, use one of the following ways:
   - Configure the [Camera] key. Press the key to save a screenshot.
     See also Camera hardkey action.
   - Add the "Screen Capture" icon to the toolbar. Tap the icon to save an image.
   - Tap "Save" in the "Screenshot" dialog box to save the image to the specified file.
   - To save the image with a dedicated filename or to another directory, tap "Browse" in the "Screenshot" dialog box.
     Select the path, enter a filename, and tap "Save".

12.5 File selection dialog

The file selection dialog provides a file explorer from which you can select a file to load or to save data to. You can also manage your files in this dialog.



Path

Navigate the path elements to change the current folder. The default folder is defined in Chapter 5.8.1, "Autonaming", on page 90.

You can save the data in a local folder on the instrument.

On the left, shortcut icons provide access to often used folders.

Toolbar

The toolbar on the top provides various functions for file management.

File name

The file name to be loaded or stored to. Tap the file name, or tap the keyboard icon to enter the file name using the online keyboard.

The default file name for new files is defined in the "Autonaming" tab, see Chapter 5.8.1, "Autonaming", on page 90.

File type

The file extension of the file to be loaded or stored to.

Save, Select

Selects the specified file for the open or save operation and closes the dialog box.

Cancel

Closes the dialog box without selecting a file.

13 Protocol analysis

Using the serial protocol options for the R&S MXO 4, you can analyze various serial protocols.

13.1 Basics of protocol analysis

With the R&S MXO 4 oscilloscope, you can decode selected protocols.

With dual-path protocol analysis, you can set the instrument sample rate for the waveform path and the oscilloscope automatically uses another internal decoupled sample rate for the decoding path. Even with very slow sample rates, the protocol data is correctly decoded.

With the R&S MXO 4, you can use deep memory to capture more packets. The oscilloscope can capture long time periods where the cause and result are distanced in time. Over the entire capture, signal detail is time-correlated with packet content for fast debug.

Before you can analyze a serial signal, the bus has to be configured according to the protocol and specifics of the signal. The configuration contains:

- Assignment of the data and clock lines to the input channels
- Logical thresholds
- Protocol-specific settings

Serial data can be analyzed in several ways:

- Triggering: You can trigger on various events that are typical for the selected protocol type, for example, on start and stop of messages, or on specified data patterns in the message.
  Triggering on a trigger event sequence is not supported, and holdoff settings are not available.
- Protocol decoding: The digitized signal data is displayed on the screen together with the decoded content of the messages in readable form, and the decode results are listed in a table.

13.1.1 Setup - general settings

For all protocols, configuration starts with the selection of the serial bus and the protocol.

Configuration settings are protocol-specific. They are described in the related chapters.

Make sure that the tab of the correct serial bus is selected.

SB1 /SB2 /SB3 /SB4
Select the correct bus tab before you enter the settings.

Protocol type
Displays the protocol type to be decoded.

Remote command:
SBUS<m>:TYPE on page 528

State
Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

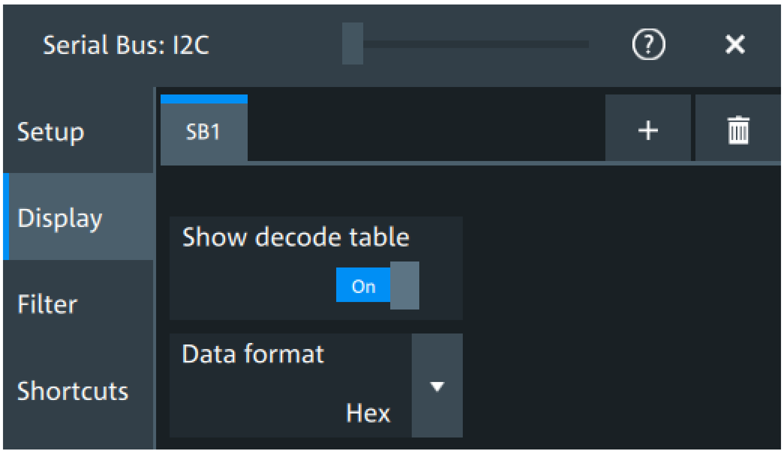
13.1.2 Advanced

Some protocols have additional more advanced settings. They are displayed in the "Advanced" tab.

The settings are protocol specific and are described in the corresponding protocol chapter.

13.1.3 Display

For all protocols, you can select to display the decoded signal as a table and to show the binary signal on the screen.



Show decode table
Opens a table with decoded data of the serial signal. The function requires the option for the analyzed protocol.

Decode results are protocol-specific.

Remote command:
`SBUS<m>:RESult` on page 529

Data format
Sets the data format for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:
`SBUS<m>:FORMat` on page 529

Zoom coupling
If enabled, the decode zoom and result table are synchronized. If you select a row in the result table, this result is shown in the decode zoom.

Remote command:
`SBUS<m>:ZCOupling` on page 529

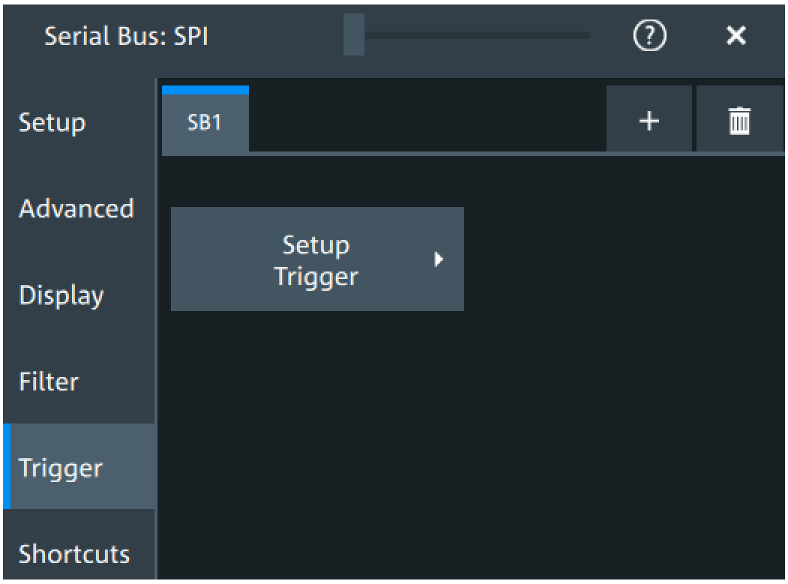
13.1.4 Filter

In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

The settings are protocol specific and are described in the corresponding protocol chapter.

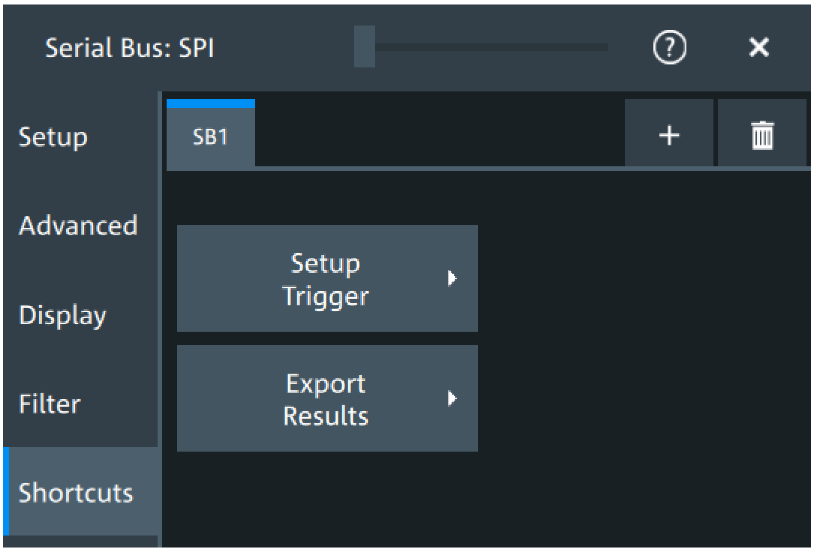
13.1.5 Trigger

The "Trigger" tab gives quick access to the "Trigger" dialog.



13.1.6 Shortcuts

The "Shortcuts" tab gives quick access to other dialogs with protocol relevant settings. The availability depends on the functions supported by the protocol.

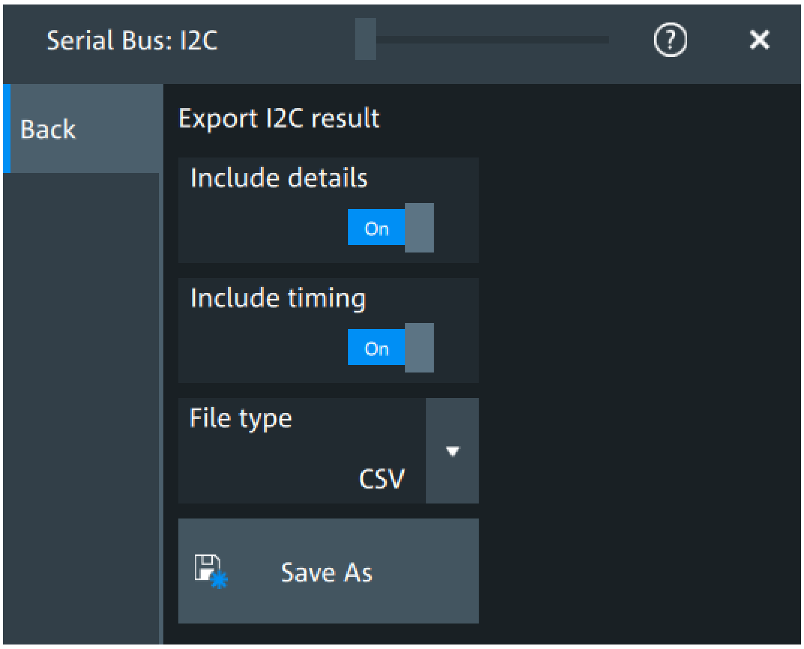


If you access a dialog from the "Shortcuts" tab, some settings are already predefined.

- "Setup trigger": you can trigger on various events that are typical for the selected protocol type, for example, on start and stop of messages, or on specified data patterns in the message.
- "Export results": in this dialog, you can select the decode results you want to export and the protocol-specific details to be included.

13.1.7 Export protocol results

In the "Export results" dialog, you can export the results and all details of the selected protocol.



Include details
If enabled, includes the detailed results for all frames in the export result file.

Remote command:
`SBUS<m>:EXPResult:DETail` on page 530

Include frame timing
If enabled, includes the frame timing in the export result file.

Remote command:
`SBUS<m>:EXPResult:TIME` on page 530

File type
Selects the file format.

".csv"	The results are saved as a CSV compatible file.
".html"	The results are saved as web page for display in a browser.
".xml"	The results are saved in an xml compatible file format.
".py"	The values are saved in a Python compatible file format.

Save as
Opens a dialog box where you can select a file name and a path for the export results file.

Remote command:
`SBUS<m>:EXPResult:SAVE` on page 530

13.2 SPI bus (option R&S MXO4-K510)

The Serial Peripheral Interface SPI is used for communication with slow peripheral devices, in particular, for transmission of data streams.

13.2.1 The SPI protocol

A 4-channel instrument is required for full support of the SPI protocol, or the MSO option R&S MXO4-B1.

The Serial Peripheral Interface SPI is used for communication with slow peripheral devices, in particular, for transmission of data streams.

Main characteristics of SPI are:

- Master-slave communication
- No device addressing; The slave is accessed by a chip select, or slave select line.
- No acknowledgement mechanism to confirm receipt of data
- Duplex capability

Most SPI buses have four lines, two data and two control lines:

- Clock line to all slaves (SCLK)
- Slave Select or Chip Select line (SS or CS)
- Master data output, slave data input (MOSI or SDI)
- Master data input, slave data output (MISO or SDO)

When the master generates a clock and selects a slave device, data may be transferred in either or both directions simultaneously.

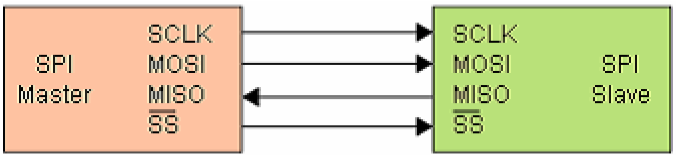


Figure 13-1: Simple configuration of SPI bus

The data bits of a message are grouped by following criteria:

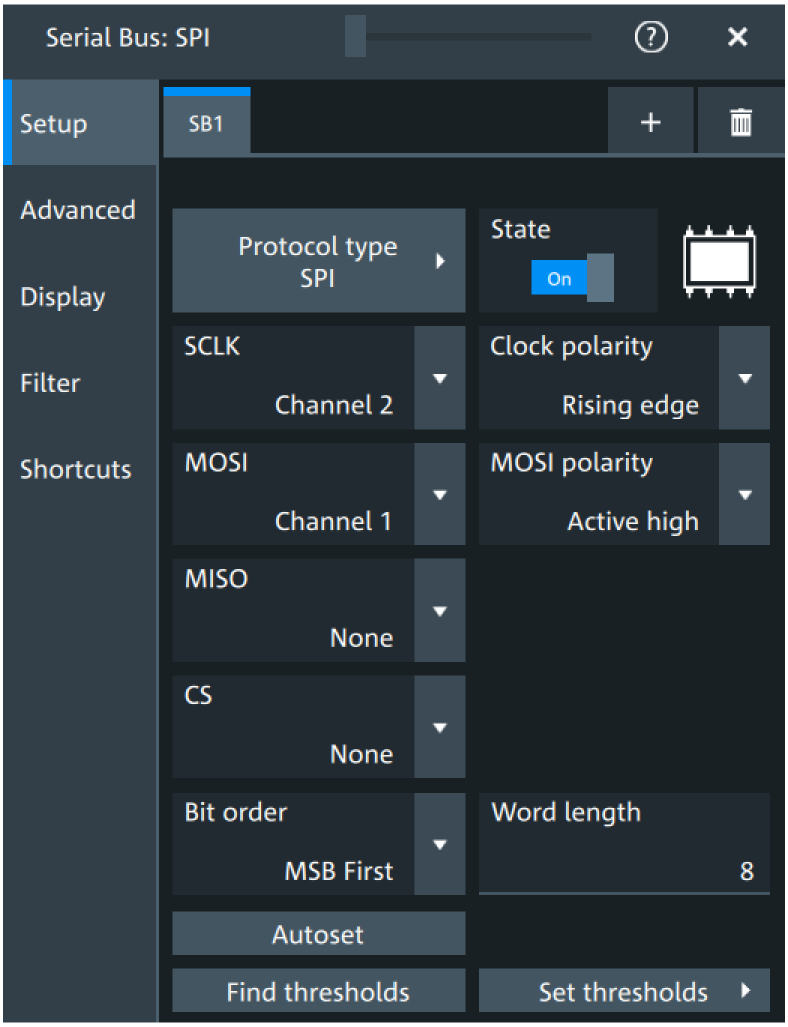
- A word contains a number of successive bits. The word length is defined in the protocol configuration.
- A frame contains a number of successive words, at least one word.

13.2.2 SPI configuration

13.2.2.1 Setup

Access: [Apps] key > "Protocol" tab > "SPI" > "Setup".

Make sure that the tab of the correct serial bus is selected.



Protocol type
Displays the protocol type to be decoded.

Remote command:
SBUS<m>:TYPE on page 528

State
Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

SCLK,MOSI,MISO,CS
Sets the input channel for the respective line:

- SCLK: clock line
- MOSI line
- MISO line

- CS: chip select

Alternatively, digital channels can be used if MSO option R&S MXO4-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
SBUS<m>:SPI:MISO:SOURce on page 534
SBUS<m>:SPI:MOSI:SOURce on page 535
SBUS<m>:SPI:SCLK:SOURce on page 535
SBUS<m>:SPI:CSELect:SOURce on page 533

Clock polarity
Two settings define the clock mode: the clock polarity and the clock phase. Together, they determine the edges of the clock signal on which the data are driven and sampled.

A master/slave pair must use the same parameter pair values to communicate. The clock phase defines the slope. It selects if data is stored with the rising or falling slope of the clock. The slope marks the begin of a new bit.

Polarity: MOSI, MISO, CS
Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
SBUS<m>:SPI:MISO:POLarity on page 533
SBUS<m>:SPI:MOSI:POLarity on page 534
SBUS<m>:SPI:CSELect:POLarity on page 532

Bit order
Selects the bit order, which determines if the data of the messages starts with MSB (most significant bit) or LSB (least significant bit).

Remote command:
SBUS<m>:SPI:BORDer on page 531

Word length
Sets the word length (or symbol size), which is the number of bits in a message. The maximum word length is 32 bit.

Remote command:
SBUS<m>:SPI:WSIZe on page 536

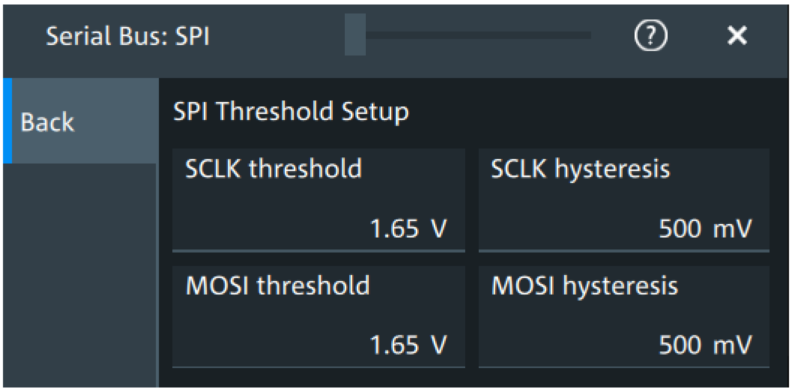
Threshold
Press "Set thresholds", to open the In the "Threshold setup" dialog.

Enter the value directly in the field of the threshold setup dialog.

Additional to the threshold, you can also set a hysteresis.

If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold.

The interpretation of high and low is defined by the "Polarity: MOSI, MISO, CS" on page 258.



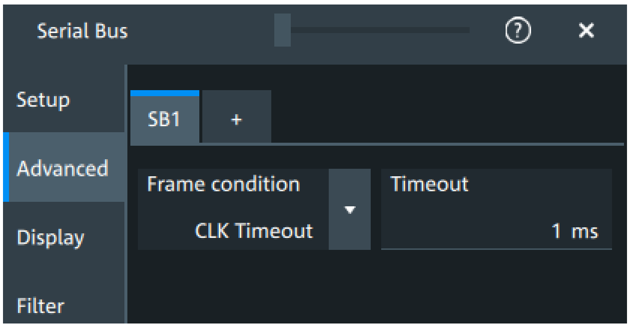
Remote command:
`SBUS<m>:SPI:MISO:HYSTeresis` on page 533
`SBUS<m>:SPI:MOSI:HYSTeresis` on page 534
`SBUS<m>:SPI:SCLK:HYSTeresis` on page 535
`SBUS<m>:SPI:CSELect:HYSTeresis` on page 532
`SBUS<m>:SPI:MISO:THReshold` on page 534
`SBUS<m>:SPI:MOSI:THReshold` on page 535
`SBUS<m>:SPI:SCLK:THReshold` on page 536
`SBUS<m>:SPI:CSELect:THReshold` on page 533

Show threshold lines ← Threshold
If enabled, the threshold lines are displayed in the diagram.

Remote command:
`SBUS<m>:THReshold` on page 529

13.2.2.2 Advanced

Access: [Apps] key > "Protocol" tab > "SPI" > "Advanced".



Frame condition
Defines the start of a frame. A frame contains a number of successive words, at least one word.

"CS" Start and end of the frame is defined by the active state of the slave select signal.

"CLK timeout" Defines a timeout on the clock line SCLK as limiter between two frames. The timeout condition is used for SPI connections without a CS line. Enter the minimum clock idle time in the field.

Remote command:
`SBUS<m>:SPI:FRCondition` on page 532

Timeout
Sets the minimum clock idle time if a timeout on the clock line SCLK is used as limiter between two frames.

See also: "Frame condition" on page 259.

Remote command:
`SBUS<m>:SPI:TIMeout` on page 536

13.2.2.3 Display settings

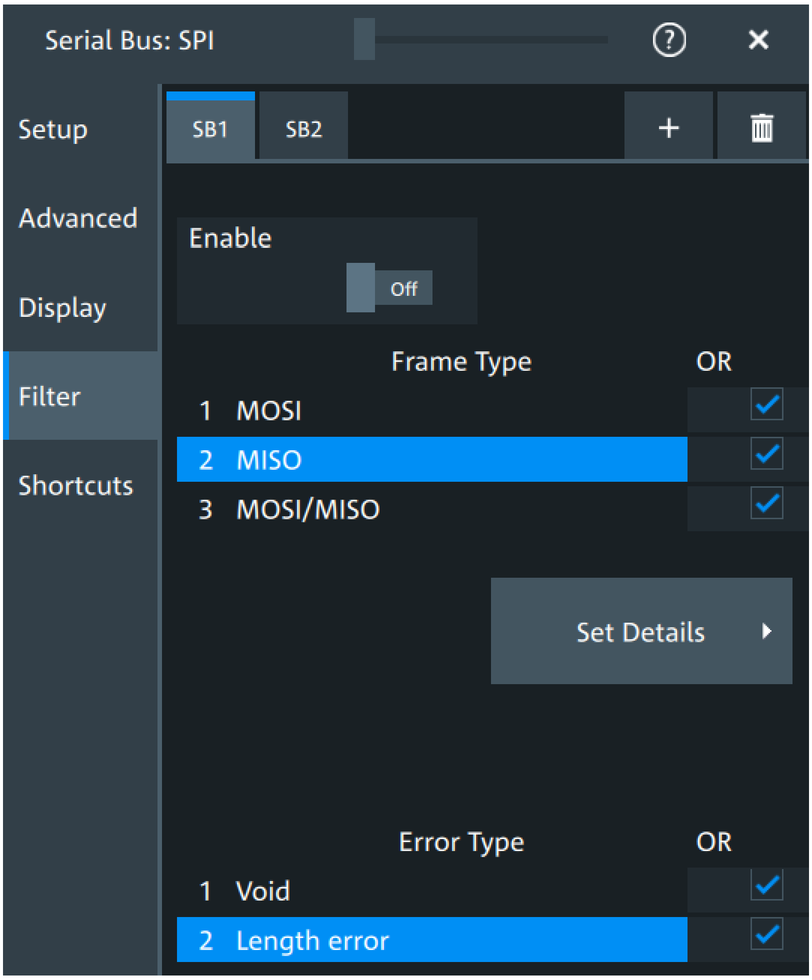
For details about the display settings, see Chapter 13.1.3, "Display", on page 252.

13.2.2.4 Shortcuts

For details about the available shortcuts, see Chapter 13.1.6, "Shortcuts", on page 254.

13.2.3 SPI filter

Access:[Apps] key > "Protocol" tab > "SPI" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Enable

Enables the filtering on SPI frames. Only the frames that match the selected filter conditions are displayed.

Remote command:

`SBUS<m>:SPI:FILTer:ENABle` on page 537

Frame type

Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

The available frames are "MOSI", "MISO" and "MOSI/MISO".

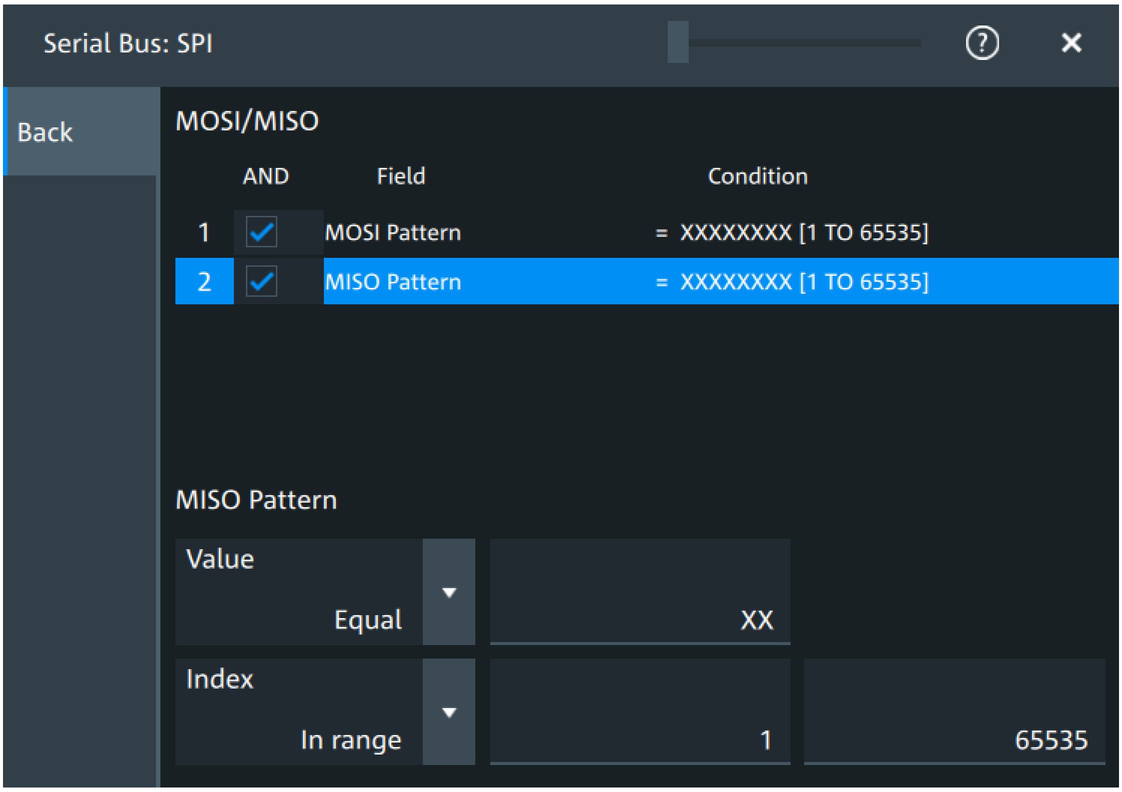
Remote command:

`SBUS<m>:SPI:FILTer:FRAMe<fr>:ENABle` on page 539

`SBUS<m>:SPI:FILTer:FRENable` on page 539

Edit

Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields are "MOSI Pattern" and "MISO Pattern".

Remote command:
SBUS<m>:SPI:FILTer:FIENable on page 539
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 539

"Condition" Displays the value condition for the selected field.

Remote command:
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 537

"Data" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 537
SBUS<m>:SPI:FILTer:DMAX on page 537
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 538
SBUS<m>:SPI:FILTer:DMIN on page 538
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 538
SBUS<m>:SPI:FILTer:DOPerator on page 538

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 539
SBUS<m>:SPI:FILTer:IMAX on page 539
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 540
SBUS<m>:SPI:FILTer:IMIN on page 540
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 540
SBUS<m>:SPI:FILTer:IOPerator on page 540

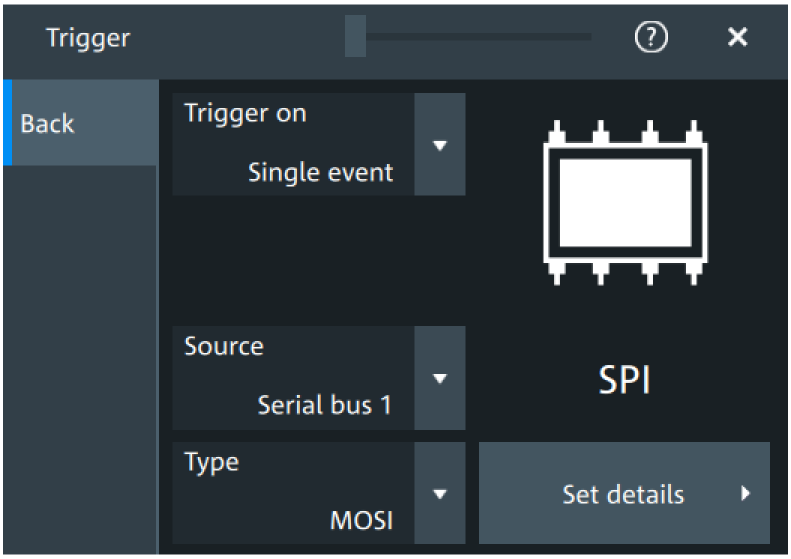
Edit
Opens a dialog to define the details of the selected frame.

Error type
Enables filtering on the selected error type.

Remote command:
SBUS<m>:SPI:FILTer:ERRor<n>:ENABle on page 538

13.2.4 SPI trigger

Access: [Apps] key > "Protocol" tab > "SPI" > "Shortcuts".



Type
Selects the trigger type for SPI analysis.

Some trigger types have additional settings that can be defined. In this case, the "Edit" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.

"Start of frame" Sets the trigger to the beginning of the frame.

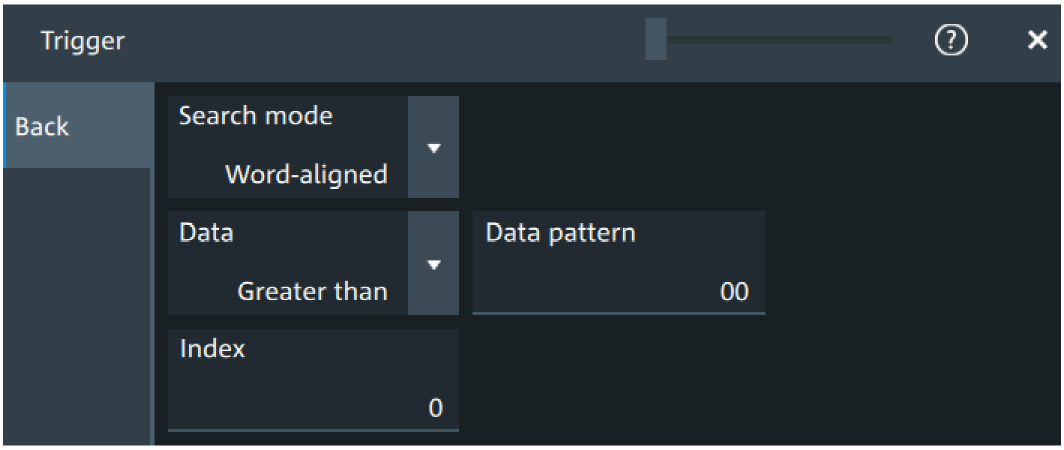
"End of frame" Sets the trigger to the end of the frame.

"MOSI" Sets the trigger to a specified data pattern expected on the MOSI line.

"MISO" Sets the trigger to a specified data pattern expected on the MISO line.

Remote command:
`TRIGger:SPI:TYPE` on page 541

MOSI and MISO data conditions
The trigger on MOSI and MISO patterns is defined in the same way:



Search mode ← MOSI and MISO data conditions
Defines how the specified data pattern is searched.

"Bit-aligned" Bit-by-bit: the pattern can start at any position in the message.

"Word-aligned" The pattern is matched only at word boundaries.

Remote command:
`TRIGger:SPI:PALignment` on page 542

Data ← MOSI and MISO data conditions
Selects the operator condition for the data pattern and sets the data pattern.

Remote command:
`TRIGger:SPI:FCONdition` on page 541
`TRIGger:SPI:DMINpattern` on page 541

Position ← MOSI and MISO data conditions
Sets the number of bits or words to be ignored before the first bit or word of interest.

Remote command:
`TRIGger:SPI:DPOSition` on page 541

13.2.5 SPI decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.

2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Chapter 13.1.3, "Display", on page 252.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Decode results table

The "Decode results" table contains information about all decoded frames.

Figure 13-2: Decoded and binary SPI signal

Green brackets [...] = Start and end of complete frame
Red brackets [...] = Start and end of incomplete frame
Yellow = Word
Red = Error

Table 13-1: Content of the "Decode results" table

Column	Description
Index	Index of the decoded frame
State	Overall state of the frame
Start	Times of frame start
Count	Number of words in the frame
MOSI values	Value of the MOSI data words. The data format is selected in the "Display" tab.

Column	Description
MISO values	Value of the MISO data words. The data format is selected in the "Display" tab.
Bit rate	Value of the bit rate

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<m>:FORMat` on page 529

Export of decode results

1. In the protocol "Shortcuts" tab, press "Export results".

   The "Export results" dialog opens.
   For details, see Chapter 13.1.7, "Export protocol results", on page 254.
2. Select the details that you want to export and the file format.
3. Tap "Save as".
4. Key in a name and select the file format.

Remote commands

Remote commands to retrieve decode results are described in Chapter 17.16.2.4, "Decode results", on page 542.

13.3 I²C (option R&S MXO4-K510)

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

13.3.1 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 webpage 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 reads (=1) or writes (=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 MXO 4 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 is written to or read from
- R/W bit: specifies if the data is 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: several data bytes with an ACK bit after every byte
- Stop condition: a rising slope on SDA while SCL is high

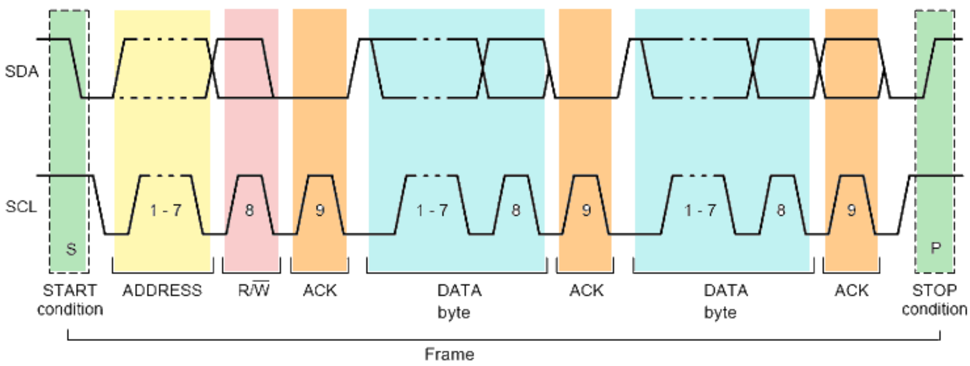


Figure 13-3: I2C writes access with 7-bit address

Address types: 7-bit and 10-bit

Slave addresses can be 7 bits or 10 bits long. A 7-bit address requires 1 byte, 7 bits for the address followed by the R/W bit.

A 10-bit address for write access requires 2 bytes: the first byte starts with the reserved sequence 11110, followed by the two MSB of the address and the write bit. The second byte contains the remaining 8 LSB of the address. The slave acknowledges each address byte.

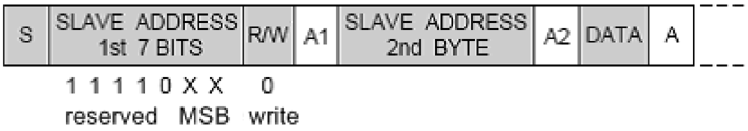


Figure 13-4: 10-bit address, write access

A 10-bit address for read access requires 3 bytes. The first 2 bytes are identical to the write access address. The third byte repeats the address bits of the first byte and sets the read bit.

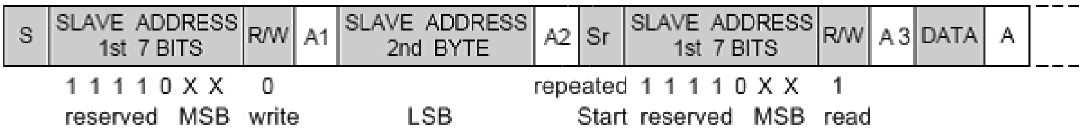


Figure 13-5: 10-bit address, read access

Trigger

The R&S MXO 4 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.

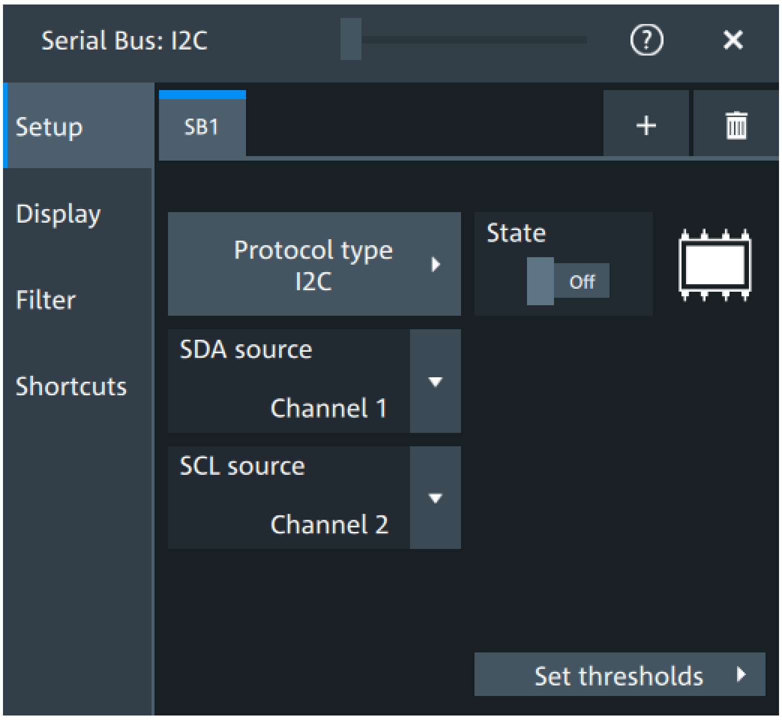
You can trigger on:

- Start or stop condition
- Repeated start condition
- Transfer direction (read or write)
- Bytes with missing acknowledge bit
- Specific data pattern in the message

13.3.2 I²C configuration

13.3.2.1 I²C configuration settings

Access: [Apps] key > "Protocol" tab > "I2C" > "Setup".



Make sure that the tab of the correct serial bus is selected.

Protocol type
Displays the protocol type to be decoded.

Remote command:
`SBUS<m>:TYPE` on page 528

State
Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

SDA source
Sets the source channel to which the data line is connected.

Remote command:
`SBUS<m>:I2C:SDA:SOURce` on page 548

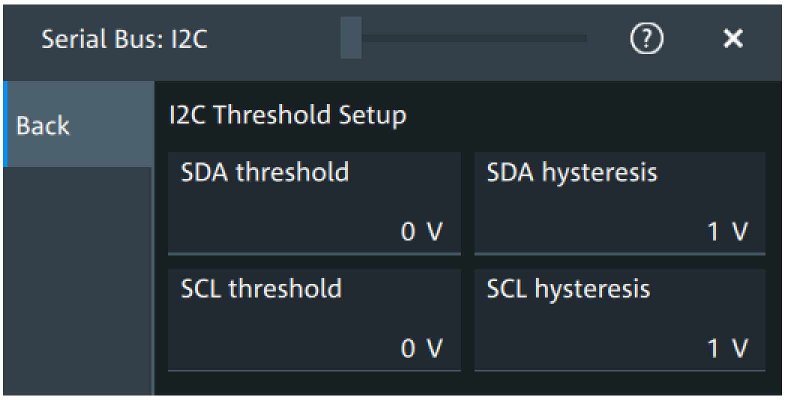
SCL source
Selects the source channel to which the clock line is connected.

Remote command:
`SBUS<m>:I2C:SCL:SOURce` on page 547

Threshold
Press "Set thresholds", to open the In the "Threshold setup" dialog.

Enter the value directly in the field of the threshold setup dialog.

Additional to the threshold, you can also set a hysteresis.



Remote command:
`SBUS<m>:I2C:SCL:THReshold` on page 547
`SBUS<m>:I2C:SDA:THReshold` on page 548
`SBUS<m>:I2C:SCL:HYSTeresis` on page 547
`SBUS<m>:I2C:SDA:HYSTeresis` on page 548

Show threshold lines ← Threshold
If enabled, the threshold lines are displayed in the diagram.

Remote command:
`SBUS<m>:THReshold` on page 529

13.3.2.2 Display settings

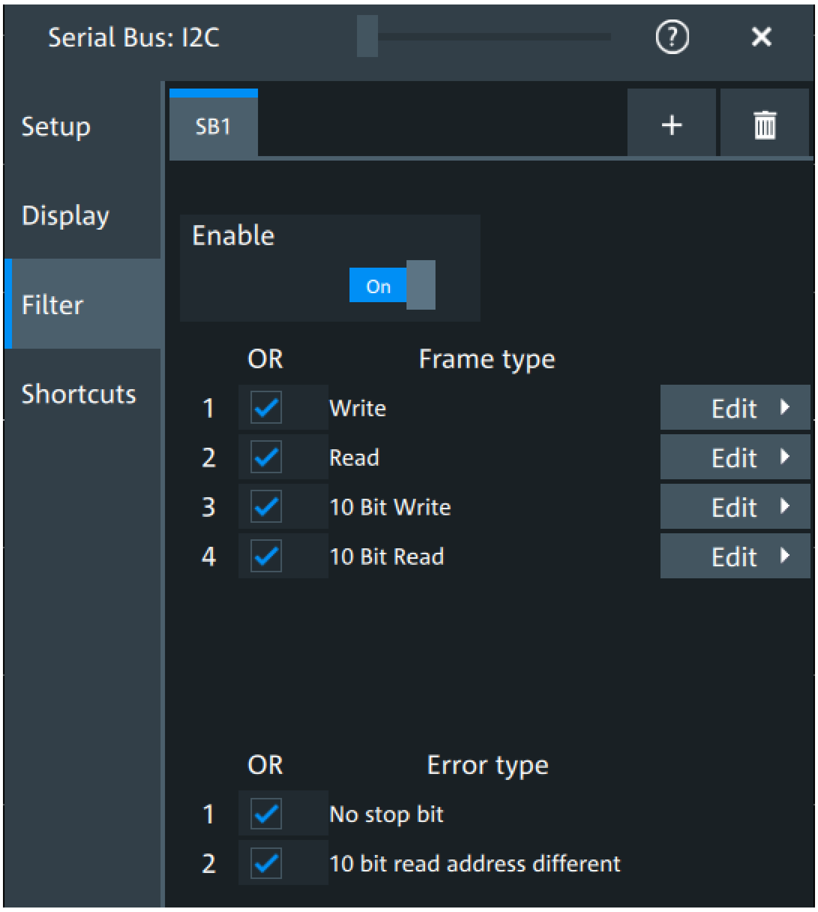
For details about the display settings, see Chapter 13.1.3, "Display", on page 252.

13.3.2.3 Shortcuts

For details about the available shortcuts, see Chapter 13.1.6, "Shortcuts", on page 254.

13.3.3 I2C filter

Access: [Apps] key > "Protocol" tab > "I2C" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Enable

Enables the filtering on I2C frames. Only the frames that match the selected filter conditions are displayed.

Enables the filtering on I2C frames. Only the frames that match the selected filter conditions are displayed.

Remote command:
`SBUS<m>:I2C:FILTer:ENABle` on page 553

Frame type

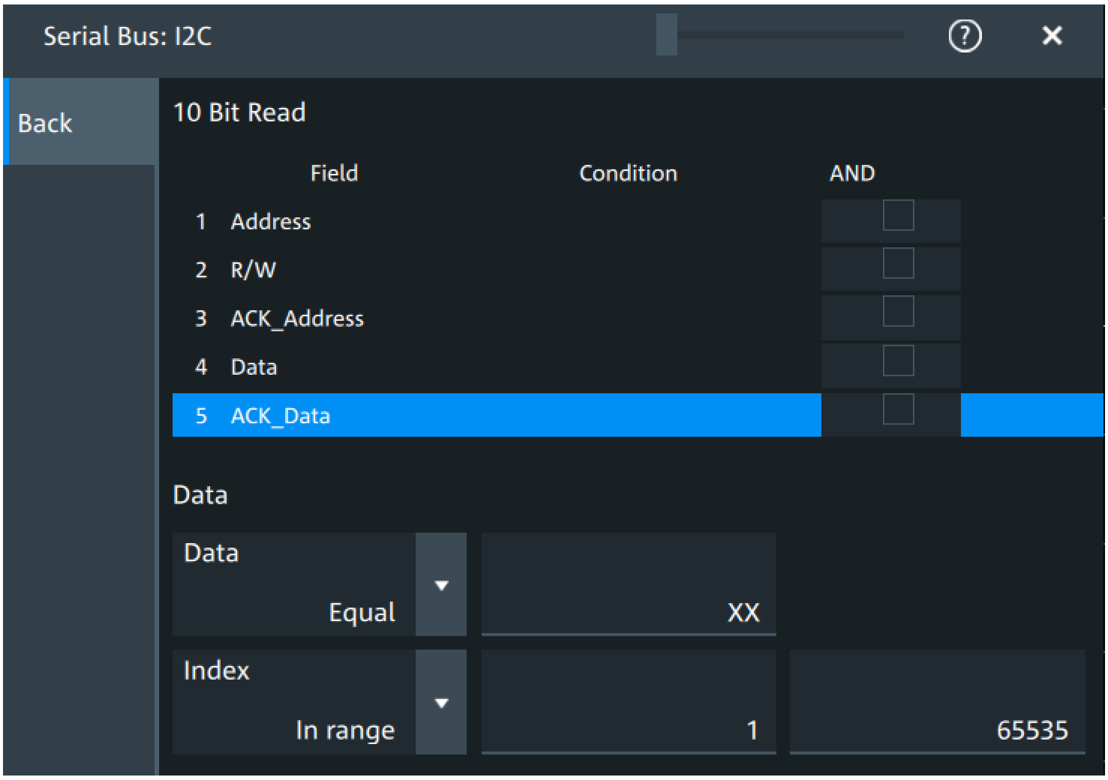
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

Remote command:
`SBUS<m>:I2C:FILTer:FRENable` on page 553
`SBUS<m>:I2C:FILTer:FRAMe<fr>:ENABle` on page 553

Edit

Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields are "Address", "R/W", "ACK_Address", "Data", and "ACK_Data".

Remote command:
`SBUS<m>:I2C:FILTer:FIENable` on page 556
`SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:ENABle` on page 556

"Condition" Displays the value condition for the selected field.

Remote command:
`SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:BIT` on page 555

"Data" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
`SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DMAX` on page 553
`SBUS<m>:I2C:FILTer:DMAX` on page 553
`SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DMIN` on page 554
`SBUS<m>:I2C:FILTer:DMIN` on page 554
`SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DOPerator` on page 554
`SBUS<m>:I2C:FILTer:DOPerator` on page 554

"Index" The index setup consists of a comparison condition and one or two index values.

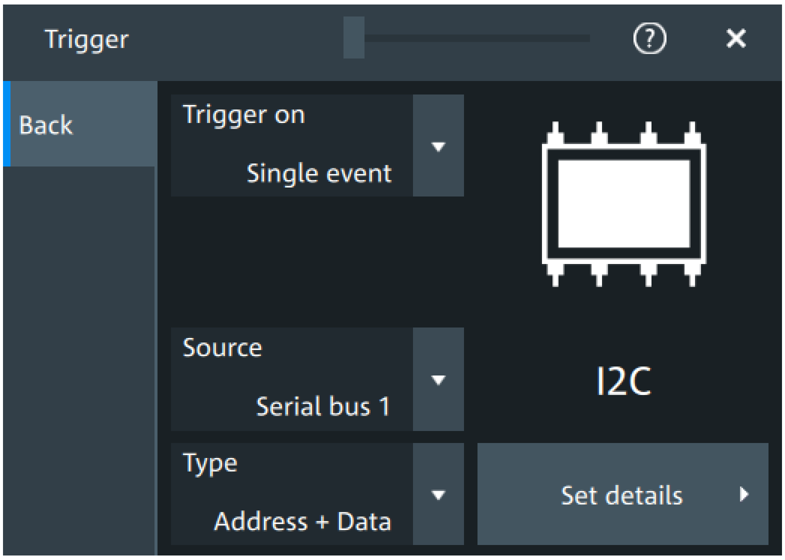
Remote command:
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 554
SBUS<m>:I2C:FILTer:IMAX on page 554
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 555
SBUS<m>:I2C:FILTer:IMIN on page 555
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 555
SBUS<m>:I2C:FILTer:IOPerator on page 555

Error type
Enables filtering on the selected error type.

Remote command:
SBUS<m>:SPI:FILTer:ERENable on page 538
SBUS<m>:SPI:FILTer:ERRor<n>:ENABle on page 538

13.3.4 I²C trigger settings

Access: [Apps] > "Protocol" > "I²C" > "Shortcuts" > "Setup trigger"



Type
Selects the trigger type for I²C analysis.

Some trigger types have additional settings that can be defined. In this case, the "Edit" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.

Remote command:
TRIGger:I2C:TYPE on page 549

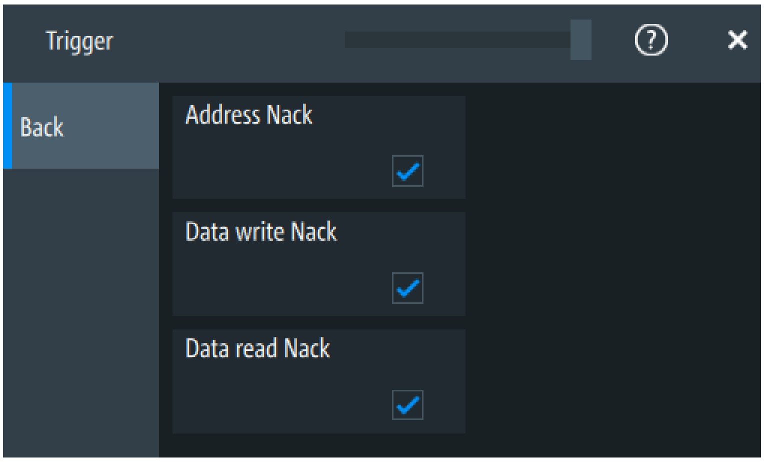
Start ← Type
Sets the trigger to the start of the message. The start condition is a falling edge on SDA while SCL is high. The trigger instant is the falling edge of the SDA line.

You can change the SDA and SCL lines here if necessary.

Repeated start ← Type
Sets the trigger to a repeated start - when the start condition occurs without previous stop condition. Repeated start conditions occur when a master exchanges multiple messages with a slave device without releasing the bus.

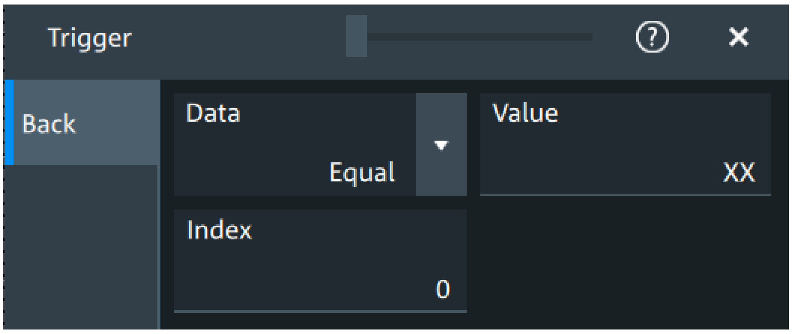
Stop ← Type
Sets the trigger to the end of the message. The stop condition is a rising slope on SDA while SCL is high.

No Ack ← Type
Missing acknowledge bit: the instrument triggers if the data line remains HIGH during the clock pulse following a transmitted byte.



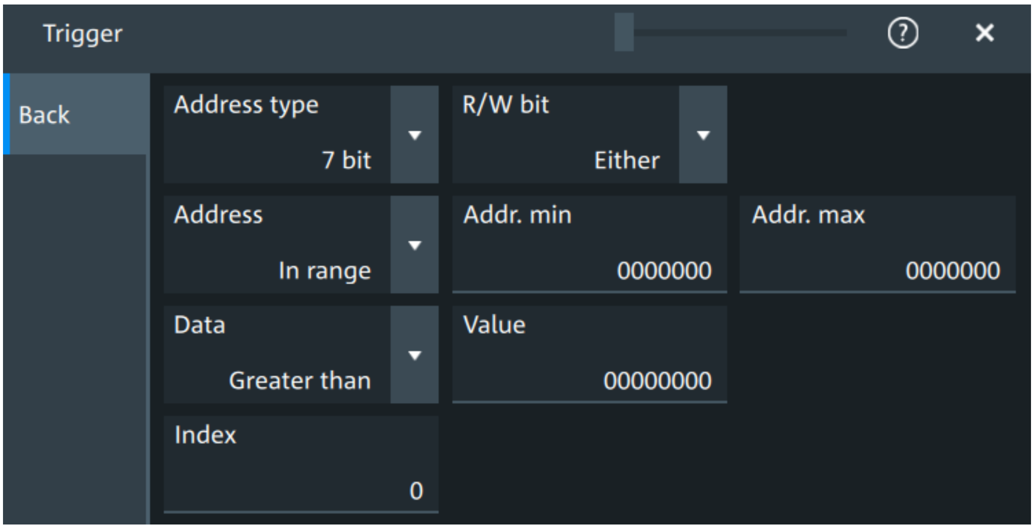
Address ← Type
Sets the trigger to one specific address condition or a combination of address conditions. The trigger time is the falling clock edge of the acknowledge bit after the address.

Data ← Type
Sets the trigger to one specific data condition or a combination of address conditions.



Address and data ← Type

Sets the trigger to a combination of address and data condition.



No Ack conditions

Selects which missing acknowledge bits is detected if the trigger type is set to "No Ack".

"Address Nack"
: No secondary recognizes the address.

"Data write Nack"
: The addressed secondary does not accept the data.

"Data read Nack"
: Marks the end of the read process when the primary reads data from the secondary. This Nack is sent according to the protocol definition, it is not an error.

Remote command:
`TRIGger:I2C:ADNack` on page 550
`TRIGger:I2C:DWNack` on page 552
`TRIGger:I2C:DRNack` on page 551

Address type

Sets the address length to be triggered on: 7 bit or 10 bit.

Remote command:
`TRIGger:I2C:AMODe` on page 551

R/W bit
Toggles the trigger condition between read and write access of the primary. Select "Either" if the transfer direction is not relevant for the trigger condition.

Remote command:
`TRIGger:I2C:ACCess` on page 549

Address
The trigger address setup consists of a comparison condition and one or two address patterns.

Defines the bit pattern of the secondary device address. The length of the entry is adjusted to the selected address type.

"Condition"	Sets the comparison condition to a specific value or a range.
"Min"	Specifies the value or sets the start value of a range.
"Max"	Sets the maximum value of a range for "Condition" = "In range"/"Out of range".

Remote command:
`TRIGger:I2C:ADDRess` on page 550
`TRIGger:I2C:ADDTo` on page 550

Data
Specifies the trigger conditions for the data bit pattern.

"Condition"	Sets the comparison condition to a specific value or a range.
"Value"	Specifies the value or sets the start value of a range. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Remote command:
`TRIGger:I2C:DCONdition` on page 551
`TRIGger:I2C:DMIN` on page 551

Index
Sets the number of data bytes to be skipped after the address.

Remote command:
`TRIGger:I2C:DPOSition` on page 551

13.3.5 I²C decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Chapter 13.1.3, "Display", on page 252.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

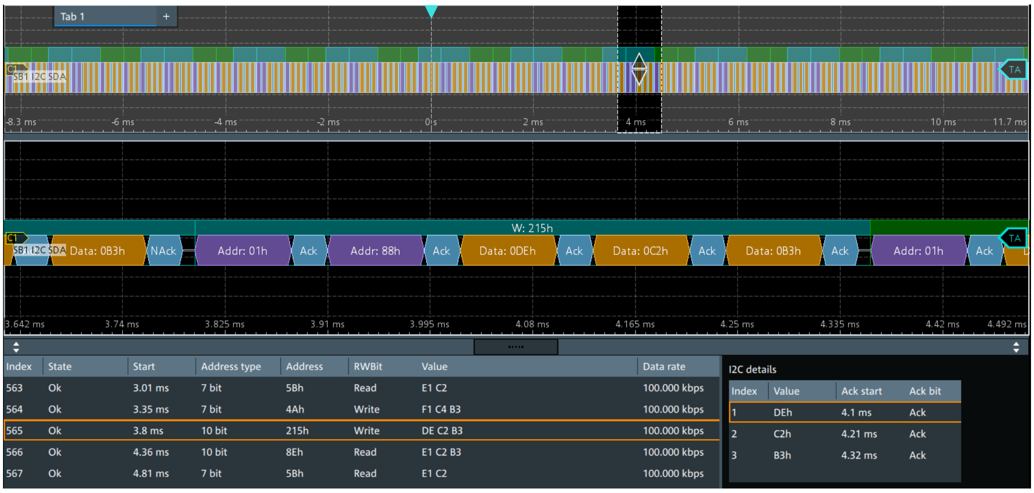


Figure 13-6: Decoded I2C signal, and decode results

Purple = Address byte
Blue = R/W bit
Cyan = ACK bit
Red = NACK bit
Gold = Data byte
Turquoise = Write frame
Green = Read frame
Crimson red = Incomplete frame

The results are shown in two tables:

- "Decode results": contains information about all decoded frames
- "Details frame": contains more detailed information about the selected frame in the "Decode results" table.

Decode results table

The "Decode results" table contains information about all decoded frames.

Table 13-2: Content of the Decode results table

Column	Description
Index	Index of the decoded frame
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.

Column	Description
Start	Time of frame start
Address type	Address length, 7 bit or 10 bit
Address value (hex)	Hexadecimal value of the address
R/W bit	Value of the R/W bit
Data rate	Value of the data rate

Table 13-3: Content of the Details results table

Column	Description
Index	Index of the decoded field
Value	Value of all data bytes of the frame
Ack bit start	Start time of the acknowledge bit
Ack bit	Value of the address acknowledge bit

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<m>:FORMat` on page 529

Export of decode results

1. In the protocol "Shortcuts" tab, press "Export results".

   The "Export results" dialog opens.
   For details, see Chapter 13.1.7, "Export protocol results", on page 254.
2. Select the details that you want to export and the file format.
3. Tap "Save as".
4. Key in a name and select the file format.

Remote commands

Remote commands to retrieve decode results are described in Chapter 17.16.3.4, "Decode results", on page 556.

13.4 UART (option R&S MXO4-K510)

13.4.1 The UART / RS232 interface

The Universal Asynchronous Receiver/Transmitter UART converts a word of data into serial data, and vice versa. It is the base of many serial protocols such as RS-232. The UART uses only one line, or two lines for transmitter and receiver.

Data transfer

The data is transmitted in words, also referred to as symbols or characters. Each word consists of a start bit, several data bits, an optional parity bit, and one or more stop bits. Several words can form a package, or frame. The end of a package is marked with a reserved word or by a pause between two words.

Start	Data0	Data1	Data2	Data3	Data4	[Data5]	[Data6]	[Data7]	[Data8]	[Parity]	Stop

Figure 13-7: Bit order in a UART word (symbol)

- The start bit is a logic 0.
- The stop bits and the idle state are always logic 1.

The UART protocol has no clock for synchronization. The receiver synchronizes by means of the start and stop bits, and the bit rate that must be known to the receiver.

Trigger

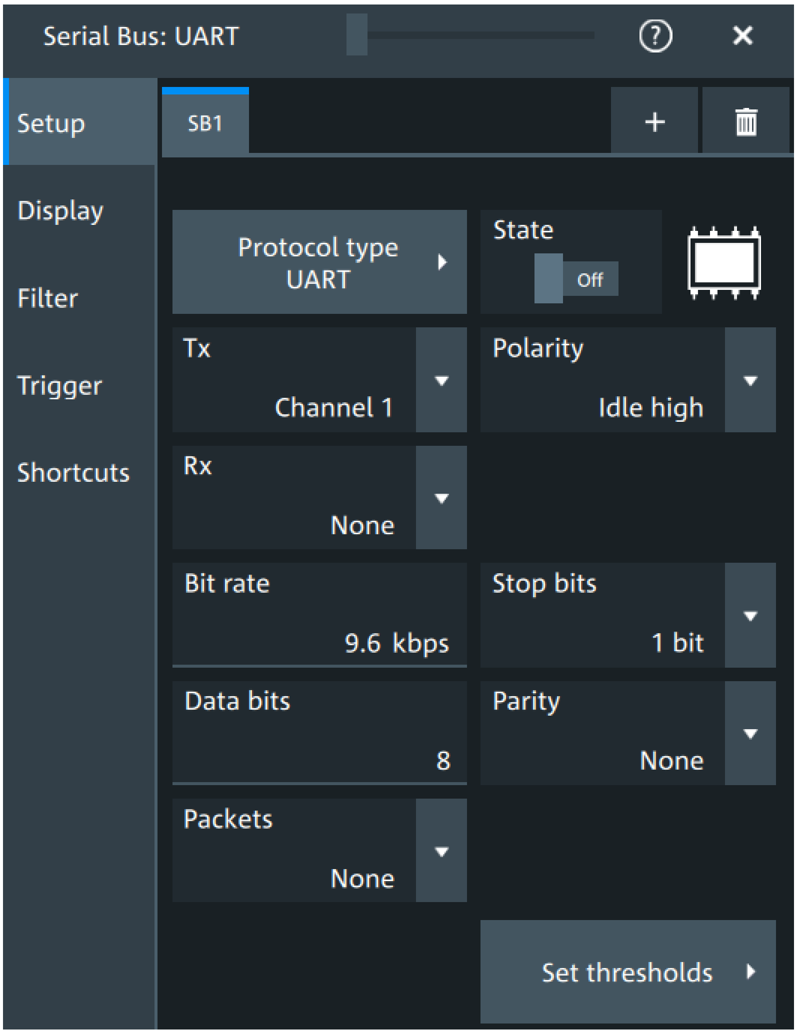
The R&S MXO 4 can trigger on specified parts of UART serial signals:

- Start bit
- Packet start
- Parity errors, and breaks
- Stop errors
- A serial pattern at any or a specified position

13.4.2 UART configuration

13.4.2.1 UART configuration settings

Access: [Apps] key > "Protocol" tab > "UART / RS232" > "Setup".



Protocol type
Displays the protocol type to be decoded.

Remote command:
`SBUS<m>:TYPE` on page 528

State
Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Source: Tx, Rx
Select the input channels for the transmitter and receiver signals.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Remote command:
`SBUS<m>:UART:TX:SOURce` on page 568
`SBUS<m>:UART:RX:SOURce` on page 566

Polarity
Defines the logic levels of the bus. The idle state corresponds to a logic 1. The start bit corresponds to a logic 0. "Idle high" (high=1) is used, for example, for control signals, while "Idle low" (low=1) is defined for data lines (RS-232).

Remote command:
`SBUS<m>:UART:POLarity` on page 565

Bit rate
Sets the number of transmitted bits per second.

Remote command:
`SBUS<m>:UART:BITRate` on page 564

Stop bits
Sets the number of stop bits: 1 or 1.5 or 2 stop bits are possible.

Remote command:
`SBUS<m>:UART:SBIT` on page 566

Data bits
Sets the number of data bits of a word in a range from 5 bits to 8 bits. If no parity bit is used, then 9 data bits are possible.

Remote command:
`SBUS<m>:UART:SSIZe` on page 567

Parity
Defines the optional parity bit that is used for error detection.

"None"	No parity bit is used.
"Odd"	The parity bit is set to "1" if the number of data bits set to "1" is even.
"Even"	The parity bit is set to "1" if the number of data bits set to "1" is odd.
"Mark"	The parity bit is always a logic 1.
"Space"	The parity bit is always a logic 0.
"Don't care"	The parity is ignored.

Remote command:
`SBUS<m>:UART:PARity` on page 565

Packets
Allows you to define packets of several words in the data stream.

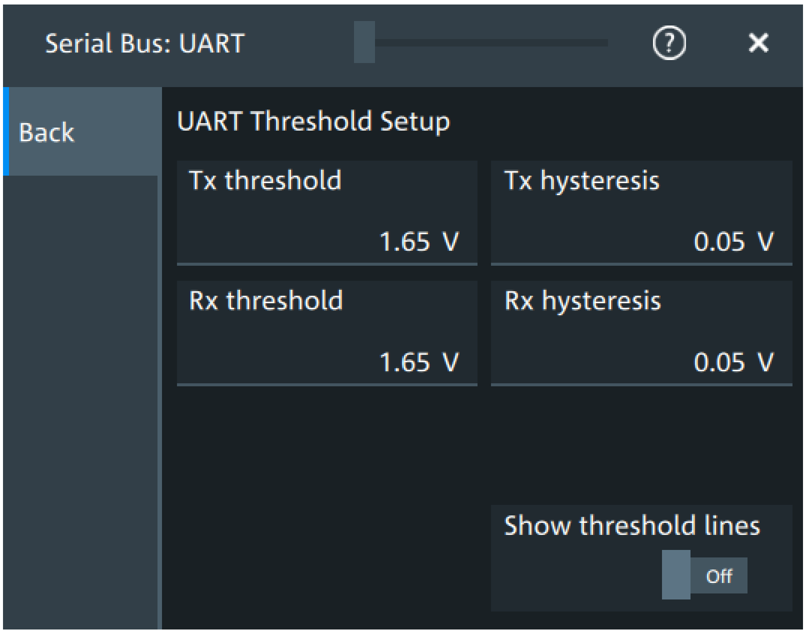
"None"	Packets are not considered.
"End word"	Defines a pattern as end condition of a packet, for example, a reserved word like CR or LF. The bit pattern editor provides frequently used values in the "Predefined values" list below the pattern table. A new packet starts with the first start bit after the defined end pattern.
"Timeout"	Defines a timeout between a stop bit and the next start bit. Enter the minimum time that marks the end of a packet. A new packet starts with the first start bit after the timeout.

Remote command:
SBUS<m>:UART:PACKets on page 565
SBUS<m>:UART:TOUT on page 567
SBUS<m>:UART:EWORd on page 564

Threshold
Press "Set thresholds", to open the In the "Threshold setup" dialog.

Enter the value directly in the field of the threshold setup dialog.

Additional to the threshold, you can also set a hysteresis.



Remote command:
SBUS<m>:UART:RX:HYSTeresis on page 566
SBUS<m>:UART:RX:THReshold on page 566
SBUS<m>:UART:TX:HYSTeresis on page 567
SBUS<m>:UART:TX:THReshold on page 568

Show threshold lines ← Threshold
If enabled, the threshold lines are displayed in the diagram.

Remote command:
SBUS<m>:THReshold on page 529

13.4.2.2 Display settings

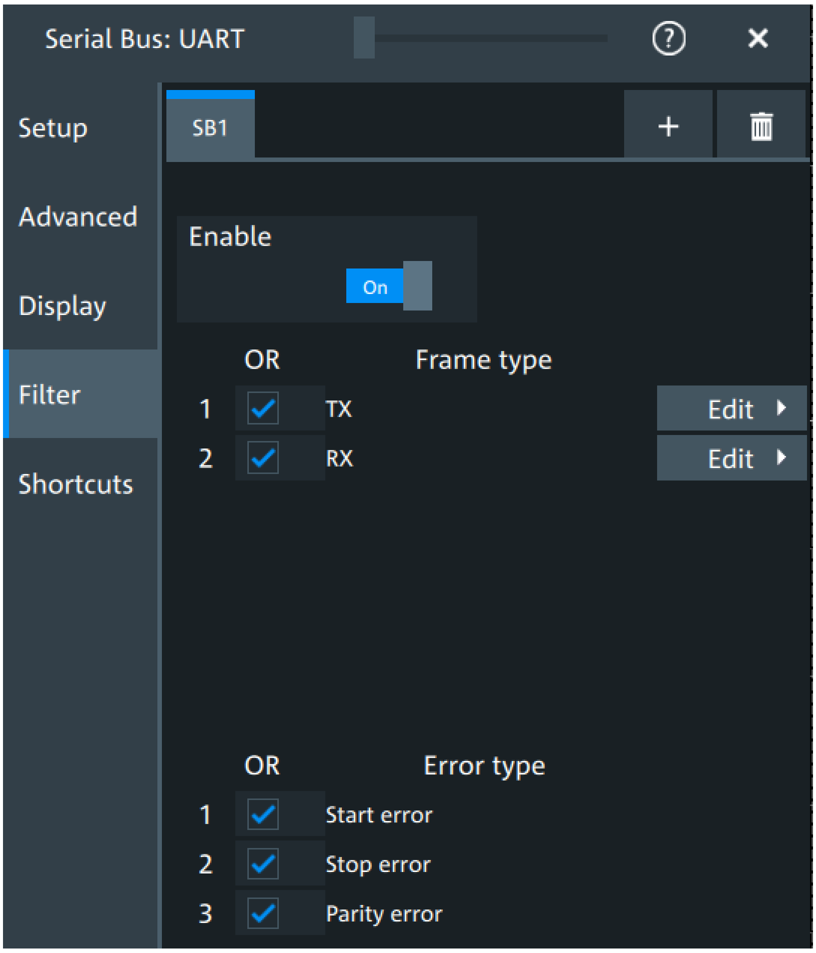
For details about the display settings, see Chapter 13.1.3, "Display", on page 252.

13.4.2.3 Shortcuts

For details about the available shortcuts, see Chapter 13.1.6, "Shortcuts", on page 254.

13.4.3 UART filter

Access:[Apps] key > "Protocol" tab >"UART / RS232" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Enable
Enables the filtering on UART frames. Only the frames that match the selected filter conditions are displayed.

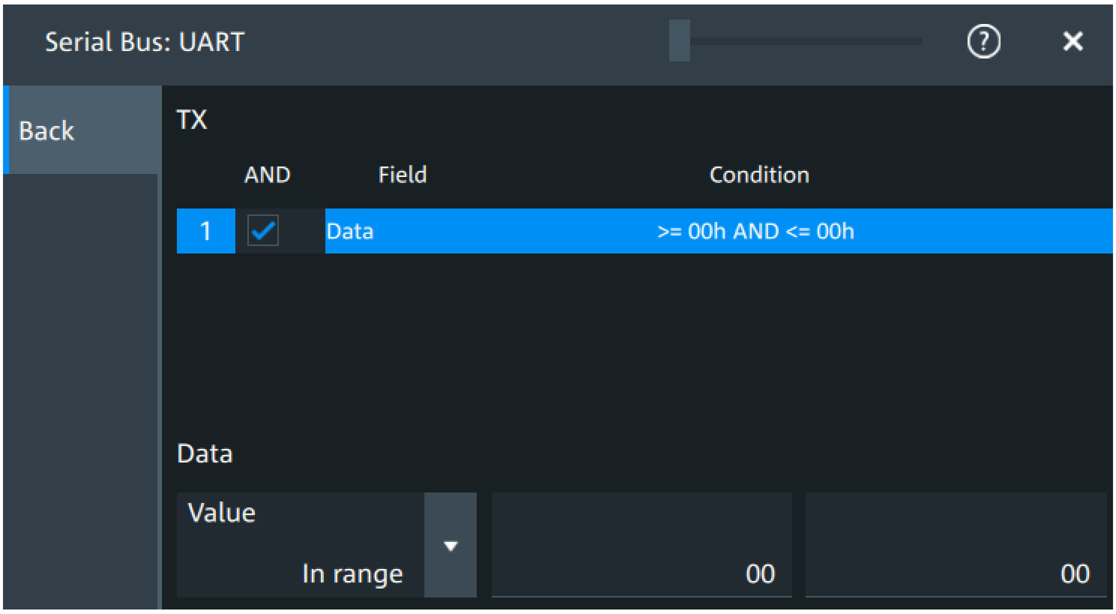
Remote command:
`SBUS<m>:UART:FILTer:ENABle` on page 570

Frame Ttype
Selects the frame type that you want to display. You can filter all enabled frame types simultaneously.

For each frame type, you can also specify conditions for the value of the fields in the "Edit" dialog.

Remote command:
SBUS<m>:UART:FILTer:FRAMe<fr>:ENABle on page 573
SBUS<m>:UART:FILTer:FRENable on page 573

Edit
Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields are "Data" and "Parity".

Remote command:
SBUS<m>:UART:FILTer:FIENable on page 573
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:ENABle on page 573

"Condition" Displays the value condition for the selected field.

Remote command:
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 573

"Data" The data setup consists of a comparison condition and one or two data patterns.

Remote command:
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:DMAX on page 572
SBUS<m>:UART:FILTer:DMAX on page 572
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:DMIN on page 572
SBUS<m>:UART:FILTer:DMIN on page 572
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:DOPerator on page 572
SBUS<m>:UART:FILTer:DOPerator on page 572

"Index" The index setup consists of a comparison condition and one or two index values.

Remote command:
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:IMAX on page 571
SBUS<m>:UART:FILTer:IMAX on page 571
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:IMIN on page 570
SBUS<m>:UART:FILTer:IMIN on page 570
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:IOPerator on page 571
SBUS<m>:UART:FILTer:IOPerator on page 571

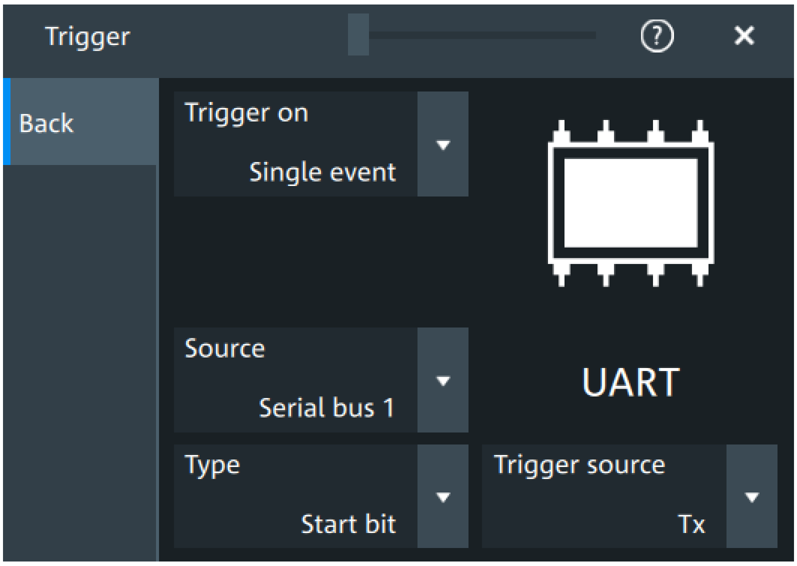
Error type
Enables filtering on the selected error type.

Remote command:
SBUS<m>:UART:FILTer:ERRor<n>:ENABle on page 571

13.4.4 UART trigger

13.4.4.1 UART trigger settings

Access: [Apps] > "Protocol" > "UART" > "Shortcuts" > "Setup trigger"



Type
Selects the trigger condition.

Some trigger types have additional settings that can be defined. In this case, the "Edit" button appears next to "Type" the function. Open it for a detailed definition of the trigger conditions.

"Start bit" Triggers on a start bit. The start bit is the first low bit after a stop bit.

"Packet start" Triggers on the begin of a data packet.

"Data"	Trigger on a serial pattern at a defined position in the data packet. The pattern can include several subsequent symbols (data frames).
"Parity error"	Triggers on a parity error indicating a transmission error. This trigger type is only available if a parity is configured for the UART bus.
"Break condition"	Triggers if a start bit is not followed by a stop bit, the data line remains at logic 0 for longer than a UART word.
"Stop error"	Triggers if the stop bit is a logic 0.

Remote command:
`TRIGger:UART:TYPE` on page 569

Trigger source
Selects the transmitter or receiver line as trigger source.

Remote command:
`TRIGger:UART:SOURce` on page 569

Data conditions
Specify the data conditions if the trigger type is set to "Data".

Data ← Data conditions
Selects the operator for the "Data" pattern.

Remote command:
`TRIGger:UART:FCONdition` on page 569

Pattern ← Data conditions
Specifies the data pattern to be found on the specified trigger source. Enter the words in msb first bit order.

Remote command:
`TRIGger:UART:DATA` on page 568

Index min ← Data conditions
Sets the number of words before the first word of interest. These offset words are ignored.

The setting is available if packet detection is enabled in the protocol configuration.

Remote command:
`TRIGger:UART:DPOSition` on page 569

13.4.5 UART decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Chapter 13.1.3, "Display", on page 252.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

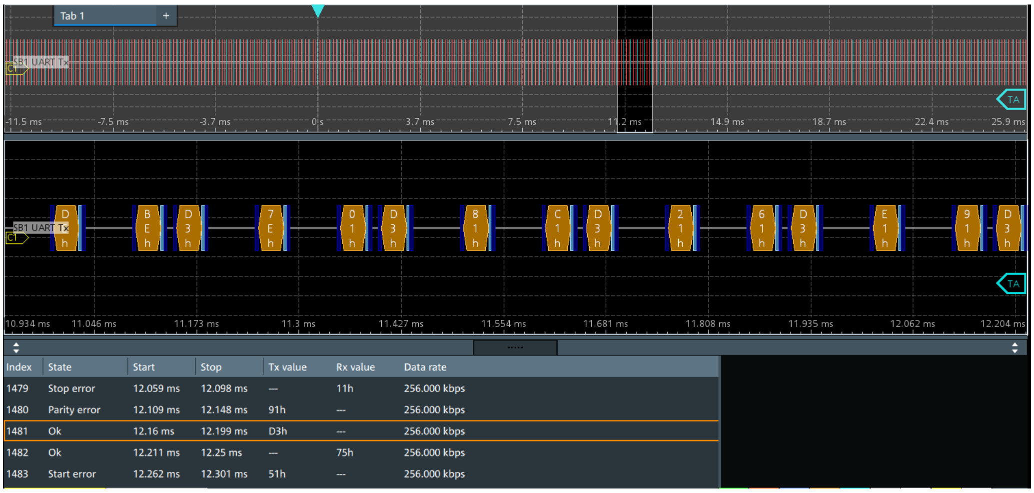


Figure 13-8: Decoded and binary UART signal

Blue = Start and stop bits if ok
Red = Start error, stop error, parity error
Cyan = Parity bit if ok
Gold = Word ok
Magenta = Word contains error

The "Decode results" table shows the detailed decoded data for each word.

Table 13-4: Content of the Decode results table

Column	Description
Index	Number of the decoded frames
State	Decoding state of the word. "Insuffcient waveform length" indicates that the word is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of the word start (start bit)
Stop	Time of the word stop (stop bit)
Tx value	Value of the Tx word. The data format is selected below the table.
Rx value	Value of the Rx word. The data format is selected below the table.
Data rate	Value of the data rate

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<m>:FORMat` on page 529

Export of decode results

1. In the protocol "Shortcuts" tab, press "Export results".

   The "Export results" dialog opens.
   For details, see Chapter 13.1.7, "Export protocol results", on page 254.
2. Select the details that you want to export and the file format.
3. Tap "Save as".
4. Key in a name and select the file format.

Remote commands

Remote commands to retrieve decode results are described in Chapter 17.16.4.4, "Decode results", on page 574.

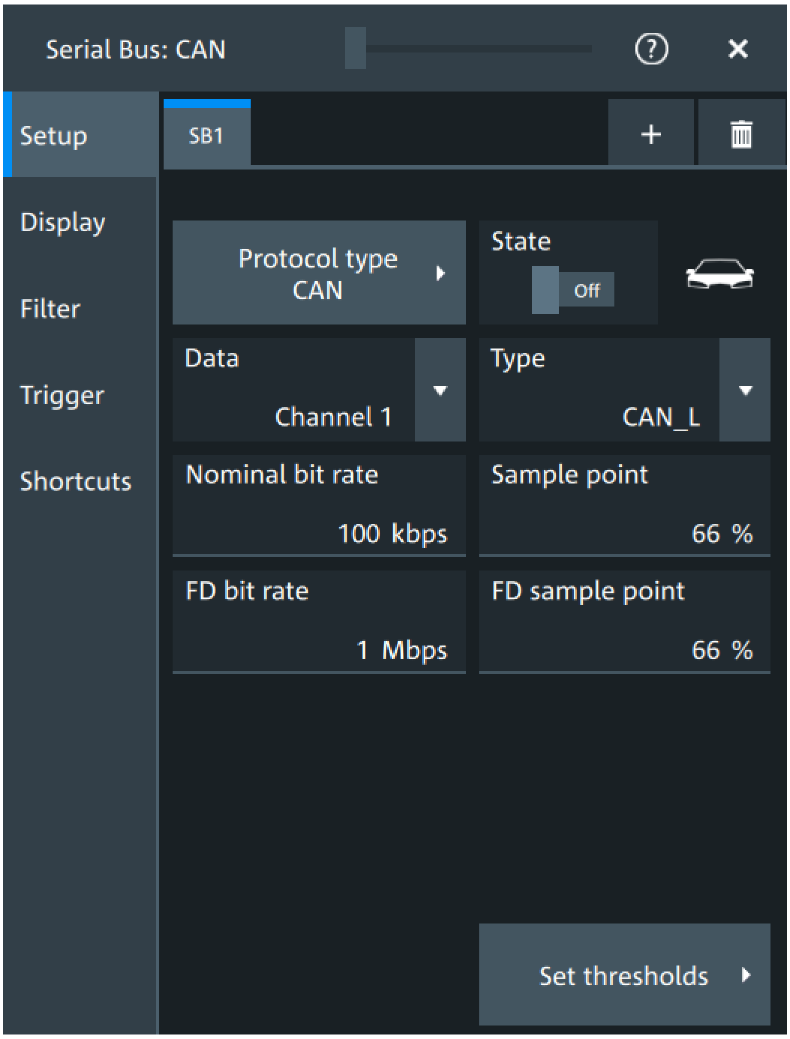
13.5 CAN (option R&S MXO4-K520)

CAN frame format and in CAN FD frame format can coexist within the same network. CAN FD shares the physical layer, with the CAN protocol as defined in the BOSCH CAN Specification 2.0. The frame format is different. There are two new control bits in the CAN FD frame, the first enabling the new frame format with different data length coding and the second optionally switching to a faster bit rate after the arbitration is decided. New CRC polynomials are introduced to secure the longer CAN FD frames.

13.5.1 CAN configuration

13.5.1.1 CAN configuration settings

Access: [Apps] key > "Protocol" tab > "CAN" > "Setup".



Make sure that the tab of the correct serial bus is selected.

Protocol type
Displays the protocol type to be decoded.

Remote command:
SBUS<m>:TYPE on page 528

State
Enables the decoding of the selected bus. The signal icon of the bus appears on the signal bar.

Data
Sets the source of the selected data line.

Remote command:
SBUS<m>:CAN:DATA:SOURce on page 577

Type
Selects the CAN-High or CAN-Low line. CAN uses both lines for differential signal transmission.

If you measure with a differential probe, connect the probe to both CAN-H and CAN-L lines, and select the data "Type" = *CAN-H*.

If you use a single-ended probe, connect the probe to either CAN_L or CAN_H, and select the data type accordingly.

Remote command:
`SBUS<m>:CAN:TYPE` on page 578

Bit rate
Sets the number of transmitted bits per second.

Remote command:
`SBUS<m>:CAN:BITRate` on page 576

Sample point
Sets the position of the sample point within the bit in percent of the nominal bit time.

Remote command:
`SBUS<m>:CAN:FDATa:SAMPlepoint` on page 578

Threshold
Press "Set thresholds", to open the In the "Threshold setup" dialog.

Enter the value directly in the field of the threshold setup dialog.

Additional to the threshold, you can also set a hysteresis.

Remote command:
`SBUS<m>:CAN:DATA:THReshold` on page 577

Show threshold lines
If enabled, the threshold lines are displayed in the diagram.

Remote command:
`SBUS<m>:THReshold` on page 529

13.5.1.2 Display settings

For details about the display settings, see Chapter 13.1.3, "Display", on page 252.

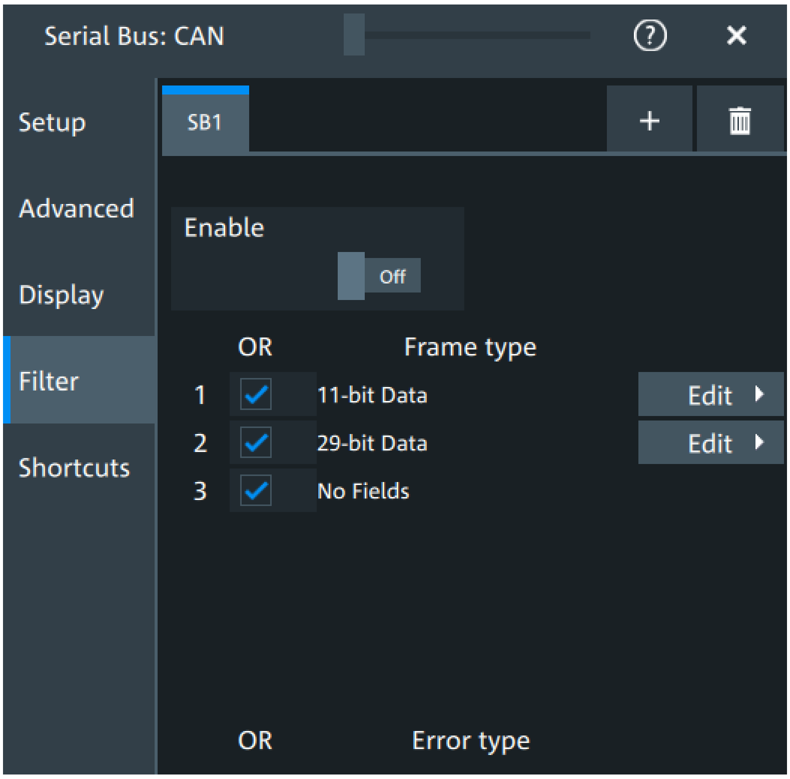
Show symbols
Symbol lists are protocol-specific. Label lists for CAN are available in CSV and PTT format.

13.5.1.3 Shortcuts

For details about the available shortcuts, see Chapter 13.1.6, "Shortcuts", on page 254.

13.5.2 CAN filter

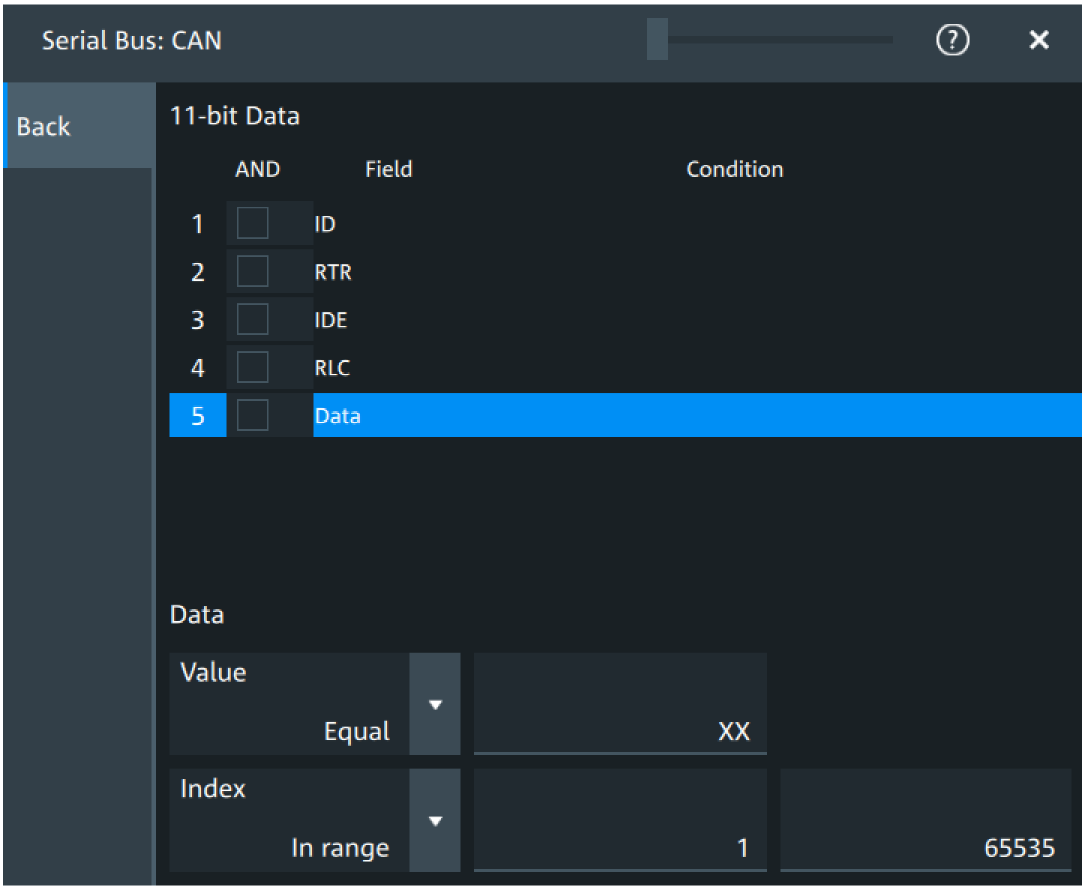
Access: [Apps] key > "Protocol" tab > "CAN" > "Filter" tab



In the "Filter" tab, you can define the settings to display only the frames that match the selected filter conditions.

Enable
Enables the filtering on CAN frames. Only the frames that match the selected filter conditions are displayed.

Edit
Opens a dialog to define the details of the selected frame.



"Field" Enables the field type that you want to filter on for the selected frame. The available fields are "ID", "RTR", "ITE", "RLC" and "Data".

"Condition" Displays the value condition for the selected field.

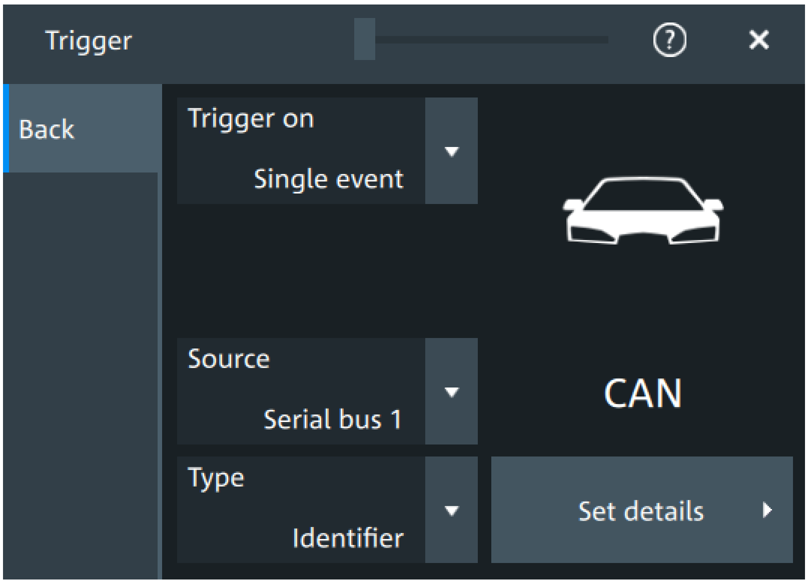
Remote command:
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:BIT on page 555

"Data" The data setup consists of a comparison condition and one or two data patterns.

"Index" The index setup consists of a comparison condition and one or two index values.

13.5.3 CAN trigger settings

Access: [Apps] > "Protocol" > "CAN" > "Shortcuts" > "Setup trigger"



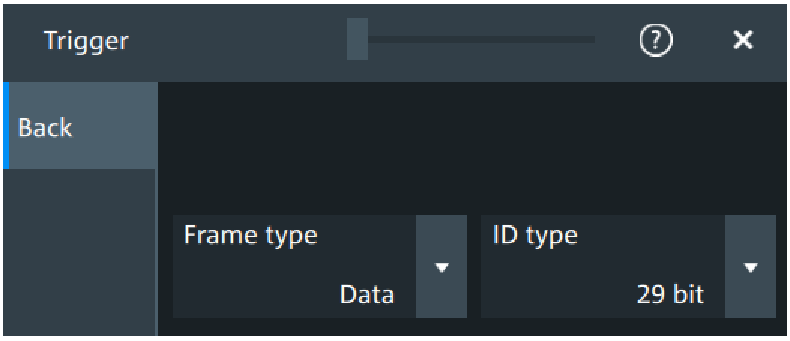
Type

Selects the trigger type for CAN analysis.

"Start of frame" Triggers on the first edge of the dominant SOF bit (synchronization bit).

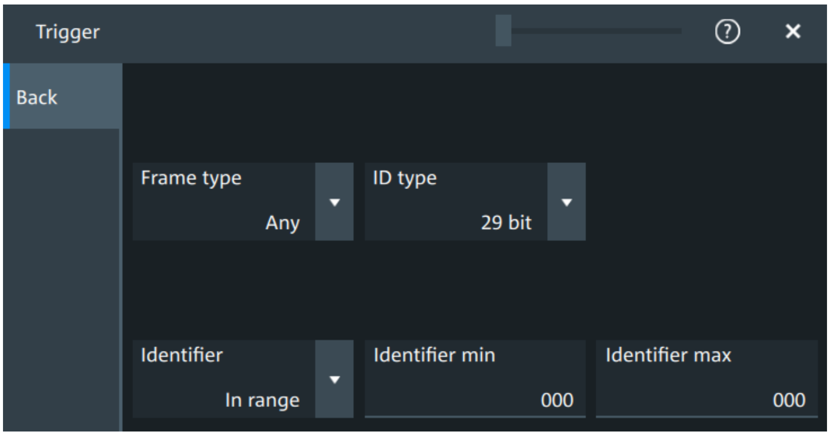
"End of frame" Triggers on the end of frame.

"Frame type" Triggers on a specified frame type (data, remote, error, or overload). For data and remote frames, also the identifier format is considered.



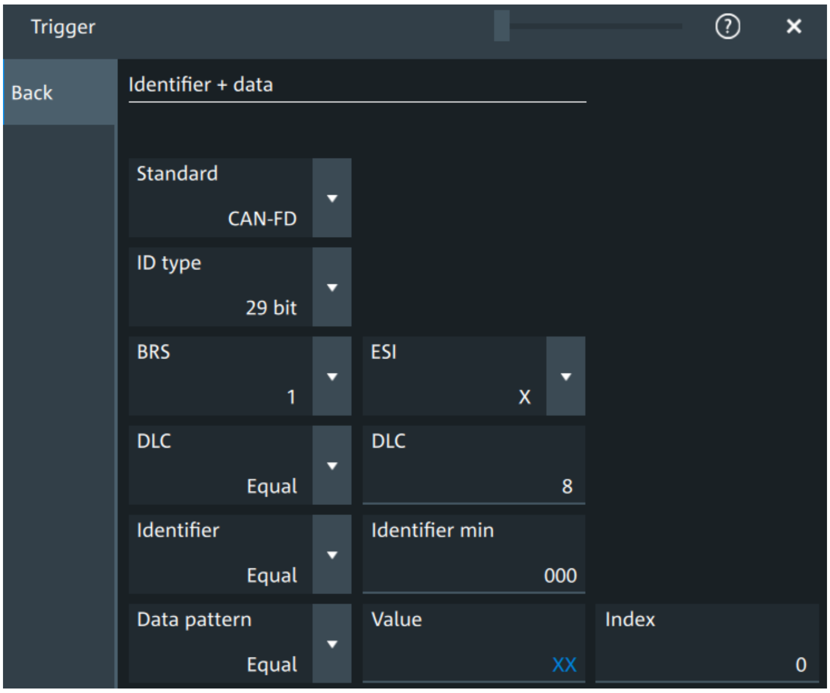
"Identifier"

Sets the trigger to a specific message identifier or an identifier range.

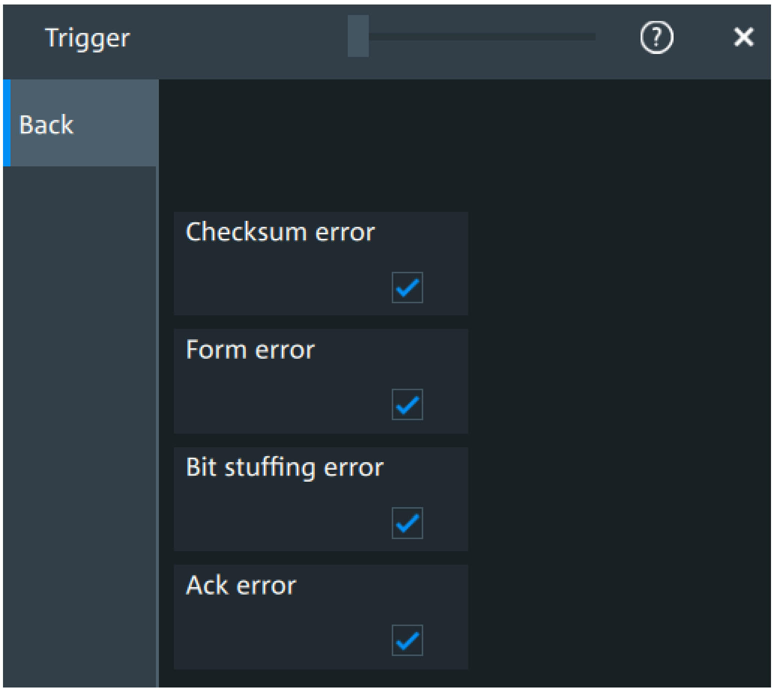


"Identifier + Data"

Sets the trigger to a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern.



"Error condition" Identifies various errors in the frame.



Remote command:
TRIGger:CAN:TYPE on page 579

Frame type
CAN has four frame types which can be used as trigger condition.

"Data" The data frame is the only frame for actual data transmission.

"Remote" The remote frame initiates the transmission of data by another node. The frame format is the same as of data frames but without the data field.

"Error" When a node recognizes an error, it cancels transmission by sending an error frame.
The instrument triggers seven-bit periods after the end of the error flag that is marked by a dominant-recessive edge.
The ID type is irrelevant for error frames.

"Overload" When a node needs a delay between data and/or remote frames, it sends and overload frame.
The instrument triggers seven-bit periods after the end of the overload flag that is marked by a dominant-recessive edge.
The ID type is irrelevant for overload frames.

Remote command:
TRIGger:CAN:FTYPe on page 584

ID type
Selects the length of the identifier:

"11 bit" Identifier length of the CAN base frame format. The instrument triggers on the sample point of the identifier extension flag (IDE) bit.

"29 bit" Identifier length of the CAN extended frame format. The instrument triggers on the sample point of the remote transmission request (RTR) bit.

"Any" The ID type and ID pattern are not relevant for the trigger condition.
If the trigger type is "Identifier", the instrument triggers on any identifier in the specified frame type.
If the trigger type is "Identifier + Data", set the "ID type" to "Any" if you want to trigger only on data.

Remote command:
`TRIGger:CAN:ITYPe` on page 585

Identifier
Specifies the identifier pattern.

"Condition" Sets the comparison condition to a specific value or a range.

"Min" Specifies the value or sets the start value of a range.

"Max" Sets the maximum value of a range for "Condition" = "In range"/"Out of range".

Remote command:
`TRIGger:CAN:ICONdition` on page 584
`TRIGger:CAN:IMAX` on page 584
`TRIGger:CAN:IMIN` on page 585

Data pattern
Specifies the data pattern.

"Condition" Sets the comparison condition to a specific value or a range.

"Min" Specifies the value or sets the start value of a range.

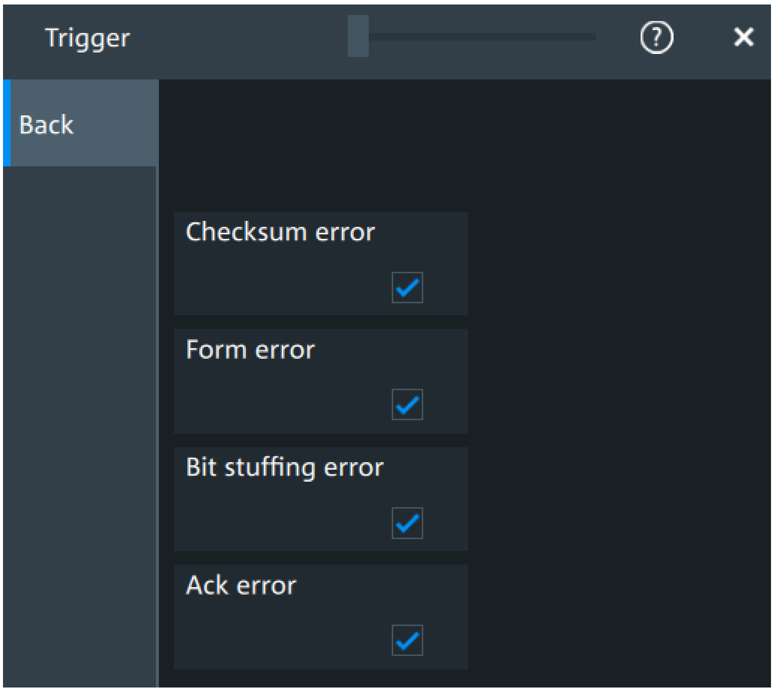
"Max" Sets the maximum value of a range for "Condition" = "In range"/"Out of range".

Remote command:
`TRIGger:CAN:DCONdition` on page 581
`TRIGger:CAN:DMIN` on page 582

DLC
The data length code (DLC) defines the number of data bytes to be found. You can set a fixed value for the DLC or define a minimum value.

Remote command:
`TRIGger:CAN:DLC` on page 581
`TRIGger:CAN:DLCCondition` on page 581

Error conditions
If a CAN detects an error, it transmits an error flag at the next bit. The R&S MXO 4 detects errors in the message and triggers on these errors even if no CAN node sends an error flag.



"Checksum error"	CAN uses the Cyclic Redundancy Check, which is a complex checksum calculation method. The transmitter calculates the CRC and sends the result in the CRC sequence. The receiver calculates the CRC in the same way. A CRC error occurs when the calculated result differs from the received value in the CRC sequence.
"Form error"	A form error occurs when a fixed-form bit field contains one or more illegal bits.
"Bit stuffing error"	The frame segments Start Of Frame, Arbitration Field, Control Field, Data Field and CRC Sequence are coded by the bit stuffing method. The transmitter automatically inserts a complementary bit into the bit stream when it detects five consecutive bits of identical value in the bit stream to be transmitted. A stuff error occurs when the 6th consecutive equal bit level in the mentioned fields is detected.
"Ack error"	An acknowledgement error occurs when the transmitter does not receive an acknowledgment - a dominant bit during the Ack Slot.

Remote command:
`TRIGger:CAN:ACKerror` on page 579
`TRIGger:CAN:BITSterror` on page 580
`TRIGger:CAN:FORMerror` on page 583
`TRIGger:CAN:CRCerror` on page 580

Standard

Selects the CAN standard frame to be triggered on.

Remote command:
`TRIGger:CAN:FDATa:STANdard` on page 583

BRS, ESI

For "Standard" = " CAN-FD" or "Any" you can trigger on specific bits.

"BRS"	The bit rate switch bit. Value 1 means that the bit rate switches from the arbitration rate to the faster data rate.
"ESI"	The error state indicator bit. Set "X" if the bit is not relevant.

Remote command:

`TRIGger:CAN:FDATa:BRS` on page 582

`TRIGger:CAN:FDATa:ESI` on page 582

13.5.4 CAN decode results

When the configuration of the serial bus is complete, the signal can be decoded:

1. Open the "Serial Bus" dialog for the respective bus.
2. In the "Setup" tab, enable "State".
3. In the "Display" tab, enable "Show decode table".

For a description of the display settings, see also Chapter 13.1.3, "Display", on page 252.

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Green = Identifier
Bright Green = DLC
Orange = Data
Blue = CRC (checksum)
Purple = End of frame
Red = Error occurred

The "Decode results" box shows the detailed decoded data for each word.

Table 13-5: Content of the "Decode results" table

Column	Description
Index	Number of the decoded frames
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of frame start
Type	Frame type: Data, Remote, Error, or Overload
ID type	11-bit standard format or 29-bit extended format
ID value (hex)	Identifier value, hexadecimal value
DLC	Data length code, coded number of data bytes
NDB	Actual number of data bytes
Stuff	Stuff count value, decimal value.
Values	Value of the data frame. Remote frames do not transmit data, therefore "- - -" is displayed.
CRC (hex)	Value of the Cyclic Redundance Check (checksum), hexadecimal value
Nominal bit rate	Number of bits per second
Data	Value of the data frame. The data format is selected below the table. Remote frames do not transmit data, therefore "---" is displayed.

Data format

You can select various data formats for the values displayed in the decode table and in the combs of the decoded signal.

Remote command:

- `SBUS<m>:FORMat` on page 529

Export of decode results

1. In the protocol "Shortcuts" tab, press "Export results".

   The "Export results" dialog opens.
   For details, see Chapter 13.1.7, "Export protocol results", on page 254.
2. Select the details that you want to export and the file format.
3. Tap "Save as".
4. Key in a name and select the file format.

Remote commands

Remote commands to retrieve decode results are described in Chapter 17.16.5.3, "Decode results", on page 585.

14 Mixed signal option (MSO, R&S MXO4-B1)

The Mixed Signal Option R&S MXO4-B1 adds logic analyzer functions to the classical oscilloscope functions. Using the MSO option, you can analyze and debug embedded systems with mixed-signal designs that use analog signals and correlated digital signals simultaneously.

The Mixed Signal Option provides 16 digital channels grouped in two logic probes (pods) with 8 channels each. The instrument ensures that analog and digital waveforms are time-aligned and synchronized so that critical timing interactions between analog and digital signals can be displayed and tested. The automatic alignment compensates the skew between the probe connectors of the analog channels and the probe boxes of the digital channels.

14.1 Logic configuration

Access: "Menu" > "Logic" > "Setup" tab

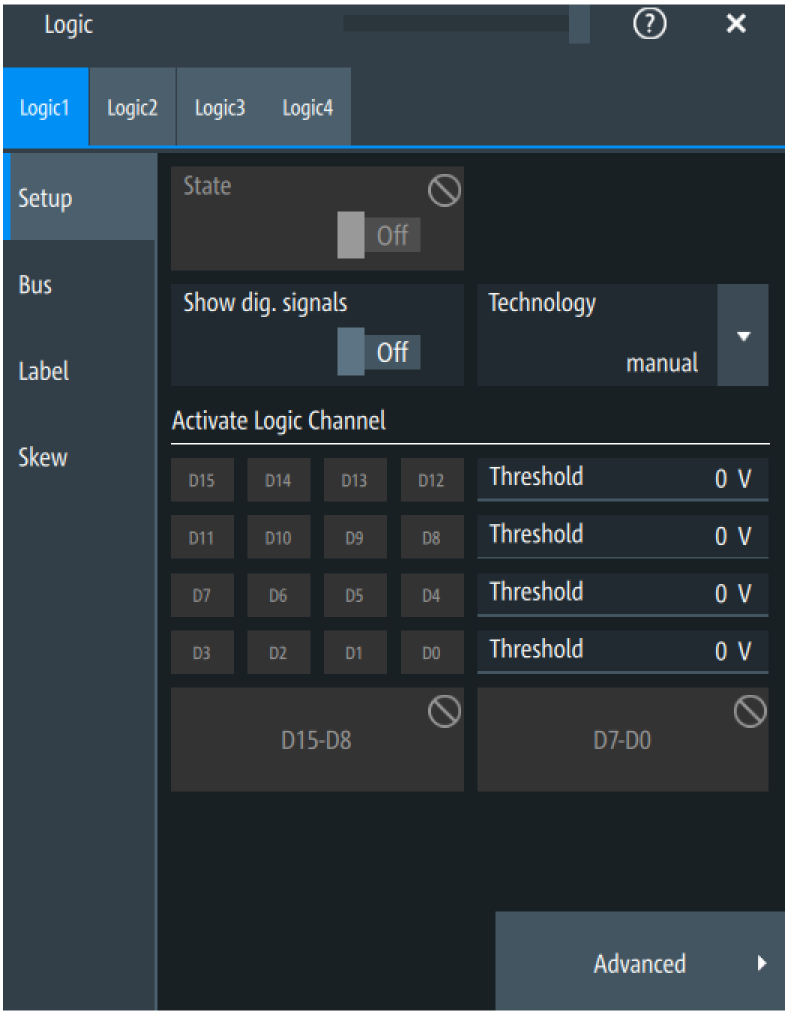
Digital channels can be displayed individually, and they can be grouped and displayed as a logic group. You can configure and enable up to 4 logic groups. Each digital channel can be assigned to one *active* logic only, the instrument disables conflicting buses automatically.

For clocked buses, you can display the decoded data in a result box.

If you have configured several logic groups and you want to modify the settings, make sure that the tab of the correct logic is selected. Disable the logic before you change the settings.

14.1.1 Setup

Access: "Menu" > "Logic" > "Setup" tab



State

Enables the selected logic group. The corresponding signal icon appears on the signal bar.

If another active bus already uses the same digital channel, the instrument disables the other bus and shows a message.

Remote command:

`PBUS<m>:STATe` on page 602

Show dig. signals

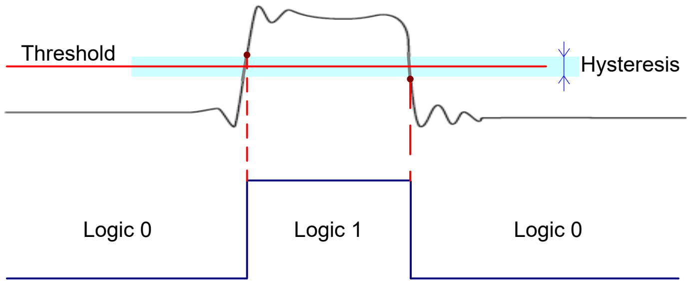
If enabled, the selected digital channels are shown in the diagram. Each channel is displayed as a logic signal.

Remote command:

`PBUS<m>:DISPlay:SHDI` on page 600

Technology,Threshold
Sets the logical threshold. For each sample, the instrument compares the input voltage with the threshold value. If the input voltage is above the threshold, the signal state "1" is stored. Otherwise, the signal state "0" is stored if the input voltage is below the threshold.

To avoid the change of signal states due to noise, a hysteresis is considered.



By default, same threshold and hysteresis value are used for all digital channels and all logic buses: "Couple thresholds" is enabled.

You can also set different thresholds for the individual channel groups. As long as the buses are disabled, you can set different thresholds for each bus. Active buses use the same threshold and hysteresis values, the settings of the last activated bus take effect.

The range of threshold levels and the minimum voltage swing is given in the data sheet.

"Threshold"	Enter the value directly in the field.
"Technology"	Selects the threshold voltage for various types of integrated circuits from a list and applies it to all digital channels. The value is set to "Manual" if a user-defined threshold was entered directly.

Remote command:
`PBUS<m>:TECHnology` on page 602
`PBUS<m>:THReshold<n>` on page 603

Advanced
Opens a dialog for advanced threshold and hysteresis settings. You can define them additional to the "Threshold" and "Technology".

Level coupling ← Advanced
Sets the threshold and the hysteresis for all digital channels and all buses to the same value.

Remote command:
`PBUS<m>:THCoupling` on page 603

Hysteresis ← Advanced
Defines the size of the hysteresis for the respective channels.

"Normal"	The instrument sets a small value suitable for the signal and its settings. Use this setting for clean signals.
"Maximum"	The instrument sets the maximum value that is possible and useful for the signal and its settings. Use this setting for noisy signals.

"Robust" — Sets different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system. Use this setting for very noisy signals.

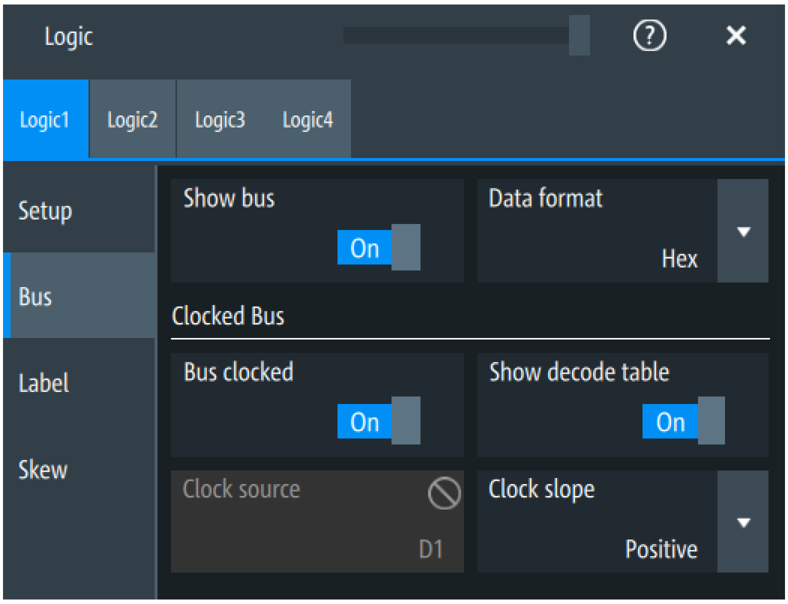
Remote command:
PBUS<m>:HYSTeresis<n> on page 601

Active logic channel
Selects the state of the respective bus channel.

Enable/Disable D7-D0,D15-D8
The buttons select or deselect all digital channels of a pod at once.

14.1.2 Bus

Access: "Menu" > "Logic" > "Bus" tab



Show bus
If enabled, the resulting bus signal and bus values are displayed in the diagram.

Remote command:
PBUS<m>:DISPlay:SHBU on page 600

Data format
Sets the data format of bus values, which are displayed in the decode table and on the comb bus display.

Available formats are: Hex, octal, binary, ASCII, string, signed, unsigned, symbolic, and auto.

Signed and Unsigned are integer data types with maximum 16-bit length. Unsigned is used for positive integers. Signed is used for positive and negative integers.

If the target file format is BIN, you can save only signed and unsigned binary data. The data format "Signed" writes signed data; all other formats are saved as unsigned binary data.

Remote command:
PBUS<m>:DATA:FORMat on page 604
PBUS<m>:DATA:HEADer? on page 605
PBUS<m>:DATA[:VALues]? on page 605

Clocked bus
If a bus is a clocked bus, one of the digital channels serves as clock of the bus.

For an unclocked bus, the logical state of the bus is determined for each sample. For a clocked bus, the logical state is determined only at the specified clock edges.

Bus clocked ← Clocked bus
Enable this option for a clocked bus.

Remote command:
PBUS<m>:CLON on page 599

Show decode table ← Clocked bus
If enabled, a results box opens with decoded values of the bus signal and its time. Each clock edge corresponds to one row in the table.

The decode table is only available for clocked buses to check the data words.

Clock source ← Clocked bus
Selects the digital channel used as clock.

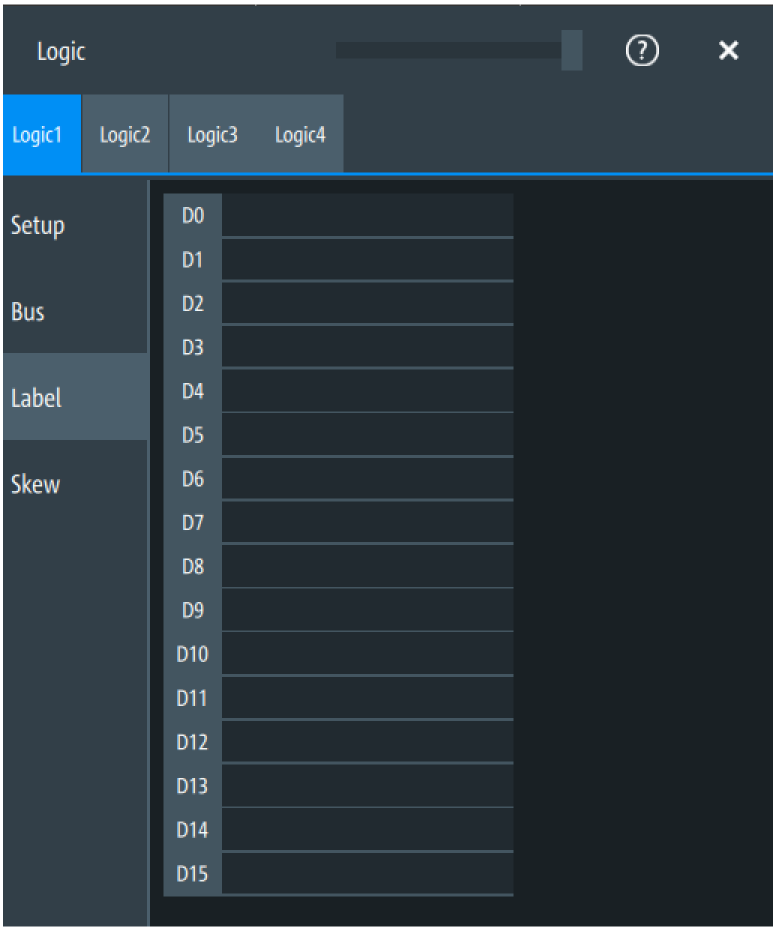
Remote command:
PBUS<m>:CLOCk on page 599

Clock slope ← Clocked bus
Selects the slope of the clock signal at which all digital channels of the bus are analyzed.

Remote command:
PBUS<m>:CLSLope on page 600

14.1.3 Label settings

Access: "Menu" > "Logic" > "Label" tab

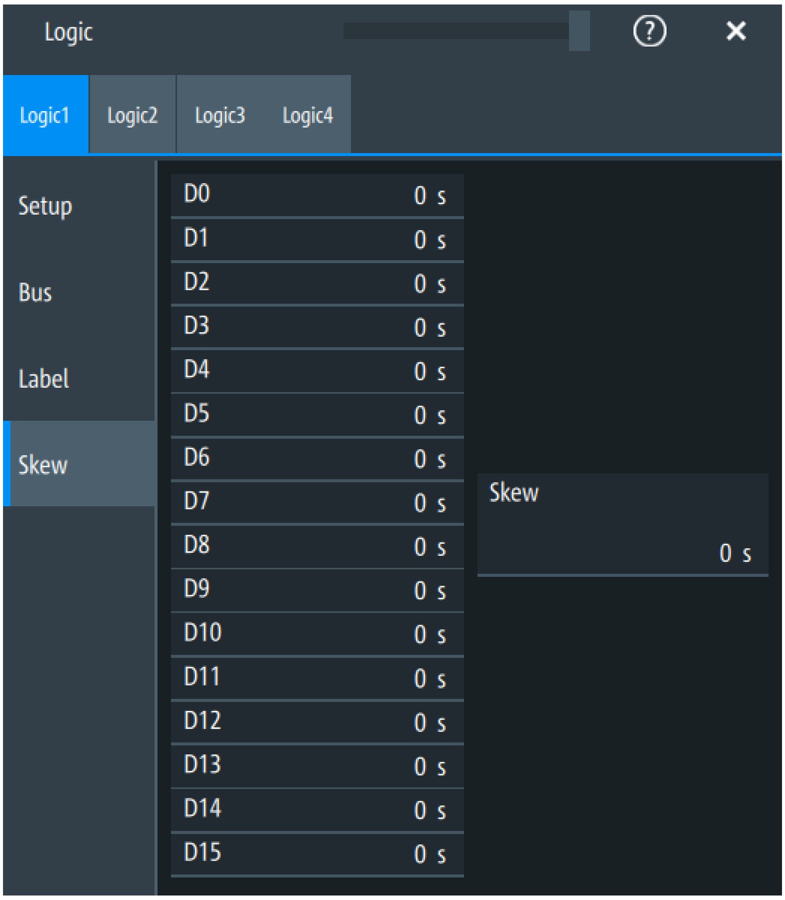


In this tab, you can enter a name for each digital channel. The name is displayed in the diagram.

PBUS<m>:BIT<n>:LABel on page 598

14.1.4 Skew settings

Access: "Menu" > "Logic" > "Skew" tab



D0-D15

Sets an individual delay for each digital channel to time-align it with other digital channels.

The skew value compensates delays that are known from the circuit specifics or caused by the different length of cables. The skew between the probe boxes of the digital channels and the probe connectors of the analog channels is automatically aligned by the instrument.

Remote command:
`PBUS<m>:BIT<n>:SKEW` on page 598

Skew

Sets a general delay for all digital channels.

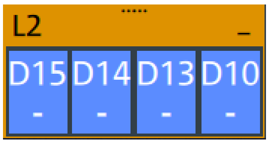
Remote command:
`PBUS<m>:SKEW` on page 601

14.2 Display

You can adjust the display of the logic bus signals and the individual digital channels to optimize the analysis of bus data:

- Show the digital channels which are assigned to the bus, drag them to the optimal position, and scale them.
- Show the result table of the decoded clocked bus signal.

Each logic group is shown in a separate diagram, and the diagrams can be minimized and arranged as usual.



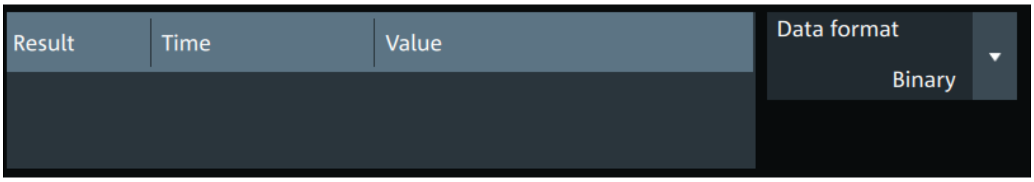
To access and analyze one or more specific acquisitions, you can use the "History" in the common way.

Furthermore, you can zoom in digital signals and bus signal in the same way as in analog waveforms.

14.2.1 Logic bus - decode table

Decoding is available for clocked buses.

The decode table shows the decoded data words of the bus signal and the corresponding time. Each clock edge corresponds to one row in the table. Beside the table, you can select the data format of the bus values.



The results can be saved to a `.csv` or `.html` file.

15 Waveform generator (option R&S MXO4-B6)

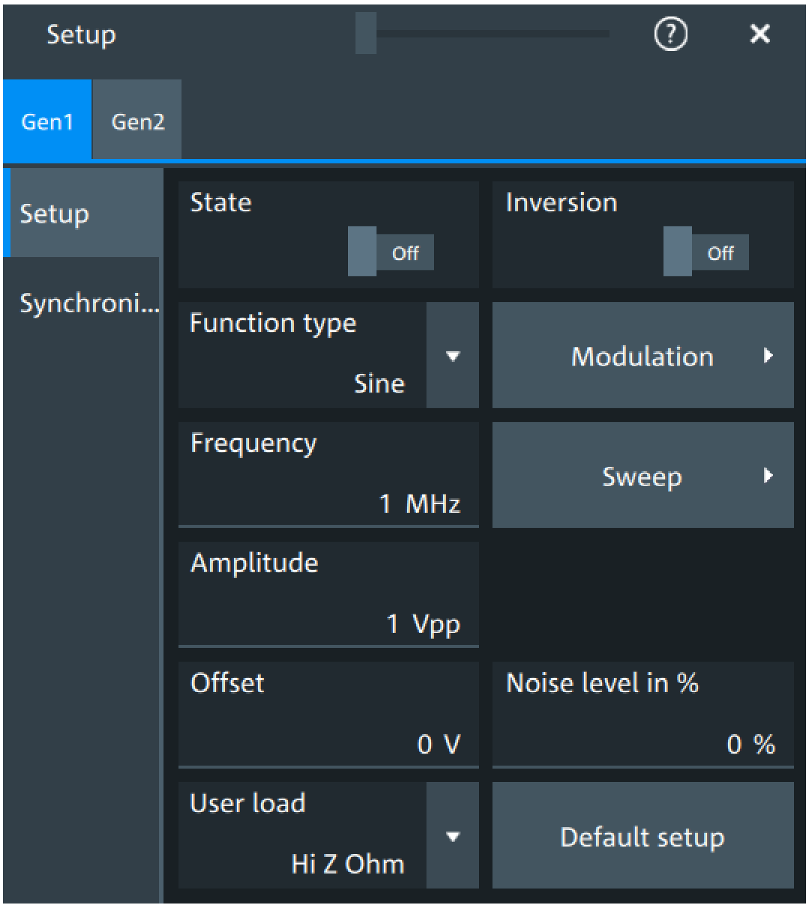
The R&S MXO 4 includes a two-channel 100 MHz waveform generator which can generate a wide range of waveform and modulation types.

With each of the waveform generators, one can output simple functions, modulated sine waveform, arbitrary waveforms and sweep waveforms. It is possible to couple and synchronize the settings of the waveform generators.

The instrument preset does not affect the generator settings. Each generator has its own preset ("Default setup").

15.1 Setup of the waveform generator

Access: [Gen] key > "Gen"1/2 > "Setup" tab.



15.1.1 General settings

State
Enables the function generator.

Remote command:
`WGENerator<wg>[:ENABle]` on page 610

Inversion
Inverts the waveform at the offset level.

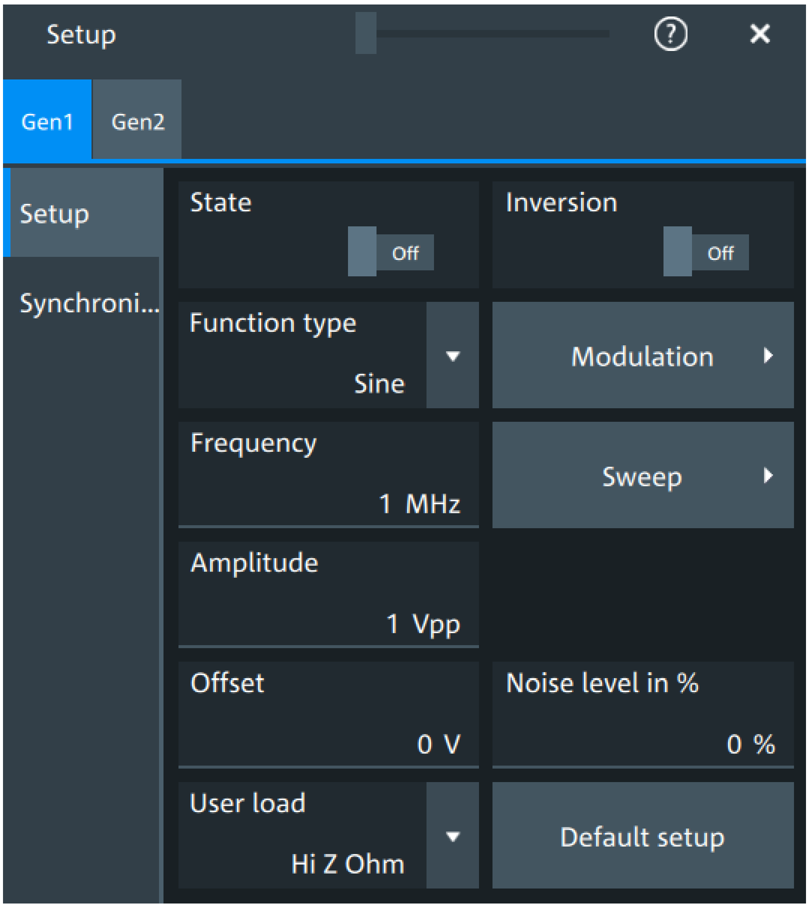
Remote command:
`WGENerator<wg>:VOLTage:INVersion` on page 609

Function type
Selects the type of waveform to be generated.

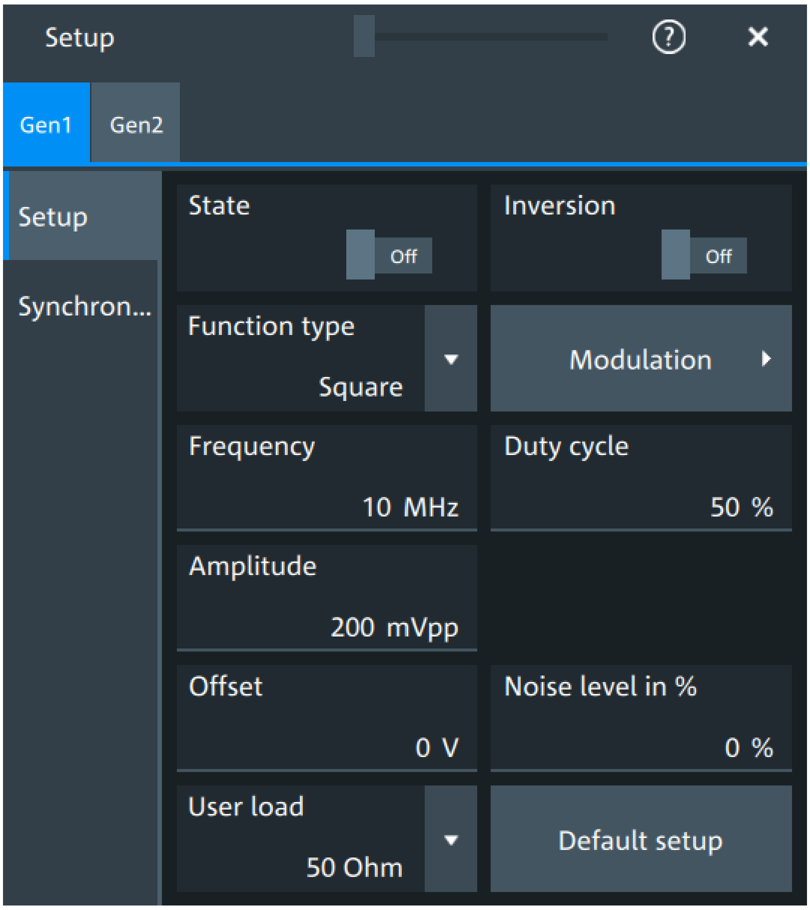
For all waveforms, you can set:

- Frequency
- Amplitude
- Offset

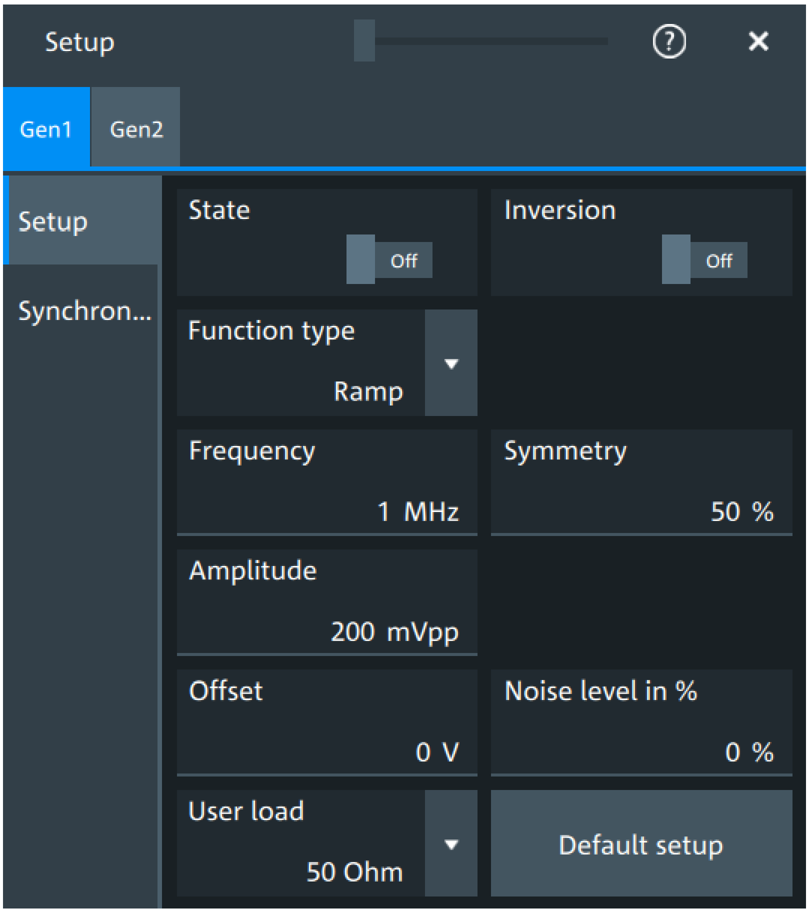
"Sine" Generates a sine wave.



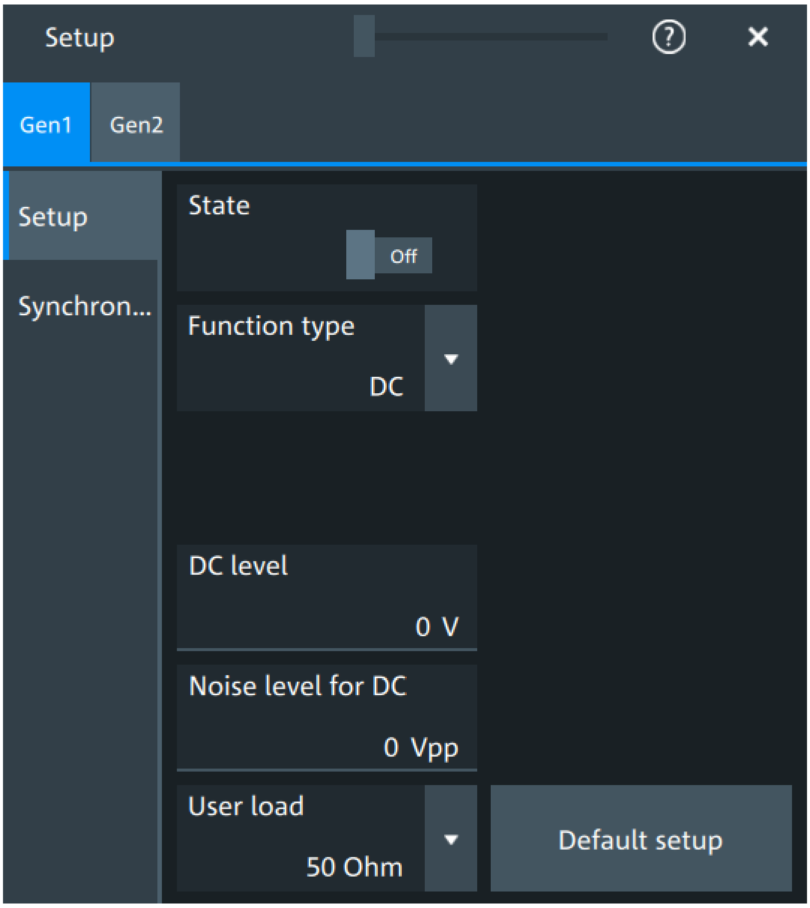
"Square" Generates a square wave.



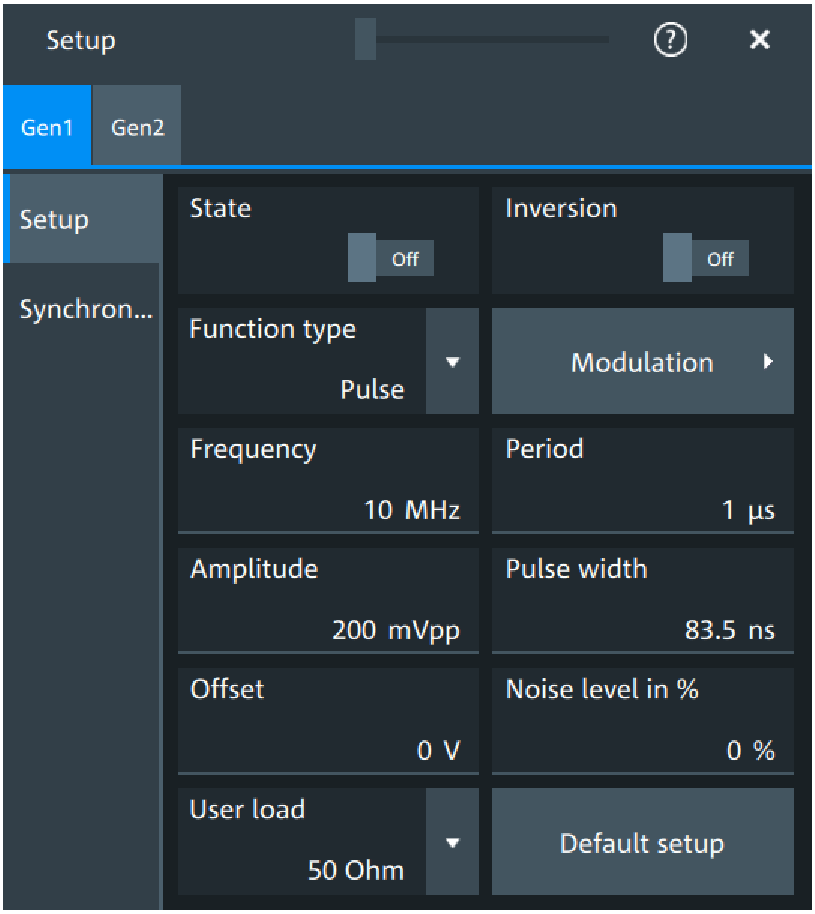
"Ramp" Generates a ramp signal. You can set the Symmetry.



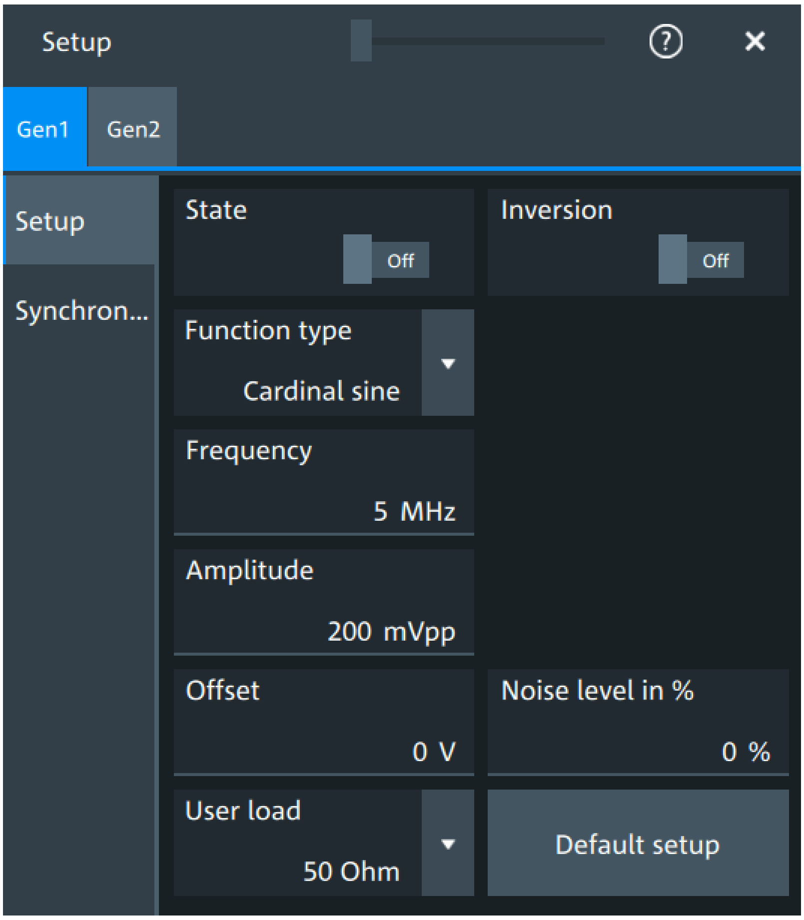
"DC" Generates a direct current (DC) signal.



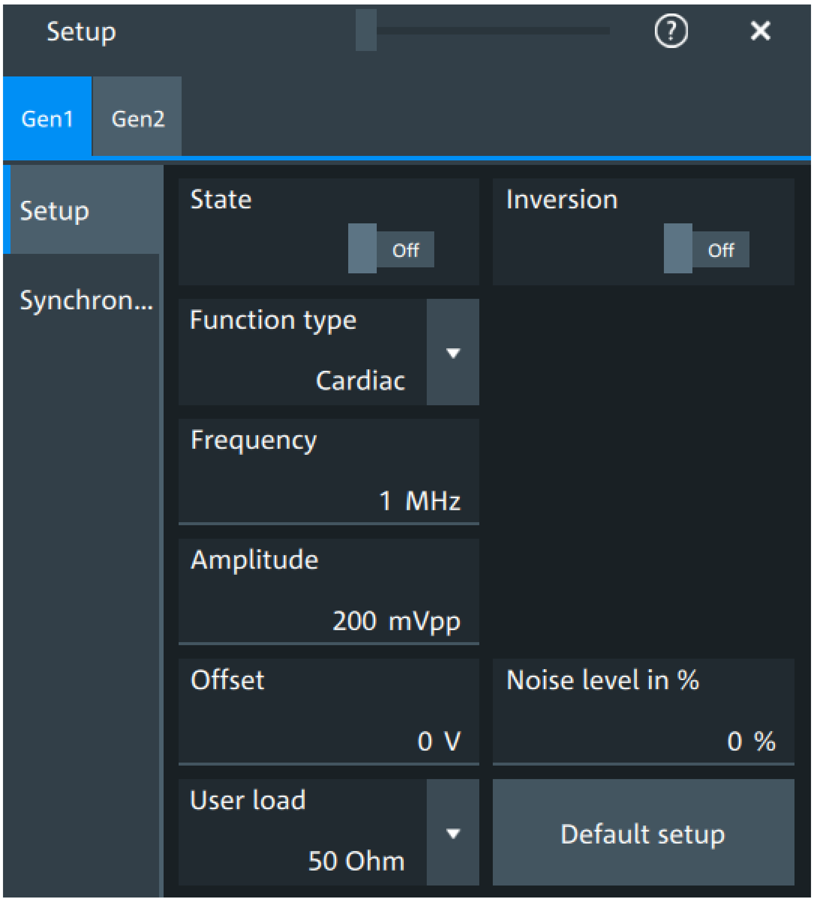
"Pulse" Generates a pulse signal. Additional settings are the Pulse width.



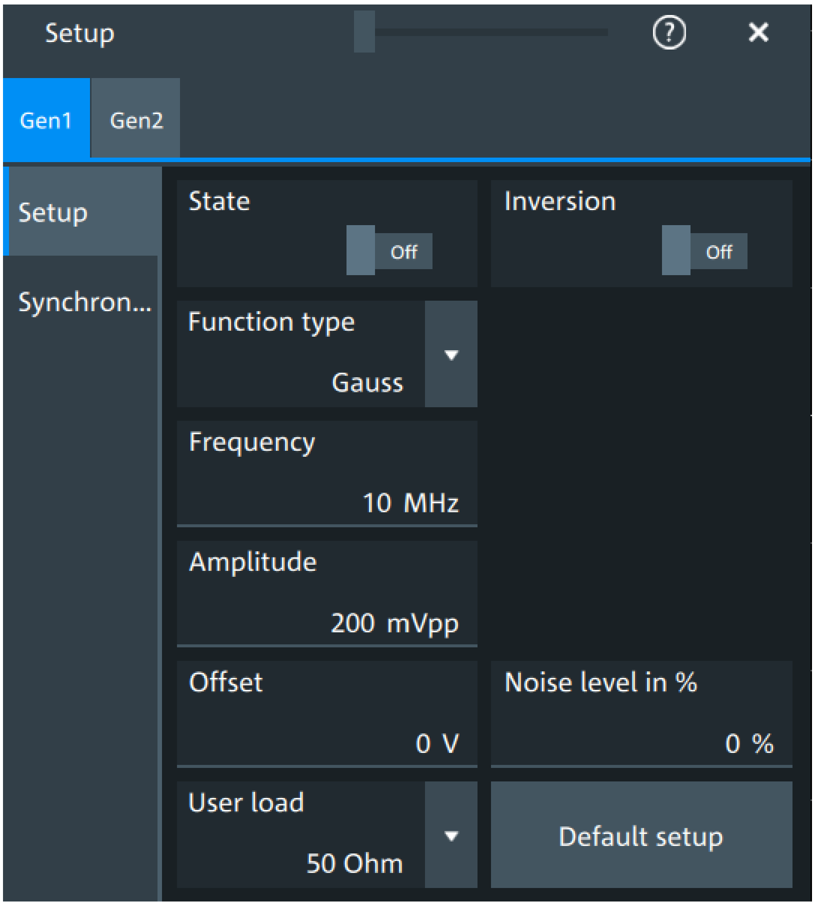
"Cardinal sine" Generates a cardinal sine wave.



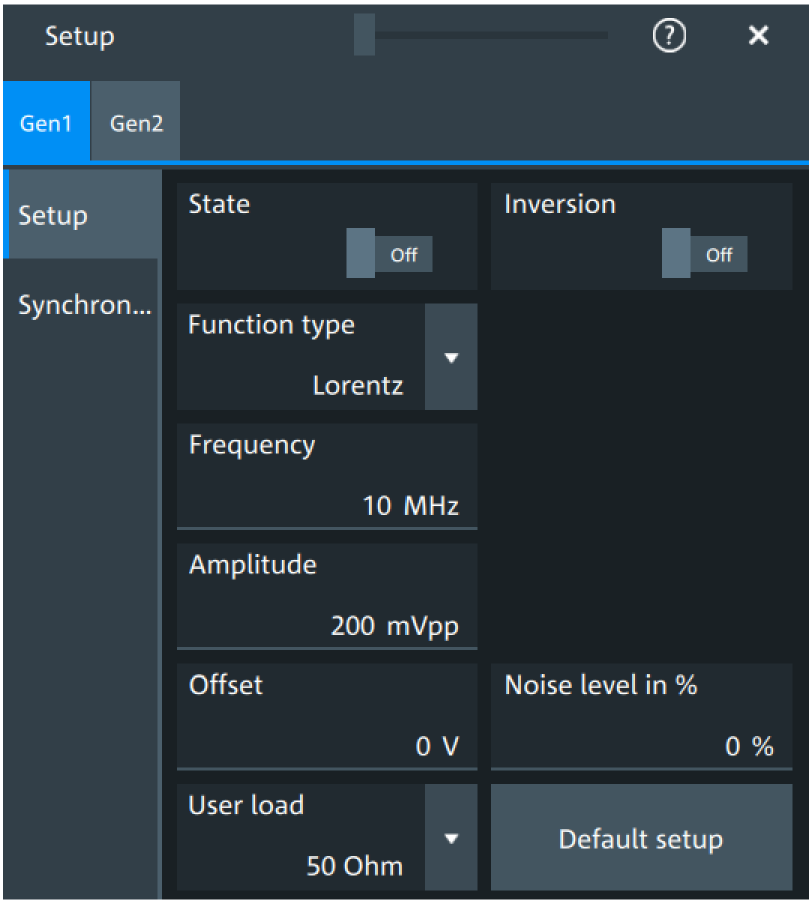
"Cardiac" Generates a cardiac signal.



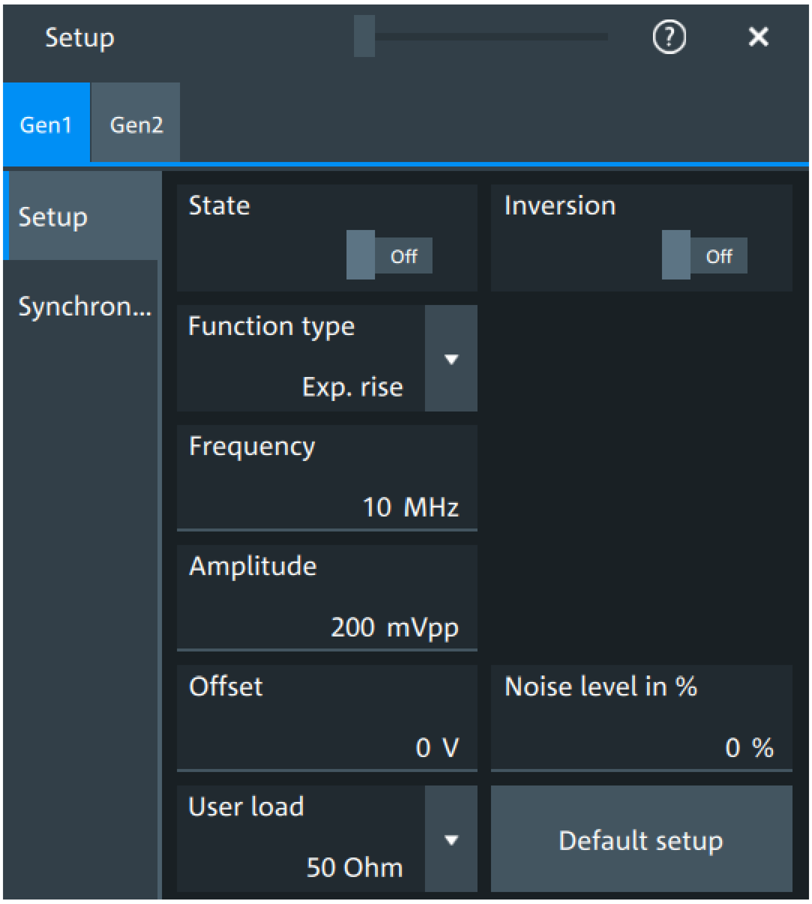
"Gauss" Generates a gauss signal.



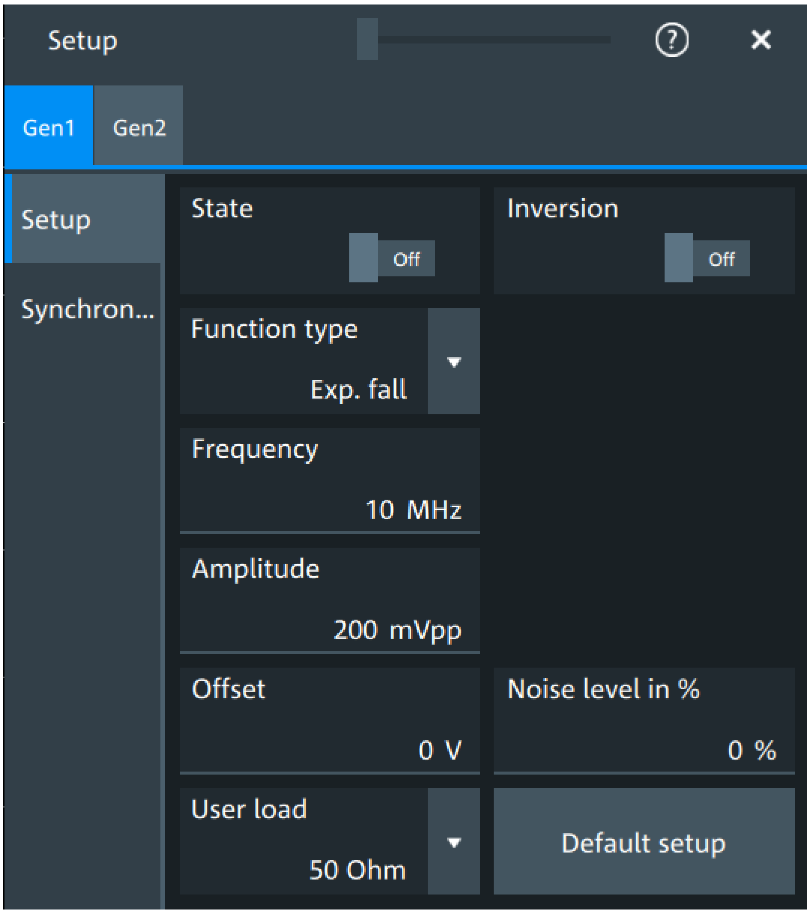
"Lorentz" Generates a Lorentz signal .



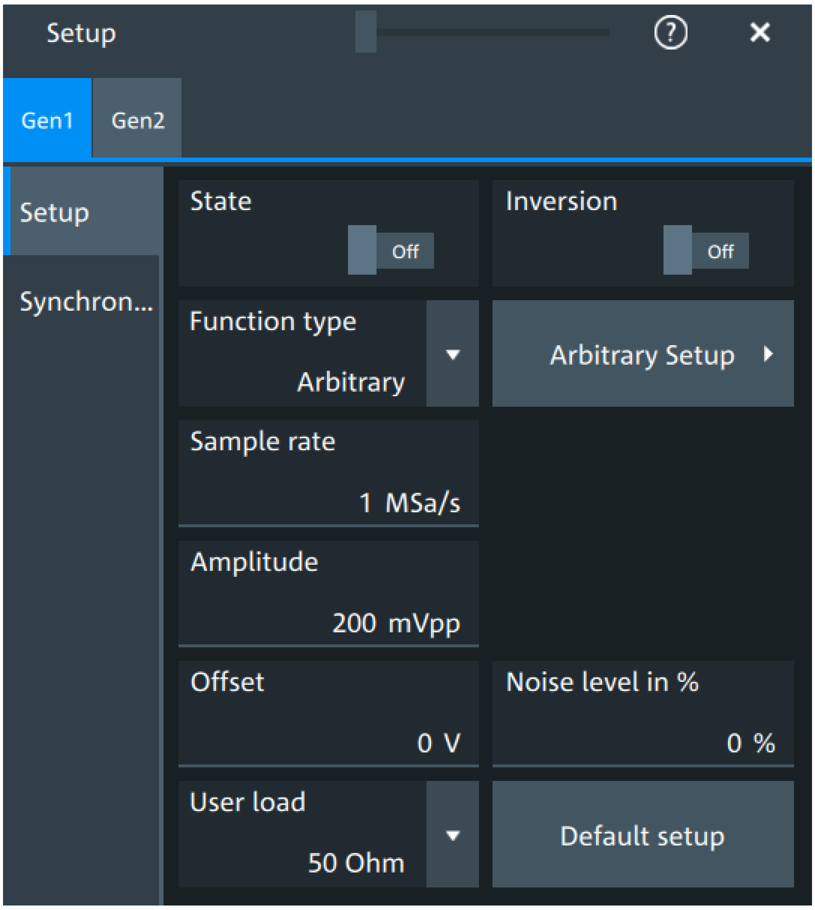
"Exp. rise" Generates an exponential rise signal.



"Exp. fall" Generates an exponential fall signal.



"Arbitrary" Generates an arbitrary waveform, which is copied from an existing waveform, or loaded from file. See Chapter 15.1.4, "Arbitrary setup settings", on page 326.



Remote command:
`WGENerator<wg>:FUNCtion[:SELect]` on page 607

Frequency
Sets the frequency of the waveform.

The available frequency range depends on the selected "Function type", see Frequency range of the function generator waveforms.

Table 15-1: Frequency range of the function generator waveforms

"Function type"	Min frequency	Max frequency
"Sine"	0.001 Hz	100 MHz
"Square"	0.001 Hz	30 MHz
"Ramp"	0.001 Hz	1 MHz
"DC"	-	-
"Pulse"	0.001 Hz	30 MHz
"Cardinal sine"	0.001 Hz	5 MHz

"Function type"	Min frequency	Max frequency
"Cardiac"	0.001 Hz	1 MHz
"Gauss"	0.001 Hz	25 MHz
"Lorentz"	0.001 Hz	10 MHz
"Exp.rise"	0.001 Hz	10 MHz
"Ep. fall"	0.001 Hz	10 MHz

Remote command:
`WGENerator<wg>:FREQuency` on page 607

Amplitude
Sets the amplitude of the waveform.

Remote command:
`WGENerator<wg>:VOLTage[:VPP]` on page 610

Offset
Sets the vertical offset of the generated waveform.

Remote command:
`WGENerator<wg>:VOLTage:OFFSet` on page 610

Arbitrary setup
Opens a menu to configure the arbitrary waveform.

See Chapter 15.1.4, "Arbitrary setup settings", on page 326.

Sweep
Opens a menu to configure the sweep.

See Chapter 15.1.3, "Sweep settings", on page 325.

Modulation
Opens a menu to configure the modulation.

See Chapter 15.1.2, "Modulation settings", on page 323.

Noise level in %
Sets the level of the noise in percentage of the set "Amplitude" output of the signal.

Remote command:
`WGENerator<wg>:MODulation:NLPCent` on page 616

User load
Select the user load, the load of the DUT at its connection.

You can select either a "50Ω" or a "High-Z" (high input impedance) load.

Remote command:
`WGENerator<wg>:OUTPut[:LOAD]` on page 608

Symmetry

Sets the symmetry of a ramp waveform, the percentage of time the waveform is rising. By changing the symmetry of the ramp, you can create, for example, triangular waveforms.

50% defines symmetric triangles. Values <50% define triangles with steeper rising edge leaned to the left. Values >50% define triangles with steeper falling edge leaned to the right.

Remote command:
`WGENerator<wg>:FUNCtion:RAMP[:SYMMetry]` on page 607

Duty cycle

Sets the duty cycle for the pulse function.

The duty cycle expresses for what percentage of the period, the signal state is high.

Remote command:
`WGENerator<wg>:FUNCtion[:SQUare]:DCYCle` on page 608

Pulse width

Sets the pulse width, the pulse duration of the generated pulse waveform.

Remote command:
`WGENerator<wg>:FUNCtion:PULSe[:WIDTh]` on page 607

Default setup

Presets the generator to a default setup. The default includes the following settings:

- "Function type" = "Sine"
- "Frequency" = "1 MHz"
- "Amplitude" = "1 Vpp"

Remote command:
`WGENerator<wg>:PRESet` on page 609

DC level

Available for "Function type" = DC.

Sets the level for the DC signal.

Remote command:
`WGENerator<wg>:VOLTage:DCLevel` on page 609

Noise level for DC

Available for "Function type" = "DC".

Sets the level of the noise for the DC signal.

Period

Available for "Function type" = "Pulse".

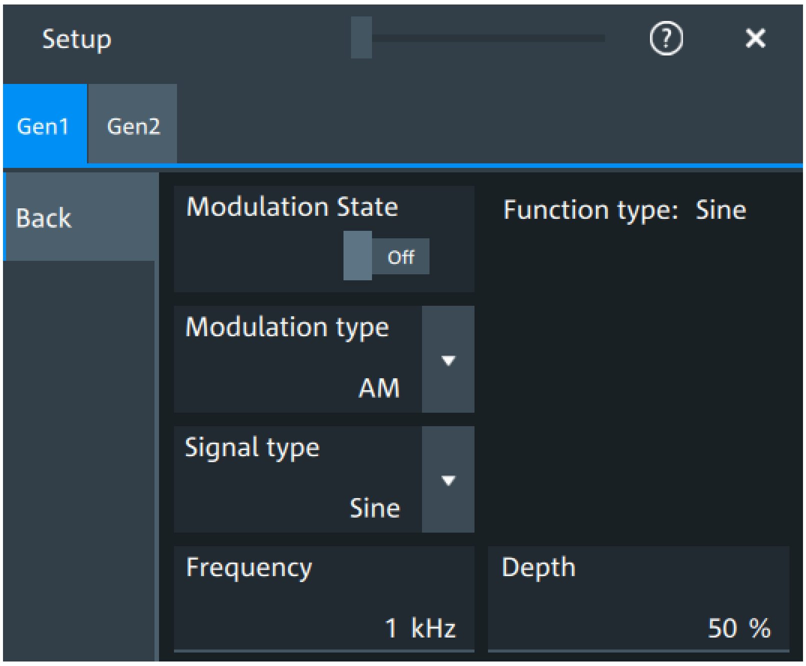
Sets the period of the pulse waveform.

Remote command:
`WGENerator<wg>:PERiod` on page 608

15.1.2 Modulation settings

Modulation is available only for "Function type" = "Sine"/"Square".

Access: [Gen] key > "Setup" tab > "Modulation".



Modulation state
Enables or disables modulation.

Modulation is available only for "Function type" = "Sine"/"Square".

Modulation type
Selects the modulation type, which defines how the carrier signal is modified.

"AM"	Amplitude modulation. The amplitude of the carrier signal is varied according to the modulation signal.
"FM"	Frequency modulation. The frequency of the carrier signal is varied according to the modulation signal.
"PWM"	Pulse width modulation. The time for which the signal is in a high state is varied according to the modulation signal.
"FSK"	Frequency shift keying (FSK) modulation. The signal frequency switches between "Frequency 1" and "Frequency 2" at a "FSK rate".

Remote command:
`WGENerator<wg>:MODulation:TYPE` on page 618

Signal type
Selects the type of the modulating signal for AM, FM or PWM modulation.

Remote command:
`WGENerator<wg>:MODulation:AM[:FUNCtion]` on page 612
`WGENerator<wg>:MODulation:FM[:FUNCtion]` on page 614
`WGENerator<wg>:MODulation:PWM[:FUNCtion]` on page 617

Frequency
Sets the frequency of the modulating waveform for AM/FM/PWM modulation.

Remote command:
`WGENerator<wg>:MODulation:AM:FREQuency` on page 612
`WGENerator<wg>:MODulation:FM:FREQuency` on page 614
`WGENerator<wg>:MODulation:PWM:FREQuency` on page 617

Depth
Sets the modulation depth, the percentage of the amplitude range that is used for AM modulation.

Remote command:
`WGENerator<wg>:MODulation:AM:DEPTh` on page 612

Duty cycle
Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Remote command:
`WGENerator<wg>:MODulation:AM:DCYCle` on page 611
`WGENerator<wg>:MODulation:FM:DCYCle` on page 613
`WGENerator<wg>:MODulation:PWM:DCYCle` on page 616

Symmetry
Sets the symmetry for the ramp modulation waveform, the percentage of time that the waveform is rising.

Remote command:
`WGENerator<wg>:MODulation:AM:SYMMetry` on page 612
`WGENerator<wg>:MODulation:FM:SYMMetry` on page 614
`WGENerator<wg>:MODulation:PWM:SYMMetry` on page 617

Deviation
Sets the frequency deviation, the maximum difference between the FM modulated signal and the carrier signal.

Remote command:
`WGENerator<wg>:MODulation:FM:DEViation` on page 614

Modulation depth
Sets the modulation depth, the percentage of the amplitude range that is used for PWM modulation.

Remote command:
`WGENerator<wg>:MODulation:PWM:DEPTh` on page 616

Frequency 1/Frequency 2
Sets the frequency of the first /second signal in FSK modulated signal.

Remote command:
`WGENerator<wg>:MODulation:FSK:FONE` on page 615
`WGENerator<wg>:MODulation:FSK:FTWO` on page 615

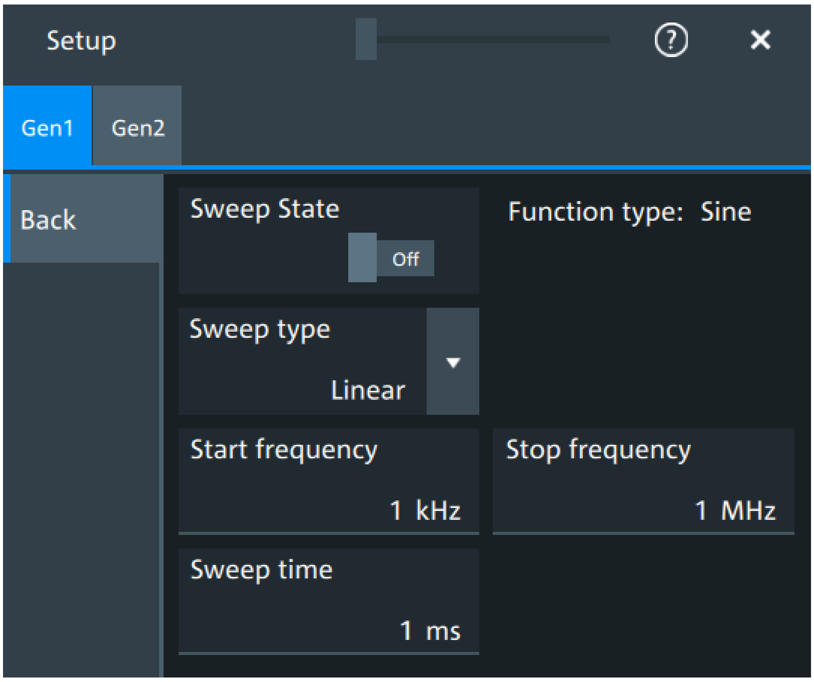
FSK rate
Sets the frequency at which signal switches between "Frequency 1" and "Frequency 2".

Remote command:
`WGENerator<wg>:MODulation:FSK[:RATE]` on page 615

15.1.3 Sweep settings

Sweep is available only for "Function type" = "Sine".

Access: [Gen] key > "Gen1/2" > "Setup" tab > "Sweep".



In the sweep mode, the R&S MXO 4 generates a signal whose frequency gradually changes from the "Start frequency" to the "Stop frequency" for a certain "Sweep time".

For a step-by-step description of the sweep setup, see Chapter 15.3.3, "Configuring a sine sweep waveform", on page 331.

Sweep state
Enables or disables the sweeping.

Remote command:
`WGENerator<wg>:SWEep[:STATe]` on page 620

Sweep type
Sets the type of the sweep, a linear or logarithmic change of the frequency.

Remote command:
`WGENerator<wg>:SWEep:TYPE` on page 620

Start frequency
Sets the start frequency of the sweep signal.

Remote command:
`WGENerator<wg>:SWEep:FSTart` on page 620

Stop frequency
Sets the stop frequency of the sweep signal.

Remote command:
`WGENerator<wg>:SWEep:FEND` on page 621

Sweep time
Sets the duration of the sweep.

Remote command:
`WGENerator<wg>:SWEep:TIME` on page 621

15.1.4 Arbitrary setup settings

Access: [Gen] key > "Gen1/2" > "Arbitrary setup"

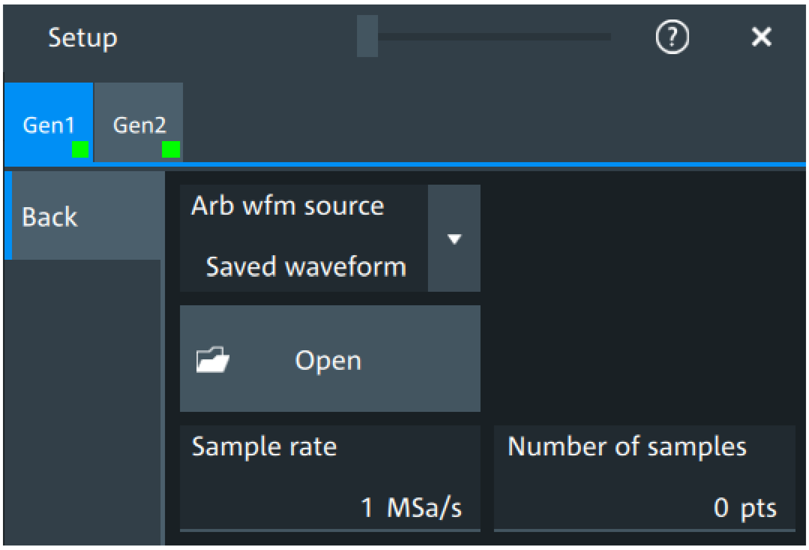
The arbitrary waveform generator allows you to output a user-defined waveform for testing your devices. An arbitrary waveform is copied from an existing waveform on the instrument, or loaded from file. You can display the arbitrary waveform on the screen.

Arb wfm source
Selects the source of the arbitrary waveform.

You can load an existing file or load the current oscilloscope waveform.

Remote command:
`WGENerator<wg>:ARBGen[:SOURce]` on page 620

Saved waveform
Opens a saved waveform.



Open ← Saved waveform
Opens a dialog to select the saved waveform.

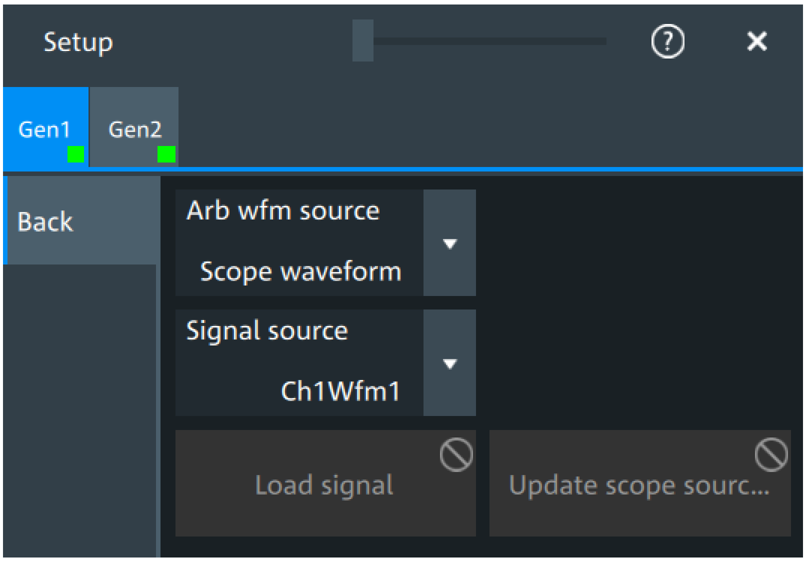
Sample rate ← Saved waveform
Sets the sample rate for the arbitrary waveform.

Remote command:
`WGENerator<wg>:ARBGen:SRATe` on page 619

Number of samples ← Saved waveform
Sets the number of samples in the loaded waveform.

Remote command:
`WGENerator<wg>:ARBGen:SAMPles?` on page 619

Scope waveform
Loads the oscilloscope waveform of the selected "Signal source".



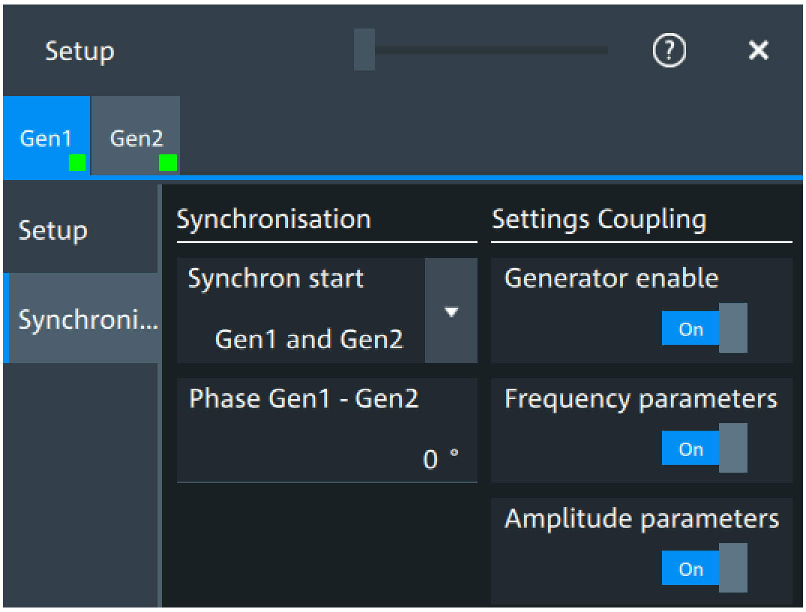
Load signal ← Scope waveform
Opens a file selection dialog box and loads the selected file.

Remote command:
`WGENerator<wg>:ARBGen:NAME` on page 618
`WGENerator<wg>:ARBGen:OPEN` on page 618

Update scope source ← Scope waveform
Updates the waveform from the selected scope source.

15.2 Synchronize settings

Access: "Menu" > "Apps" > "Gen1" > "Synchronisation" tab.



Synchron start
Selects, which signals generated from the waveform generator are synchronized.

Selecting one of the sync options indicates that the first samples of those signals are generated at the same time, irrespective of if the generators are on or off. Selecting one of the coupling options automatically syncs the signals generated by the two waveform generators.

Remote command:
`GENerator:SYNC[:COMBination]` on page 623

Generator enable
Enables the coupling of the generators, with the selected set of parameters: amplitude and frequency.

Remote command:
`WGENerator<wg>:COUPling:ALL` on page 621

Frequency parameters
Couples all frequency parameters of "Gen1" and "Gen2". The values are taken from the currently selected generator.

You can still change the other settings of the generators independently.

Remote command:
`WGENerator<wg>:COUPling:AMPLitude` on page 622

Amplitude parameters
Couples all amplitude parameters of "Gen1" and "Gen2" including the load. The values are taken from the currently selected generator.

Remote command:
`WGENerator<wg>:COUPling[:FREQuency]` on page 622

Phase Gen1 - Gen2
Sets the phase shift between the waveform of Gen1 and Gen2 when the frequency parameters of the two waveforms are coupled.

Remote command:
`WGENerator<wg>:COUPling:PHASeshift` on page 622

15.3 Configuring the waveform generator

This chapter explains step by step how to configure the waveform generator.

15.3.1 Configuring a function waveform

1. Press the [Gen] key on the front panel.
2. In the "Setup" tab, select the "Function type" that you want to generate, e.g. "Sine".
3. Depending on the selected "Function type", configure the settings of the waveform like "Frequency" and "Amplitude".
4. If necessary, change the "User load" settings or add "Noise level in %" to the waveform.
5. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

15.3.2 Configuring a modulation waveform

Generating an AM modulated waveform

1. Press the [Gen] key on the front panel.
2. In the "Setup" tab, set the "Function type" = "Sine".
3. Press "Modulation" to open the modulation dialog.
4. Set "Modulation type" = "AM".
5. Set the "Carrier frequency" and the "Carrier period".
6. Tap "Modulation signal" and select the required waveform.
7. Depending on the selected "Modulation signal", configure the settings of the waveform like "Modulation freq" and "Modulation depth".
8. Set "Modulation state" = "On" to enable the modulation.
9. Press "Back" to return to the "Setup" tab.
10. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

Generating an FM modulated waveform

1. Press the [Gen] key on the front panel.
2. In the "Setup" tab, set the "Function type" = "Sine".
3. Press "Modulation" to open the modulation dialog.
4. Set "Modulation type" = "FM".
5. Select the "Signal type".
6. Set the "Frequency" and the "Deviation".
7. Set "Modulation state" = "On" to enable the modulation.
8. Press "Back" to return to the "Setup" tab.
9. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

Generating an FSK modulated waveform

1. Press the [Gen] key on the front panel.
2. In the "Setup" tab, set the "Function type" = "Sine".
3. Press "Modulation" to open the modulation dialog.
4. Set "Modulation type" = "FSK".
5. Set the "Frequency 1", "Frequency 2" and the "FSK rate".

6. Set "Modulation state" = "On" to enable the modulation.
7. Press "Back" to return to the "Setup" tab.
8. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

Generating a PWM modulated waveform

1. Press the [Gen] key on the front panel.
2. In the "Setup" tab, set the "Function type" = "Square".
3. Press "Modulation" to open the modulation dialog.
4. Set "Modulation type" = "PWM".
5. Tap "Signal type" and select the required waveform.
6. Configure the settings of the waveform like "Frequency" and "Modulation depth".
7. Set "Modulation state" = "On" to enable the modulation.
8. Press "Back" to return to the "Setup" tab.
9. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

15.3.3 Configuring a sine sweep waveform

1. Press the [Gen] key on the front panel.
2. In the "Setup" tab, set "Function type" = "Sine".
3. Press "Sweep" to open the sweep dialog.
4. Select the "Sweep type".
5. Set the "Start frequency", the "Stop frequency" and the "Sweep time".
6. Set "Sweep state" = "On" to enable the sweep.
7. Press "Back" to return to the "Setup" tab.
8. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

15.3.4 Configuring an arbitrary waveform

Generating an arbitrary waveform from a saved file

1. Press the [Gen] key on the front panel.
2. In the "Setup" tab, set "Function type" = "Arbitrary".

3. Press "Arbitrary setup" to open the arbitrary dialog.
4. Set the "Arb wfm source" to "Saved waveform".
5. Set the "Sample rate" and the "Number of samples".
6. Press "Back" to return to the "Setup" tab.
7. Set "Setup" = "On" to output the waveform at the output connector of the waveform generator.

Generating an arbitrary waveform from the scope waveform

1. Press the [Gen] key on the front panel.
2. In the "Setup" tab, set "Function type" = "Arbitrary".
3. Press "Arbitrary setup" to open the arbitrary dialog.
4. Set the "Arb wfm source" to "Scope waveform".
5. Press "Signal source" to select the channel source for the waveform.
6. Press "Load signal" to load the selected waveform.
7. Press "Back" to return to the "Setup" tab.
8. Set "State" = "On" to output the waveform at the output connector of the waveform generator.

16 Network operation and remote control

The operating system is the basis of the instrument's firmware, it provides basic functions such as logon, password protection, virus protection, and connection to a network.

In addition to working with the R&S MXO 4 directly, using the touchscreen and the keys, you can also operate the instrument from a remote PC. Various methods of remote operation and control in a LAN network are supported:

- Using the web interface
- Using a VNC client
- Remote control with SCPI commands

The following descriptions provide information required for operating the R&S MXO 4 remotely. Definitions specified in the SCPI standard are not provided.

For basic knowledge on remote control operation and additional information, see the following documents, available on the Rohde & Schwarz website:

- Remote control via SCPI

16.1 Connecting the instrument to the network (LAN)

Network environment

Before connecting the product to a local area network (LAN), consider the following:

- Install the latest firmware to reduce security risks.
- For internet or remote access, use secured connections if applicable.
- Ensure that the network settings comply with the security policies of your company. Contact your local system administrator or IT department before connecting your product to your company LAN.
- When connected to the LAN, the product may potentially be accessed from the internet, which may be a security risk. For example, attackers might misuse or damage the product.

16.1.1 Connecting the instrument to the network

There are two methods to establish a LAN connection to the instrument:

- A non-dedicated network (Ethernet) connection from the instrument to an existing network.
- A dedicated network connection (Point-to-point connection) between the instrument and a single computer.

NOTICE

Risk of network failure

Consult your network administrator before performing the following tasks:

- Connecting the instrument to the network
- Configuring the network
- Changing IP addresses
- Exchanging hardware

Errors can affect the entire network.

► Connect an RJ-45 cable to the LAN connector on the rear panel and to the LAN.

The LAN interface supports 10/100/1000BASE-T.

16.1.2 Assigning the IP address

Depending on the network capacities, the TCP/IP address information for the instrument can be obtained in different ways.

- If the network supports the Dynamic Host Configuration Protocol (DHCP), the address is assigned automatically.
- If the network does not support DHCP, or if the instrument is set to use manual configuration, the addresses must be set manually.

By default, the instrument is configured to use DHCP and obtains all address information automatically. Thus it is safe to establish a physical connection to the LAN without any previous instrument configuration.

To assign the IP address manually on the instrument

1. **NOTICE!** 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.
2. Open "Menu" > "Settings".
3. Select "System" > "Network" > "Advanced".
4. Disable "Automatic IP (DHCP)".

5. Enter the address information as obtained from the network administrator.

16.1.3 Using device names

In a LAN that uses a DNS server (Domain Name System server), each PC or instrument in the LAN can be accessed via an unambiguous device name (or host name, computer name) instead of the IP address. The DNS server translates the host name to the IP address. Device names are useful when a DHCP server is used, as a new IP address can be assigned each time the instrument is restarted.

Each instrument is delivered with an assigned device name, but this name can be changed.

The default device name is a non-case-sensitive string with the following syntax: <instrument>-<serial_number>

The default device name of an R&S MXO 4 with a serial number 123456 is MXO4-123456.

The serial number can be found on the rear panel of the instrument. It is the third part of the device ID printed on the bar code sticker:

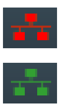
To change the device name

1. Open the "Menu" > "Settings" dialog.
2. Select "System" > "Network".
3. Enter the new "Device name" and confirm the entry.

16.2 Web interface

If the R&S MXO 4 is connected to a computer via LAN, you can operate the instrument from the computer. No additional tools are required, you need only a web browser.

16.2.1 Settings on the R&S MXO 4



The connection status icon in the upper right corner indicates the status of the LAN connection. A green icon indicates that the instrument is connected to the LAN; a red symbol indicates a connection error - mostly the LAN cable is not connected.

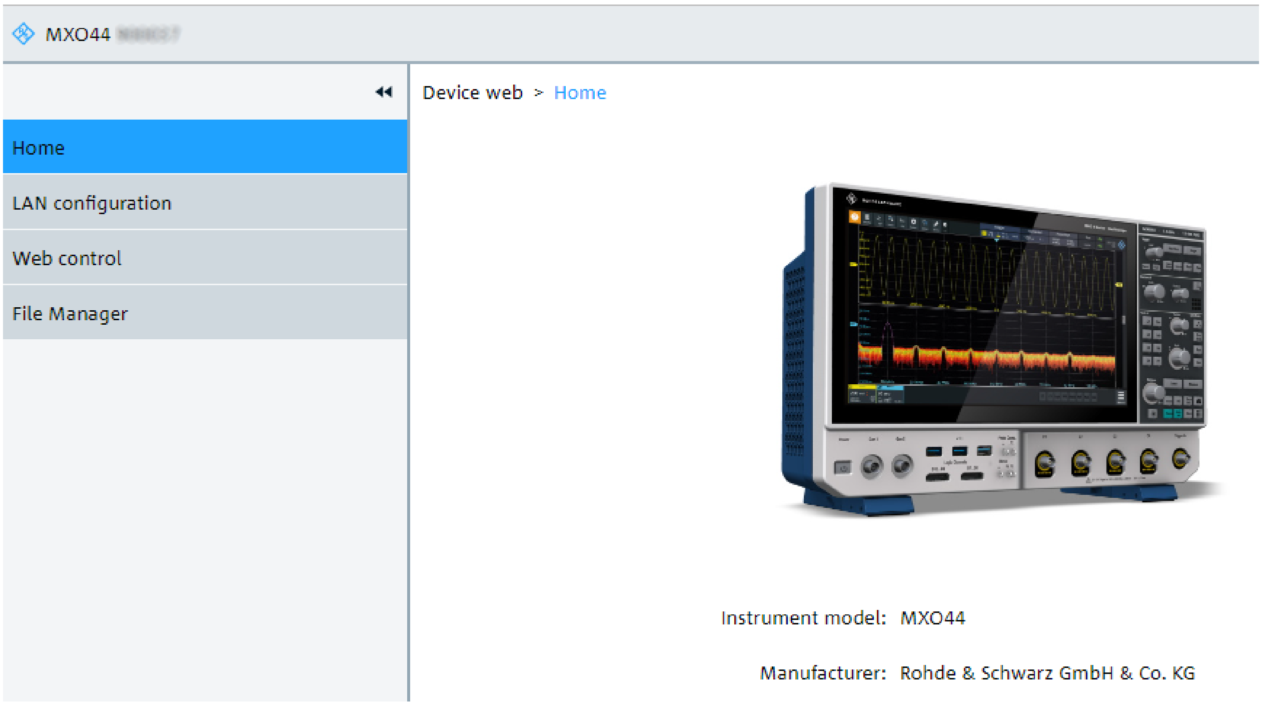
The "Network" tab of the "System" dialog box provides network information and settings. See Chapter 5.1.2, "Network settings", on page 66.

16.2.2 Web browser

The instrument's web interface works with all W3C compliant browsers.

1. Open a web browser on the computer.
2. Type the instrument's host name or IP address in the address field of the browser on your PC, e.g. "http://11.113.11.203".

   The instrument home page opens.



The instrument home page displays the device information in read-only format, including DNS host names and the VISA resource string.

The navigation menu if the browser interface has the following items:

- "LAN Configuration" opens the menu with configuration pages.
- "Web Control" emulates the front panel and shows the instrument display. You see a live image of the instrument, and you can operate the instrument remotely. You can use the keys, the knobs and the menus in the same way as directly on the instrument.
- "File manager" provides access to the user data that is saved on the instrument, upload and download.

16.2.2.1 LAN configuration

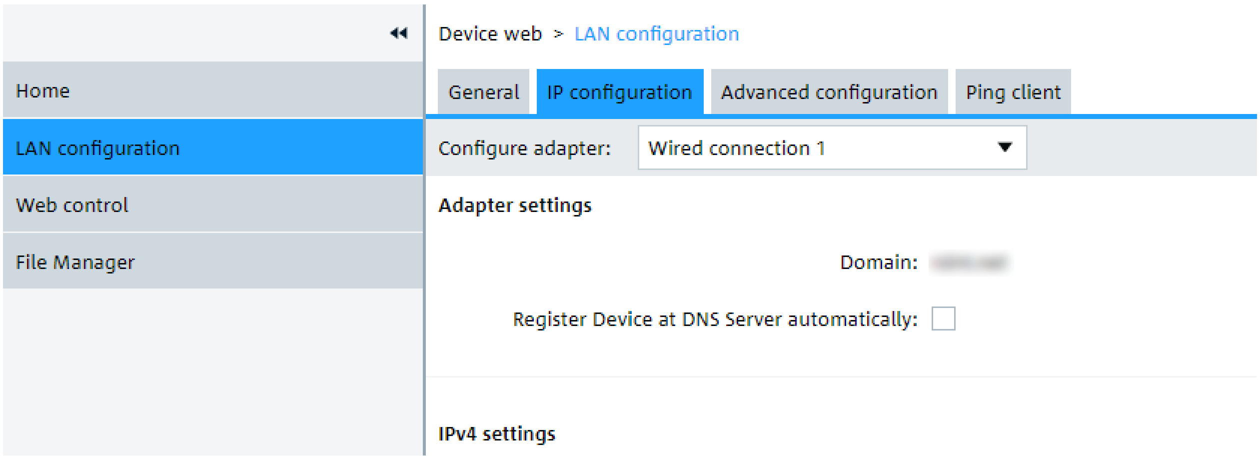
The LAN configuration consists of several parts:

- "General"
- "IP configuration" provides all mandatory LAN parameters.
- "Advanced configuration" provides LAN settings that are not declared mandatory by the standard.
- "Ping client" provides the ping utility to verify the connection between the instrument and other devices.

Changing the LAN parameters requires the "Web Ifc Password" password, which is set on the instrument.

IP configuration

The "LAN Configuration > IP configuration" web page displays all mandatory LAN parameters and allows their modification. Changing the LAN parameters requires the "Web Ifc Password" password, which is set on the instrument.



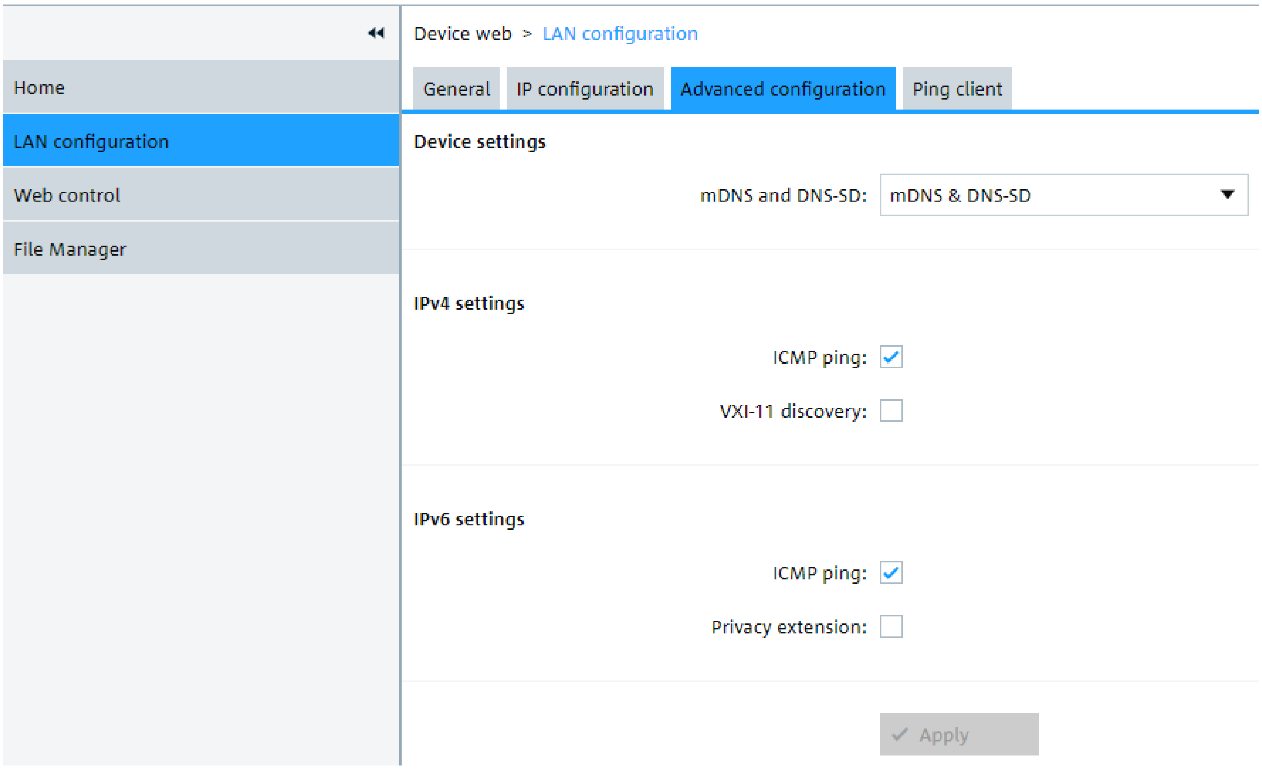
The "IP address mode" controls how the IP address for the instrument gets assigned. For the manual configuration mode, at least the static IP address, subnet mask, and default gateway are used to configure the LAN. The automatic configuration mode uses DHCP server or Dynamic Link Local Addressing to obtain the instrument IP address.

The same settings are available on the instrument under "Menu" > "Settings" > "System" > "Network" > "Advanced".

Advanced configuration

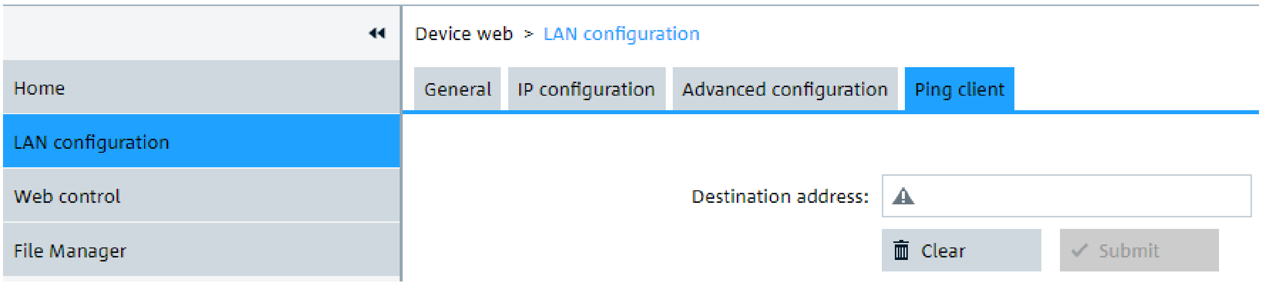
The "LAN Configuration > Advanced configuration" parameters are used as follows:

- mDNS and DNS-SD are two additional protocols: Multicast DNS and DNS Service Discovery. They are used for device communication in zero configuration networks working without DNS and DHCP.
- "ICMP ping" must be enabled to use the ping utility.
- "VXI-11" is the protocol that is used to detect the instrument in the LAN.



Ping client

Ping is a utility that verifies the connection between the instrument and another device. The ping command uses the `ICMP` echo request and echo reply packets to determine whether the LAN connection is functional. Ping is useful for diagnosing IP network or router failures. The ping utility is not password-protected.

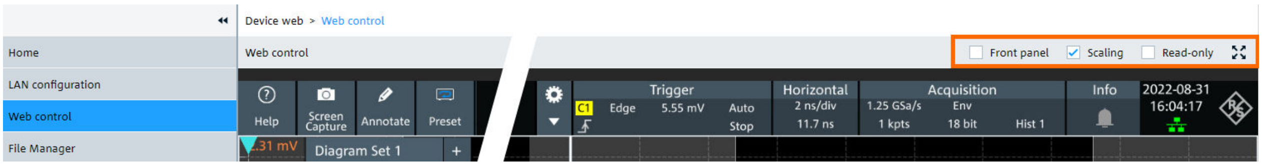


To initiate a ping between the compliant instrument and a second connected device:

1. Enable "ICMP ping" on the "Advanced configuration" page (enabled by default).
2. On the "Ping client" page, enter the IP address of the second device **without the ping command and without any further parameters** into the "Destination address" field (e.g. *11.113.11.203*).
3. Click "Submit".

16.2.2.2 Web control

"Web Control" emulates the front panel and shows the instrument display. You see a live image of the instrument, and you can operate the instrument remotely. You can use the keys, the knobs and the menus in the same way as directly on the instrument.



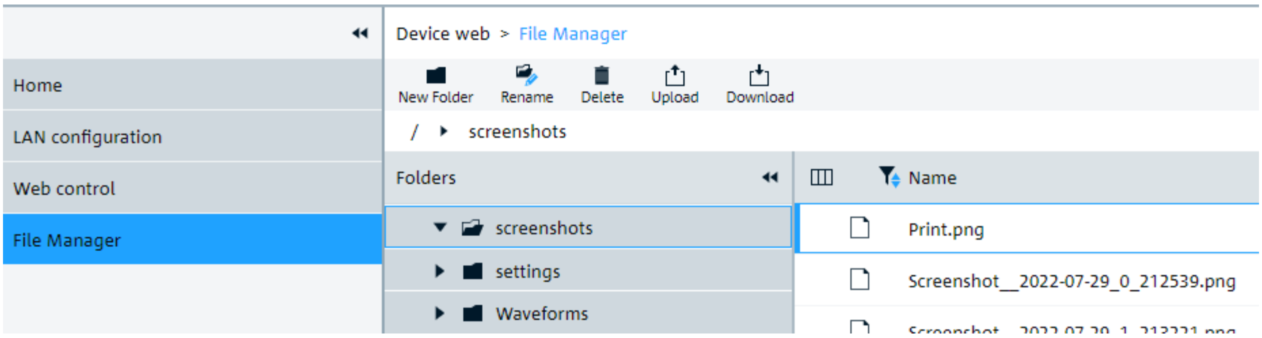
In the upper right corner above the emulated display, you see some options:

- "Front panel" hides or shows the front panel.
- "Scaling" scales the diagram to show it completely. If disabled, the diagram is shown in its original size.
- "Read-only" disables operating, only viewing is possible
- The arrows icon hides or shows the menu.

16.2.2.3 File manager

The file manager in the web browser provides access to the user data that is stored on the instrument.

You can organize the data on the instrument: create folders, rename and delete files. You can also upload and download files.



16.3 Remote operation with VNC client

If the R&S MXO 4 is connected to a computer via LAN, you can operate the instrument from the computer using a VNC client. Therefore, install a VNC client on the computer.

To operate the instrument via VNC client:

1. Start the VNC client.

2. Enter the hostname (device name) of the instrument. You find the name in the instrument information on the oscilloscope. Tap the Rohde & Schwarz logo to show the information.
3. Connect to the instrument.

   You see the display of the oscilloscope and can use the menus, dialogs, SmartGrid and all operating means of the display.

16.4 Remote control

Remote control automates the operation of the instrument using SCPI commands, scripts and programs.

For general information on remote control of Rohde & Schwarz products via SCPI, refer to www.rohde-schwarz.com/rc-via-scpi.

The following sections describe the instrument-specific basics of remote control. SCPI commands are listed described in chapter Chapter 17, "Remote control commands", on page 351.

16.4.1 Remote control interfaces and protocols

The instrument supports different interfaces for remote control. The following table gives an overview.

Table 16-1: Remote control interfaces and protocols

Interface	Protocols, VISA address string	Remarks

Local Area Network (LAN)	**Protocol HiSLIP**
	VISA address string:
	`TCPIP::<host address>::hislip0[,<port>][::INSTR]`
	Protocol VXI-11
	VISA address string:
	`TCPIP::<host address>[::inst0]::[INSTR]`
		The LAN connector is located on rear panel of the instrument.
		The interface is based on TCP/IP and supports various protocols.

16.4.1.1 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. The interface details are given in the specifications.

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 (shielded or unshielded twisted-pair category 5 or better). The TCP/IP network protocol and the associated network services are preconfigured on the instrument. Software for instrument control and the VISA program library must be installed on the controller.

IP address

Only the IP address or a valid DNS host name is required to set up the connection. The host address is part of the "VISA resource string" used by programs to identify and control the instrument. The VISA resource string has the form:

`TCPIP::<host address>::hislip0[,<port>][::INSTR]` for HiSLIP protocol

`TCPIP::<host address>[::inst0][::INSTR]` for VXI-11 protocol

Where:

- `host address` identifies the instrument in the network, usually the IP address. If the LAN is supported by a DNS server, the host name can be used instead of the IP address. The DNS server (Domain Name System server) translates the host name to the IP address.
- `hislip0` indicates the HiSLIP protocol.
- `inst0` is the default LAN device name. VISA supports several devices running on the instrument. On R&S MXO 4, only one device is configured, so the LAN device name can be omitted.
- `INSTR` specifies a VISA resource of the type INSTR. By default, the VISA resource name control is set to the INSTR class.

Example: HiSLIP

IP address is *192.1.2.3*: the valid resource string is: `TCPIP::192.1.2.3::hislip0`

Instrument name is *RSRT1*: the valid resource string is: `TCPIP::RSRT1::hislip0`.

DNS host name is *MXO 4-123456*: the valid resource string is:
`TCPIP::MXO 4-123456::hislip0`.

Example: VXI-11

IP address is *192.1.2.3*: the valid resource string is: `TCPIP::192.1.2.3`

Instrument name is *RSRT1*: the valid resource string is: `TCPIP::RSRT1`.

DNS host name is *MXO 4-123456*: the valid resource string is:
`TCPIP::MXO 4-123456`.

16.4.2 Starting and stopping remote control

16.4.2.1 Starting a remote control session

When you switch on the instrument, it is always in manual operation state ("local" state). It can be operated via the front panel, the touch screen and external keyboard and/or mouse.

► To start remote control:
- Send a command from the controller.
- VXI-11 protocol (LAN or USB interface): Use `&GTR` interface message.

While remote control is active, the instrument settings are optimized for maximum measurement speed; the display is switched off. Operation via the front panel is disabled.

On the touchscreen, two buttons appear in the upper left corner: "Local" and "View".

16.4.2.2 Using the display during remote control

You can observe the screen while a remote control script is executed. This is helpful for program test purposes but tends to slow down the measurement. Therefore it is recommended that you switch off the display in real measurement applications where a tested program script is to be executed repeatedly.

► To switch on the display, do one of the following:
- Tap the "View" button in the upper left corner of the touch screen.
- Use the `SYSTem:DISPlay:UPDate ON` command.

► To switch off the display, do one of the following:
- Tap the "View" button again.
- Use the `SYSTem:DISPlay:UPDate OFF` command.

16.4.2.3 Returning to manual operation

The instrument switches back to manual operation when the remote connection is closed. Besides, you can return to manual operation manually or via remote control.

► To return to manual operation:
- Tap the "Local" button in the upper left corner of the touch screen.
- VXI-11 protocol: Use `&GTL` interface message.

16.5 Remote control - status reporting system

The status reporting system stores all information on the current operating state of the instrument, and on errors which have occurred. This information is stored in the status registers and in the error queue. Both can be queried via `STATus`... commands.

16.5.1 Hierarchy of status registers

As shown in the following figure, the status information is of hierarchical structure.

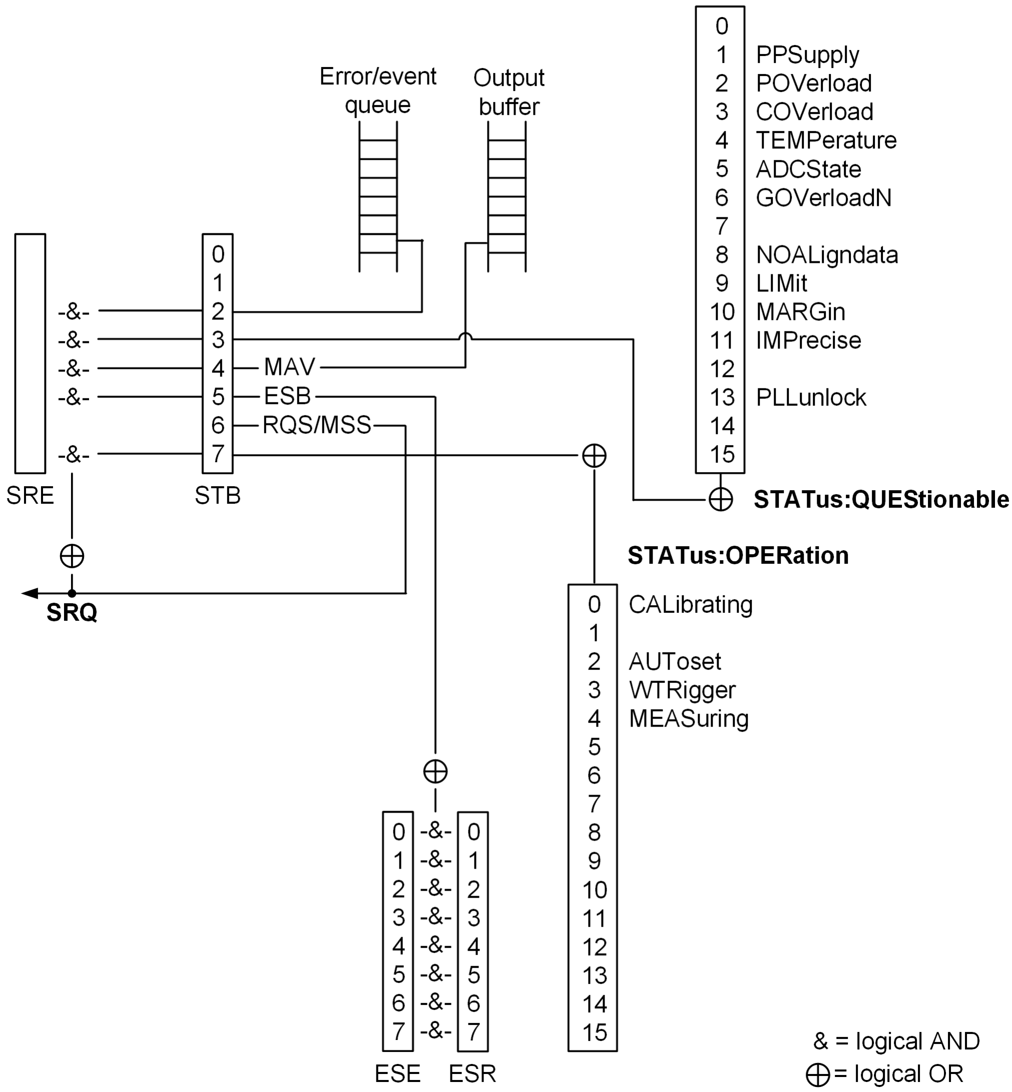


Figure 16-1: Overview of the status registers hierarchy

- **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.

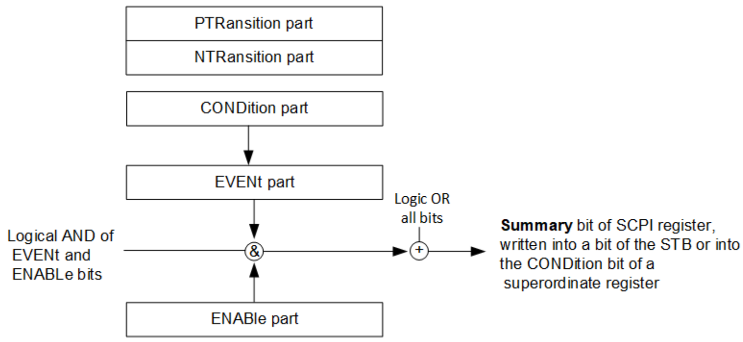
All status registers have the same internal structure.

16.5.2 Structure of a SCPI status register

The `STATus:OPERation` and the `STATus:QUEStionable` SCPI status registers consists of five parts.

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.

Description of the five status register parts



The five parts of a SCPI status register have different properties and functions:

- **CONDition**
  The `CONDition` part reflects the current instrument status. For summary bits, the `CONDition` bit mirrors the sum of the enabled `EVENt` bits of the next lower register.
  This register part can only be read, but not written into or cleared. Its contents are not affected by reading.
- **PTRansition / NTRansition**
  The two transition register parts define which state transition of the `CONDition` part (none, 0 to 1, 1 to 0 or both) is stored in the `EVENt` part.
  The **Positive-TRansition** part acts as a transition filter. When a bit of the `CONDition` part is changed from 0 to 1, the associated `PTR` bit decides whether the `EVENt` bit is set to 1.
  - PTR bit =1: the `EVENt` bit is set.
  - PTR bit =0: the `EVENt` bit is not set.

  All positive transitions are enabled by default.
  This part can be written into and read as required. Its contents are not affected by reading.

The **Negative-TRansition** part also acts as a transition filter. When a bit of the CONDition part is changed from 1 to 0, the associated NTR bit decides whether the EVENt bit is set to 1.

– NTR bit =1: the EVENt bit is set.
– NTR bit =0: the EVENt bit is not set.

All negative transitions are disabled by default.
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 allows you to detect the occurrence of events reliably, even if they have changed the state of the CONDition bit for a very brief interval. It only indicates events passed on by the transition filters.
This part can only be read by the user. **Reading the register clears it.**
- **ENABle**
The ENABle part determines whether the associated EVENt bit contributes to the summary 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 summary bit via an "OR" function (symbol '+').
ENABle bit = 0: the associated EVENt bit does not contribute to the summary bit
ENABle bit = 1: if the associated EVENt bit is "1", the summary 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.

16.5.3 Contents of the status registers

16.5.3.1 Status byte (STB) and service request enable register (SRE)

The STatus Byte (STB) is already defined in IEEE 488.2. It provides a rough overview of the instrument status by collecting the pieces of information of the lower registers. A special feature is that bit 6 acts as the sum bit of the remaining bits of the status byte.

The STB can thus be compared with the CONDition part of an SCPI register and assumes the highest level within the SCPI hierarchy.

The STB is read using the command *STB? or a serial poll.

The STatus Byte (STB) is linked to the Service Request Enable (SRE) register. Each bit of the STB is assigned a bit in the SRE. Bit 6 of the SRE is ignored. If a bit is set in the SRE and the associated bit in the STB changes from 0 to 1, a service request (SRQ) is generated. The SRE can be set using the command *SRE and read using the command *SRE?.

Table 16-2: 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 register summary bit The bit is set if an `EVENt` bit is set in the `QUEStionable` status register and the associated `ENABle` bit is set to 1. A set bit indicates a questionable instrument status, which can be specified in greater detail by querying the `STATus:QUEStionable` status register.
4	MAV bit (message available) The bit is set if a message is available in the output queue which can be read. This bit can be used to enable data to be automatically read from the instrument to the controller.
5	ESB bit Sum bit of the event status register. It is set if one of the bits in the event status register is set and enabled in the event status enable register. Setting of this bit indicates a serious error which can be specified in greater detail by polling the event status register.
6	MSS bit (main status summary bit) The bit is set if the instrument triggers a service request. This is the case if one of the other bits of this registers is set together with its mask bit in the service request enable register SRE.
7	`STATus:OPERation` status register summary bit The bit is set if an `EVENt` bit is set in the `OPERation` status register and the associated `ENABle` bit is set to 1. A set bit indicates that the instrument is just performing an action. The type of action can be determined by querying the `STATus:OPERation` status register.

16.5.3.2 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 16-3: Meaning of the bits used in the event status register

Bit No.	Meaning
0	Operation Complete This bit is set on receipt of the command `*OPC` exactly when all previous commands have been executed.
1	Not used

Bit No.	Meaning
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 when you turn on the instrument.

16.5.3.3 STATus:OPERation register

In the `CONDition` part, this register contains information on which actions the instrument is executing. In the `EVENt` part, it contains information on which actions the instrument has executed since the last reading.

It can be read using the commands `STATus:OPERation:CONDition?` or `STATus:OPERation[:EVENt]?`, see also Chapter 17.19.2, "STATus:OPERation register", on page 623.

Table 16-4: Bits in the STATus:OPERation register

Bit No.	Meaning
0	`ALIGnment` This bit is set as long as the instrument is performing a self-alignment.
1	Not used
2	`AUToset` This bit is set while the instrument is performing an auto setup.
3	`WTRIgger` The wait for trigger status bit indicates that the instrument is ready to trigger, and the pre-trigger time is expired. The bit is set if the instrument did not trigger for more than 10 ms.

Bit No.	Meaning
4	`MEASuring` The bit is set as long as an acquisition - sampling and postprocessing - is running. In run continuous mode, the bit is always set.
5 - 15	Not used

16.5.3.4 STATus:QUEStionable register

This register contains information about indefinite states which may occur if the unit / functions are operated without meeting the specifications. It can be read using the commands `STATus:QUEStionable:CONDition?` and `STATus:QUEStionable[:EVENt]?`

The remote commands for the STATus:QUEStionable register are described in Chapter 17.19, "Status reporting", on page 623.

Table 16-5: Bits in the STATus:QUEStionable register

Bit No.		Meaning
0	-	For future use.
1	`PPSupply`	This bit is set if probe power supply overload occurs.
2	`POVerload`	This bit is set if a probe overload occurs.
3	`COVerload`	This bit is set if a questionable channel overload occurs.
4	`TEMPerature`	This bit is set if a questionable temperature occurs.
5	`ADCState`	The bit is set if the signal is clipped on the upper or lower edge of the screen-overflow of the ADC occurs.
6	`GOVerload`	This bit is set if a generator overload occurs.
7	-	For future use.
8	`NOALigndata`	This bit is set if no alignment data is available - the instrument is uncalibrated.
9	`LIMit`	This bit is set if a limit value is violated.
10	`MARGin`	This bit is set if a margin value is violated, and the limit value is not violated.
11	`IMPRecise`	This bit is set if the magnitude of the signal is too low to get reliable measurement results.
12	-	For future use.
13	-	For future use.
14	-	For future use.

16.5.3.5 Application of the status reporting system

The purpose of the status reporting system is to monitor the status of one or several instruments in a test system. The controller must receive and evaluate the information of all devices.

The following standard methods are used:

- **Service request**: An SRQ is initiated by the instrument.
- Query of a **specific register** by commands
- Query of the **error queue**

These methods are described in the following sections.

Service request

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.

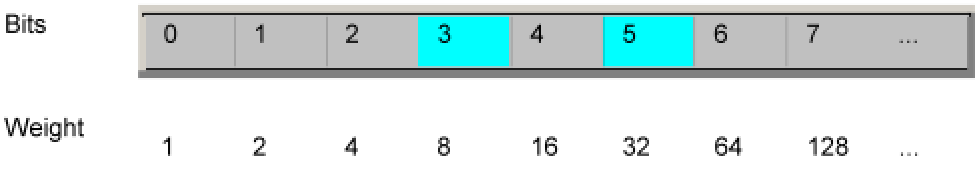
An SRQ is initiated if one or several of bits 2, 3, 4, 5 or 7 of the STB are set and enabled in the SRE. Each of these bits combines the information of a lower-level register, the error queue or the output buffer.

The `ENABle` parts of the status registers can be set such that arbitrary bits in an arbitrary status register initiate an SRQ. To use service requests effectively, set all bits to "1" in the mask registers SRE and ESE.

The SRQ is the only possibility for the instrument to become active on its own. Configure the instrument so that it initiates a service request if errors occur. And ensure that your program reacts appropriately to service requests.

Query of a register

The STB and ESR registers contain 8 bits, the SCPI registers 16 bits. The contents of a status register are specified and transferred as a single decimal number. To make this possible, each bit is assigned a weighted value. The decimal number is calculated as the sum of the weighted values of all bits in the register that are set to 1.



Example:

The decimal value 40 = 32 + 8 indicates that bits no. 3 and 5 in the status register (e.g. the `QUEStionable` status summary bit and the `ESB` bit in the `STatus` Byte) are set.

16.5.4 Error queue

Each error state in the instrument leads to an entry in the error queue.

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.

16.5.5 Reset values of the status reporting system

The following table contains the different commands and events causing the status reporting system to be reset. None of the commands, except `*RST` and `SYSTem:PRESet`, influence the functional instrument settings. In particular, `DCL` does not change the instrument settings.

Table 16-6: Resets of the status reporting system

Event	`DCL, SDC` **(Device Clear, Selected Device Clear)**	`*RST` **or** `SYSTem:PRESet`	`STATus:PRESet`	`*CLS`
Clear STB, ESR	-	-	-	yes
Clear SRE, ESE	-	-	-	-
Clear EVENt parts of the registers	-	-	-	yes
Clear ENABle parts of all OPERation and QUEStionable registers; Fill ENABle parts of all other registers with "1".	-	-	yes	-
Fill PTRansition parts with "1"; Clear NTRansition parts	-	-	yes	-
Clear error queue	-	-	-	yes
Clear output buffer	yes	1)	1)	1)
Clear command processing and input buffer	yes	-	-	-
1) The first command in a command line that immediately follows a <PROGRAM MESSAGE TERMINATOR> clears the output buffer.				

17 Remote control commands

This chapter describes all remote commands available for R&S MXO 4 and provides examples and information how to use the commands.

17.1 Conventions used in remote command description

The following conventions are used in the remote command descriptions:

- **Command usage**
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.
- **Parameter usage**
  If not specified otherwise, a parameter can be used to set a value and it is the result of a query.
  Parameters required only for setting are indicated as **Setting parameters**.
  Parameters required only to refine a query are indicated as **Query parameters**.
  Parameters that are only returned as the result of a query are indicated as **Return values**.
- **Conformity**
  Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the R&S MXO 4 follow the SCPI syntax rules.
- **Asynchronous commands**
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an **Asynchronous command**.
- **Reset values (*RST)**
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as ***RST** values, if available.
- **Default unit**
  The default unit is used for numeric values if no other unit is provided with the parameter.

17.2 Finding the appropriate command

In the following chapters, the commands are sorted according to the menu and dialog structure of the instrument.

A list of all commands in alphabetical order is given in the "List of Commands" at the end of this documentation.

To find the appropriate command for a setting easily, you can use the context help:

1. Enable the "Help" icon on the toolbar.
2. Tap the parameter for which you need information.

   The "Help" window opens and displays the comprehensive description and the corresponding remote command.
3. Tap the remote command link to open the command description.

17.3 Frequently used parameters and suffixes

This chapter describes in general those parameters and suffixes that are used in several subsystems.

17.3.1 Waveform parameter

Many commands require one of the waveforms to be specified as source. The following table lists all waveforms. For each command using a waveform parameter, the available waveforms are specified in the command description.

Waveform	Description
C1 | C2 | C3 | C4 CHAN1 = C1, CHAN2 = C2, CHAN3 = C3, CHAN4 = C4	Channel waveforms
M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8	Math waveforms
R1 | R2 | R3 | R4	Reference waveforms
SBUS1 | SBUS2 | SBUS3 | SBUS4	Serial buses
D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15	Digital channels (option R&S MXO4-B1)
PBUS1 | PBUS2 | PBUS3 | PBUS4	Digital buses (option R&S MXO4-B1)
SPECMAXH1 | SPECMINH1 | SPECNORM1 | SPECAVER1	Spectrum traces: SPECMAXH1 : Spectrrum1 maxhold SPECMINH1: Spectrrum1 minhold SPECNORM1: Spectrrum1 normal SPECAVER1: Spectrrum1 average

17.3.2 Slope parameter

The slope parameter is used with several trigger and search condition commands.

Slope	Description
POSitive	Rising edge, which is a positive voltage change.
NEGative	Falling edge, which is a negative voltage change.
EITHer	Rising as well as the falling edge.

17.3.3 Polarity parameter

The polarity parameter is used with several trigger and search condition commands.

Polarity	Description
POSitive	Positive going pulses.
NEGative	Negative going pulses.
EITHer	Both positive and negative going pulses.

17.4 Programming examples

17.4.1 SmartGrid layout with zoom

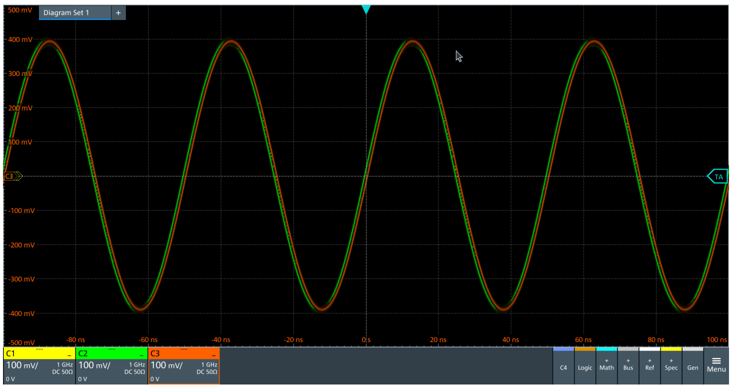
The following example uses 3 sine waves, all with frequency 20 MHz and an amplitude of ±0.4 V. The vertical scale is 100 mV/div, the time scale is 20 ns/div.

In the example, 2 layouts (diagram sets) are created, waveforms are assigned, and zoom and spectrum are added.

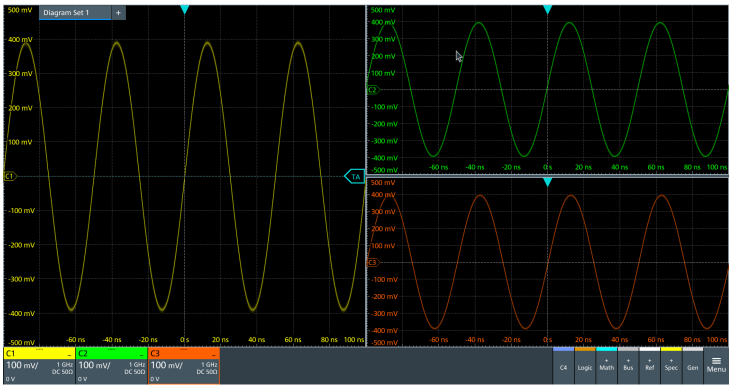
For a description of the commands, see:

- Chapter 17.7.2, "SmartGrid", on page 364
- Chapter 17.10.1, "Zoom", on page 439
- Chapter 17.14.1, "Spectrum setup", on page 502

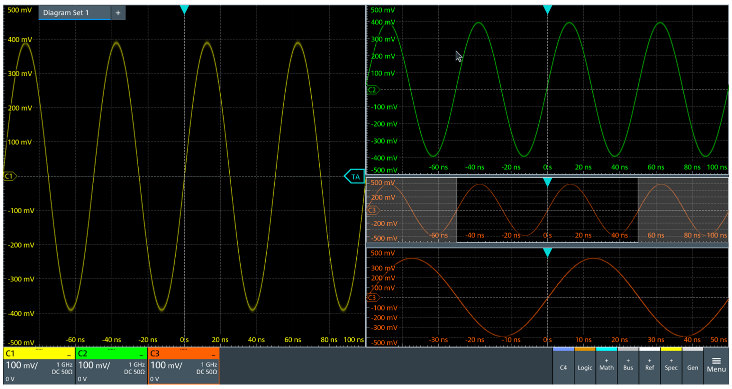
```
//Prepeare: 3 channel signals.
//Enable C1, C2 and C3.
CHAN1:STAT 1
CHAN2:STAT 1
CHAN3:STAT 1
```



```
//Create new diagrams for C2 and C3.
//Assign sources C2 and C3 to these diagrams.
LAY:DIAG2:ENAB 1
LAY:DIAG2:SOUR C2
LAY:DIAG3:ENAB 1
LAY:DIAG3:SOUR C3
//Create new node (node 2) and assign new diagrams to that node
//Place C2 on top, C3 at bottom
LAY:NODE2:ENAB 1
LAY:NODE2:CHIL1:CONT:TYPE DIAG
LAY:NODE2:CHIL1:CONT:ID 2
LAY:NODE2:CHIL2:CONT:TYPE DIAG
LAY:NODE2:CHIL2:CONT:ID 3
LAY:NODE2:STYP VERT
//Insert node 2 into the base node (initial node)
//Diagram1 is initially located at child 1
LAY:NODE1:CHIL2:CONT:TYPE NODE
LAY:NODE1:CHIL2:CONT:ID 2
//Place both nodes side by side
LAY:NODE1:STYP HOR
```

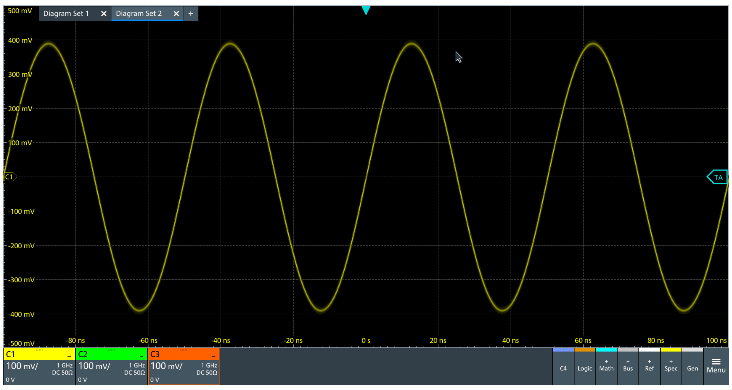


```
//Add zoom to C3. The zoom is located in diagram 3.
LAY:ZOOM:ENAB 1
LAY:ZOOM:SOUR 3
```

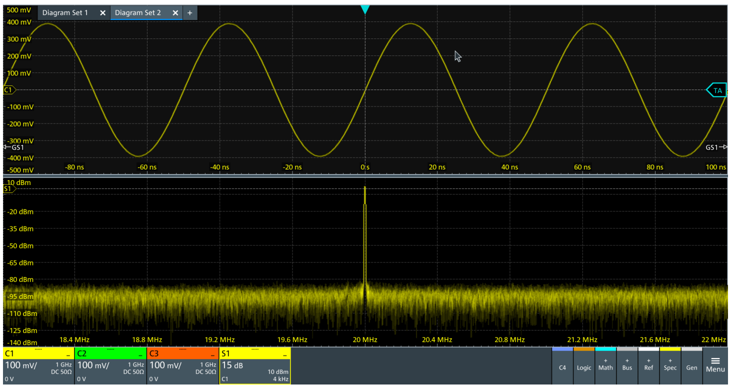


```
//Add a second layout with C1 and spectrum of C1.
//By default, the new layout is empty.
LAY2:ENAB 1
```

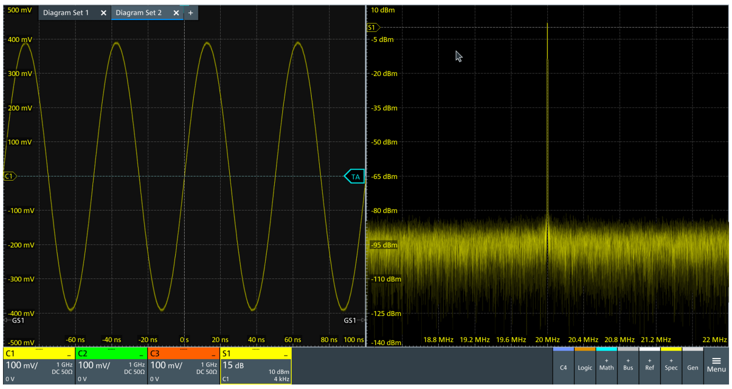
```
//Assign C1 to layout 2.
LAY2:DIAG1:SOUR C1
```



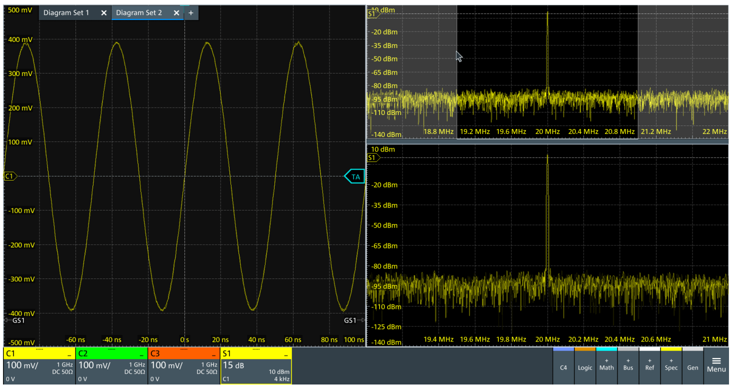
```
//Turn on spectrum of C1.
//By default, the spectrum is set below its analog source, and into the next
//free diagram (here diagram 2).
CALC:SPEC:STAT 1
CALC:SPEC:FREQ:CENT 20e6
CALC:SPEC:FREQ:SPAN 4e6
CALC:SPEC:FREQ:SCAL 15
```



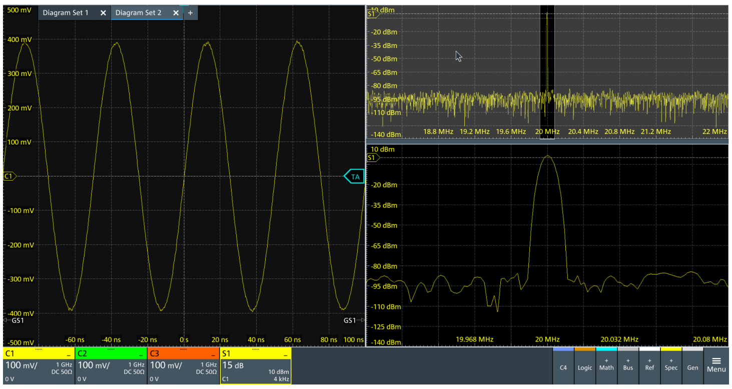
```
//Set C1 and spectrum side by side by changing the split type.
LAY2:NODE1:STYP HOR
```



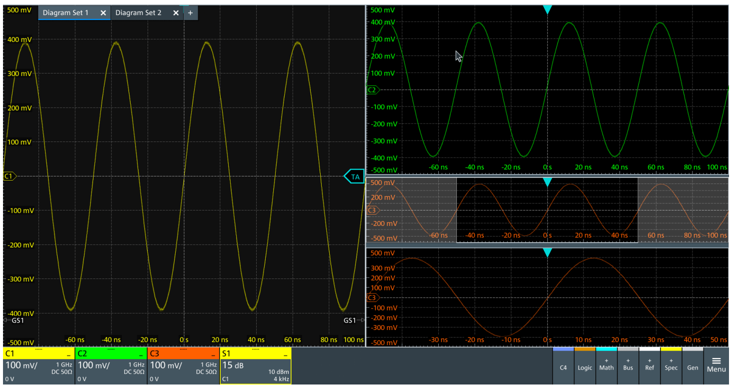
```
//Add zoom to spectrum. The zoom is located in layout 2, in diagram 2.
LAY2:ZOOM:ENAB 1
LAY2:ZOOM:SOUR 2
```



```
//Change zoom area.
LAY2:ZOOM:HOR:MODE REL
LAY2:ZOOM:HOR:REL:START 48
LAY2:ZOOM:HOR:REL:STOP 52
```



```
//Switch back to first layout (diagram set 1).
LAY1:SACT
```



17.5 Common commands

Common commands are described in the IEEE 488.2 (IEC 625-2) standard. These commands have the same effect and are employed in the same way on different devices. The headers of these commands consist of "*" followed by three letters. Many common commands are related to the Status Reporting System.

Available common commands:

*CAL?

Starts a self-alignment of the instrument, and then queries a status response. Return values ≠ 0 indicate an error.

Return values:

<State>	0: no error 1: alignment failed 2: not aligned, e.g. init 3: device needs longer warmup time before selfalignment can start 4: input signal connected during selfalignment
Usage:	Query only

*CLS

Clear status

Sets the status byte (STB), the standard event register (ESR) and the `EVENt` part of the `QUEStionable` and the `OPERation` registers to zero. The command does not alter the mask and transition parts of the registers. It clears the output buffer.

Usage: Setting only

*IDN?

Identification

Returns the instrument identification.

Return values:

<ID>	"Rohde&Schwarz,<device type>,<part number>/<serial number>,<firmware version>"
Example:	`Rohde&Schwarz,MXO4,1335.5050K04/100222,1.00.0.2` Model assignment:
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 writes a "1" into the output buffer when all preceding commands have been executed, which is useful for command synchronization.

*OPT?

Option identification query

Queries the options included in the instrument. For a list of all available options and their description, refer to the data sheet.

Return values:

<Options> The query returns a list of options. The options are returned at fixed positions in a comma-separated string. A zero is returned for options that are not installed.

Usage: Query only

***RCL** <Number>

Recall

Loads the instrument settings from an intermediate memory identified by the specified number. The instrument settings can be stored to this memory using the command `*SAV` with the associated number.

***RST**

Reset

Sets the instrument to a defined default status. The default settings are indicated in the description of commands.

This command does not affect the waveform generator settings. To reset the generator use `WGENerator<wg>:PRESet`.

Usage: Setting only

***SAV** <Number>

Save

Stores the current instrument settings under the specified number in an intermediate memory. The settings can be recalled using the command `*RCL` with the associated number.

***SRE** <Contents>

Service request enable

Sets the service request enable register to the indicated value. This command determines under which conditions a service request is triggered.

Parameters:

<Contents> Contents of the service request enable register in decimal form. Bit 6 (MSS mask bit) is always 0.

Range: 0 to 255

***STB?**

Status byte query

Reads the contents of the status byte in decimal form.

Usage: Query only

***TRG**

Trigger

Triggers all actions waiting for a trigger event. In particular, *TRG generates a manual trigger signal. This common command complements the commands of the `TRIGger` subsystem.

Usage: Event

***WAI**

Wait to continue

Prevents servicing of the subsequent commands until all preceding commands have been executed and all signals have settled (see also command synchronization and `*OPC`).

Usage: Event

17.6 General remote settings

This chapter describes commands that affect many other remote commands in different applications of the instrument.

FORMat[:DATA] [<Format>],[<Length>]
FORMat[:DATA]? [<Format>]

Selects the data type that is used for transmission of data from analog channels, math and reference waveforms, and some measurement results from the instrument to the controlling computer.

Setting parameters:
<Length> *RST: ASCii

Parameters for setting and query:
<Format> ASCii | REAL | INT

ASCii
Data values are returned in ASCII format as a list of comma-separated values in floating point format. The length can be omitted. It is 0 which means that the instrument selects the number of digits to be returned. The query returns both values (`ASC,0`).

REAL,32
The data is stored as binary data (Definite Length Block Data according to IEEE 488.2). Each waveform value is formatted in 32-Bit IEEE 754 Floating Point Format.
The schema of the result string is as follows:
`#41024<value1><value2>…<value n>` with:
`#4` = number of digits (= 4 in the example) of the following number
`1024` = number of following data bytes (= 1024 in the example)
`<value>` = 4-byte floating point values
For large data (≥ 1 GB), the result string starts with "#(data length)". The number inside the parentheses indicates the real data length in bytes.

INT,8 | INT,16 | INT,32
Signed integer data with length 8 bit, 16 bit, or 32 bit.
The result string has the same schema as the REAL format.
Fot INT,16 you can set the byte order using the command.
For digital channel data, math and histogram data, INT formats are not available.

Example:
```
FORMat:DATA REAL,32
FORMat:DATA?
REAL,32
```

Usage: SCPI confirmed

Manual operation: See "Transfer data format" on page 69

FORMat:BPATtern <BtPattFmt>

Sets the number format for remote bit pattern queries on serial protocols.

Parameters:
<BtPattFmt> DEC | HEX | OCT | BIN | ASCII | ASCii | STRG
*RST: HEX

Manual operation: See "Bitpattern format" on page 69

SYSTem:DISPlay:UPDate <DisplayUpdate>

Defines whether the display is updated while the instrument is in the remote state. If the display is switched off, the normal GUI is replaced by a static image while the instrument is in the remote state. Switching off the display can speed up the measurement. This is the recommended state.

Parameters:

<DisplayUpdate> ON | OFF

`ON | 1`: Display is shown and updated during remote control.

`OFF | 0`: Display shows static image during remote control.

*RST: OFF

Example:
```
SYSTem:DISPlay:UPDate 1
```
Switch on the display update.

SYSTem:DISPlay:MESSage:STATe <DispMessSt>

Enables and disables the display of an additional text in remote control.

To define the text, use `SYSTem:DISPlay:MESSage[:TEXT]`.

Parameters:

<DispMessSt> ON | OFF

*RST: OFF

SYSTem:DISPlay:MESSage[:TEXT] <DisplayMessage>

Defines an additional text that is displayed during remote control operation.

To enable the text display, use `SYSTem:DISPlay:MESSage:STATe`.

Parameters:

<DisplayMessage>

17.7 Instrument setup

17.7.1 System

DIAGnostic:SERVice:COMPutername <Hostname>

The query returns the device name that is currently defined. The device name is required when configuring a network.

The setting command changes the device name. The change takes effect after the next reboot of the device.

Parameters:

<Hostname>	String parameter

Manual operation: See "Device name" on page 67

SYSTem:DATE <Year>,<Month>,<Day>

Sets the date of the internal calendar.

Parameters:

<Year> Year, to be entered as a four-digit number (including the century and millennium information)

Range: 2012 to 2099
Increment: 1
*RST: 2012

<Month> Month, 1 (January) to 12 (December)

Range: 1 to 12
Increment: 1
*RST: 1

<Day> Day, 1 to the maximum number of days in the specified month

Range: 1 to 31
Increment: 1
*RST: 1

Example: `SYSTem:DATE?`
Returned value: `2022,09,28`

Manual operation: See "Date and time" on page 71

SYSTem:TIME <Hours>,<Minutes>,<Seconds>

Returns the current time of the clock.

Parameters:

<Hours> Range: 0 to 24
Increment: 1
*RST: 1

<Minutes> Range: 0 to 59
Increment: 1
*RST: 1

<Seconds> Range: 0 to 59
Increment: 1
*RST: 1

Manual operation: See "Date and time" on page 71

17.7.2 SmartGrid

The following `LAYout` commands configure the SmartGrid. In manual operation, you configure the SmartGrid by drag and drop.

Table 17-1: Terms and definitions of SmartGrid configuration

Term	Definition
Layout	A layout is a SmartGrid configuration. Several configurations can exist but only one configuration is active. By default, SmartGrid configurations named "Diagram Set" on the display.
Children	A child is an area where data (data table, result table) or waveforms (diagram) are dis- played. Also a node can be a child (nested node).
Node	A node consists of one or two children. A node is created with one child that has con- tent.
Diagram	A diagram displays waveforms, the graphical visualization of data.

LAYout<m>:COUNt?

Returns the number of available layouts, i.e. SmartGrid configurations. By default, they named "Diagram Set" on the display.

Suffix:
<m> Irrelevant, omit the suffix.

Return values:
<Count> Number of SmartGrid configurations

Usage: Query only
Asynchronous command

LAYout<m>[:ENABle] <State>

Creates a new SmartGrid configuration and sets it active.

Suffix:

<m>	1...4, index of the SmartGrid layout

Parameters:

<State>	ON | OFF

Example: See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.

Usage: Asynchronous command

LAYout<m>:ACTive <ActiveKey>

Sets the active SmartGrid configuration. The query returns the index of the active layout.

Suffix:

<m>	Irrelevant, omit the suffix.

Parameters:

<ActiveKey>	Index of the active layout

Usage: Asynchronous command

LAYout<m>:SACTive

Activates the specified SmartGrid configuration. The command has the same effect as `LAYout<m>:ACTive` but it has no query, and the active layout is specified by the suffix.

Suffix:

<m>	1...4, index of the SmartGrid layout

Example: See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.

Usage: Setting only
Asynchronous command

LAYout<m>:LABel <Label>

Defines a name for the specified layout (SmartGrid configuration).

Suffix:

<m>	1...4, index of the SmartGrid layout

Parameters:

<Label>	String with the layout name

Usage: Asynchronous command

LAYout<m>:DIAGram<n>:COUNt?

Returns the number of diagrams in a specified layout.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	Irrelevant, omit the suffix.

Return values:

<Count>	Number of diagrams

Usage: Query only
Asynchronous command

LAYout<m>:DIAGram<n>[:ENABle] <State>

Creates and displays a specified diagram in a specified layout. OFF deletes the diagram.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...8, index of the diagram

Parameters:

<State>	ON | OFF

Example: See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.

Usage: Asynchronous command

LAYout<m>:DIAGram<n>:SOURce <SignalKeys>

Assigns the waveforms to a diagram.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...8, index of the diagram

Parameters:

<SignalKeys>	String with a comma-separated list of waveforms, e.g. `"C1, C2, M1"`

Example: See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.

Usage: Asynchronous command

LAYout<m>:DIAGram<n>:LABel <Label>

Defines a name for the specified diagram in a specified layout.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...8, index of the diagram

Parameters:

<Label>	String with the diagram name

Usage: Asynchronous command

LAYout<m>:NODE<n>:COUNt?

Returns the maximum number of nodes that can be defined. This number is the maximum value for the node suffix.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	Irrelevant, omit the suffix.

Return values:

<Count>	Maximum value for the node suffix

Usage: Query only
Asynchronous command

LAYout<m>:NODE<n>[:ENABle] <State>

Creates the specified node in the specified layout. OFF deletes the node and its children.

The query returns whether the specified node exists (1) or not (0).

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	Index of the node

Parameters:

<State>	ON | OFF

Example: See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.

Usage: Asynchronous command

LAYout<m>:NODE<n>:CHILdren<o>:CONTent<p>:ID <ID>

Sets the content ID, the number of the specified content type.

For example, the "Diagram5" has Type=DIAGRAM and ID=5.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	Index of the node
<o>	1 | 2, child index
<p>	Irrelevant, omit the suffix.

Parameters:

<ID>	Numeric value

Example: See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.

Usage: Asynchronous command

LAYout<m>:NODE<n>:CHILdren<o>:CONTent<p>:TYPE <Type>

Sets the content type for a specified child in a specified node: diagram, result table, another node, or empty.

For example, the "Diagram5" has Type=DIAGRAM and ID=5.

Suffix:

<m> — 1...4, index of the SmartGrid layout

<n> — Index of the node

<o> — 1 | 2, child index

<p> — Irrelevant, omit the suffix.

Parameters:

<Type> — NONE | DIAG | DIAGRAM | RES | RESULT | NODE

DIAG = DIAGRAM, RES = RESULT

*RST: NONE

Example: See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.

Usage: Asynchronous command

LAYout<m>:NODE<n>:RATio <SplitRatio>

Sets the size ratio of the two children in the specified node.

Suffix:

<m> — 1...4, index of the SmartGrid layout

<n> — Index of the node

Parameters:

<SplitRatio> — Size ratio of the children. 0.5 assigns 50% of the node size to each child. 0.3 assigns 30% to child 1 and 70% to child 2.

Range: 0 to 1
Increment: 0.0001
*RST: 0.5

Usage: Asynchronous command

LAYout<m>:NODE<n>:STYPe <SplitType>

Creates a second child (e.g. diagram) in the node if only one child exists, and sets the splitting of the node. If two children exist, only the splitting is set.

Suffix:

<m> — 1...4, index of the SmartGrid layout

<n> — Index of the node

Parameters:

<SplitType> HOR | HORIZONTAL | VERT | VERTICAL

HOR = HORIZONTAL, VERT = VERTICAL

*RST: NONE

Example: See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.

Usage: Asynchronous command

17.7.3 Appearance

17.7.3.1 Waveform colors

DISPlay:COLor:SIGNal:CATalog?

Returns a comma-separated list of valid signal names. The signal names are needed in other DISPlay:COLor commands to set the <Signal> parameter.

Usage: Query only
Asynchronous command

DISPlay:COLor:SIGNal:COLor <Signal>,<Value>

Selects the color of the selected waveform.

Parameters:

<Value> Decimal value of the ARGB color. Use the color dialog box on the instrument to get the hex value of the color, and convert the hex value to a decimal value.
0 is fully transparent black.
4278190080 (dec) = FF000000 (hex) is opaque black.
4294967295 (dec) = FFFFFFFF (hex) is opaque white.

Setting parameters:

<Signal> Signal name as returned by `DISPlay:COLor:SIGNal:CATalog?`.

Usage: Asynchronous command

Manual operation: See "Color" on page 73

DISPlay:COLor:SIGNal:ASSign <Signal>,<ColorTable>

Assigns a color table to the source waveform instead of a dedicated color.

Parameters:

<ColorTable> String with the name of the color table

Setting parameters:

<Signal> Signal name as returned by `DISPlay:COLor:SIGNal:CATalog?`.

Usage: Asynchronous command

Manual operation: See "Assigned color table" on page 73

DISPlay:COLor:SIGNal:USE <Signal>,<State>

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

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

Parameters:

<State> ON | OFF

Setting parameters:

<Signal> Signal name as returned by `DISPlay:COLor:SIGNal:CATalog?`.

Usage: Asynchronous command

Manual operation: See "Use color table" on page 73

17.7.3.2 Grid appearance

DISPlay:DIAGram:CROSshair <Crosshair>

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

Parameters:

<Crosshair> ON | OFF

*RST: ON

Usage: Asynchronous command

Manual operation: See "Show crosshair" on page 75

DISPlay:DIAGram:FINegrid <ShowFineScale>

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

Parameters:
<ShowFineScale> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "Show fine grid scale" on page 75

DISPlay:DIAGram:GRID <Show>

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

Parameters:
<Show> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "Show grid" on page 75

DISPlay:DIAGram:LABels <ShowLabels>

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

Parameters:
<ShowLabels> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "Show labels" on page 75

DISPlay:DIAGram:YFIXed <YGridFixed>

If enabled, the horizontal grid lines remain in their position when the position of the curve is changed. Only the values at the grid lines are adapted.

Fixed horizontal grid lines correspond to the behavior of traditional oscilloscopes.

Parameters:
<YGridFixed> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "Keep Y-grid fixed" on page 76

17.7.3.3 Peak list appearance

CALCulate:SPECtrum<sp>:PLISt:LABel:BORDer <LabelBorder>

Defines the layout of the labels, full border or none.

Suffix:
<sp> *

Parameters:
<LabelBorder> NOBorder | FULL

FULL: Full border

*RST: FULL

Usage: Asynchronous command

Manual operation: See "Frame type" on page 78

17.7.4 Display

17.7.4.1 Persistence

DISPlay:PERSistence:INFinite <State>

If infinite persistence is enabled, each new waveform point remains on the screen until this option is disabled. Use infinite persistence to display rare events in the signal.

Parameters:
<State> ON | OFF

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Infinite persistence" on page 80

DISPlay:PERSistence:RESet

Resets the display, removing persistent all waveform points.

Usage: Setting only
Asynchronous command

Manual operation: See "Reset" on page 80

DISPlay:PERSistence:TIME <Time>

Sets a time factor that controls how long the waveforms points fade away from the display. Thus, the R&S MXO 4 emulates the persistence of analog phosphor screens.

Parameters:
<Time> Range: 0.05 to 50
Increment: 0.05
*RST: 0.05
Default unit: s

Usage: Asynchronous command

Manual operation: See "Time" on page 80

DISPlay:PERSistence[:STATe] <State>

If enabled, each new data point in the diagram area remains on the screen for the duration defined using `DISPlay:PERSistence:TIME`, or as long as `DISPlay:PERSistence:INFinite` is enabled.

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

Parameters:
<State> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "Enable" on page 80

17.7.4.2 Signal

DISPlay:INTensity <Intensity>

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

Parameters:
<Intensity> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Intensity" on page 81

DISPlay:DIAGram:STYLe <Style>

Selects the style in which the waveform is displayed.

Parameters:

<Style> VECTors | DOTS

VECTors
The individual data points are connected by a line.

DOTS
Only the individual data points are displayed.

*RST: VECTors

Usage: Asynchronous command

Manual operation: See "Waveform style" on page 81

17.7.4.3 Save/Recall

Autonaming

MMEMory:AUTonaming:PREFix <MainNmeStemSt>
MMEMory:AUTonaming:TIME <DateTime>
MMEMory:AUTonaming:INDex <NameIndex>

Includes or excludes the prefix/ date/time /index in the file name pattern for automatic file name generation. This name is used as the default file name.

The prefix indicates the type of data that is saved, for example, RefCurve, Settings.

Parameters:

<NameIndex> ON | OFF

*RST: ON

Manual operation: See "Index" on page 92

MMEMory:AUSave:ENABle <EnableAutosave>

Enables the automatic saving of the waveform. You can set the autosave interval with `MMEMory:AUSave:INTerval`.

Parameters:

<EnableAutosave> ON | OFF
*RST: ON

Manual operation: See "Enable autosave" on page 92

MMEMory:AUSave:INTerval <AutosaveIntvl>

Defines the time interval for the automatic saving of the waveform, if `MMEMory:AUSave:ENABle` is set to `ON`.

Parameters:

<AutosaveIntvl> Range: 1 to 360000
Increment: 1
*RST: 300
Default unit: s

Manual operation: See "Enable autosave" on page 92

MMEMory:AUTonaming:USERtext <NmeStringSt>

If enabled, inserts the specified user text after the prefix.

You can define the text with `MMEMory:AUTonaming:TEXT`.

Parameters:

<NmeStringSt> ON | OFF
*RST: OFF

Manual operation: See "User text" on page 91

MMEMory:AUTonaming:DEFaultpath <Path>

Sets the path where data and settings files will be stored. On the instrument, all user data is written to `home/storage/userData`. You can create subfolders in this folder.

Parameters:

<Path> String parameter

Manual operation: See "Default path for all file operations" on page 92

MMEMory:AUTonaming:RESall

Resets all autonaming settings to the default value, including the path.

Usage: Setting only

Manual operation: See "Reset path" on page 92

MMEMory:AUTonaming:RESPath

Resets the path for file operations to the factory default path.

Usage: Setting only

Manual operation: See "Reset path" on page 92

MMEMory:AUTonaming:TEXT <NameString>

Defines a text that can be included in the autonaming pattern.

Parameters:

<NameString> String parameter

Manual operation: See "User text" on page 91

CSV export

EXPort:RESult:DELimiter <Delimiter>

Selects the list separator symbol from a list. Available are semicolon, comma, space, tab and colon.

Parameters:

<Delimiter> SEMICOLON | COMMA | SPACE | TAB | COLON

*RST: COMMA

Manual operation: See "CSV delimiter" on page 93

17.7.5 Maintenance

CALibration:DATE?

Returns the date of the last selfalignment.

Return values:

<Date>

Usage: Query only
Asynchronous command

Manual operation: See "Date, Time, Overall alignment state" on page 88

CALibration:TIME?

Returns the time of the last selfalignment.

Return values:
<Time>

Usage: Query only
Asynchronous command

Manual operation: See "Date, Time, Overall alignment state" on page 88

CALibration:RESult?

Returns the result of the last selfalignment and the current alignment status. In remote mode, `*CAL?` provides more detailed information.

Return values:
<ResultState> PASSed | FAILed | NOALigndata
*RST: FAILed

Usage: Query only
Asynchronous command

Manual operation: See "Date, Time, Overall alignment state" on page 88

SYSTem:APUP <AutoPowerUp>

If enabled, the instrument powers up automatically when it is connected to the mains voltage.

Parameters:
<AutoPowerUp> ON | OFF
*RST: ON

Manual operation: See "Auto power up" on page 90

17.8 Acquisition and setup

17.8.1 Starting and stopping acquisition

RUNCont
RUN

Starts the continuous acquisition.

Usage: Event
Asynchronous command

Manual operation: See "[Run / Stop]" on page 35

RUNSingle
SINGle

Starts a defined number of acquisition cycles. The number of cycles is set with `ACQuire:COUNt`.

Usage: Event
Asynchronous command

Manual operation: See "[Single]" on page 35

STOP

Stops the running acquisition.

Usage: Event
Asynchronous command

Manual operation: See "[Run / Stop]" on page 35

17.8.2 Horizontal setup

AUToscale

Performs an autoset process: analyzes the enabled channel signals, and obtains appropriate horizontal, vertical, and trigger settings to display stable waveforms.

Rohde & Schwarz does not recommend using the autoset in remote control. To adjust the oscilloscope remotely, especially for automated testing applications, use the remote commands that adjust the horizontal, vertical and trigger settings.

Usage: Event
Asynchronous command

TIMebase:SCALe <TimebaseScale>

Sets the horizontal scale, the time per division, for all waveforms in the time domain, for example, channel and math waveforms.

Parameters:

<TimebaseScale>	Range:	200E-12 to 10E3
	Increment:	1E-12
	*RST:	20E-9
	Default unit:	s/div

Usage: Asynchronous command

Manual operation: See "[Scale]" on page 36

TIMebase:RANGe <TimebaseRange>

Sets the time of one acquisition, which is the time across the 10 divisions of the diagram: *Acquisition time = Time scale * 10 divisions*.

Parameters:

<TimebaseRange>	Range:	Device specific to Device specific
	Increment:	1E-12
	*RST:	Device specific
	Default unit:	s

Usage: Asynchronous command

Manual operation: See "Timebase range" on page 95

TIMebase:DIVisions?

Returns the number of horizontal divisions on the screen. The number cannot be changed.

Return values:

<HorizDivCnt>	*RST:	10

Usage: Query only
Asynchronous command

TIMebase:HORizontal:POSition <Position>

Defines the time distance between the reference point and the trigger point, which is the zero point of the diagram. The horizontal position is also known as trigger offset.

Parameters:

<Position>	Range:	Device specific to 1E+26
	Increment:	1E-12
	*RST:	0
	Default unit:	s

Usage: Asynchronous command

Manual operation: See "[Position]" on page 36

TIMebase:REFerence <RescaleCtrPos>

Sets the position of the reference point in % of the screen. It defines which part of the waveform is shown.

Parameters:

<RescaleCtrPos>	Range: 0 to 100 Increment: 1 *RST: 50 Default unit: %

Usage: Asynchronous command

Manual operation: See "Reference point" on page 96

17.8.3 Vertical setup

The channel suffix <ch> selects the input channel that is affected by the command.

CHANnel<ch>:STATe <State>

Switches the selected channel signal on or off.

Suffix:

<ch>	1 to 4, index of the analog channel

Parameters:

<State>	ON | OFF *RST: OFF

Usage: Asynchronous command

Manual operation: See "[C <n>]" on page 37

CHANnel<ch>:SCALe <Scale>

Sets the vertical scale in Volts per division. The vertical scale defines the displayed amplitude of the selected waveform.

Suffix:
<ch> — 1 to 4, index of the analog channel

Parameters:
<Scale> — Range: 0.001 to 1
Increment: 0.001
*RST: 0.05
Default unit: V/div

Usage: Asynchronous command

Manual operation: See "[Scale]" on page 38

CHANnel<ch>:RANGe <Range>

Sets the voltage range across the 10 vertical divisions of the diagram. The command is an alternative to `CHANnel<ch>:SCALe`.

Suffix:
<ch> — 1 to 4, index of the analog channel

Parameters:
<Range> — Range: 0.01 to 10
Increment: 0.01
*RST: 0.5
Default unit: V/div

Usage: Asynchronous command

CHANnel<ch>:OFFSet <Offset>

Sets the offset voltage, which corrects an offset-affected signal. The vertical center of the selected channel is shifted by the offset value and the signal is repositioned within the diagram.

Suffix:
<ch> — 1 to 4, index of the analog channel

Parameters:
<Offset> — Range: -1 to 1
Increment: 0.01
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "[Position]" on page 37

CHANnel<ch>:POSition <Position>

Moves the selected signal up or down in the diagram. While the offset sets a voltage, position is a graphical setting given in divisions. The visual effect is the same as for offset.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Position> Positive values move up the waveform, negative values move it down.

Range: -5 to 5
Increment: 0.02
*RST: 0
Default unit: div

Usage: Asynchronous command

Manual operation: See "[Position]" on page 37

CHANnel<ch>:COUPling <Value>

Sets the connection of the channel signal, i.e. the input impedance (coupling) and a filter (termination). The command determines what part of the signal is used for waveform analysis and triggering.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Value> DC | DCLimit | AC

DC
Connection with 50 Ω termination, passes both DC and AC components of the signal.

DCLimit
Connection with 1 MΩ termination, passes both DC and AC components of the signal.

AC
Connection with 1 MΩ termination through DC capacitor, removes DC and very low-frequency components. The waveform is centered on zero volts.

Usage: Asynchronous command

Manual operation: See "Coupling" on page 108

CHANnel<ch>:INVert <InvertChannel>

Turns the inversion of the signal amplitude on or off. To invert means to reflect the voltage values of all signal components against the ground level.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:

<InvertChannel> ON | OFF

ON: inverted waveform
OFF: normal waveform

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Invert channel" on page 109

CHANnel<ch>:SKEW:TIME <Offset>

Sets a skew value to compensate for the delay of the measurement setup or from the circuit specifics that the instrument cannot compensate automatically. It affects only the selected input channel.

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<Offset> Range: -1E-07 to 1E-07
Increment: 1E-12
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Skew" on page 109

CHANnel<ch>:BANDwidth <BandwidthLimit>

Sets the bandwidth limit. The specified bandwidth indicates the range of frequencies that the instrument can acquire and display accurately with less than 3 dB attenuation. Frequencies above the limit are removed from the signal, and noise is reduced.

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<BandwidthLimit> FULL | B2G | B1G5 | B1G | B700 | B500 | B350 | B200 | B100 | B50 | B20

FULL
Sets the bandwidth to the maximum bandwidth of the instrument. Bandwidth extension options are considered.

B700 | B500 | B350 | B200 | B100 | B50 | B20
Sets a bandwidth limit lower than the maximum. The number indicates the bandwidth limit in MHz.

B1G5 | B1G
Sets the bandwidth limit to 1500 MHz or 1000 MHz if these values are lower than the maximum.

*RST: FULL

Usage: Asynchronous command

Manual operation: See "Bandwidth" on page 109

CHANnel<ch>:EATScale <ExtAttScl>

Sets the attenuation scale for an external divider: linear or logarithmic.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<ExtAttScl> LIN | LOG
*RST: LIN

Usage: Asynchronous command

Manual operation: See "External Attenuation: Scale, Attenuation" on page 110

CHANnel<ch>:EATTenuation <ExtAtt>

Consider a voltage divider that is part of the DUT before the measuring point. The external attenuation is included in the measurement, and the instrument shows the results that would be measured before the divider. External attenuation can be used with all probes.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<ExtAtt> Values depend on the selected scale (`CHANnel<ch>:EATScale` on page 384) and the unit of the waveform. See "External Attenuation: Scale, Attenuation" on page 110. Limits below are for linear scale.
Range: 0.001 to 1000000
Increment: 0.01
*RST: 1

Usage: Asynchronous command

Manual operation: See "External Attenuation: Scale, Attenuation" on page 110

CHANnel<ch>:IMPedance <Impedance>

Sets the impedance of the connected probe for power calculations and measurements.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Impedance> Range: 0.1 to 100000
Increment: 1
*RST: 50
Default unit: Ω

Usage: Asynchronous command

Manual operation: See "Impedance" on page 111

17.8.4 Waveform data export

To set the export data format, see `FORMat[:DATA]`.

CHANNel<ch>[:WAVeform<wf>]:DATA:HEADer?

Returns the header of channel waveform data. The header contains attributes of the waveform.

Table 17-2: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. For most waveforms, the result is 1. For peak detect and envelope waveforms, it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).	1

Suffix:
<ch> 1 to 4, index of the analog channel

<wf> 1, can be omitted

Example:
```
CHAN1:WAV1:DATA:HEAD?
-9.477E-008,9.477E-008,200000,1
```

Usage: Query only
Asynchronous command

CHANNel<ch>[:WAVeform<wf>]:DATA[:VALues]? [<Offset>], [<Length>]

Returns the data of the channel waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

Without parameters, the complete waveform is retrieved. Using the offset and length parameters, data can be retrieved in smaller portions, which makes the command faster.

To set the export format, use `FORMat[:DATA]` on page 360.

Suffix:

<ch> 1 to 4, index of the analog channel

<wf> 1, can be omitted

Query parameters:

[<Offset>] Number of offset waveform points.

Range: 0 to m. Limit: n + m <= record length

[<Length>] Number of waveform points to be retrieved.

Range: 1 to n. Limit: n + m <= record length

Return values:

<Data> List of values according to the format and content settings.

Example: Retrieve the complete channel 1 waveform, only Y-values:

```
FORM ASC
EXP:WAV:INCX OFF
CHAN1:WAV1:DATA?
<-- -0.125000,-0.123016,-0.123016,-0.123016,-0.123016,-0.123016,...
```

Example: Retrieve the first 10 values of the waveform:

```
CHANnel:WAVeform:DATA:VALues? 0,10
<-- -0.10079051554203,-0.098814234137535,-0.098814234137535,
    -0.096837945282459,-0.094861663877964,-0.094861663877964,
    -0.092885382473469,-0.090909093618393,-0.090909093618393,
    -0.088932812213898
```

Example: Skip 5 samples and retrieve the next 5 samples:

```
CHANnel:WAVeform:DATA:VALues? 5,5
<-- -0.094861663877964,-0.092885382473469,-0.090909093618393,
    -0.090909093618393,-0.088932812213898
```

Usage: Asynchronous command

17.8.5 Acquisition setup

ACQuire:AVAilable?

Number of acquisitions that is saved in the memory and available for history viewing. It is also the number of acquisitions in a fast segmentation acquisition series.

Return values:

<AcquisitionCount>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only
Asynchronous command

Manual operation: See "Available acqs" on page 174

ACQuire:AVERage?

Returns the current number of acquired waveforms that contribute to the average.

Return values:

<CurrAverageCount>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only
Asynchronous command

Manual operation: See "Current Average count" on page 101

ACQuire:COUNt <MaxAcqCnt>

Sets the acquisition and average count, which has a double effect:

- It sets the number of waveforms acquired with `RUNSingle`.
- It defines the number of waveforms used to calculate the average waveform.

Parameters:

<MaxAcqCnt>	Range:	1 to 16777215
	Increment:	10
	*RST:	1

Usage: Asynchronous command

Manual operation: See "N-single/Avg count" on page 100

ACQuire:CURRent?

Returns the current number of acquisitions that have been acquired.

Return values:

<CurrAcqCnt>	Range:	0 to 18446744073709551615
	Increment:	1
	*RST:	0

Usage: Query only
Asynchronous command

ACQuire:INTerpolate <IntpolMd>

Selects the interpolation method.

Parameters:

<IntpolMd> LINear | SINX | SMHD

LINear
Linear interpolation between two adjacent sample points

SINX
Interpolation with a sin(x)/x function.

SMHD
Sample/Hold causes a histogram-like interpolation.

*RST: SINX

Usage: Asynchronous command

Manual operation: See "Interpolation" on page 101

ACQuire:POINts[:VALue] <RecordLength>

Sets the record length in manual record length mode. In automatic record length mode, it sets the maximum value of the record length for automatic calculation.

The record length is the number of waveform samples that are stored in one waveform record after processing, including interpolation.

Parameters:

<RecordLength>	Range:	1000 to Device specific
	Increment:	2
	*RST:	1000
	Default unit:	pts

Usage: Asynchronous command

Manual operation: See "Record length, Record length limit" on page 100

ACQuire:POINts:ARATe?

Returns the sample rate of the ADC, before waveform processing. The result is the interleaved sample rate or the non-interleaved one, depending on the channel usage.

Return values:

<ADCSampleRate> Range: 5 Gsample/s (interleaved), 2,5 Gsample/s (non-interleaved)
Default unit: Hz

Usage: Query only
Asynchronous command

ACQuire:POINts:MAXimum <RecLengthLimit>

Sets the maximum record length, if ACQuire:POINts:MODE is se to AUTO.

Parameters:

<RecLengthLimit> Range: 1000 to 800E+6
Increment: 2
*RST: 10E+6
Default unit: pts

Usage: Asynchronous command

ACQuire:POINts:MODE <RecLengthMode>

Selects the mode of the waveform record length adjustment.

Parameters:

<RecLengthMode> AUTO | MANual

AUTO
Record length is determined automatically and changes due to instrument internal adjustments.

MANual
The waveform record length is defined with ACQuire:POINts[:VALue].

*RST: AUTO

Usage: Asynchronous command

Manual operation: See "RL mode" on page 100

ACQuire:RESolution <Resolution>

Defines the time between two waveform samples in the waveform record. It considers the processing of the captured samples including interpolation. A fine resolution with low values produces a more precise waveform record.

The resolution is the reciprocal value of ACQuire:SRATe[:VALue].

Parameters:

<Resolution> Range: 1E-15 to Device specific
Increment: 1E-11
*RST: Device specific
Default unit: s

Usage: Asynchronous command

Manual operation: See "Resolution" on page 101

ACQuire:SRATe[:VALue] <SampleRate>

Sets the number of waveform points per second in manual sample rate mode. In automatic sample rate mode, it sets the minimum value of the sample rate for automatic calculation.

The sample rate considers the samples of the ADC, and the processing of the captured samples including interpolation.

The value takes effect if `ACQuire:SRATe:MODE` is set to MANual.

Parameters:

<SampleRate>
Range: Device specific to Device specific
Increment: 1
*RST: Device specific
Default unit: Sa/s

Usage: Asynchronous command

Manual operation: See "Sample rate, Min. sample rate" on page 100

ACQuire:SRATe:MINimum <SampleRateMin>

Sets the minimum sample rate, if `ACQuire:SRATe:MODE` is set to `AUTO`.

Parameters:

<SampleRateMin>
Increment: 1
*RST: 10000
Default unit: Sa/s

Usage: Asynchronous command

ACQuire:SRATe:MODE <SampleRateMode>

Defines how the sample rate is set.

Parameters:

<SampleRateMode> AUTO | MANual

AUTO
Sample rate is determined automatically and changes due to instrument internal adjustments.

MANual
The sample rate is defined with `ACQuire:SRATe[:VALue]`.

*RST: AUTO

Usage: Asynchronous command

Manual operation: See "SR mode" on page 99

ACQuire:SRReal <HWSampleRate>

Returns the sample rate of the waveform after HW processing. Interpolation is not considered.

Parameters:

<HWSampleRate> Range: Device specific to ADC sample rate
Increment: 0
*RST: Device specific
Default unit: Sa/s

Usage: Asynchronous command

ACQuire:TYPE <AcqMd>

Sets how the waveform is built from the captured samples.

Parameters:

<AcqMd> SAMPle | PDETect | ENVelope | AVERage
*RST: SAMPle

Usage: Asynchronous command

Manual operation: See "Acquisition mode" on page 101

17.8.6 Fast segmentation

ACQuire:SEGMented:STATe <State>

If fast segmentation is enabled, the acquisitions are performed as fast as possible, without processing and displaying the waveforms. When acquisition has been stopped, the data is processed and the latest waveform is displayed. Older waveforms are stored in segments. You can display and analyze the segments using the history.

Parameters:

<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Fast segmentation" on page 103

ACQuire:SEGMented:MAX <MaxAcqs>

If ON, the instrument acquires the maximum number of segments that can be stored in the memory. The maximum number depends on the current sample rate and record length settings.

If OFF, define the number of segments in a fast segmentation cycle with `ACQuire:COUNt`.

Parameters:

<MaxAcqs>	ON | OFF *RST: OFF

Usage: Asynchronous command

Manual operation: See "Acquire maximum" on page 102

17.8.7 Probes

17.8.7.1 Common probe settings

The probe suffix <ch> selects the input channel to which the probe is connected.

PROBe<ch>:SETup:ATTenuation[:AUTO]?

Returns the attenuation of a detected or predefined probe.

Suffix:

<ch>	1 to 4, index of the analog channel

Return values:

<Attenuation>	Range: 0.001 to 1000 Increment: 0.1 *RST: 1 Default unit: V/V

Usage: Query only
Asynchronous command

Manual operation: See "Manual attenuation" on page 113

PROBe<ch>:SETup:ATTenuation:MANual <Attenuation>

Sets the attenuation for an unknown probe.

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<Attenuation>
Range: 0.0001 to 10000
Increment: 0.1
*RST: 1
Default unit: V/V

Usage: Asynchronous command

Manual operation: See "Manual attenuation" on page 113

PROBe<ch>:SETup:ATTenuation:DEFProbe <PredefinedProbe>

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<PredefinedProbe> NONE | USER | ZC10 | ZC20 | ZC30 | ZD01A100 | ZD01A1000 | ZS10L | ZC02100 | ZC021000 | ZC03

USER
Probe is not detected and not known to the instrument. Set unit and attenuation manually.

ZC10 | ZC20 | ZC30 | ZS10L | ZC03
Type of the probe

ZD01A100 | ZD01A1000
High voltage differential probes, attenuation ratio according to the setting on the probe.
A100 = 100:1
A1000 = 1000:1

ZC02100 | ZC021000
Current probes 100 A or 1000 A according to the setting on the probe.

*RST: NONE

Usage: Asynchronous command

Manual operation: See "Predefined probe, name and type of the probe" on page 112

PROBe<ch>:SETup:ATTenuation:UNIT <Unit>

Returns the unit of the connected probe if the probe is detected or predefined. For unknown probes, you can select the required unit.

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<Unit> V | A | W

Voltage probe (V), current probe (A), power probe (W)

*RST: V

Usage: Asynchronous command

Manual operation: See "Vertical unit" on page 113

PROBe<ch>:SETup:BANDwidth?

Returns the bandwidth of the connected probe.

Suffix:

<ch> 1 to 4, index of the analog channel

Return values:

<Bandwidth> Range: 10000 to 20000000000
Increment: 10
*RST: 1000000000
Default unit: Hz

Usage: Query only
Asynchronous command

Manual operation: See "Probe Bandwidth" on page 113

PROBe<ch>:SETup:OFFSet:TOMean

Compensates automatically for a DC component of the input signal using the result of a background mean measurement.

Suffix:

<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

Manual operation: See "Set offset to mean" on page 113

PROBe<ch>:SETup:OFFSet:AZERo

Measures the zero error. Short the signal pin and the ground pin together and connect them to the ground of the DUT before sending the command.

Suffix:

<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

Manual operation: See "AutoZero, Use AutoZero" on page 114

PROBe<ch>:SETup:OFFSet:USEautozero <UseAutoZeroOffset>

Includes the AutoZero offset in measurement results. The auto zero error is detected with `PROBe<ch>:SETup:OFFSet:AZERo`.

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<UseAutoZeroOffset> ON | OFF

*RST: OFF

Example:
```
PROB2:SET:OFFS:AZER
PROB2:SET:OFFS:USE ON
```
Detects the zero error and uses it for correction of measurement results.

Usage: Asynchronous command

Manual operation: See "AutoZero, Use AutoZero" on page 114

PROBe<ch>:SETup:NAME?

Queries the name of the probe.

Suffix:

<ch> 1 to 4, index of the analog channel

Return values:

<Name> Name string

Usage: Query only
Asynchronous command

Manual operation: See "Predefined probe, name and type of the probe" on page 112

PROBe<ch>:SETup:STATe?

Queries if the probe at the specified input channel is active (detected) or not active (not detected). To switch the probe on, use `CHANnel<ch>:STATe`.

Suffix:

<ch> 1 to 4, index of the analog channel

Return values:

<State> DETected | NDETected

*RST: NDETected

Usage: Query only
Asynchronous command

Manual operation: See "Predefined probe, name and type of the probe" on page 112

PROBe<ch>:SETup:TYPE?

Queries the type of the probe.

Suffix:

<ch> 1 to 4, index of the analog channel

Return values:

<Type> String containing one of the following values:
– None (no probe detected)
– Passive Probe
– active single-ended

Usage: Query only
Asynchronous command

Manual operation: See "Predefined probe, name and type of the probe" on page 112

17.8.7.2 Settings for active voltage probes

The probe suffix <ch> selects the input channel to which the probe is connected.

PROBe<ch>:SETup:MODE <Mode>

The micro button is located on the probe head. Pressing this button, you initiate an action on the instrument directly from the probe. The button is disabled during internal automatic processes, for example, during self alignment, autoset, and level detection.

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

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<Mode> RCONtinuous | RSINgle | AUToset | AZERo | OTMean | SITFile | NOACtion | FTRiglevel | PRSetup

RCONtinuous
Run continuous: The acquisition is running as long as the probe button is pressed.

RSINgle
Run single: Starts a defined number of acquisitions (same as [Single] key).

AUToset
Starts the autoset procedure.

AZERo
AutoZero: performs an automatic correction of the zero error.

OTMean
Set offset to mean: performs an automatic compensation for a DC component of the input signal.

SITFile
Save Image To File:
Directs the display image to a file.

NOACtion
Nothing is started on pressing the micro button.

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

PRSetup
Opens the "Probes Setup" dialog box.

*RST: RCONtinuous

Usage: Asynchronous command

Manual operation: See "MicroButton" on page 116

PROBe<ch>:SETup:ACCoupling <ProbeCouplingAC>

Enables AC coupling in R&S RT-ZPR power rail probes, which removes DC and very low-frequency components. The R&S RT-ZPR probe requires 50 Ω input termination, for which the channel AC coupling is not available. The probe setting allows AC coupling also at 50 Ω inputs.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<ProbeCouplingAC> ON | OFF

*RST: OFF

Usage: Asynchronous command

Manual operation: See "AC Coupling" on page 119

PROBe<ch>:SETup:CMOFfset <CMOffset>

Sets the common-mode offset to compensate for a common DC voltage that is applied to both input sockets (referenced to the ground socket). The setting is available for Rohde & Schwarz differential probes.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<CMOffset> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "CM offset" on page 118

PROBe<ch>:SETup:DISPlaydiff <DisplayDiff>

Selects the voltage to be measured by the ProbeMeter of differential active probes:

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<DisplayDiff> DIFFerential | SINGleended

DIFFerential
Measures differential and common mode voltages

SINGleended
Measures the voltage between the positive/negative signal socket and the ground.

*RST: DIFFerential

Usage: Asynchronous command

Manual operation: See "Display" on page 118

PROBe<ch>:SETup:ZAXV <AttenuationZA15>

If you use the external attenuator R&S RT-ZA15 together with one of the differential active probes R&S RT-ZD10/20/30, enable "RT-ZA15 attenuator" to include the external attenuation in the measurements.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<AttenuationZA15> ON | OFF

*RST: OFF

Usage: Asynchronous command

Manual operation: See "RT-ZA15 attenuator" on page 118

PROBe<ch>:PMETer:STATe <State>

Activates the integrated R&S ProbeMeter on probes with Rohde & Schwarz probe interface.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "ProbeMeter" on page 116

PROBe<ch>:PMETer:RESults:SINGle?

Returns the ProbeMeter measurement result of single-ended active Rohde & Schwarz probes, the voltage measured between the probe tip and the ground.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Result> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "ProbeMeter" on page 116

PROBe<ch>:PMETer:RESults:COMMon?

Returns the ProbeMeter measurement result of differential active R&S probes: the common mode voltage, which is the mean voltage between the signal sockets and the ground socket.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Result> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "ProbeMeter" on page 116

PROBe<ch>:PMETer:RESults:DIFFerential?

Returns the ProbeMeter measurement result of differential active Rohde & Schwarz probes, the differential voltage - the voltage between the positive and negative signal sockets.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Result> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "ProbeMeter" on page 116

PROBe<ch>:PMETer:RESults:NEGative?

Returns the ProbeMeter measurement result of differential active R&S probes, the voltage that is measured between the negative signal socket and the ground.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Result> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Query only
Asynchronous command

Manual operation: See "ProbeMeter" on page 116

PROBe<ch>:PMETer:RESults:POSitive?

Returns the ProbeMeter measurement result of differential active R&S probes: the voltage that is measured between the positive signal socket and the ground.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:

<Result>	Range:	-1E+26 to 1E+26
	Increment:	0.001
	*RST:	0
	Default unit:	V

Usage: Query only
Asynchronous command

Manual operation: See "ProbeMeter" on page 116

PROBe<ch>:SETup:ADVanced:AUDioverload <Sound>

Activates the acoustic overrange warning in the probe control box. The command is relevant for R&S RT-ZHD probes.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Sound> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Audible Overrange" on page 122

PROBe<ch>:SETup:ADVanced:FILTer <State>

Activates the lowpass filter in the probe control box. The filter frequency depends on the probe type and is indicated on the probe control box.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Bandwidth Limit" on page 121

PROBe<ch>:SETup:ADVanced:RANGe <ProbeRange>

Sets the voltage range of an R&S RT-ZHD probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<ProbeRange> AUTO | MHIGh | MLOW

AUTO
The voltage range is set with `CHANnel<ch>:SCALe`.

MHIGh
Sets the higher voltage range of the connected probe. To query the value, use `PROBe<ch>:SETup:ATTenuation[:AUTO]?`.

MLOW
Sets the lower voltage range of the connected probe. To query the value, use `PROBe<ch>:SETup:ATTenuation[:AUTO]?`.

*RST: AUTO

Usage: Asynchronous command

Manual operation: See "Range" on page 122

PROBe<ch>:SETup:ADVanced:PMToffset

Sets the measured ProbeMeter value as offset. Thus, the value is considered in measurements.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Setting only
Asynchronous command

Manual operation: See "ProbeMeter to offset" on page 120

17.8.7.3 Settings for current probes

The probe suffix <ch> selects the input channel to which the probe is connected.

PROBe<ch>:SETup:GAIN:AUTO?

Returns the gain of a detected or predefined current probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Gain> Range: 0.001 to 1000
Increment: 0.1
*RST: 1
Default unit: A/V

Usage: Query only
Asynchronous command

Manual operation: See "Manual gain" on page 123

PROBe<ch>:SETup:GAIN:MANual <Gain>

Sets the gain for an unknown current probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Gain>
Range: 0.0001 to 10000
Increment: 0.0001
*RST: 1
Default unit: V/V

Usage: Asynchronous command

Manual operation: See "Manual gain" on page 123

PROBe<ch>:SETup:DEGauss

Demagnetizes the core if it has been magnetized by switching the power on and off, or by an excessive input. Always carry out demagnetizing before measurement.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

Manual operation: See "DeGauss" on page 124

PROBe<ch>:SETup:OFFSet:ZADJust <ZeroAdjustValue>

Set the waveform to zero position. It corrects the effect of a voltage offset or temperature drift. To set the value by the instrument, use `PROBe<ch>:SETup:OFFSet:AZERo`
.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<ZroAdjVal>
Range: -100 to 100
Increment: 0.1
*RST: 0
Default unit: %

Usage: Asynchronous command

Manual operation: See "Zero adjust" on page 124

PROBe<ch>:SETup:OFFSet:STPRobe

Saves the zero adjust value in the probe box. If you connect the probe to another channel or to another Rohde & Schwarz oscilloscope, the value is read out again, and you can use the probe without further adjustment.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Event
Asynchronous command

Manual operation: See "Save to probe" on page 124

17.8.7.4 Probe attributes

PROBe<ch>:ID:PARTnumber?

Queries the Rohde & Schwarz part number of the probe.

Suffix:
<ch> — 1 to 4, index of the analog channel

Return values:
<PartNumber> — Part number in a string.

Usage: Query only
Asynchronous command

PROBe<ch>:ID:PRDate?

Queries the production date of the probe.

Suffix:
<ch> — 1 to 4, index of the analog channel

Return values:
<ProductionDate> — Date in a string.

Usage: Query only
Asynchronous command

PROBe<ch>:ID:SRNumber?

Queries the serial number of the probe.

Suffix:
<ch> — 1 to 4, index of the analog channel

Return values:
<SerialNo> — Serial number in a string.

Usage: Query only
Asynchronous command

PROBe<ch>:ID:SWVersion?

Queries the version of the probe firmware.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<Softwareversion> Version number in a string.

Usage: Query only
Asynchronous command

PROBe<ch>:SETup:CAPacitance?

Queries the input capacitance of the probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<InputCapacity> Range: 1E-13 to 1E-07
Default unit: F

Usage: Query only
Asynchronous command

PROBe<ch>:SETup:IMPedance?

Queries the termination of the probe.

Suffix:
<ch> 1 to 4, index of the analog channel

Return values:
<InputImpedance> Range: 0 to 1E+9
Default unit: Ω

Usage: Query only
Asynchronous command

17.8.8 High definition mode

HDEFinition:BWIDth <Bandwidth>

Sets the filter bandwidth for the high definition mode.

Parameters:

<Bandwidth>	Range: 10000 to 2E+9 Increment: 1000 *RST: 100E+6 Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Bandwidth" on page 104

HDEFinition:RESolution?

Displays the resulting vertical resolution in high definition mode. The higher the filter bandwidth, the lower the resolution.

Return values:

<Resolution>	Range: 0 to 18 Increment: 0.1 *RST: 0 Default unit: bit

Usage: Query only
Asynchronous command

Manual operation: See "Resolution in bits" on page 104

HDEFinition:STATe <State>

Enables high definition mode, which increases the numeric resolution of the waveform signal.

Parameters:

<State> ON | OFF

`ON`: high definition mode

`OFF`: normal oscilloscope mode

*RST: OFF

Usage: Asynchronous command

Manual operation: See "State" on page 104

17.8.9 Reference clock

SENSe[:ROSCillator]:OUTPut[:ENABle] <ReferenceOutput>

Sends the internal reference clock signal to the Ref. Out connector.

Parameters:

<ReferenceOutput> ON | OFF

*RST: OFF

Usage: SCPI confirmed
Asynchronous command

Manual operation: See "Output 10 MHz ref. signal" on page 96

SENSe[:ROSCillator]:SOURce <RefSource>

Enables the use of an external 10 MHz reference signal instead of the internal reference clock.

Parameters:

<RefSource> INTernal | EXTernal
*RST: INTernal

Usage: Asynchronous command

Manual operation: See "Use external ref. clock" on page 96

17.9 Trigger

Trigger commands use several suffixes.

LEVel<n>, Noise<m>

The suffix indicates the analog channel, for which the command takes effect. C1 has suffix 1, C2 has suffix 2, and so on.

Event<m>

The suffix indicates the sequence step, for which the command takes effect when you trigger on a sequence. If you trigger on a single event, the suffix = 1 and can be omitted.

- 1 = A-trigger
- 2 = B-trigger
- 3 = R-trigger (reset event)

Asynchronous commands

Some of the commands in the following chapter are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, chapter "Command Sequence and Synchronization"

17.9.1 Common trigger settings

TRIGger:MEVents:MODE <Class>

Parameters:

<Class> SINGle | SEQuence

*RST: SINGle

Usage: Asynchronous command

Manual operation: See "Trigger on" on page 128

TRIGger:EVENt<m>:TYPE <Type>

Selects the trigger type specific for each condition in a trigger sequence.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Type> EDGE | GLITch | WIDTh | RUNT | WINDow | TIMeout | INTerval | SLEWrate | SETHold | STATe | PATTern | ANEDge

ANEDge = analog edge trigger is the only trigger type if the extern trigger source is used.
For SETHold, also DATatoclock can be used.

*RST: EDGE

Usage: Asynchronous command

Manual operation: See "Type" on page 129

TRIGger:EVENt<m>:LEVel<n>[:VALue] <Level>

Sets the trigger level for the specified event and source (channel).

If the trigger source is serial bus, the trigger level is set by the thresholds in the protocol configuration.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<Level> Range: -10 to 10
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "[Level]" on page 34

TRIGger:FINDlevel

Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*.

Usage: Event
Asynchronous command

Manual operation: See "Find level" on page 130

TRIGger:EVENt<m>:SOURce <SourceDetailed>

Selects the source of the trigger signal for the selected trigger event. The trigger source works even if it is not displayed in a diagram.

Available sources depend on the trigger sequence setting. If you trigger on a single event, all inputs can be used as trigger source. If you trigger on a sequence, only analog channels can be set as trigger source.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<SourceDetailed> C1 | C2 | C3 | C4 | EXTernanalog | LINE | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | SBUS1 | SBUS2 | SBUS3 | SBUS4

C1 | C2 | C3 | C4
Available for single event and all events in a trigger sequence

EXTernanalog | LINE | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | SBUS1 | SBUS2 | SBUS3 | SBUS4
Available for single event (EVENt1)

*RST: C1

Usage: Asynchronous command

Manual operation: See "Source" on page 129

17.9.2 Trigger sequence

TRIGger:MEVents:AEVents <Type>

Selects the type of the trigger sequence.

Parameters:

<Type> AONLy | ABR

ABR = sequence A → B → R

*RST: AONLy

Usage: Asynchronous command

Manual operation: See "Trigger sequence" on page 131

TRIGger:MEVents:SEQuence<se>:COUNt <Events>

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

Suffix:

<se> 1..3

2

Parameters:

<Events> Range: 1 to 2147483647

Increment: 1

*RST: 1

Usage: Asynchronous command

Manual operation: See "B event count" on page 132

TRIGger:MEVents:SEQuence<se>:DELay <Delay>

Sets the time that the instrument waits after an A-trigger until it recognizes B-triggers.

Suffix:

<se> 1

Parameters:

<Delay> Range: 0 to 50

Increment: 1E-12

*RST: 0

Default unit: s

Usage: Asynchronous command

Manual operation: See "Delay" on page 131

TRIGger:MEVents:SEQuence<se>:RESet:EVENt <State>

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

Suffix:
<se> 3

Parameters:
<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Enable reset event" on page 132

TRIGger:MEVents:SEQuence<se>:RESet:TIMeout:TIME <ResetTimeout>

The time the instrument waits for the number of B-events specified using `TRIGger:MEVents:SEQuence<se>:COUNt`, before the sequence is restarted with the A-trigger.

Suffix:
<se> Irrelevant, omit the suffix.

Parameters:
<ResetTimeout> Range: 0 to 50
Increment: 1E-12
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Enable reset by time, Reset timeout" on page 132

TRIGger:MEVents:SEQuence<se>:RESet:TIMeout[:ENABle] <State>

If set to ON, the instrument waits for the time defined using `TRIGger:MEVents:SEQuence<se>:RESet:TIMeout:TIME` for the specified number of B-events. If no trigger occurs during that time, the sequence is restarted with the A-event.

Suffix:
<se> Irrelevant, omit the suffix.

Parameters:
<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Enable reset by time, Reset timeout" on page 132

17.9.3 Edge trigger

TRIGger:EVENt<m>:EDGE:SLOPe <Slope>

Sets the edge direction for the trigger.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Slope> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Slope" on page 133

TRIGger:ANEDge:LEVel <ExtTrigLev>

Sets the trigger level for the external trigger source.

Parameters:
<ExtTrigLev> Range: - 5 to 5
Default unit: V

Usage: Asynchronous command

Manual operation: See "Level" on page 129

TRIGger:ANEDge:COUPling <Coupling>

Sets the connection of the external trigger signal, i.e. the input impedance and a termination. The coupling determines what part of the signal is used for triggering.

Parameters:
<Coupling> DC | DCLimit | AC

DC
Connection with 50 Ω termination, passes both DC and AC components of the signal.

DCLimit
Connection with 1 MΩ termination, passes both DC and AC components of the signal.

AC
Connection with 1 MΩ termination through DC capacitor, removes DC and very low-frequency components. The waveform is centered on zero volts.

*RST: DCLimit

Usage: Asynchronous command

Manual operation: See "Coupling" on page 134

TRIGger:ANEDge:FILTer <Filter>

Selects the filter mode for the external trigger signal.

Parameters:
<Filter> OFF | LFReject | RFReject

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Filter, Cut-off" on page 135

TRIGger:ANEDge:CUToff:HIGHpass <CutOffFreq>

Frequencies below the cut-off frequency are rejected, higher frequencies pass the filter.

Parameters:
<CutOffFreq> KHZ5 | KHZ50

KHZ5 = 5 kHz
KHZ50 = 50 kHz

*RST: KHZ50

Usage: Asynchronous command

Manual operation: See "Filter, Cut-off" on page 135

TRIGger:ANEDge:CUToff:LOWPass <CutOffFreq>

Frequencies higher than the cut-off frequency are rejected, lower frequencies pass the filter.

Parameters:
<CutOffFreq> KHZ50 | MHZ50

KHZ50 = 50 kHz
MHZ50 = 50 MHz

*RST: KHZ50

Usage: Asynchronous command

Manual operation: See "Filter, Cut-off" on page 135

TRIGger:ANEDge:NREJect <NoiseReject>

Enables an automatic hysteresis on the trigger level to avoid unwanted trigger events caused by noise.

Parameters:

<NoiseReject> ON | OFF

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Trigger noise reject" on page 135

17.9.4 Glitch trigger

TRIGger:EVENt<m>:GLITch:POLarity <Polarity>

Sets the polarity of a pulse, which is the direction of the first pulse slope.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Polarity> POSitive | NEGative | EITHer

*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Polarity" on page 136

TRIGger:EVENt<m>:GLITch:RANGe <RangeMode>

Selects which glitches are identified: shorter or longer than the width specified using `TRIGger:EVENt<m>:GLITch:WIDTh`.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<RangeMode> SHORter | LONGer

SHORter
Glitches shorter than the specified width are identified.

LONGer
Glitches longer than the specified width are identified.

*RST: SHORter

Usage: Asynchronous command

Manual operation: See "Range" on page 136

TRIGger:EVENt<m>:GLITch:WIDTh <Width>

Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value, depending on the value set with `TRIGger:EVENt<m>:GLITch:RANGe`.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Width> Range: 1E-10 to 10000
Increment: 0.0001
*RST: 1E-09
Default unit: s

Usage: Asynchronous command

Manual operation: See "Width" on page 136

17.9.5 Width trigger

TRIGger:EVENt<m>:WIDTh:DELTa <WidthDelta>

Defines a range around the width value.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<WidthDelta> Range: 0 to 432
Increment: 5E-10
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "±Delta" on page 138

TRIGger:EVENt<m>:WIDTh:POLarity <Polarity>

Sets the polarity of a pulse, which is the direction of the first pulse slope.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Polarity> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Polarity" on page 137

TRIGger:EVENt<m>:WIDTh:RANGe <RangeMode>

Selects how the range of a pulse width is defined.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<RangeMode> WITHin | OUTSide | SHORter | LONGer
*RST: WITHin

Usage: Asynchronous command

Manual operation: See "Range" on page 138

TRIGger:EVENt<m>:WIDTh:WIDTh <Width>

Depending on the values of `TRIGger:EVENt<m>:WIDTh:RANGe` the width sets:

- For the ranges `Within` and `Outside`, the width defines the center of a time range which is defined by the limits "±Delta" (see `TRIGger:EVENt<m>:WIDTh:DELTa`).
- For the ranges `Shorter` and `Longer`, it defines the maximum and minimum time lapse, respectively.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Width> Range: 1E-10 to 10000
Increment: 1E-07
*RST: 5E-09
Default unit: s

Usage: Asynchronous command

Manual operation: See "Width" on page 138

17.9.6 Runt trigger

TRIGger:EVENt<m>:LEVel<n>:RUNT:LOWer <Level>

Sets the lower voltage limit.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<Level> Range: -10 to 10
Increment: 0.001
*RST: -0.1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Lower limit" on page 139

TRIGger:EVENt<m>:LEVel<n>:RUNT:UPPer <Level>

Sets the upper voltage limit.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<Level> Range: -10 to 10
Increment: 0.001
*RST: 0.1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper limit" on page 139

TRIGger:EVENt<m>:RUNT:DELTa <WidthDelta>

Defines a range around the runt width specified using `TRIGger:EVENt<m>:RUNT:WIDTh`.

Available if `TRIGger:EVENt<m>:RUNT:RANGe` is set to `WITHin` or `OUTSide`.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<WidthDelta> Range: 1E-10 to 864
Increment: 1E-07
*RST: 1E-10
Default unit: s

Usage: Asynchronous command

Manual operation: See "±Delta" on page 140

TRIGger:EVENt<m>:RUNT:POLarity <Polarity>

Sets the polarity of a pulse, which is the direction of the first pulse slope.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Polarity> POSitive | NEGative | EITHer

*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Polarity" on page 136

TRIGger:EVENt<m>:RUNT:RANGe <Mode>

Defines the time limit of the runt pulse in relation to the `TRIGger:EVENt<m>:RUNT:WIDTh` and `TRIGger:EVENt<m>:RUNT:DELTa` settings.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Mode> ANY | LONGer | SHORter | WITHin | OUTSide

ANY
Triggers on all runts fulfilling the level condition, without time limitation.

LONGer
Triggers on runts longer than the given runt width.

SHORter
Triggers on runts shorter than the given runt width.

WITHin
Triggers if the runt length is inside a given time range. The range is defined by runt width and ±Delta.

OUTSide
Triggers if the runt length is outside a given time range. The range is defined by runt width and ±Delta.

*RST: ANY

Usage: Asynchronous command

Manual operation: See "Range" on page 140

TRIGger:EVENt<m>:RUNT:WIDTh <Width>

Defines the upper or lower voltage threshold.

It is not available if `TRIGger:EVENt<m>:RUNT:RANGe` is set to `ANY`.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Width> Range: 1E-10 to 10000
Increment: 1E-07
*RST: 5E-09
Default unit: s

Usage: Asynchronous command

Manual operation: See "Runt width" on page 140

17.9.7 Window trigger

TRIGger:EVENt<m>:LEVel<n>:WINDow:LOWer <Level>

Sets the lower voltage limit.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<Level> Range: -10 to 10
Increment: 0.001
*RST: -0.1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Lower limit" on page 142

TRIGger:EVENt<m>:LEVel<n>:WINDow:UPPer <Level>

Sets the upper voltage limit.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<Level> Range: 0 to 1000
Increment: 1E-06
*RST: 0.1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper limit" on page 141

TRIGger:EVENt<m>:WINDow:DELTa <WidthDelta>

Defines a range around the width value.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<WidthDelta>
Range: 0 to 432
Increment: 5E-10
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "±Delta" on page 142

TRIGger:EVENt<m>:WINDow:RANGe <RangeMode>

Selects how the signal run is compared with the window.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<RangeMode> ENTer | EXIT | WITHin | OUTSide

ENTer
Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.

EXIT
Triggers when the signal leaves the window.

WITHin
Triggers if the signal stays between the upper and lower level for a specified time. The time is defined with `TRIGger:EVENt<m>:WINDow:TIME`.

OUTSide
Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is defined with `TRIGger:EVENt<m>:WINDow:TIME`.

*RST: ENTer

Usage: Asynchronous command

Manual operation: See "Vertical condition" on page 141

TRIGger:EVENt<m>:WINDow:TIME <TimeRangeMode>

Available for `TRIGger:EVENt<m>:WIDTh:RANGe` = `WITHin` and `OUTSide`.

Selects how the time limit of the window is defined.

You can specify the width with `TRIGger:EVENt<m>:WIDTh:WIDTh` and the delta with `TRIGger:EVENt<m>:WINDow:DELTa`.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<TimeRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width - Delta* and for *Width + Delta* at the most.

OUTSide
"Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width - Delta* or longer than *Width + Delta*.

SHORter
Triggers if the signal crosses vertical limits before the specified width time is reached.

LONGer
Triggers if the signal crosses vertical limits before the specified width time is reached.

*RST: WITHin

Usage: Asynchronous command

Manual operation: See "Time condition" on page 142

TRIGger:EVENt<m>:WINDow:WIDTh <Width>

Depending on the values of `TRIGger:EVENt<m>:WINDow:RANGe` the width sets:

- For the ranges `Within` and `Outside`, the width defines the center of a time range. The range is defined by the limits "±Delta", see `TRIGger:EVENt<m>:WINDow:DELTa`.
- For the ranges `Shorter` and `Longer`, it defines the maximum and minimum time lapse, respectively.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Width>
Range: 1E-10 to 10000
Increment: 1E-07
*RST: 5E-09
Default unit: s

Usage: Asynchronous command

Manual operation: See "Width" on page 142

17.9.8 Timeout trigger

TRIGger:EVENt<m>:TIMeout:RANGe <TimeoutMode>

Sets the relation of the signal level to the trigger level for the timeout trigger.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<TimeoutMode> HIGH | LOW | EITHer

HIGH = stays high, the signal level stays above the trigger level.
LOW = stays low, the signal level stays below the trigger level.
EITHer = stays high or low.

*RST: HIGH

Usage: Asynchronous command

Manual operation: See "Range" on page 143

TRIGger:EVENt<m>:TIMeout:TIME <Time>

Sets the time limit for the timeout at which the instrument triggers.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Time> Range: 1E-10 to 10000
Increment: 1E-07
*RST: 1E-07
Default unit: s

Usage: Asynchronous command

Manual operation: See "Time" on page 143

17.9.9 Interval trigger

TRIGger:EVENt<m>:INTerval:DELTa <WidthDelta>

Sets a range around the interval width value specified with `TRIGger:EVENt<m>:INTerval:WIDTh`.

Suffix:

<m>	1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<WidthDelta>
Range: 0 to 10
Increment: 1E-07
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "±Delta" on page 145

TRIGger:EVENt<m>:INTerval:RANGe <RangeMode>

Defines the range of an interval in relation to the interval width specified using `TRIGger:EVENt<m>:INTerval:WIDTh` and `TRIGger:EVENt<m>:INTerval:DELTa`.

Suffix:

<m>	1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range is defined by the interval width ±delta.

OUTSide
Triggers on pulses outside a given range. The range is defined by the interval width ±delta.

SHORter
Triggers on pulses shorter than the given interval width.

LONGer
Triggers on pulses longer than the given interval width.

*RST: OUTSide

Usage: Asynchronous command

Manual operation: See "Range" on page 144

TRIGger:EVENt<m>:INTerval:SLOPe <Slope>

Sets the edge for the trigger. You can analyze the interval between positive edges or between negative edges.

Suffix:

<m>	1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Slope> POSitive | NEGative | EITHer

*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Slope" on page 144

TRIGger:EVENt<m>:INTerval:WIDTh <Width>

Sets the time between two pulses for the interval trigger.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Width>
Range: 1E-10 to 10000
Increment: 1E-07
*RST: 5E-09
Default unit: s

Usage: Asynchronous command

Manual operation: See "Interv. width" on page 145

17.9.10 Slew rate trigger

TRIGger:EVENt<m>:LEVel<n>:SLEW:LOWer <Level>

Sets the lower voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<Level>
Range: -10 to 10
Increment: 0.001
*RST: -0.1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Lower limit" on page 147

TRIGger:EVENt<m>:LEVel<n>:SLEW:UPPer <Level>

Sets the upper voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<Level>
Range: -10 to 10
Increment: 0.001
*RST: 0.1
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper limit" on page 146

TRIGger:EVENt<m>:SLEW:DELTa <TimeDelta>

Defines a time range around the given slew rate.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<TimeDelta>
Range: 0 to 10
Increment: 1E-07
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "±Delta" on page 147

TRIGger:EVENt<m>:SLEW:RANGe <RangeMode>

Selects how the time limit for the slew rate is defined. The time measurement starts when the signal crosses the first trigger level - the upper or lower limit depending on the selected slope. The measurement stops when the signal crosses the second level.

You can select the rate with `TRIGger:EVENt<m>:SLEW:RATE` and set the delta with `TRIGger:EVENt<m>:SLEW:DELTa`.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<RangeMode> INSRange | OUTRange | LTHan | GTHan

INSRange
Triggers on pulses inside a given range. The range is defined by the slew rate ±delta.

OUTRange
Triggers on pulses outside a given range. The range is defined by the slew rate ±delta.

LTHan
Triggers on pulses shorter than the given slew rate.

GTHan
Triggers on pulses longer than the given slew rate.

*RST: GTHan

Usage: Asynchronous command

Manual operation: See "Range" on page 147

TRIGger:EVENt<m>:SLEW:RATE <Time>

For `TRIGger:EVENt<m>:SLEW:RANGe` = `INSRange` and `OUTRange`, the slew rate defines the center of a range which is defined by the limits "±Delta".

For `TRIGger:EVENt<m>:SLEW:RANGe` = `LTHan` and `GTHan`, the slew rate defines the maximum and minimum slew rate limits, respectively. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope (see `TRIGger:EVENt<m>:SLEW:SLOPe`).

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Time> Range: 1E-10 to 10000
Increment: 1E-07
*RST: 1E-10
Default unit: s

Usage: Asynchronous command

Manual operation: See "Slew rate" on page 147

TRIGger:EVENt<m>:SLEW:SLOPe <Slope>

Sets the edge direction for the trigger.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<Slope> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Slope" on page 133

17.9.11 Setup & Hold

TRIGger:EVENt<m>:SETHold:CSOurce:EDGE <ClockEdge>

Sets the edge of the clock signal. Edge and level define the time reference point.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<ClockEdge> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Clock edge" on page 148

TRIGger:EVENt<m>:SETHold:CSOurce:LEVel <ClockLevel>

Sets the voltage level for the clock signal.

Both the clock level and the clock edge define the starting point for calculation of the setup and hold time.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:
<ClockLevel> Range: -10 to 10
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Clock level" on page 149

TRIGger:EVENt<m>:SETHold:CSOurce[:VALue] <ClockSource>

Selects the input channel of the clock signal.

Suffix:
<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<ClockSource> C1 | C2 | C3 | C4

The following values are also accepted:
C1 = CHAN1 = CHANnel1, C2 = CHAN2 = CHANnel2,
C3 = CHAN3 = CHANnel3, C4 = CHAN4 = CHANnel4

*RST: C1

Usage: Asynchronous command

Manual operation: See "Clock source" on page 148

TRIGger:EVENt<m>:SETHold:HTIMe <HoldTime>

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

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<HoldTime> Range: -9.9999E-08 to 1E-07
Increment: 1E-09
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Hold time" on page 149

TRIGger:EVENt<m>:SETHold:STIMe <SetupTime>

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

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<SetupTime> Range: -9.9999E-08 to 1E-07
Increment: 1E-09
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Setup time" on page 149

17.9.12 State trigger

TRIGger:EVENt<m>:STATe:QUALify:ANALog:CHAN<n>:HLX <HLX>

Set the state for each channel. For the state trigger, the clock source is indicated and does not get a state.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<HLX> HIGH | LOW | DONTcare

State of the individual channels

*RST: DONTcare

Example:

```
TRIG:EVEN1:SOUR C1
TRIG:EVEN1:SLOP POS
TRIG:EVEN1:STAT:QUAL:ANAL:CHAN2:HLX HIGH
TRIG:EVEN1:STAT:QUAL:ANAL:CHAN3:HLX LOW
TRIG:EVEN1:STAT:QUAL:ANAL:CHAN4:HLX HIGH
TRIG:EVEN1:STAT:QUAL:LOG AND
```

Usage: Asynchronous command

Manual operation: See "Source: channel states" on page 153

TRIGger:EVENt<m>:STATe:QUALify:LOGic <StateOperator>

Defines the logic combination of the channels and their states.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<StateOperator> AND | OR

*RST: AND

Usage: Asynchronous command

Manual operation: See "State Operator" on page 153

TRIGger:EVENt<m>:STATe:SLOPe <Slope>

Sets the edge direction for the trigger.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<Slope> POSitive | NEGative | EITHer

*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Slope" on page 150

17.9.13 Pattern trigger

TRIGger:EVENt<m>:PATTern:QUALify:ANALog:CHAN<n>:HLX <HLX>

Set the state for each channel. For the state trigger, the clock source is indicated and does not get a state.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

<n> 1 to 4, index of the analog channel

Parameters:

<HLX> HIGH | LOW | DONTcare

State of the individual channels

*RST: DONTcare

Example:

```
TRIG:EVEN1:PATT:QUAL:ANAL:CHAN1:HLX LOW
TRIG:EVEN1:PATT:QUAL:ANAL:CHAN2:HLX HIGH
TRIG:EVEN1:PATT:QUAL:ANAL:CHAN3:HLX LOW
TRIG:EVEN1:PATT:QUAL:ANAL:CHAN4:HLX HIGH
TRIG:EVEN1:PATT:QUAL:LOG AND
```

Usage: Asynchronous command

Manual operation: See "Source: channel states" on page 153

TRIGger:EVENt<m>:PATTern:QUALify:LOGic <StateOperator>

Defines the logic combination of the channels and their states.

Suffix:

<m> 1 = A-trigger, 2 = B-trigger, 3 = reset event

Parameters:

<StateOperator> AND | OR

*RST: AND

Usage: Asynchronous command

Manual operation: See "State Operator" on page 153

17.9.14 Trigger mode, holdoff

TRIGger:MODE <TriggerMode>

Sets the trigger mode which determines the behavior of the instrument with and without a trigger event.

Parameters:

<TriggerMode> AUTO | NORMal | FREErun

AUTO
The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. The time interval depends on the time base.

NORMal
The instrument acquires a waveform only if a trigger occurs.

FREErun
The instrument triggers after a very short time interval - faster than in AUTO mode. Real triggers are ignored.

*RST: AUTO

Usage: Asynchronous command

Manual operation: See "[Auto Norm]" on page 35

TRIGger:FORCe

Provokes an immediate single acquisition. Force the trigger if the acquisition is running in normal mode and no valid trigger occurs. Thus, you can confirm that a signal is available and use the waveform display to determine how to trigger on it.

Usage: Setting only
Asynchronous command

Manual operation: See "Force trigger" on page 154

TRIGger:HOLDoff:MODE <Mode>

Selects the method to define the holdoff condition.

The trigger holdoff defines when the next trigger after the current will be recognized. Thus, it affects the next trigger to occur after the current one. Holdoff helps to obtain stable triggering when the oscilloscope is triggering on undesired events.

Holdoff settings are not available if the trigger source is an external trigger input or serial bus, and if you trigger on a sequence of events.

Parameters:

<Mode> TIME | EVENts | RANDom | AUTO | OFF

TIME
Defines the holdoff directly as a time period. The next trigger occurs only after the holdoff time has passed, which is defined using TRIGger:HOLDoff:TIME).

EVENts
Defines the holdoff as a number of trigger events. The next trigger occurs only when this number of events is reached. The number of triggers to be skipped is defined with TRIGger:HOLDoff:EVENts.

RANDom
Defines the holdoff as a random time limited by TRIGger:HOLDoff:MIN and TRIGger:HOLDoff:MAX. For each acquisition cycle, the instrument selects a new random holdoff time from the specified range.

AUTO
The holdoff time is calculated automatically based on the current horizontal scale.

OFF
No holdoff

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 155

TRIGger:HOLDoff:AUTotime?

Returns the resulting holdoff time, if TRIGger:HOLDoff:MODE is set to AUTO: *Auto time = Auto time scaling * Horizontal scale*. The auto time scaling factor is defined with TRIGger:HOLDoff:SCALing.

Return values:
<AutoTime>
Range: 1E-07 to 10
Increment: 0.0002
*RST: 0.001
Default unit: s

Usage: Query only
Asynchronous command

Manual operation: See "Holdoff mode" on page 155

TRIGger:HOLDoff:SCALing <AutoTimeScl>

Sets the auto time scaling factor that the horizontal scale is multipied with, if TRIGger:HOLDoff:MODETRIGger:HOLDoff:MODETRIGger:HOLDoff:MODE is set to AUTO.
*Auto time = Auto time scaling * Horizontal scale*

The next trigger occurs only after this time has passed.

Parameters:

<AutoTimeScl>	Range:	0.001 to 1000
	Increment:	1
	*RST:	0.5

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 155

TRIGger:HOLDoff:EVENts <Events>

Defines the number of triggers to be skipped, if `TRIGger:HOLDoff:MODETRIGger:HOLDoff:MODETRIGger:HOLDoff:MODE` is set to `EVENts`. The next trigger only occurs when this number of events is reached.

Parameters:

<Events>	Range:	1 to 2147483647
	Increment:	10
	*RST:	1

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 155

TRIGger:HOLDoff:MAX <RandomMaxTime>

Defines the upper limit for the random time holdoff, if `TRIGger:HOLDoff:MODE` `TRIGger:HOLDoff:MODETRIGger:HOLDoff:MODE` is set to `RANDom`.

Parameters:

<RandomMaxTime>	Range:	1E-07 to 10
	Increment:	0.0002
	*RST:	0.002
	Default unit:	s

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 155

TRIGger:HOLDoff:MIN <RandomMinTime>

Defines the lower limit for the random time holdoff, if `TRIGger:HOLDoff:MODE` `TRIGger:HOLDoff:MODETRIGger:HOLDoff:MODE` is set to `RANDom`.

Parameters:

<RandomMinTime>	Range:	1E-07 to 5
	Increment:	0.0002
	*RST:	0.001
	Default unit:	s

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 155

TRIGger:HOLDoff:TIME <Time>

Defines the holdoff time period, if `TRIGger:HOLDoff:MODE` is set to `TIME`. The next trigger occurs only after this time has passed.

Parameters:

<Time> Range: 1E-07 to 10
Increment: 0.0002
*RST: 0.001
Default unit: s

Usage: Asynchronous command

Manual operation: See "Holdoff mode" on page 155

17.9.15 Hysteresis

TRIGger:NOISe<m>:ABSolute <Absolute>

Defines a range in absolute values around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:

<m> 1 to 4, index of the analog channel

Parameters:

<Absolute>

Usage: Asynchronous command

Manual operation: See "Absolute hysteresis" on page 156

TRIGger:NOISe<m>:EFFective?

Returns the hysteresis that is set by the instrument in automatic hysteresis mode.

Suffix:

<m> 1 to 4, index of the analog channel

Return values:

<Effective> numeric value

Usage: Query only
Asynchronous command

Manual operation: See "HW hysteresis" on page 156

TRIGger:NOISe<m>:MODE <Mode>

Selects whether the hysteresis is defined in absolute or relative values. The setting is available only in manual hysteresis mode.

Suffix:
<m> 1 to 4, index of the analog channel

Parameters:
<Mode> ABS | REL

Usage: Asynchronous command

Manual operation: See "Hysteresis mode" on page 156

TRIGger:NOISe<m>:PERDivision <InDivision>

Defines a range in divisions around the trigger level in division units. If the signal oscillates inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:
<m> 1 to 4, index of the analog channel

Parameters:
<InDivision> Range: 0 to 5
Increment: 0.01
*RST: 0
Default unit: div

Usage: Asynchronous command

Manual operation: See "Relative hysteresis" on page 156

TRIGger:NOISe<m>:RELative <Relative>

Defines a range in divisions around the trigger level as percentage. If the signal oscillates inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:
<m> 1 to 4, index of the analog channel

Parameters:
<Relative> Range: 0 to 50
Increment: 1
*RST: 0
Default unit: %

Usage: Asynchronous command

Manual operation: See "Relative hysteresis" on page 156

TRIGger:NOISe<m>[:STATe] <Mode>

Selects how the hysteresis is set.

Suffix:

<m>	1 to 4, index of the analog channel

Parameters:

<Mode> AUTO | MANual

AUTO
Automatic mode is the recommended mode. The hysteresis is set by the instrument to reject the internal noise of the instrument.

MANual
The hysteresis is defined with `TRIGger:NOISe<m>:ABSolute` or `TRIGger:NOISe<m>:RELative`.

Usage: Asynchronous command

17.9.16 Channel filter

TRIGger:MODE <TriggerMode>

Sets the trigger mode which determines the behavior of the instrument with and without a trigger event.

Parameters:

<TriggerMode> AUTO | NORMal | FREerun

AUTO
The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. The time interval depends on the time base.

NORMal
The instrument acquires a waveform only if a trigger occurs.

FREerun
The instrument triggers after a very short time interval - faster than in AUTO mode. Real triggers are ignored.

*RST: AUTO

Usage: Asynchronous command

Manual operation: See "[Auto Norm]" on page 35

TRIGger:FILTermode <Mode>

Selects the filter mode for the trigger channel.

Parameters:
<Mode> OFF | LFReject | RFReject
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Trigger filter mode" on page 157

TRIGger:LFReject <Bandwidth>

Sets the limit frequency limit for the high-pass filter of the trigger signal. Frequencies lower than this value are rejected, higher frequencies pass the filter.

Parameters:
<Bandwidth> Range: 50 kHz
*RST: 50 kHz
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "LF reject BW" on page 157

TRIGger:RFReject <Bandwidth>

Sets the limit frequency limit for the low-pass filter of the trigger signal. Frequencies higher than this value are rejected, lower frequencies pass the filter.

Parameters:
<Bandwidth> Range: 100E+3 to 4E+9
Increment: 1000
*RST: 1E+6
Default unit: Hz

Usage: Asynchronous command

Manual operation: See "RF reject BW" on page 157

17.9.17 Actions on trigger

TRIGger:ACTions:OUT:STATe <State>

Activates the outgoing pulse on the [Aux Out] connector on the rear panel.

Parameters:
<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Trigger out" on page 158

TRIGger:ACTions:OUT:DELay <Delay>

Defines the delay of the first pulse edge to the trigger point. The minimum delay is 600 ns.

Parameters:

<Delay>
Range: 6E-07 to 1
Increment: 1E-09
*RST: 6E-07
Default unit: s

Usage: Asynchronous command

Manual operation: See "Delay" on page 159

TRIGger:ACTions:OUT:PLENgth <PulseLength>

Sets the length of the trigger out pulse.

Parameters:

<PulseLength>
Range: 1.6E-08 to 0.05
Increment: 1.6E-08
*RST: 9.6E-08
Default unit: s

Usage: Asynchronous command

Manual operation: See "Pulse length" on page 159

TRIGger:ACTions:OUT:POLarity <Polarity>

Sets the polarity of the trigger out pulse, which is the direction of the first pulse edge.

Parameters:

<Polarity>
POSitive | NEGative
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Polarity" on page 159

17.10 Waveform analysis

Some of the commands in the following chapter are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, chapter "Command Sequence and Synchronization"

17.10.1 Zoom

LAYout<m>:ZOOM<n>[:ENABle] <State>

Enables the zoom.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...4, index of the zoom

Parameters:

<State>	ON | OFF

Example:	See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.
Usage:	Asynchronous command
Manual operation:	See "State" on page 161

LAYout<m>:ZOOM<n>:COUNt?

Returns the max number of available zooms.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...4, index of the zoom

Return values:

<Count>

Usage:	Query only Asynchronous command

LAYout<m>:ZOOM<n>:HORizontal:ABSolute:POSition <Center>

Defines the x-value of the centerpoint of the zoom area in absolute values.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...4, index of the zoom

Parameters:

<Center>	Range: -1E+26 to 1E+26 Increment: 0.01 *RST: 0.01
Usage:	Asynchronous command
Manual operation:	See "Position Range" on page 162

LAYout<m>:ZOOM<n>:HORizontal:ABSolute:SPAN <Span>

Defines the width of the zoom area in absolute values.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...4, index of the zoom

Parameters:

<Span>	Range: 0 to 1E+26 Increment: 0.01 *RST: 0.01
Usage:	Asynchronous command
Manual operation:	See "Position Range" on page 162

LAYout<m>:ZOOM<n>:HORizontal:ABSolute:STARt <Start>

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

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...4, index of the zoom

Parameters:

<Start>
Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 162

LAYout<m>:ZOOM<n>:HORizontal:ABSolute:STOP <Stop>

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

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...4, index of the zoom

Parameters:

<Stop>
Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 162

LAYout<m>:ZOOM<n>:HORizontal:ABSolute:WIDTh <Span>

Defines the width of the zoom area in absolute values.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...4, index of the zoom

Parameters:

<Span>
Range: 0 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

LAYout<m>:ZOOM<n>:HORizontal:MODE <Mode>

Defines if absolute or relative values are used to specify the x-axis values. Since the zoom area refers to the active signal, relative values ensure that the zoom area remains the same.

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<Mode> ABS | REL

*RST: ABS

Example: See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.

Usage: Asynchronous command

Manual operation: See "Mode" on page 162

LAYout<m>:ZOOM<n>:HORizontal:RELative:POSition <RelativeCenter>

Defines the x-value of the centerpoint of the zoom area in relative values.

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<RelativeCenter> Relative position of the centerpoint (x-value)

Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Usage: Asynchronous command

Manual operation: See "Position Range" on page 162

LAYout<m>:ZOOM<n>:HORizontal:RELative:SPAN <RelativeSpan>

Defines the width of the zoom area in relative values.

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<RelativeSpan> Range: 1E-15 to 100
Increment: 0.1
*RST: 1
Default unit: %

Usage: Asynchronous command

Manual operation: See "Position Range" on page 162

LAYout<m>:ZOOM<n>:HORizontal:RELative:STARt <RelativeStart>

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

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<RelativeStart>
Range: 0 to 100
Increment: 0.1
*RST: 0
Default unit: %

Example: See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 162

LAYout<m>:ZOOM<n>:HORizontal:RELative:STOP <RelativeStop>

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

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<RelativeStop>
Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Example: See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 162

LAYout<m>:ZOOM<n>:HORizontal:RELative:WIDTh <RelativeSpan>

Defines the width of the zoom area in relative values.

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<RelativeSpan>	Range: 1E-15 to 100 Increment: 0.1 *RST: 1 Default unit: %
Usage:	Asynchronous command

LAYout<m>:ZOOM<n>:SOURce <Diagram>

Indicates which of the waveform diagrams is selected for zooming. The number is displayed on the screen in the middle of each diagram.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...4, index of the zoom

Parameters:

<Diagram>	Index of the diagram, which is zoomed.
Example:	See Chapter 17.4.1, "SmartGrid layout with zoom", on page 353.
Usage:	Asynchronous command
Manual operation:	See "Diagram" on page 161

LAYout<m>:ZOOM<n>:VERTical:ABSolute:POSition <Center>

Defines the y-value of the centerpoint of the zoom area in absolute values.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...4, index of the zoom

Parameters:

<Center>	Range: -1E+26 to 1E+26 Increment: 0.01 *RST: 0.01
Usage:	Asynchronous command
Manual operation:	See "Position Range" on page 162

LAYout<m>:ZOOM<n>:VERTical:ABSolute:RANGe <Span>
LAYout<m>:ZOOM<n>:VERTical:ABSolute:SPAN <Span>

Defines the height of the zoom area in absolute values.

Suffix:

<m>	1...4, index of the SmartGrid layout
<n>	1...4, index of the zoom

Parameters:

<Span>
Range: 0 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Position Range" on page 162

LAYout<m>:ZOOM<n>:VERTical:ABSolute:STARt <Start>

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

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<Start>
Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 162

LAYout<m>:ZOOM<n>:VERTical:ABSolute:STOP <Stop>

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

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<Stop>
Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 162

LAYout<m>:ZOOM<n>:VERTical:MODE <Mode>

Defines if absolute or relative values are used to specify the y-axis values. Since the zoom area refers to the active signal, relative values ensure that the zoom area remains the same.

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<Mode> ABS | REL

*RST: REL

Usage: Asynchronous command

Manual operation: See "Mode" on page 162

LAYout<m>:ZOOM<n>:VERTical:RELative:POSition <RelativeCenter>

Defines the y-value of the centerpoint of the zoom area in relative values.

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<RelativeCenter> Range: 0 to 100
Increment: 0.1
*RST: 50
Default unit: %

Usage: Asynchronous command

Manual operation: See "Position Range" on page 162

LAYout<m>:ZOOM<n>:VERTical:RELative:STARt <RelativeStart>

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

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<RelativeStart> Range: 0 to 100
Increment: 0.1
*RST: 0
Default unit: %

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 162

LAYout<m>:ZOOM<n>:VERTical:RELative:STOP <RelativeStop>

Defines the upper limit of the zoom area on the x-axis, in relative values.

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Usage: Asynchronous command

Manual operation: See "Start Stop" on page 162

LAYout<m>:ZOOM<n>:VERTical:RELative:WIDTh <RelativeSpan>
LAYout<m>:ZOOM<n>:VERTical:RELative:SPAN <RelativeSpan>

Defines the height of the zoom area in relative values.

Suffix:

<m> 1...4, index of the SmartGrid layout

<n> 1...4, index of the zoom

Parameters:

<RelativeSpan> Range: 1E-15 to 100
Increment: 0.1
*RST: 100
Default unit: %

Usage: Asynchronous command

Manual operation: See "Position Range" on page 162

17.10.2 Mathematics

CALCulate:MATH<m>:STATe <First>

Activates the selected Math channel and displays the defined math waveforms.

Suffix:

<m> 1...5, index of the math waveform

Parameters:

<First> ON | OFF

Usage: Asynchronous command

Manual operation: See "Display" on page 167

CALCulate:MATH<m>[:EXPRession][:DEFine] <Expression>

Defines the math expression to be calculated for the specified math channel.

Suffix:
<m> 1...5, index of the math waveform

Parameters:
<Expression> String with regular expression for calculation

Example: `CALC:MATH 'C1*C2'`
Defines the multiplication of waveforms Channel 1 and Channel 2.

Usage: Asynchronous command

Manual operation: See "Operator" on page 167

CALCulate:MATH<m>:VERTical:SCALe[:VALue] <VerticalScale>

Sets the scale of the y-axis in the math function diagram. The value is defined as "<unit> per division", e.g. *50 mV/div*. In this case, the horizontal grid lines are displayed in intervals of 50 mV.

Suffix:
<m> 1...5, index of the math waveform

Parameters:
<VerticalScale> Range: 1E-12 to 100E+12
Increment: 1E-05
*RST: 0.5
Default unit: V

Usage: Asynchronous command

Manual operation: See "[Scale]" on page 38

CALCulate:MATH<m>:VERTical:OFFSet <VerticalOffset>

Sets a voltage offset to adjust the vertical position of the math function on the screen. Negative values move the waveform, positive values move it down.

Suffix:
<m> 1...5, index of the math waveform

Parameters:
<VerticalOffset> Range: -100000000000000 to 100000000000000
Increment: 0.01
*RST: 0
Default unit: div

Usage: Asynchronous command

Manual operation: See "Vertical offset" on page 170

CALCulate:MATH<m>:ENVSelection <EnvelopeCurve>

Selects the upper or lower part of the input waveform for mathematic calculation, or a combination of both.

Suffix:
<m> 1...5, index of the math waveform

Parameters:
<EnvelopeCurve> MIN | MAX | BOTH
*RST: BOTH

Usage: Asynchronous command

Manual operation: See "Envelope wfm selection" on page 168

CALCulate:MATH<m>:VERTical:SCALe:MODE <VertSclMd>

Sets how the vertical scale is adapted to the current measurement results. By default, scaling is done automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

Suffix:
<m> 1...5, index of the math waveform

Parameters:
<VertSclMd> MANual | AUTO
*RST: AUTO

Usage: Asynchronous command

Manual operation: See "Scale mode" on page 170

CALCulate:MATH<m>:DATA:HEADer?

Returns the header of math waveform data. The header contains attributes of the waveform.

Table 17-3: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. For most waveforms, the result is 1. For envelope waveforms, it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).	1

Suffix:
<m> 1...5, index of the math waveform

Example:
```
CALC:MATH1:DATA:HEAD?
-9.477E-008,9.477E-008,200000,1
```

Usage: Query only
Asynchronous command

CALCulate:MATH<m>:DATA:STYPe?

Returns the signal type of the source of the math waveform.

Suffix:
<m> 1...5, index of the math waveform

Return values:
<SignalType> SOUR | CORR | MEAS | NONE

SOURce = normal signal
CORRelation = correlated signal, specific math signal
MEAsurement = result of a measurement
NONE = undefined

Usage: Query only
Asynchronous command

CALCulate:MATH<m>:DATA[:VALues]? [<Offset>], [<Length>]

Returns the data of the math waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

Suffix:
<m> 1...5, index of the math waveform

Query parameters:
[<Offset>] Number of offset waveform points.
Range: 0 to m. Limit: n + m <= record length

[<Length>] Number of waveform points to be retrieved.
Range: 1 to n. Limit: n + m <= record length

Return values:
<Data> List of values according to the format and content settings.

Example:
```
:CALCulate:MATH1:DATA:VALues? 100,10
```
Returns 10 points from the start index 100.

Usage: Asynchronous command

17.10.3 History

ACQuire:HISTory:CURRent <CurrentAcqIndex>

Accesses a particular acquisition in the memory to display it, or to save it. The newest acquisition always has the index "0". Older acquisitions have a negative index.

Parameters:

<CurrentAcqIndex>	Range:	-2147483648 to 0
	Increment:	1
	*RST:	0

Usage: Asynchronous command

Manual operation: See "Current acq" on page 173

ACQuire:HISTory:PLAY

Starts and stops the replay of the history waveforms.

Usage: Event
Asynchronous command

Manual operation: See "Player" on page 172

ACQuire:HISTory:REPLay <AutoRepeat>

If enabled, the replay of the history waveform sequence repeats automatically.

Otherwise, the replay stops at the stop index set with `ACQuire:HISTory:STOP` on page 452.

Parameters:

<AutoRepeat> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Auto repeat" on page 174

ACQuire:HISTory:STARt <StartAcqIndex>

Sets the index of the first (oldest) acquisition to be displayed or exported. The index is always negative.

Parameters:

<StartAcqIndex>	Range:	-2147483648 to 0
	Increment:	1
	*RST:	0

Usage: Asynchronous command

Manual operation: See "Start acq" on page 173

ACQuire:HISTory:STOP <StopAcqIndex>

Sets the index of the last (newest) acquisition to be displayed or exported. The newest acquisition of the complete acquisition series always has the index "0".

Parameters:

<StopAcqIndex>	Range:	-2147483648 to 0
	Increment:	1
	*RST:	0

Usage: Asynchronous command

Manual operation: See "Stop acq" on page 173

ACQuire:HISTory:TPACq <TimePerAcq>

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

Parameters:

<TimePerAcq>	Range:	4E-05 to 10
	Increment:	1
	*RST:	0.05
	Default unit:	s

Usage: Asynchronous command

Manual operation: See "Display time" on page 173

ACQuire:HISTory:TSABsolute?

Returns the absolute daytime of the current acquisition (`ACQuire:HISTory:CURRent`).

Return values:

<TimeAbsString> String containing the time and unit

Usage: Query only
Asynchronous command

Manual operation: See "Time stamp" on page 173

ACQuire:HISTory:TSDate?

Returns the date of the current acquisition (ACQuire:HISTory:CURRent).

Return values:
<DateAbsString> String parameter with acquisition date

Usage: Query only
Asynchronous command

Manual operation: See "Time stamp" on page 173

ACQuire:HISTory:TSRelative?

Returns the relative time of the current acquisition - the time difference to the newest acquisition (index = 0).

See also: ACQuire:HISTory:CURRent.

Return values:
<TimeRelativ>
Range: -1E+26 to 1E+26
Increment: 1
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

Manual operation: See "Time stamp" on page 173

ACQuire:HISTory:TSRReference?

Returns the relative time of the currently selected acquisition and the internal reference time (horizontal alignment) in history view in relation to the acquisition with index 0.

Return values:
<TimeRelIntRef>
Range: -1E+26 to 1E+26
Increment: 1
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

Manual operation: See "Time stamp" on page 173

ACQuire:HISTory[:STATe] <State>

Enables the history mode and allows you to save history waveforms to file.

Parameters:
<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show history" on page 172

17.10.4 Reference waveforms

17.10.4.1 Setup

REFCurve<rc>:NAME <Name>

Defines the name of the reference waveform file to be loaded, saved or deleted.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<Name>

Usage: Asynchronous command

REFCurve<rc>:OPEN

Loads the reference waveform file selected by `REFCurve<rc>:NAME` on page 454. Note that reference waveforms can be loaded only from `.ref` files.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Event
Asynchronous command

Manual operation: See "Recall" on page 179

REFCurve<rc>:CLEar

The selected reference waveform disappears, its memory is deleted.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Setting only
Asynchronous command

Manual operation: See "Clear" on page 179

REFCurve<rc>:RESTore

Resets the time scale and the reference point to the original values of the reference waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Setting only
Asynchronous command

Manual operation: See "Restore settings" on page 180

REFCurve<rc>:SAVE

Saves the reference waveform to the file selected by `REFCurve<rc>:NAME`.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Event
Asynchronous command

Manual operation: See "Save" on page 179

REFCurve<rc>:SOURce <Source>

Selects the source waveform from the active waveforms, e.g. input channels, math waveforms, or spectrum.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<Source> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | SPECMAXH1 | SPECMINH1 | SPECNORM1 | SPECAVER1
Source of the reference waveform.

Usage: Asynchronous command

Manual operation: See "Source" on page 178

REFCurve<rc>:STATe <State>

Enables the display of the reference waveform in the diagram.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show" on page 178

REFCurve<rc>:UPDate

Copies/updates the selected source waveform with all its settings to the memory of the reference waveform. If the acquisition is running, the reference waveform is a snapshot.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Event
Asynchronous command

Manual operation: See "Create/Update" on page 179

REFCurve<rc>:OFFSet <VerticalOffset>

The vertical offset moves the reference waveform vertically. Enter a value with the unit of the waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<VerticalOffset> Range: -1E+26 to 1E+26
Increment: 1E-06
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Vertical offset" on page 181

17.10.4.2 Scaling

REFCurve<rc>:SCALe <VerticalScale>

Sets the vertical scale in Volts per division. The vertical scale defines the displayed amplitude of the selected waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<VerticalScale> Range: 1E-15 to 1E+26
Increment: 1E-05
*RST: 0.5
Default unit: V/div

Usage: Asynchronous command

Manual operation: See "[Scale]" on page 38

REFCurve<rc>:POSition <VertPosi>

Available, if `REFCurve<rc>:VMODe` is set to `INDependent`.

Moves the reference waveform up or down in the diagram.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<VertPosi> Range: -1E+26 to 1E+26
Increment: 0.02
*RST: 0
Default unit: div

Usage: Asynchronous command

Manual operation: See "Vertical position" on page 182

REFCurve<rc>:HMODe <HorizontalMode>

Selects the coupling of horizontal settings.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<HorizontalMode> ORIGinal | COUPled

ORIGinal
Horizontal scaling and reference point of the source waveform are used.

COUPled
The current horizontal settings of the diagram are used.
*RST: ORIGinal

Usage: Asynchronous command

Manual operation: See "Mode" on page 183

REFCurve<rc>:RESCale:HORizontal:FACTor <ScaleFactor>

Sets the horizontal scale factor. A factor greater than 1 stretches the waveform horizontally, a factor lower than 1 compresses the curve.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<ScaleFactor> Range: 1E-06 to 1000000
Increment: 0.1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Scale factor" on page 183

REFCurve<rc>:RESCale:HORizontal:OFFSet <Offset>

Moves the waveform horizontally. Enter a value with a time unit suitable for the time scale of the diagram.

Positive values shift the waveform to the right, negative values shift it to the left.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<Offset> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Horizontal offset" on page 183

REFCurve<rc>:RESCale:HORizontal:STATe <State>

If enabled, the horizontal offset and factor are applied to the reference waveform.

Stretching and offset change the display of the waveform independent of the horizontal settings of the source waveform and of the horizontal diagram settings.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:

<State> ON | OFF

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Enable" on page 183

REFCurve<rc>:RESCale:VERTical:FACTor <ScaleFactor>

Sets the vertical scale factor. A factor greater than 1 stretches the waveform vertically, a factor lower than 1 compresses the curve.

Suffix:

<rc> 1...4, index of the reference waveform

Parameters:

<ScaleFactor> Range: -1000000 to 1000000
Increment: 0.1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Scale factor" on page 183

REFCurve<rc>:RESCale:VERTical:OFFSet <Offset>

The vertical offset moves the reference waveform vertically. Enter a value with the unit of the waveform.

Like vertical offset of a channel waveform, the offset of a reference waveform is subtracted from the measured value. Negative values shift the waveform up, positive values shift it down.

Suffix:

<rc> 1...4, index of the reference waveform

Parameters:

<Offset> Range: -1E+26 to 1E+26
Increment: 1E-06
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Vertical offset" on page 183

REFCurve<rc>:RESCale:VERTical:STATe <State>

If enabled, the vertical offset and factor are applied to the reference waveform.

Stretching and offset change the display of the waveform independent of the vertical scale and position.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Enable" on page 182

REFCurve<rc>:TOORiginal

Available, if `REFCurve<rc>:VMODe` is set to `INDependent`.

Restores the original vertical settings of the reference waveform (vertical scale, position, and offset).

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Setting only
Asynchronous command

Manual operation: See "Set to original" on page 181

REFCurve<rc>:VMODe <VerticalMode>

Selects the coupling of vertical settings.

Suffix:
<rc> 1...4, index of the reference waveform

Parameters:
<VerticalMode> COUPled | INDependent

COUPled
Vertical position and scale of the source are used.

INDependent
Scaling and position can be set specific to the reference waveform.
*RST: INDependent

Usage: Asynchronous command

Manual operation: See "Mode" on page 181

17.10.4.3 Reference waveform data export

Commands to transmit the data of reference waveforms are listed below. Commands for saving waveform data to file are described in Chapter 17.11.3, "Waveform export to file", on page 469.

REFCurve<rc>:DATA:STYPe?

Returns the signal type of the source of the reference waveform.

Suffix:
<rc> 1...4, index of the reference waveform

Return values:
<SignalType>

Usage: Query only
Asynchronous command

REFCurve<rc>:DATA:HEADer?

Returns information on the reference waveform.

Table 17-4: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. Depends on the source waveform from which the reference waveform was created	1

Suffix:
<rc> 1...4, index of the reference waveform

Example:
```
REFC:DATA:HEAD?
-9.477E-008,9.477E-008,200000,1
```

Usage: Query only
Asynchronous command

REFCurve<rc>:DATA[:VALues]?

Returns the data of the channel waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]` on page 360.

Suffix:
<rc> 1...4, index of the reference waveform

Usage: Query only
Asynchronous command

17.11 Data management

Some of the commands in the following chapter are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, chapter "Command Sequence and Synchronization"

17.11.1 Instrument settings

The Mass MEMory subsystem provides commands to access the storage media and to save and reload instrument settings.

File and directory names

The <file_name> and <directory_name> parameters are strings. Some commands use a fixed directory; for others the <file_name> can contain the complete path including the drive name and all subdirectories. If no complete path is specified, the file location is relative to the current directory, queried with `MMEMory:CDIRectory?`. The file name itself may contain the period as a separator for extensions.

File and directory names can be chosen according to Windows™ conventions; the restrictions placed on file names known from DOS systems do not apply. All letters and numbers are allowed, as well as the special characters "_", "^", "$", "~", "!", "#", "%", "&", "-", "{", "}", "(", ")", "@" and "`". Reserved file names are CON, AUX, COM1, ..., COM4, LPT1, ..., LPT3, NUL and PRN.

The use of wildcards ? and * is not allowed.

MMEMory:DRIVes?

Returns the path list of available drives.

Return values:

<Drive>	List of strings, for example: Instrument only: `"/home/storage/userData"` Instrument with connected USB flash drive: `"/home/storage/userData","/run/media/usb/MYDATA"`. MYDATA is the partition name, which is also shown in the file explorer. Instrument with connected USB flash drive: `"/home/storage/userData","/run/media/usb/8AF8-3EBA"`. 8AF8-3EBA is an example ID. ID is used if the partition does not have a name, or the name cannot be read.

Usage: Query only

MMEMory:DCATalog? [<PathName>]

Returns the subdirectories of the current or of a specified directory.

Query parameters:

<PathName>	String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be set and queried with `MMEMory:CDIRectory`.

Return values:

<FileEntry>	Names of the subdirectories separated by colons. The first two strings are related to the parent directory.

Example: `MMEM:DCAT?`

Usage: Query only

MMEMory:DCATalog:LENGth? [<PathName>]

Returns the number of subdirectories of the current or of a specified directory. The number includes the parent directory strings "." and ".." and corresponds to the number of strings returned by the `MMEMory:DCATalog?` command.

Query parameters:

<PathName>	String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be set and queried with `MMEMory:CDIRectory`.

Return values:

<FileEntryCount>	Number of parent and subdirectories.

Example: `MMEM:DCAT:LENG?`
`5`

Usage: Query only

MMEMory:CDIRectory [<DirectoryName>]

Changes the default directory for file access.

Parameters:
<DirectoryName> String parameter to specify the directory.
*RST: "\"

Example: `MMEM:CDIR 'home/storage/userData/Waveforms'`

Usage: SCPI confirmed

MMEMory:MDIRectory <DirectoryName>

Creates a new directory with the specified name.

Setting parameters:
<DirectoryName> String parameter to specify the new directory. If the path consists of several subdirectories, the complete tree will be created if necessary.

Example: `MMEM:MDIR 'home/storage/userData/Waveforms'`

Usage: Setting only

MMEMory:RDIRectory <DirectoryName>

Deletes the specified directory.

Setting parameters:
<DirectoryName> String parameter to specify the directory to be deleted.
This directory must be empty, otherwise it is not deleted.

Example: `MMEM:RDIR 'home/storage/userData/Test'`

Usage: Setting only

MMEMory:CATalog? [<PathName>][, <Format>]

Returns the a list of files contained in the specified directory. The result corresponds to the number of files returned by the MMEMory:CATalog:LENgth command.

Query parameters:
<PathName> String parameter to specify the directory. If the directory is omitted, the command queries directory specified with `MMEMory:CDIRectory`.

<Format> ALL | WTIMe

ALL: Extended result including file, date, time and attributes
WTIMe: Extended result including file, date, time

Return values:

<UsedMemory> Total amount of storage currently used in the directory, in bytes.

<FreeMemory> Total amount of storage available in the directory, in bytes.

<FileEntry> All files and subdirectories of the directory are listed with their file name, format and size in bytes. The first two strings are related to the parent directory.

Example:

```
MMEM:CAT? 'home/storage/userData'
529479,1831777894400,".,DIR,0","..,DIR,0",
"Backup,DIR,0","CSS,DIR,0","DATEN,DIR,0",
"Commands.jar,BIN,529479","FAVORITES,DIR,0",
"LOG,DIR,0","DATA,DIR,0","test,DIR,0",
"TotalCMD,DIR,0"
```

Usage: Query only
SCPI confirmed

MMEMory:CATalog:LENGth? [<PathName>]

Returns the number of files and subdirectories of the current or specified directory. The number includes the parent directory strings "." and ".." and it corresponds to the number of <FileEntry> strings returned by the `MMEMory:CATalog?` command.

Query parameters:

<PathName> String parameter, directory to be queried. If the directory is omitted, the current directory is queried, specified with `MMEMory:CDIRectory`.

Return values:

<Count> Number of files and subdirectories including parent directory entries.

Example:

```
MMEM:CDIR 'home/storage/userData'
MMEM:CAT:LENG?
11
```

Usage: Query only

MMEMory:COPY <FileSource>[, <FileDestination>]

Copies an existing file to a new file.

Setting parameters:

<FileSource> String parameter, contains name and path of the file to be copied. Wildcards (* and ?) are allowed.

<FileDestination> String parameter, contains name and path of the new file. If the file already exists, it is overwritten without notice. If no file destination is specified, the source file is written to the current directory specified with `MMEMory:CDIRectory`.

Usage: Setting only
SCPI confirmed

MMEMory:MOVE <FileSource>, <FileDestination>

Moves the specified file to a new location on the same drive and renames it.

Setting parameters:

<FileSource> String parameter, contains name and path of the file to be copied.
Wildcards (* and ?) are allowed. Therefore, specify a directory for <FileDestination>. Renaming is not possible.

<FileDestination> String parameter, contains name and path of the new file. If no path is specified, the <FileSource> directory is used - the file is renamed.

Usage: Setting only
SCPI confirmed

MMEMory:DELete <FileName>

Removes the specified file(s). To delete directories, use `MMEMory:RDIRectory`.

Setting parameters:

<FileName> String parameter to specify the name and directory of the file to be removed. Wildcards (* and ?) are allowed.
If no path is defined, the current directory is used, specified with `MMEMory:CDIRectory`.

Example: `MMEM:DEL '*.CFG'`
Deletes all cfg files from the current directory.

Usage: Setting only
SCPI confirmed

MMEMory:DATA <FileName>, <Data>
MMEMory:DATA? <FileName>

Stores data in the specified file to the storage location specified using `MMEMory:CDIRectory`.

Parameters:

<Data> <block>

488.2 block data format. The delimiter EOI must be selected to achieve correct data transfer.
The block begins with character '#'. The next digit is the length of the length information, followed by this given number of digits providing the number of bytes in the following binary data.

Parameters for setting and query:

<FileName> String parameter, the name of the file the data is stored to.

Example: `MMEM:DATA 'abc.txt', #216This is the file`
#2: the length infomation has two digits
16: the binary data has 16 bytes

Example: `MMEM:DATA? 'abc.txt'`
Returns the data from file `abc.txt`.

MMEMory:ATTRibute <FileName>, <Attributes>
MMEMory:ATTRibute? <FileName>

Sets file attributes for the specified file(s). The command can be used for files only.

Setting parameters:

<Attributes> String with attributes and setting information.
'+' before the attribute: sets the attribute
'-' before the attribute: deletes the attribute
'R': read only
'H': hidden file

Parameters for setting and query:

<FileName> String parameter, contains name and path of the file. Wildcards (* and ?) are allowed.

Return values:

<FileEntry> String containing: "<file_name>,<file_attributes>"

MMEMory:SAV <FileDestination>

Stores the current instrument settings to the specified file.

This command has the same effect as the combination of `*SAV` and `MMEMory:STORe:STATe`.

Parameters:

<FileDestination> String parameter specifying path and filename of the target file. Wildcards are not allowed.

Usage: Event

MMEMory:RCL <FileSource>

Restores the instrument settings from the specified file.

This command has the same effect as the combination of MMEMory:LOAD:STATe and *RCL.

Parameters:

'<FileSource>' String parameter specifying the path and filename of the source file. Wildcards are not allowed.

Usage: Event

MMEMory:STORe:STATe <MemoryNumber>, <FileName>

Stores the instrument settings from the specified internal memory to the specified file. To store the current instrument settings to the internal memory, use *SAV first.

Setting parameters:

<MemoryNumber> Number of the internal memory

Range: 1 to 99

<FileName> String parameter specifying the complete path and filename of the source file.

Usage: Setting only

MMEMory:LOAD:STATe <MemoryNumber>, <FileName>

Loads the instrument settings from the specified file to the specified internal memory. After the file has been loaded, the settings must be activated using a *RCL command.

Setting parameters:

<MemoryNumber> Number of the internal memory

Range: 1 to 99

<FileName> String parameter specifying the complete path and filename of the source file.

Usage: Setting only

17.11.2 Saveset

SAVeset:CONFig:PREView <IncludeImage>

If set to OFF, the saveset is stored without the preview image to reduce the file size.

Use the command each time before you save a saveset.

Parameters:

<IncludeImage> ON | OFF

*RST: ON

17.11.3 Waveform export to file

EXPort:WAVeform:NAME <name>

Sets the path, the filename and the file format of the export file.

Parameters:

<name>   String with path and file name with extension `*xml`, `*ref`, `*csv`.
For local storage, the path is always `home/storage/userData`.

Example:
```
EXP:WAV:NAME
'home/storage/userData/Export_C1.csv'
EXP:WAV:SCOP DISP
EXP:WAV:SAVE
```
Saves the visible waveform data of channel 1 in xml format to `home/storage/userData/Export_C1.csv`.

Usage: Asynchronous command

Manual operation: See "Location" on page 238

EXPort:WAVeform:SAVE

Saves the waveform to the file specified with `EXPort:WAVeform:NAME`.

Usage: Event
Asynchronous command

Manual operation: See "Location" on page 238

EXPort:WAVeform:SCOPe <Scope>

Defines the part of the waveform record that has to be stored.

Parameters:

<Scope>   DISPlay | ALL | CURSor | GATE | MANual

DISPlay
Waveform data that is displayed in the diagram.

ALL
Complete waveform, which is usually longer than the displayed waveform.

CURSor
Data between the cursor lines if a cursor measurement is defined for the source waveform.

GATE
Data included in the measurement gate if a gated measurement is defined for the source waveform.

MANual
Saves the data between user-defined start and stop values to be set with `EXPort:WAVeform:STARt` and `EXPort:WAVeform:STOP`.

*RST: DISPlay

Usage: Asynchronous command

Manual operation: See "Export mode" on page 237

EXPort:WAVeform:SOURce <Source>

Selects the waveform to be exported to file.

Parameters:

<Source> C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4 | SPECMAXH1 | SPECMINH1 | SPECNORM1 | SPECAVER1

Usage: Asynchronous command

Manual operation: See "Source" on page 237

EXPort:WAVeform:STARt <Start>

Sets the start time value of the waveform section for export, if `EXPort:WAVeform:SCOPe` on page 469 is set to `Manual`.

Parameters:

<Start> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01
Default unit: s

Usage: Asynchronous command

Manual operation: See "Export mode" on page 237

EXPort:WAVeform:STOP <Stop>

Sets the end time value of the waveform section for export, if `EXPort:WAVeform:SCOPe` on page 469 is set to `Manual`.

Parameters:

<Stop>	Range: -1E+26 to 1E+26 Increment: 0.01 *RST: 0.01 Default unit: s

Usage: Asynchronous command

Manual operation: See "Export mode" on page 237

EXPort:WAVeform:GATE

Selects the gate to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `GATE`.

Usage: Asynchronous command

Manual operation: See "Export mode" on page 237

EXPort:WAVeform:CURSorset <Cursorset>

Sets the cursor set to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `CURSor`.

Parameters:

<Cursorset> CURSOR1 | CURSor1 | CURSOR2 | CURSor2

CURSOR*x* = CURSor*x*

Usage: Asynchronous command

Manual operation: See "Export mode" on page 237

17.11.4 Results

EXPort:RESult:NAME <FilePath>

Sets the path, the filename and the file format of the export file.

Parameters:

<FilePath> String with path and file name with extension `.csv`.

Usage: Asynchronous command

EXPort:RESult:SAVE

Saves the results to file. The target file is set using EXPort:RESult:NAME. To select the results to be exported, use EXPort:RESult:SELect:CURSor and EXPort:RESult:SELect:MEASurement.

Usage: Event
Asynchronous command

EXPort:RESult:SELect:CURSor <CursorResult>

Includes the current cursor results in the export file.

Parameters:

<CursorResult> ON | OFF
*RST: OFF

Usage: Asynchronous command

EXPort:RESult:SELect:MEASurement <MeasResult>

Includes the current automatic measurement results in the export file.

Parameters:

<MeasResult> ON | OFF
*RST: OFF

Usage: Asynchronous command

17.11.5 Screenshots

The HCOPy subsystem and some other commands control the output of display information for documentation purposes. The instrument allows two independent output configurations which can be set separately with the suffix.

Note that the remote mode is intended for maximum performance. Therefore, the display does not follow the remote commands constantly. To get a correct screenshot, turn the display on using SYSTem:DISPlay:UPDate.

HCOPy:DESTination<m> <medium>

Selects the output medium: file or clipboard.

Suffix:
<m> 1..2

Parameters:
<medium>

Manual operation: See "Directory" on page 248

HCOPy:DEVice<m>:LANGuage <FileFormat>

Defines the file format for output of the display image to file.

Suffix:
<m> 1..2

Parameters:
<FileFormat> PNG | JPG | BMP | TIFF | PDF
*RST: PNG

HCOPy:DEVice<m>:INVerse <InverseColor>

Inverts the colors of the output, i.e. a dark waveform is shown on a white background.

See also `HCOPy:WBKG` and White background.

Suffix:
<m> 1..2

Parameters:
<InverseColor> ON | OFF
*RST: ON

Manual operation: See "Inverse color" on page 248

HCOPy:IMMediate<m>:NEXT

Starts the output of the next display image, depending on the `HCOPy:DESTination<m>` destination setting.

If the screenshot is saved to a file, the file name used in the last saving process is automatically counted up to the next unused name.

Suffix:
<m> 1..2
Selects the output configuration.

Usage: Event
Asynchronous command

HCOPy:IMMediate<m>[:DUM]

Starts the immediate output of the display image, depending on the HCOPy:DESTination<m> destination setting.

To get a correct screenshot of the diagrams, results, and dialog boxes, turn on the display using SYSTem:DISPlay:UPDate.

Suffix:

<m> 1..2
Selects the output configuration.

Usage: Event
Asynchronous command

HCOPy:ISBA <IncludeSignBar>

If enabled, the screenshot shows the signal bar below the diagram area.

Parameters:

<IncludeSignBar> ON | OFF
*RST: ON

Manual operation: See "Include signal bar" on page 248

HCOPy:SSD <ShwSetDialog>

If enabled, the currently open dialog box is included in the screenshot.

Parameters:

<ShwSetDialog> ON | OFF
*RST: OFF

Manual operation: See "Show setup dialog" on page 248

HCOPy:WBKG <WhiteBackground>

Inverts the background color, so you can picture waveforms with normal waveform colors on white background.

If both HCOPy:WBKG and HCOPy:DEVice<m>:INVerse are ON, the instrument inverts the background twice, and it appears black.

Parameters:

<WhiteBackground> ON | OFF
*RST: OFF

Manual operation: See "White background" on page 248

HCOPy:CMAP<m>:DEFault <PrintColorSet>

Defines the default color set for printing of the display image.

To set the output to printer, use HCOPy:DESTination<m>.

Suffix:

<m>	1..2 Selects the output configuration.

Parameters:

<PrintColorSet>	DEF1 | DEF2 | DEF3 | DEF4 *RST: DEF1

17.12 Automatic measurements

This chapter contains all remote commands to set up automatic measurements and to analyze the measurement results.

Measurement suffix <mg>

The suffix <mg> indicates the number of the measurement, for which the command takes effect.

17.12.1 General settings

MEASurement<mg>:COUNt?

Returns the maximum number of measurements, which is the maximum value for the <mg> suffix.

Suffix:

<mg>	Irrelevant, omit the suffix.

Return values:

<Count>	Maximum number of measurements

Usage:	Query only Asynchronous command

MEASurement<mg>[:ENABle] <First>

Switches the indicated measurement on or off.

Suffix:

<mg>	1...16, index of the measurement

Parameters:
<First> ON | OFF

Usage: Asynchronous command

MEASurement<mg>:SOURce <SignalSource>,[<SignalSource2>]

Sets the source of the measurement.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<SignalSource> NONE | C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5

<SignalSource2> NONE | C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Source" on page 206

MEASurement<mg>:FSRC <Source>

Defines the first measurement source.

The command is an alternative to `MEASurement<mg>:SOURce`.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<Source> NONE | C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

MEASurement<mg>:SSRC <Source2>

Defines the second measurement source.

The command is an alternative to `MEASurement<mg>:SOURce`.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<Source2> NONE | C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5

Usage: Asynchronous command

Manual operation: See "Clock source" on page 209

MEASurement<mg>:MAIN <MeasType>

Defines the measurement that is used as a source for math calculations and result analysis.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<MeasType> HIGH | LOW | AMPLitude | MAXimum | MINimum | PDELta | MEAN | RMS | STDDev | CRESt | POVershoot | NOVershoot | AREA | RTIMe | FTIMe | PPULse | NPULse | PERiod | FREQuency | PDCYcle | NDCYcle | CYCarea | CYCMean | CYCRms | CYCStddev | CMAXimum | CMINimum | CPDelta | PULCnt | DELay | PHASe | BWIDth | EDGecount | SETup | HOLD | SHT | SHR | DTOTrigger | SLERising | SLEFalling

Usage: Asynchronous command

MEASurement<mg>:ENVSelect <EnvelopeCurve>

Relevant only for measurements on envelope waveforms. It selects the envelope to be used for measurement.

Prerequisites:

- `ACQuire:TYPE` on page 391 is set to `ENVElope`.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<EnvelopeCurve> MIN | MAX | BOTH

MIN
Measures on the lower envelope.

MAX
Measures on the upper envelope.

BOTH
The envelope is ignored, and the waveform is measured as usual.

*RST: BOTH

Usage: Asynchronous command

Manual operation: See "Envelope" on page 206

17.12.2 Measurement-specific settings

MEASurement<mg>:AMPTime:CSLope <SetHoldClkSlp>

Sets the edge of the clock from which the setup and hold times are measured.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<SetHoldClkSlp> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Clock slope" on page 209

MEASurement<mg>:AMPTime:ESLope <EdgesSlope>

Sets the edge direction to be counted: rising edges, falling edges, or both. The setting is only relevant for edge count measurement `MEASurement<mg>:MAIN` is set to `EDGecount`.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<EdgesSlope> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Edges slope" on page 208

MEASurement<mg>:AMPTime:PTCount <PulseCount>

Sets the number of positive pulses for the pulse train measurement. It measures the duration of N positive pulses from the rising edge of the first pulse to the falling edge of the N-th pulse.

Suffix:
<mg> 1...16, index of the measurement

Parameters:

<PulseCount>
Range: 1 to 2147483647
Increment: 1
*RST: 1

Usage: Asynchronous command

Manual operation: See "Pulse count" on page 207

MEASurement<mg>:AMPTime:PSLope <PulsesSlope>

Sets the first slope of the pulses to be counted. The setting is only relevant for pulse count measurement (MEASurement<mg>:MAIN is set to PULCnt.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<PulsesSlope> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Pulse slope" on page 207

MEASurement<mg>:AMPTime:DELay<n>:DIRection <EdgeCountDir>

Selects the direction for counting slopes for each source: from the beginning of the waveform, or from the end.

Suffix:

<mg> 1...16, index of the measurement
Selects the source number.

<n> 1..2

Parameters:

<EdgeCountDir> FRFI | FRLA

FRFI - FRom FIrst, counting starts with the first edge of the waveform.
FRLA - FRom LAst, counting starts with the last edge of the waveform.
*RST: FRFI

Usage: Asynchronous command

Manual operation: See "Direction" on page 210

MEASurement<mg>:AMPTime:DTOTrigger<n>:SLOPe <DlyTrigSlp>

Sets the edge direction to be used for delay measurement.

Suffix:

<mg> 1...16, index of the measurement

<n> — 1..2
Selects the source number.

Parameters:
<DlyTrigSlp> — POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Delay to trigger measurement settings" on page 210

MEASurement<mg>:AMPTime:DELay<n>:SLOPe <Slope>

Sets the edge of each source, between which the delay is measured.

Suffix:
<mg> — 1...16, index of the measurement

<n> — 1..2
Selects the source number.

Parameters:
<Slope> — POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Slope" on page 210

17.12.3 Results

MEASurement<mg>:RESult[:ACTual]?
MEASurement<mg>:RESult:AVG?
MEASurement<mg>:RESult:NPEak?
MEASurement<mg>:RESult:PPEak?

MEASurement<mg>:RESult:RELiability? [<MeasType>]
MEASurement<mg>:RESult:RMS?
MEASurement<mg>:RESult:WFMCount?
MEASurement<mg>:RESult:EVTCount?
MEASurement<mg>:RESult:STDDev?

Return the statistic results of the specified measurement. If no parameter is specified, the result of the main measurement is returned. The main measurement is defined using `MEASurement<mg>:MAIN`.

- [:ACTual]: current measurement result
- AVG: average of the measurement results
- EVTCount: number of measurement results in the measurement
- NPEak: negative peak value of the measurement results
- PPEak: positive peak value of the measurement results
- RELiability: reliability of the measurement result
- RMS: RMS value of the measurement results
- STDDev: standard deviation of the measurement results

Suffix:

<mg>	1...16, index of the measurement

Return values:

<StdDev>	Range:	-1E+26 to 1E+26
	Increment:	1E-10
	*RST:	0

Usage: Query only
Asynchronous command

MEASurement<mg>:RESult:STARt?
MEASurement<mg>:RESult:STOP?

Return the start and stop times of the specified measurement. The parameter defines the measurement. If no parameter is specified, the result of the main measurement is returned. The main measurement is defined using `MEASurement<mg>:MAIN`.

Suffix:

<mg>	1...16, index of the measurement

Return values:

<Stop>	Range:	-1E+26 to 1E+26
	Increment:	0
	*RST:	0

Usage: Query only
Asynchronous command

MEASurement<mg>:RESult:EVENts:COUNt?

Returns the number of measured events in one acquisition.

The command is relevant for measurements of all events, see MEASurement<mg>:MULTiple.

Suffix:

<mg>	1...16, index of the measurement

Return values:

<Count>	Number of events

Usage: Query only
Asynchronous command

MEASurement<mg>:RESult:EVENts:STARt? <EventIndex>

Returns the start time of the indicated measured event.

The command is relevant for measurements of all events, see MEASurement<mg>:MULTiple.

Suffix:

<mg>	1...16, index of the measurement

Setting parameters:

<EventIndex>	Index number of the measured event.

Return values:

<EventStart>	Range: -1E+26 to 1E+26 Increment: 0 *RST: 0

Usage: Query only
Asynchronous command

MEASurement<mg>:RESult:EVENts:STOP? <EventIndex>

Returns the end time of the indicated measured event.

The command is relevant for measurements of all events, see MEASurement<mg>:MULTiple.

Suffix:

<mg>	Irrelevant, omit the suffix.

Setting parameters:

<EventIndex>	Index number of the measured event.

Return values:

<EventStop>	Range: -1E+26 to 1E+26 Increment: 0 *RST: 0

Usage: Query only
Asynchronous command

MEASurement<mg>:RESult:EVENts:VALue? <MeasResEvtIdx>

Returns the measured value of the indicated measured event.

The command is relevant for measurements of all events, see `MEASurement<mg>:MULTiple`.

Suffix:

<mg>	1...16, index of the measurement

Setting parameters:

<EventIndex>	Index number of the measured event.

Return values:

<EventValue>	Range:	-1E+26 to 1E+26
	Increment:	1E-10
	*RST:	0

Usage: Query only
Asynchronous command

17.12.4 Statistics

MEASurement<mg>:CLEar

Deletes the statistic results of the indicated mesurement.

Suffix:

<mg>	1...16, index of the measurement

Usage: Setting only
Asynchronous command

MEASurement<mg>:STATistics[:ENABle] <GlobalEnable>

Enables statistics calculation for all measurements.

Suffix:

<mg>	Irrelevant, omit the suffix.

Parameters:

<GlobalEnable>	ON | OFF	
	*RST:	OFF

Usage: Asynchronous command

Manual operation: See "Statistics" on page 212

MEASurement<mg>:STATistics:RESet

Resets the statistics for all measurements.

Suffix:
<mg> Irrelevant, omit the suffix.

Usage: Setting only
Asynchronous command

Manual operation: See "Clear results" on page 212

MEASurement<mg>:MULTiple <GlobalMeassAll>

If ON, the measurement is performed repeatedly if the measured parameter occurs several times inside the acquisition or defined gate. All results are included in evaluation, e.g. in statistics. To set the number of results to be considered, use `MEASurement<mg>:MNOMeas`.

Suffix:
<mg> Irrelevant, omit the suffix.

Parameters:
<GlobalMeassAll> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Measure all events" on page 212

MEASurement<mg>:MNOMeas <MaxMeasPerAcq>

Sets the maximum number of measurements per acquisition if `MEASurement<mg>:MULTiple` is on.

Suffix:
<mg> Irrelevant, omit the suffix.

Parameters:
<MaxMeasPerAcq> Range: 2 to 1000000
Increment: 1
*RST: 1000

Usage: Asynchronous command

Manual operation: See "Max. No. of events" on page 212

17.12.5 Gate

GATE<m>:ENABle <First>

Enables the gate.

Suffix:

<m>	1...2, index of the gate

Parameters:

<First>	ON | OFF
Usage:	Asynchronous command
Manual operation:	See "Add " on page 198

GATE<m>:GCOupling <CouplingMode>

The gate coupling mode selects how the gate area is defined.

Suffix:

<m>	1...2, index of the gate

Parameters:

<CouplingMode> MANual | CURSor | ZOOM | SPECtrum

MANual
Manually define the gate with a user-defined start and stop values.

CURSor
Cursor coupling is available if a cursor is defined. The gate area is defined by the cursor lines of an active cursor measurement.

ZOOM
Zoom coupling is available if a zoom is defined. The gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.

SPECtrum
Spectrum coupling is available if a spectrum is enabled.

*RST: MANual

Usage:	Asynchronous command
Manual operation:	See "Coupling mode" on page 198

GATE<m>:CURSor <Cursorset>

Available for `GATE<m>:GCOupling` = `CURSor`.

Selects the cursor set to be used for measurement gating. The gate area is defined by the cursor lines.

Suffix:
<m> 1...2, index of the gate

Parameters:
<Cursorset> CURSOR1 | CURSor1 | CURSOR2 | CURSor2

CURSOR*x* = CURSor*x*

*RST: CURSOR1

Usage: Asynchronous command

Manual operation: See "Coupling mode" on page 198

GATE<m>:ZDIagram <GateName>,<DiagramGroup>,<ZoomDiagram>

Available for `GATE<m>:GCOupling` = `ZOOM`.

The gate area is defined identically to the zoom area for the selected zoom diagram.

Suffix:
<m> 1...2, index of the gate

Parameters:
<DiagramGroup> String with the name of the diagram on which the zoom is based

<ZoomDiagram> String with the name of the diagram on which the zoom is based

Setting parameters:
<GateName> String with the name of the gate on which the zoom is based

Manual operation: See "Coupling mode" on page 198

GATE<m>:MODE <Mode>

Selects if the gate settings are configured using absolute or relative values.

Suffix:
<m> 1...2, index of the gate

Parameters:
<Mode> ABS | REL

*RST: ABS

Usage: Asynchronous command

Manual operation: See "Mode" on page 199

GATE<m>:ABSolute:STARt <Start>
GATE<m>:ABSolute:STOP <Stop>

Define the absolute start and end values for the gate, respectively.

Available, if `GATE<m>:GCOupling` = `MANUal` and `GATE<m>:MODE` =`ABS`.

Suffix:
<m> 1...2, index of the gate

Parameters:
<Stop> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Mode" on page 199

GATE<m>:RELative:STARt <RelativeStart>
GATE<m>:RELative:STOP <RelativeStop>

Define the relative start and end values for the gate, respectively.

Available, if `GATE<m>:GCOupling` = `MANUal` and `GATE<m>:MODE` =`REL`.

Suffix:
<m> 1...2, index of the gate

Parameters:
<RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Usage: Asynchronous command

Manual operation: See "Mode" on page 199

GATE<m>:SHOW <DisplayState>

If enabled, the gate area is indicated in the source diagram.

Suffix:
<m> 1...2, index of the gate

Parameters:
<DisplayState> ON | OFF
*RST: ON

Usage: Asynchronous command

MEASurement<mg>:GATE <Gate>

Sets the gate of the measurement. Enable a gate before you assign a measurement to it (`GATE<m>:ENABle` =`ON`).

The query returns 0, if no gate is assigned.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<Gate>

Usage: Asynchronous command

Manual operation: See "Measurements gated by G1/G2" on page 199

17.12.6 Reference levels

REFLevel<rl>:LMODe <LevelMode>

Defines if the reference level is set in absolute or relative values.

Suffix:
<rl> 1...2, index of the reference level

Parameters:
<LevelMode> ABS | REL
*RST: REL

Usage: Asynchronous command

Manual operation: See "Level mode" on page 201

REFLevel<rl>:ABSolute:HYSTeresis <HystAbs>

Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Suffix:
<rl> 1...2, index of the reference level

Parameters:
<HystAbs> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0.005
Default unit: V

Usage: Asynchronous command

Manual operation: See "Hysteresis" on page 202

REFLevel<rl>:ABSolute:LLEVel <LowerLevel>

Sets the lower reference level in absolute values. This is required, e.g., to determine a fall.

Suffix:
<rl> 1...2, index of the reference level

Parameters:
<LowerLevel> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level, Lower level" on page 201

REFLevel<rl>:ABSolute:MLEVel <MiddleLevel>

Sets the middle reference level in absolute values.

Suffix:
<rl> 1...2, index of the reference level

Parameters:
<MiddleLevel> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level, Lower level" on page 201

REFLevel<rl>:ABSolute:ULEVel <UpperLevel>

Sets the upper reference level in absolute values. This is required to determine a rise.

Suffix:
<rl> 1...2, index of the reference level

Parameters:
<UpperLevel> Range: -1E+26 to 1E+26
Increment: 0.001
*RST: 0
Default unit: V

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level, Lower level" on page 201

REFLevel<rl>:RELative:HYSTeresis <HystRel>

Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Suffix:

<rl>	1...2, index of the reference level

Parameters:

<HystRel>	Range: 0 to 50 Increment: 1 *RST: 10 Default unit: %

Usage: Asynchronous command

Manual operation: See "Hysteresis" on page 202

REFLevel<rl>:RELative:LOWer <LowRefLevRel>

Sets the lower relative reference level if `REFLevel<rl>:RELative:MODE` is set to `USER`.

Suffix:

<rl>	1...2, index of the reference level

Parameters:

<LowRefLevRel>	Range: -100 to 200 Increment: 1 *RST: 10 Default unit: %

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level,Lower level" on page 202

REFLevel<rl>:RELative:MIDDle <MidRefLevRel>

Sets the middle relative reference level if `REFLevel<rl>:RELative:MODE` is set to `USER`.

Suffix:

<rl>	1...2, index of the reference level

Parameters:

<MidRefLevRel>	Range: -100 to 200 Increment: 1 *RST: 50 Default unit: %

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level,Lower level" on page 202

REFLevel<rl>:RELative:MODE <RelativeLevels>

The lower, middle and upper reference levels, defined as percentages of the high signal level.

Suffix:
<rl> 1...2, index of the reference level

Parameters:
<RelativeLevels> FIVE | TEN | TWENty | USER

FIVE
5/50/95

TEN
10/50/90

TWENty
20/50/80

USER
Set the reference levels to individual values with `REFLevel<rl>:RELative:LOWer`, `REFLevel<rl>:RELative:MIDDle`, and `REFLevel<rl>:RELative:UPPer`.

*RST: TEN

Usage: Asynchronous command

Manual operation: See "Relative levels" on page 201

REFLevel<rl>:RELative:UPPer <UppRefLevRel>

Sets the upper relative reference level if `REFLevel<rl>:RELative:MODE` is set to `USER`.

Suffix:
<rl> 1...2, index of the reference level

Parameters:
<UppRefLevRel> Range: -100 to 200
Increment: 1
*RST: 90
Default unit: %

Usage: Asynchronous command

Manual operation: See "Upper level, Middle level,Lower level" on page 202

17.13 Cursor measurements

Some of the commands in the following chapter are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, chapter "Command Sequence and Synchronization"

17.13.1 Cursor setup

CURSor<cu>:AOFF

Switches all cursors off.

Suffix:

<cu>	Irrelevant, omit the suffix.

Usage:	Setting only Asynchronous command

CURSor<cu>:COUNt?

Returns the maximum number of cursor sets, which is the maximum value for the cursor suffix.

Suffix:

<cu>	Irrelevant, omit the suffix.

Return values:

<Count> Number of cursor sets

Usage: Query only
Asynchronous command

CURSor<cu>:STATe <State>

Enables the selected cursor measurement.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<State> ON | OFF

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show cursor" on page 188

CURSor<cu>:FUNCtion <Type>

Defines the cursor type to be used for the measurement.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<Type> VERTical | HORizontal | PAIRed

HORizontal
A pair of horizontal cursor lines.

VERTical
A pair of vertical cursor lines.

PAIRed
Both vertical and horizontal cursor line pairs.

*RST: PAIRed

Usage: Asynchronous command

Manual operation: See "Type" on page 189

CURSor<cu>:SOURce <Source>

Selects the cursor source.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<Source> C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | M1 | M2 | M3 | M4 | M5 | SPECMAXH1 | SPECMINH1 | SPECNORM1 | SPECAVER1

Usage: Asynchronous command

Manual operation: See "Source" on page 189

CURSor<cu>:USSource <UseSource2>

Enables the second cursor source. To select the second source, use `CURSor<cu>:SSOurce`.

If enabled, the second cursor lines Cx.2 measure on the second source. Using a second source, you can measure differences between two channels with cursors.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<UseSource2> ON | OFF

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Second source, Source 2" on page 189

CURSor<cu>:SSOurce <Source2>

Selects the second cursor source.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<Source2> C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | M1 | M2 | M3 | M4 | M5 | SPECMAXH1 | SPECMINH1 | SPECNORM1 | SPECAVER1

Second source of the cursor measurement.

Usage: Asynchronous command

Manual operation: See "Second source, Source 2" on page 189

CURSor<cu>:X1Position <X1Position>

Defines the position of the left vertical cursor line.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<X1Position>
Range: 0 to 500
Increment: 0.1
*RST: depends on time scale, at 25% of the time axis
Default unit: s

Usage: Asynchronous command

Manual operation: See "X1 position, X2 position" on page 190

CURSor<cu>:X2Position <X2Position>

Defines the position of the right vertical cursor line.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<X2Position>
Range: 0 to 500
Increment: 0.1
*RST: depends on time scale, at 75% of the time axis
Default unit: s

Usage: Asynchronous command

Manual operation: See "X1 position, X2 position" on page 190

CURSor<cu>:Y1Position <YPosition1>

Defines the position of the lower horizontal cursor line.

If `CURSor<cu>:TRACking[:STATe]` is enabled, the y-positions are set automatically. The query returns the measurement result - the lower vertical value of the waveform.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<YPosition1>
Range: -50 to 50
Increment: 0.01
*RST: 0

Usage: Asynchronous command

Manual operation: See "Y1 position, Y2 position" on page 190

CURSor<cu>:Y2Position <YPosition2>

Defines the position of the upper horizontal cursor line.

If `CURSor<cu>:TRACking[:STATe]` is enabled, the y-positions are set automatically. The query returns the measurement result - the upper vertical value of the waveform.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<YPosition2>
Range: -50 to 50
Increment: 0.01
*RST: 0

Usage: Asynchronous command

Manual operation: See "Y1 position, Y2 position" on page 190

CURSor<cu>:TRACking[:STATe] <TrackCurve>

If enabled, the horizontal cursor lines tracks the waveform.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<TrackCurve> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "Track waveform" on page 190

CURSor<cu>:LABel <ShowLabel>

Shows the cursor labels in the diagram.

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<ShowLabel> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show label" on page 191

CURSor<cu>:SIAD <ShwInAllDiags>

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

Suffix:

<cu> 1...2, index of the cursor set

Parameters:

<ShwInAllDiags> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "Show in all diagrams" on page 191

CURSor<cu>:XCOupling <Coupling>

Defines the positioning mode of the vertical cursor.

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<Coupling> ON | OFF

ON
Moving one cursor line moves the other cursor line too. The cursor lines always remain a fixed distance.

OFF
Each cursor line is positioned independently.

*RST: OFF

Usage: Asynchronous command

Manual operation: See "X, Y" on page 191

CURSor<cu>:YCOupling <Coupling>

Defines the positioning mode of the horizontal cursor. If the horizontal cursor lines track the waveform, the y-coupling is irrelevant (`CURSor<cu>:TRACking[:STATe]` is `ON`).

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<Coupling> ON | OFF

ON
Moving one cursor line moves the other cursor line too. The cursor lines always remain a fixed distance.

OFF
Each cursor line is positioned independently.

*RST: OFF

Usage: Asynchronous command

Manual operation: See "X, Y" on page 191

CURSor<cu>:X1ENvelope <EnvlpCurveSelSource1>
CURSor<cu>:X2ENvelope <EnvlpCurveSelSource2>

Defines how the first horizontal cursor is positioned.

Prerequisites:

- `ACQuire:TYPE` on page 391 is set to `ENVElope`.
- `CURSor<cu>:TRACking[:STATe]` is set to `ON`.

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<EnvlpCurveSelSource2> MIN | MAX

MIN
The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope.

MAX
The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope.

*RST: MAX

Usage: Asynchronous command

Manual operation: See "Envelope, Envelope 2" on page 189

17.13.2 Cursor results

CURSor<cu>:XDELta[:VALue]?

Queries the delta value (distance) of two vertical cursor lines.

Suffix:
<cu> 1...2, index of the cursor set

Return values:
<Delta> Range: -1E+26 to 1E+26
Increment: 0.1
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

CURSor<cu>:XDELta:INVerse?

Queries the inverse value of the delta value (distance) of the two vertical cursor lines.

Suffix:
<cu> 1...2, index of the cursor set

Return values:
<DeltaInverse> Range: -1E+26 to 1E+26
Increment: 0.1
*RST: 0
Default unit: Hz

Usage: Query only
Asynchronous command

CURSor<cu>:YDELta[:VALue]?

Queries the delta value (distance) of the two horizontal cursor lines.

Suffix:
<cu> 1...2, index of the cursor set

Return values:
<Delta> Range: -1E+26 to 1E+26
Increment: 0
*RST: 0

Usage: Query only
Asynchronous command

CURSor<cu>:YDELta:SLOPe <DeltaSlope>

Returns the inverse value of the voltage difference - the reciprocal of the vertical distance of two horizontal cursor lines: *1/ΔV*.

Suffix:
<cu> 1...2, index of the cursor set

Parameters:
<DeltaSlope> Range: -1E+26 to 1E+26
Increment: 0
*RST: 0

Usage: Asynchronous command

17.13.3 Peak search using cursors

CURSor<cu>:FFT:SETCenter

Sets the center frequency to the frequency value that is measured at cursor line Cu1.

Suffix:
<cu> 1...2, index of the cursor set

Usage: Setting only
Asynchronous command

Manual operation: See "Set center frequency to" on page 193

CURSor<cu>:FFT:TOCenter

Sets the vertical cursor line Cu1 to the center frequency.

Suffix:
<cu> 1...2, index of the cursor set

Usage: Setting only
Asynchronous command

Manual operation: See "Center frequency" on page 193

CURSor<cu>:MAXimum[:PEAK]

Sets both cursors to the absolute peak value.

Suffix:
<cu> 1...2, index of the cursor set

Usage: Event
Asynchronous command

Manual operation: See "Absolute peak" on page 192

CURSor<cu>:MAXimum:LEFT

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

Suffix:
<cu> 1...2, index of the cursor set

Usage: Event
Asynchronous command

Manual operation: See "Next peak left" on page 193

CURSor<cu>:MAXimum:RIGHt

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

Suffix:
<cu> 1...2, index of the cursor set

Usage: Event
Asynchronous command

Manual operation: See "Next peak right" on page 193

CURSor<cu>:MAXimum:NEXT

Cursor 2 is set to the next smaller absolute peak from the current position.

Suffix:

<cu>	1...2, index of the cursor set

Usage: Event
Asynchronous command

Manual operation: See "Next peak" on page 192

CURSor<cu>:PEXCursion <Value>

Sets the minimum level by which the waveform must rise or fall so that it will be identified as a maximum or a minimum by the search functions.

Suffix:

<cu>	1...2, index of the cursor set

Parameters:
<Value>

Usage: Asynchronous command

Manual operation: See "Peak excursion" on page 193

CURSor<cu>:THReshold <Value>

Sets an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

Suffix:

<cu>	1...2, index of the cursor set

Parameters:
<Value>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 193

17.13.4 Cursor appearance

CURSor<cu>:STYLe <Style>

Defines how the cursor is displayed in the diagram.

Suffix:

<cu>	1...2, index of the cursor set

Parameters:

<Style>	LINes | LRHombus | VLRHombus | RHOMbus

LINes
The cursors are displayed as lines.

LRHombus
The cursors are displayed as lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

VLRHombus
The cursors are displayed only as vertical lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

RHOMbus
The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

*RST: LINes

Usage: Asynchronous command

Manual operation: See "Cursor style" on page 188

17.14 Spectrum analysis

17.14.1 Spectrum setup

CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution]:AUTO <AutoRBW>

Couples the frequency span to the "RBW" setting.

Suffix:

<sp>	* 1

Parameters:

<AutoRBW>	ON | OFF *RST: ON

Usage: Asynchronous command

Manual operation: See "Auto RBW" on page 218

CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution]:RATio <SpanRBWRatio>

Defines the coupling ratio for Span/RBW.

Available, if `CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution]:AUTO` is set to `ON`.

Suffix:

<sp>	* 1

Parameters:

<SpanRBWRatio>	Range: 10 to 10000 Increment: 1 *RST: 1000

Usage: Asynchronous command

Manual operation: See "Span/RBW" on page 218

CALCulate:SPECtrum<sp>:FREQuency:BANDwidth[:RESolution][:VALue] <RBW>

Queries or defines the used resolution bandwidth.

Suffix:

<sp>	1

Parameters:

<RBW>	Range: 0.0002 to 2000000 Increment: 0.01 *RST: 2000000 Default unit: Hz

Usage: Asynchronous command

Manual operation: See "RBW" on page 218

CALCulate:SPECtrum<sp>:FREQuency:CENTer <Center>

Defines the position of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The width of the range is defined using the frequency span setting.

Suffix:

<sp> *

1

Parameters:

<Center> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Center" on page 218

CALCulate:SPECtrum<sp>:FREQuency:SCALe <VerticalScale>

Sets the unit for the y-axis.

Suffix:

<sp> *

1

Parameters:

<VerticalScale> Range: 1E-12 to 100000000000000
Increment: 1E-05
*RST: 10
Default unit: V/div

Usage: Asynchronous command

CALCulate:SPECtrum<sp>:FREQuency:SPAN <Span>

The span is specified in Hertz and defines the width of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The position of the span is defined using the "Center" setting.

Suffix:

<sp> *

1

Parameters:

<Span> Range: 0 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Span" on page 218

CALCulate:SPECtrum<sp>:FREQuency:STARt <Start>

Defines the start frequency of the displayed frequency span.

Suffix:

<sp> *

1

Parameters:

<Start> Range: -1E+26 to 1E+26

Increment: 0.01

*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Start" on page 218

CALCulate:SPECtrum<sp>:FREQuency:STOP <Stop>

Sets the stop frequency of the displayed frequency span.

Suffix:

<sp> *

1

Parameters:

<Stop> Range: -1E+26 to 1E+26

Increment: 0.01

*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Stop" on page 218

CALCulate:SPECtrum<sp>:FREQuency:WINDow:TYPE <WindowFunction>

Selects the window type. Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

Various different window functions are provided in the R&S MXO 4 to suit different input signals. Each of the window functions has specific characteristics, including some advantages and some trade-offs. Consider these characteristics carefully to find the optimum solution for the measurement task.

Suffix:

<sp> *

1

Parameters:

<WindowFunction> RECTangular | HAMMing | HANN | BLACkharris | GAUSsian | FLATTOP2 | FLATtop2 | KAISerbessel

RECTangular
The rectangular window has the best frequency resolution, but a poor amplitude accuracy and is recommended for separating two tones with almost equal amplitudes and a small frequency distance.

HAMMing
The Hamming window is bell shaped and has a good frequency resolution and fair amplitude accuracy. It is recommended for frequency response measurements and sine waves, periodic signals and narrow-band noise.

HANN
The Hann window is bell shaped and has a slightly worse frequency resolution but smaller sidelobe level than the Hamming window. The applications are the same.

BLACkharris
The Blackman window is bell shaped and has a poor frequency resolution, but very good amplitude accuracy. It is recommended mainly for signals with single frequencies to detect harmonics.

GAUSsian
Good frequency resolution and best magnitude resolution, recommended for weak signals and short duration

FLATTOP2 = FLATtop2
The flat top window has a poor frequency resolution, but the best amplitude accuracy and the sharpest side lobe. It is recommended for accurate single-tone amplitude measurements.

KAISerbessel
The Kaiser-Bessel window has a fair frequency resolution and good amplitude accuracy, and a very high sidelobe level. It is recommended for separating two tones with differing amplitudes and a small frequency distance.

*RST: BLACkharris

Usage: Asynchronous command

Manual operation: See "Window type" on page 219

CALCulate:SPECtrum<sp>:MAGNitude:LEVel <VerticalMax>

Sets the maximum displayed value on the vertical scale.

Suffix:

<sp> *
1

Parameters:

<VerticalMax> Range: -1E+26 to 1000000000000000
Increment: 0.01
*RST: 10

Usage: Asynchronous command

Manual operation: See "Vertical maximum" on page 221

CALCulate:SPECtrum<sp>:MAGNitude:RANGe <VerticalRange>

Sets the range of the spectrum values to be displayed.

Suffix:

<sp>	* 1

Parameters:

<VerticalRange>	Range:	0 to 1000000000000000
	Increment:	0.01
	*RST:	100

Usage: Asynchronous command

Manual operation: See "Vertical range" on page 221

CALCulate:SPECtrum<sp>:MAGNitude:SCALe <Unit>

Sets the unit for the y-axis.

Suffix:

<sp>	* 1

Parameters:

<Unit> LINear | DBM | DBV | DBUV

*RST: DBM

Usage: Asynchronous command

Manual operation: See "Magnitude unit" on page 220

CALCulate:SPECtrum<sp>:PRESet

Presets the spectrum measurement.

Suffix:

<sp> *

Usage: Setting only
Asynchronous command

Manual operation: See "Spectrum preset" on page 220

CALCulate:SPECtrum<sp>:SOURce <Source>

Selects the source for the spectrum.

Suffix:

<sp>	* 1

Parameters:
<Source> C1 | C2 | C3 | C4 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4

Usage: Asynchronous command

Manual operation: See "Source" on page 217

CALCulate:SPECtrum<sp>:STATe <State>

Enables the spectrum.

Suffix:
<sp> *
1

Parameters:
<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Display" on page 217

CALCulate:SPECtrum<sp>:THReshold <Threshold>

Sets an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

Suffix:
<sp> *
1

Parameters:
<Threshold> Range: -500 to 500
Increment: 1
*RST: -70
Default unit: dBm

Usage: Asynchronous command

Manual operation: See "Threshold" on page 193

CALCulate:SPECtrum<sp>:PEXCursion <PeakExcursion>

Defines a relative threshold, the minimum level value by which the waveform must rise by to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

Suffix:
<sp> *
1

Parameters:

<PeakExcursion>
Range: 0 to 100
Increment: 1
*RST: 5
Default unit: dB

Usage: Asynchronous command

Manual operation: See "Peak excursion" on page 193

CALCulate:SPECtrum<sp>:WAVeform:AVERage:COUNt <AverageCount>

Sets the number of segments used for the averaging of the spectrum.

Suffix:

<sp> *
1

Parameters:

<AverageCount>
Range: 2 to 65534
Increment: 1
*RST: 1000

Usage: Asynchronous command

Manual operation: See "Traces" on page 219

CALCulate:SPECtrum<sp>:WAVeform:AVERage:ENABle <Enable>

Enables the average trace.

Suffix:

<sp> *
1

Parameters:

<Enable> ON | OFF

Usage: Asynchronous command

Manual operation: See "Traces" on page 219

CALCulate:SPECtrum<sp>:WAVeform:MAXimum:ENABle <Enable>

Enables the maximum trace.

Suffix:

<sp> *
1

Parameters:

<Enable> ON | OFF

Usage: Asynchronous command

Manual operation: See "Traces" on page 219

CALCulate:SPECtrum<sp>:WAVeform:MINimum:ENABle <Enable>

Enables the minimum trace.

Suffix:
<sp> *
1

Parameters:
<Enable> ON | OFF

Usage: Asynchronous command

Manual operation: See "Traces" on page 219

CALCulate:SPECtrum<sp>:WAVeform:NORMal[:ENABle] <Enable>

Enables the normal spectrum trace.

Suffix:
<sp> *
1

Parameters:
<Enable> ON | OFF

Usage: Asynchronous command

Manual operation: See "Traces" on page 219

17.14.2 Spectrum gate

CALCulate:SPECtrum<sp>:GATE:POSition <Center>

Sets the position of the displayed frequency range.

Suffix:
<sp> *
1

Parameters:
<Center> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Position" on page 221

CALCulate:SPECtrum<sp>:GATE:STARt <Start>

Sets the starting value for the gate.

Suffix:

<sp> *
1

Parameters:

<Start> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Start" on page 221

CALCulate:SPECtrum<sp>:GATE:STOP <Stop>

Sets the end value for the gate.

Suffix:

<sp> *
1

Parameters:

<Stop> Range: -1E+26 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Stop" on page 221

CALCulate:SPECtrum<sp>:GATE:WIDTh <Span>

Defines the width of the displayed gate.

Suffix:

<sp> *
1

Parameters:

<Span> Range: 0 to 1E+26
Increment: 0.01
*RST: 0.01

Usage: Asynchronous command

Manual operation: See "Width" on page 222

17.14.3 Peak list

CALCulate:SPECtrum<sp>:PLISt:LABel:FREQuency[:STATe] <ShowFrequency>

Includes the frequency of the detected peak in the diagram labels.

Suffix:
<sp> *
1

Parameters:
<ShowFrequency> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "Show frequency" on page 224

CALCulate:SPECtrum<sp>:PLISt:LABel:MAXCount <MaxNumberPeaks>

Sets the maximum number of measurement results that are listed in the result table.

Suffix:
<sp> *
1

Parameters:
<MaxNumberPeaks> Range: 1 to 100
Increment: 1
*RST: 10

Usage: Asynchronous command

CALCulate:SPECtrum<sp>:PLISt:MAXCount <MaxNoRess>

Sets the maximum number of measurement results that are listed in the result table.

Suffix:
<sp> *
1

Parameters:
<MaxNoRess> Range: 1 to 1000
Increment: 1
*RST: 10

Usage: Asynchronous command

Manual operation: See "Max results" on page 224

CALCulate:SPECtrum<sp>:PLISt:MODE <ResultMode>

Selects how the measurement results are displayed.

Suffix:
<sp> *
1

Parameters:
<ResultMode> ABS | REL
*RST: ABS

Usage: Asynchronous command

Manual operation: See "Result mode" on page 224

CALCulate:SPECtrum<sp>:PLISt:SOURce <Source>

Selects the source of the peak table. You can select one of the traces that is enabled with Traces.

Suffix:
<sp> *
1

Parameters:
<Source> SPECMAXH1 | SPECMINH1 | SPECNORM1 | SPECAVER1

Usage: Asynchronous command

Manual operation: See "Source" on page 224

CALCulate:SPECtrum<sp>:PLISt[:STATe] <ShowTable>

Enables the display of the peak table.

Suffix:
<sp> *
1

Parameters:
<ShowTable> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Peak table" on page 223

17.14.4 Data export of spectrum waveforms

For each of the spectrum traces, a dedicated command is available. For a description of the traces, see "Traces" on page 219.

CALCulate:SPECtrum<sp>:WAVeform:AVERage:DATA:HEADer?
CALCulate:SPECtrum<sp>:WAVeform:MAXimum:DATA:HEADer?
CALCulate:SPECtrum<sp>:WAVeform:MINimum:DATA:HEADer?
CALCulate:SPECtrum<sp>:WAVeform:NORMal:DATA:HEADer?

Returns the header of spectrum data. The header contains attributes of the waveform.

Table 17-5: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Always = 1	1

Suffix:
<sp> 1

Usage: Query only
Asynchronous command

CALCulate:SPECtrum<sp>:WAVeform:AVERage:DATA[:VALues] [<start>],[<size>]
CALCulate:SPECtrum<sp>:WAVeform:MAXimum:DATA[:VALues] [<start>],[<size>]
CALCulate:SPECtrum<sp>:WAVeform:MINimum:DATA[:VALues] [<start>],[<size>]
CALCulate:SPECtrum<sp>:WAVeform:NORMal:DATA[:VALues]? [<Offset>], [<Length>]

Returns the data of the spectrum points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

Without parameters, the complete waveform is retrieved. Using the offset and length parameters, data can be retrieved in smaller portions, which makes the command faster.

To set the export format, use `FORMat[:DATA]` on page 360.

Suffix:
<sp> 1

Query parameters:

[<Offset>] Number of offset waveform points.
Range: 0 to m. Limit: n + m <= record length

[<Length>] Number of waveform points to be retrieved.
Range: 1 to n. Limit: n + m <= record length

Return values:

<Data> List of values according to the format and content settings.

Usage: Asynchronous command

17.15 Applications

17.15.1 Frequency response analysis (option R&S MXO4-K36)

17.15.1.1 Frequency response analysis settings

FRANalysis:STATe <Value>

Starts the frequency response analysis.

Parameters:

<Value> RUN | STOP

Usage: Asynchronous command

Manual operation: See "Run" on page 230

FRANalysis:ENABle <State>

Parameters:

<State>	ON | OFF

Usage: Asynchronous command

FRANalysis:AMPLitude:MODE <AmplitudeMode>

Selects, if the amplitude is a constant value (`FRANalysis:GENerator:AMPLitude`) or is defined as an amplitude profile.

Parameters:

<AmplitudeMode>	CONStant | PROFile *RST: CONStant

Usage: Asynchronous command

Manual operation: See "Amplitude profile" on page 229

FRANalysis:FREQuency:STARt <StartFrequency>

Sets the start frequency of the sweep.

Parameters:

<StartFrequency>	Range: 10 to 100000000 Increment: 1 *RST: 100 Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Start, Stop" on page 229

FRANalysis:FREQuency:STOP <StopFrequency>

Sets the stop frequency of the sweep.

Parameters:

<StopFrequency>	Range: 10 to 100000000 Increment: 1 *RST: 10000 Default unit: Hz

Usage: Asynchronous command

Manual operation: See "Start, Stop" on page 229

FRANalysis:GENerator:AMPLitude <GenAmplitude>

Sets a fixed amplitude for the frequency response analysis.

Parameters:
<GenAmplitude> Range: 0.01 to 12
Increment: 0.1
*RST: 1
Default unit: Vpp

Usage: Asynchronous command

Manual operation: See "Amplitude" on page 229

FRANalysis:GENerator:LOAD <GenLoad>

Selects the generator voltage display for 50Ω or high impedance load.

Parameters:
<GenLoad> FIFTy | HIZ
`HIZ`: high input impedance
*RST: FIFTy

Usage: Asynchronous command

Manual operation: See "User load" on page 229

FRANalysis:GENerator[:CHANnel] <GenCh>

Selects the built-in generator to start a frequency sweep for a defined frequency range.

Parameters:
<GenCh> GEN1 | GEN2
*RST: GEN1

Usage: Asynchronous command

Manual operation: See "Generator" on page 229

FRANalysis:INPut[:SOURce] <InputChannel>

Sets the channel for the input signal of the DUT.

Parameters:
<InputChannel> C1 | C2 | C3 | C4
*RST: C1

Usage: Asynchronous command

Manual operation: See "Input" on page 228

FRANalysis:MEASurement:DELay:STATe <MeasDelay>

Enables the measurement delay. Set a measurement delay time with `FRANalysis:MEASurement:DELay[:TIME]`.

Parameters:
<MeasDelay> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Measurement delay, Delay time" on page 232

FRANalysis:MEASurement:DELay[:TIME] <MeasDelayTime>

Sets a time delay, that the system waits before measuring the next point of the plot. This is helpful in systems that need more time to adapt to the new frequency, for example if filters with significant time group delays are present.

Available, if `FRANalysis:MEASurement:DELay:STATe` = `ON`.

Parameters:
<MeasDelayTime> Range: 0 to 10
Increment: 0.001
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Measurement delay, Delay time" on page 232

FRANalysis:MEASurement:POINt[:DISPlay] <Points>

Enables the display of the measurement points for the frequency response analysis.

Parameters:
<Points> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "Display points" on page 233

FRANalysis:MEASurement:RBW <RBW>

Sets the resolution bandwidth.

Parameters:
<RBW> HIGH | MID | LOW
*RST: MID

Usage: Asynchronous command

Manual operation: See "RBW" on page 232

FRANalysis:OUTPut[:SOURce] <OutputChannel>

Sets the channel for the output signal of the DUT.

Parameters:
<OutputChannel> C1 | C2 | C3 | C4
*RST: C2

Usage: Asynchronous command

Manual operation: See "Output" on page 229

FRANalysis:POINts:LOGarithmic <PtsPerDecade>

Selects the number of points that are measured per decade, if FRANalysis:POINts:MODE is set to DECade.

Parameters:
<PtsPerDecade> Range: 10 to 500
Increment: 1
*RST: 10

Usage: Asynchronous command

Manual operation: See "Points" on page 229

FRANalysis:POINts:MODE <PointsMode>

Selects, if the number of points for the FRA are measured as total or per decade.

You can set the number of points with FRANalysis:POINts:TOTal/ FRANalysis:POINts:LOGarithmic.

Parameters:
<PointsMode> TOTal | DECade
*RST: DECade

Usage: Asynchronous command

Manual operation: See "Points" on page 229

FRANalysis:POINts:TOTal <TotalPoints>

Set the total number of points for the FRA analysis, if FRANalysis:POINts:MODE on page 519 is set to TOTal.

Parameters:
<TotalPoints> Range: 10 to 5000
Increment: 1
*RST: 100

Usage: Asynchronous command

Manual operation: See "Points" on page 229

FRANalysis:REPeat <Repeat>

Repeats the measurement, using the same parameters.

Parameters:

<Repeat> ON | OFF

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Repeat" on page 230

FRANalysis:RESet

Resets the frequency response analysis.

Usage: Setting only
Asynchronous command

FRANalysis:PHASe:MAXimum <MaxPhase>

Sets the upper boundary of the vertical phase window.

The lower boundary is given by "Maximum phase" - 360°.

By default, the "Maximum phase" is set to 180° for a phase window ranging from -180° to 180° accordingly.

Parameters:

<MaxPhase> Range: 0 to 360
Increment: 1
*RST: 180
Default unit: °

Usage: Asynchronous command

Manual operation: See "Maximum phase" on page 232

17.15.1.2 Frequency response analysis amplitude profile

FRANalysis:AMPLitude:PROFile:COUNt <Value>

Returns the number of defined points for the amplitude profile.

Parameters:
<Value>

Usage: Asynchronous command

Manual operation: See "Step start freq, Amplitude" on page 230

FRANalysis:AMPLitude:PROFile:APOint

Adds a new point to the amplitude profile.

Usage: Setting only
Asynchronous command

Manual operation: See "Add" on page 231

FRANalysis:AMPLitude:PROFile:POINt<m>:REMove

Removes the selected amplitude point from the list.

Suffix:
<m> *
Index of the amplitude profile point

Usage: Setting only
Asynchronous command

Manual operation: See "Delete" on page 231

FRANalysis:AMPLitude:PROFile:SORT

Sorts the points in the amplitude table by frequency, starting with the lowest frequency.

Usage: Setting only
Asynchronous command

Manual operation: See "Sort" on page 231

FRANalysis:AMPLitude:PROFile:MODE <VoltageChange>

Selects if the voltage change is done as a single step or as a ramp.

Parameters:
<VoltageChange> SINGle | RAMP
*RST: SINGle

Usage: Asynchronous command

Manual operation: See "Voltage change" on page 231

FRANalysis:AMPLitude:PROFile:POINt<m>:FREQuency <Frequency>
FRANalysis:AMPLitude:PROFile:POINt<m>:AMPLitude <Amplitude>

Set the frequency and amplitude values for the selected point.

Suffix:

<m>	* Index of the amplitude profile point

Parameters:

<Amplitude>	Range: 0 to 5.995 Increment: 0.1 *RST: 1 Default unit: Vpp

Usage: Asynchronous command

Manual operation: See "Step start freq, Amplitude" on page 230

17.15.1.3 Frequency response analysis diagram settings

FRANalysis:PHASe:DATA?

Returns the data of the phase waveform.

Usage: Query only
Asynchronous command

FRANalysis:PHASe:ENABle <State>

Enables the phase waveform for the frequency response analysis.

Parameters:

<State>	ON | OFF *RST: OFF

Usage: Asynchronous command

FRANalysis:PHASe:OFFSet <VerticalOffset>

Sets a vertical offset of the phase waveform.

Parameters:

<VerticalOffset> Range: -10000 to 10000
Increment: 1
*RST: 0
Default unit: °

Usage: Asynchronous command

FRANalysis:PHASe:SCALe <VerticalScale>

Sets the vertical scale for the phase waveform.

Parameters:

<VerticalScale> Range: 1 to 180
Increment: 1
*RST: 36
Default unit: °/div

Usage: Asynchronous command

FRANalysis:GAIN:DATA?

Returns the data of the gain waveform.

Usage: Query only
Asynchronous command

FRANalysis:GAIN:ENABle <State>

Enables the gain waveform for the frequency response analysis.

Parameters:

<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

FRANalysis:GAIN:OFFSet <VerticalOffset>

Sets a vertical offset of the gain waveform.

Parameters:

<VerticalOffset> Range: -2000 to 2000
Increment: 1
*RST: 10
Default unit: dB

Usage: Asynchronous command

FRANalysis:GAIN:SCALe <VerticalScale>

Sets the vertical scale for the gain waveform.

Parameters:

<VerticalScale>
Range: 0.1 to 20
Increment: 1
*RST: 10
Default unit: dB/div

Usage: Asynchronous command

FRANalysis:FREQuency:DATA?

Returns the data of the frequency.

Usage: Query only
Asynchronous command

FRANalysis:AMPLitude:SCALe <VerticalScale>

Sets the vertical scale for the amplitude waveform.

Parameters:

<VerticalScale>
Range: 0.01 to 10
Increment: 0.01
*RST: 0.5
Default unit: Vpp/div

Usage: Asynchronous command

FRANalysis:AMPLitude:ENABle <State>

Enables the amplitude signal for the frequency response analysis. You can then define the amplitude profile of the signal.

Parameters:

<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Amplitude profile" on page 229

FRANalysis:AMPLitude:OFFSet <VerticalOffset>

Sets a vertical offset of the amplitude waveform.

Parameters:

<VerticalOffset>	Range: -100 to 100 Increment: 0.01 *RST: 5 Default unit: Vpp

Usage: Asynchronous command

17.15.1.4 Frequency response analysis results

FRANalysis:RESult:STATe <Table>

Enables the display of the result table for the FRA.

Parameters:

<Table>	ON | OFF *RST: ON

Usage: Asynchronous command

Manual operation: See "Result table" on page 233

FRANalysis:MARGin:STATe <Margins>

Enables the display of the margin table for the FRA.

Parameters:

<Margins>	ON | OFF *RST: ON

Usage: Asynchronous command

Manual operation: See "Margin" on page 233

FRANalysis:MARGin:GAIN:FREQuency?

Returns the frequency of the gain margin.

Return values:
<Frequency>

Usage: Query only
Asynchronous command

FRANalysis:MARGin:GAIN:VALue?

Returns the value of the gain margin.

Return values:
<Phase>

Usage: Query only
Asynchronous command

FRANalysis:MARGin:PHASe:FREQuency?

Returns the frequency of the phase margin.

Return values:
<Frequency>

Usage: Query only
Asynchronous command

FRANalysis:MARGin:PHASe:VALue?

Returns the value of the phase margin.

Return values:
<Phase>

Usage: Query only
Asynchronous command

FRANalysis:MARKer<m>:STATe <Markers>

Enables the display of the marker table for the FRA.

Suffix:
<m> *

Parameters:
<Markers> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "Markers" on page 233

FRANalysis:MARKer<m>:FREQuency <Frequency>

Returns the frequency for the specified marker.

Suffix:

<m> — 1..2
Selects the marker number.

Parameters:

<Frequency> — Range: 0.01 to 1000000000
Increment: 1
*RST: 1000
Default unit: Hz

Usage: Asynchronous command

FRANalysis:MARKer<m>:GAIN?

Returns the gain for the specified marker.

Suffix:

<m> — 1..2
Selects the marker number.

Usage: Query only
Asynchronous command

FRANalysis:MARKer<m>:PHASe?

Returns the phase value for the specified marker.

Suffix:

<m> — 1..2
Selects the marker number.

Usage: Query only
Asynchronous command

FRANalysis:MARKer<m>:SSCReen

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

Suffix:

<m> — 1..2
Selects the marker number.

Usage: Setting only
Asynchronous command

17.16 Protocols

17.16.1 Configuration settings for all serial protocols

17.16.1.1 General settings

SBUS<m>[:STATe] <ProtocolState>

Enables the decoding of the specified bus.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<ProtocolState> ON | OFF

Usage: Asynchronous command

SBUS<m>:TYPE <Protocol Type>

Selects the bus type for analysis. The type of available buses depends on the installed options.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Protocol Type> I2C | SPI | UART | CAN

Usage: Asynchronous command

Manual operation: See "Protocol type" on page 252

SBUS<m>:RESult <ShwResTbl>

Enables a table with decoded data of the serial signal. The function requires the option for the analyzed protocol.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<ShwResTbl> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show decode table" on page 252

SBUS<m>:FORMat <DataFormat>

Sets the number format for decoded data values of the indicated serial bus. It defines the format in the decode table, and in the combs of the decoded signal on the screen.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<DataFormat> HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG
*RST: HEX

Manual operation: See "Data format" on page 253

SBUS<m>:ZCOupling <ZoomCoupling>

If enabled, the protocol decode zoom and result table are synchronized.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<ZoomCoupling> ON | OFF
*RST: OFF

Manual operation: See "Zoom coupling" on page 253

SBUS<m>:THReshold <ShwThresLines>

If enabled, the threshold lines are displayed in the diagram.

Suffix:
<m> 1..4

Parameters:
<ShwThresLines> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show threshold lines" on page 259

SBUS<m>:SETReflevels

Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Suffix:
<m> 1..4

Usage: Event
Asynchronous command

17.16.1.2 Export results settings

SBUS<m>:EXPResult:DETail <IncludeDetails>

If enabled, includes the detailed results for all frames in the export result file.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<IncludeDetails> ON | OFF
*RST: ON

Manual operation: See "Include details" on page 255

SBUS<m>:EXPResult:SAVE <FileName>

Saves the selected results to the indicated file.

Suffix:
<m> 1...4, index of the serial bus

Setting parameters:
<FileName>

Usage: Setting only

Manual operation: See "Save as" on page 255

SBUS<m>:EXPResult:TIME <IncludeTiming>

If enabled, includes the frame timing in the export result file.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<IncludeTiming> ON | OFF
*RST: ON

Manual operation: See "Include frame timing" on page 255

17.16.2 SPI (option R&S MXO4-K510)

17.16.2.1 Configuration

SBUS<m>:SPI:BORDer <BitOrder>

Selects the bit order, which determines if the data of the messages starts with MSB (most significant bit) or LSB (least significant bit).

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<BitOrder> LSBF | MSBF
*RST: MSBF

Usage: Asynchronous command

Manual operation: See "Bit order" on page 258

SBUS<m>:SPI:FRCondition <FrameCondition>

Defines the start of a frame. A frame contains a number of successive words, at least one word.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<FrameCondition> CS | CLKTimeout

CS
Start and end of the frame is defined by the active state of the slave select signal, see `SBUS<m>:SPI:CSELect:POLarity`.

CLKTimeout
Defines a timeout on the clock line SCLK as limiter between two frames. The timeout condition is used for SPI connections without a CS line.

*RST: CS

Manual operation: See "Frame condition" on page 259

SBUS<m>:SPI:CSELect:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the CS channel.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Manual operation: See "Threshold" on page 258

SBUS<m>:SPI:CSELect:POLarity <SSPolarity>

Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<SSPolarity> ACTLow | ACTHigh

*RST: ACTLow

Usage: Asynchronous command

Manual operation: See "Polarity: MOSI, MISO, CS" on page 258

SBUS<m>:SPI:CSELect:SOURce CSSource

Sets the input channel of the CS line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
CSSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4

Usage: Asynchronous command

Manual operation: See "SCLK,MOSI,MISO,CS" on page 257

SBUS<m>:SPI:CSELect:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Threshold>

Manual operation: See "Threshold" on page 258

SBUS<m>:SPI:MISO:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the MISO channel.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Manual operation: See "Threshold" on page 258

SBUS<m>:SPI:MISO:POLarity <MISOPolarity>

Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<MISOPolarity> ACTLow | ACTHigh

*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Polarity: MOSI, MISO, CS" on page 258

SBUS<m>:SPI:MISO:SOURce MISOSource

Sets the input channel of the MISO line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
MISOSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4

Usage: Asynchronous command

Manual operation: See "SCLK,MOSI,MISO,CS" on page 257

SBUS<m>:SPI:MISO:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Threshold>

Manual operation: See "Threshold" on page 258

SBUS<m>:SPI:MOSI:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the MOSI channel.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Manual operation: See "Threshold" on page 258

SBUS<m>:SPI:MOSI:POLarity <MOSIPolarity>

Selects if the transmitted signal for the respective line is active high (high = 1) or active low (low = 1).

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<MOSIPolarity> ACTLow | ACTHigh
*RST: ACTHigh

Usage: Asynchronous command

Manual operation: See "Polarity: MOSI, MISO, CS" on page 258

SBUS<m>:SPI:MOSI:SOURce MOSISource

Sets the input channel of the MOSI line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
MOSISource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4

Usage: Asynchronous command

Manual operation: See "SCLK,MOSI,MISO,CS" on page 257

SBUS<m>:SPI:MOSI:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Threshold>

Manual operation: See "Threshold" on page 258

SBUS<m>:SPI:SCLK:HYSTeresis <Hysteresis>

Sets a value for the hysteresis for the SCLK channel.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Manual operation: See "Threshold" on page 258

SBUS<m>:SPI:SCLK:SOURce SCLKSource

Sets the input channel of the SCLK line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
SCLKSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4

Usage: Asynchronous command

Manual operation: See "SCLK,MOSI,MISO,CS" on page 257

SBUS<m>:SPI:SCLK:THReshold <Threshold>

Sets a user-defined threshold value for the line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Threshold>

Manual operation: See "Threshold" on page 258

SBUS<m>:SPI:TIMeout <ClockTimeout>

Sets the minimum clock idle time if a timeout on the clock line SCLK is used as limiter between two frames.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<ClockTimeout> Range: 5E-08 to 10
Increment: 1E-06
*RST: 0.001
Default unit: s

Manual operation: See "Timeout" on page 260

SBUS<m>:SPI:WSIZe <WordLength>

Sets the word length (or symbol size), which is the number of bits in a message. The maximum word length is 32 bit.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<WordLength> Range: 4 to 32
Increment: 1
*RST: 8

Usage: Asynchronous command

Manual operation: See "Word length" on page 258

17.16.2.2 Filter

SBUS<m>:SPI:FILTer:ENABle <Enable>

Enables the filtering on SPI frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<m> 1...4, index of the serial bus

Parameters:

<Enable> ON | OFF

*RST: OFF

Manual operation: See "Enable" on page 261

SBUS<m>:SPI:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<BitState> ONE | ZERO

*RST: ZERO

Manual operation: See "Edit" on page 262

SBUS<m>:SPI:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<Data_Max>

Manual operation: See "Edit" on page 262

SBUS<m>:SPI:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<Data_Min>

Manual operation: See "Edit" on page 262

SBUS<m>:SPI:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Manual operation: See "Edit" on page 262

SBUS<m>:SPI:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<m>:SPI:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<m> 1...4, index of the serial bus

<n> index of the error

Parameters:

<Enable> ON | OFF
*RST: ON

Manual operation: See "Error type" on page 263

SBUS<m>:SPI:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<CondEnabler> ON | OFF
*RST: OFF

Manual operation: See "Edit" on page 262

SBUS<m>:SPI:FILTer:FRENable <Frame>,<Enabler>
SBUS<m>:SPI:FILTer:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Parameters:

<Enable> ON | OFF
*RST: ON

Manual operation: See "Frame type" on page 261

SBUS<m>:SPI:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<Index_Max> — Range: 1 to 65535; Increment: 1; *RST: 65535

Manual operation: See "Edit" on page 262

SBUS<m>:SPI:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<m> — 1...4, index of the serial bus

<fr> — index of the frame

<fl> — index of the field

Parameters:

<Index_Min> — Range: 1 to 65535; Increment: 1; *RST: 1

Manual operation: See "Edit" on page 262

SBUS<m>:SPI:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<m>:SPI:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<m> — 1...4, index of the serial bus

<fr> — index of the frame

<fl> — index of the field

Parameters:

<Index_Operator> — EQUal | INRange | RANGe; *RST: INRange

Manual operation: See "Edit" on page 262

17.16.2.3 Trigger

Trigger commands for serial buses affect the current trigger source. Therefore, set the trigger source to the required serial bus with `TRIGger:EVENt<m>:SOURce` before sending the bus-specific trigger commands.

TRIGger:SPI:TYPE <Type>

Selects the trigger type for SPI analysis.

Parameters:
<Type> FRSTart | FRENd | MOSI | MISO

FRSTart
Triggers on the beginning of the frame.

FRENd
Triggers on the end of the frame.

MOSI
Triggers on a specified data pattern in that is expected on the MOSI line.

MISO
Triggers on a specified data pattern in that is expected on the MISO line.

*RST: FRSTart

Manual operation: See "Type" on page 263

TRIGger:SPI:DMINpattern <DataPattern>

Specifies a data bit pattern, or sets the start value of a pattern range.

Parameters:
<DataPattern>

Usage: Asynchronous command

Manual operation: See "Data" on page 264

TRIGger:SPI:DPOSition <DataPosition>

Sets the number of bits or words to be ignored before the first bit or word of interest. The effect is defined by `TRIGger:SPI:PALignment`.

Parameters:
<DataPosition> Range: 0 to 4095
Increment: 1
*RST: 0

Manual operation: See "Position" on page 264

TRIGger:SPI:FCONdition <DataOperator>

Selects the operator for the MISO and MOSI pattern.

Parameters:
<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan

*RST: EQUal

Manual operation: See "Data" on page 264

TRIGger:SPI:PALignment <DataAlignment>

Defines how the specified data pattern is searched.

Parameters:
<DataAlignment> WORD | BIT

WORD
The pattern is matched only at word boundaries.

BIT
Bit-by bit: the pattern can be at any position in the data word.

*RST: WORD

Manual operation: See "Search mode" on page 264

17.16.2.4 Decode results

SBUS<m>:SPI:FCOunt?

Returns the number of decoded frames.

Suffix:
<m> 1...4, index of the serial bus

Return values:
<Count>

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:BITRate?

Returns the bit rate of the specified frame.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<PrimaryBitRate> Range: 0 to 100000000000
Increment: 1
*RST: 0
Default unit: bps

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:COUNt?

Returns the number of decoded frames.

Suffix:

<m> 1...4, index of the serial bus

<fr> *
Not relevant.

Return values:

<Count> Total number of decoded frames.

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:DATA?

Returns the data words of the specified frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<FrameData> Comma-separated sequence of integer values (N, L1, R1,…, LN, RN). N is the number of word pairs in the frame, and {L1,R1}…{LN,RN} are the value pairs. The values Lx and Rx are associated with the MOSI and the MISO channel, respectively. If a channel is disabled, an empty value is returned.

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:STARt?

Returns the start time of the specified frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<FrameStart>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:STATus?

Returns the overall state of the specified frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<FrameState> OK | VOID | INC | LENGth

`OK`: the frame is valid.
`VOID`: the frame is empty.
`INComplete`: INComplete word. The word does not have the expected word length.
`LENGth`: The frame is not completely contained in the acquisition.

*RST: OK

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:STOP?

Returns the end time of the specified frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<FrameStop>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:WCOunt?

Returns the number of words in the specified frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:
<FrameWordCount> Range: 0 to 4096
Increment: 1
*RST: 0

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:WORD<w>:FMISo?

Returns the formatted value of the specified word on the MISO line.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

<w> index of the word

Return values:
<FormattedMISOVal>

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:WORD<w>:FMOSi?

Returns the formatted value of the specified word on the MOSI line.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

<w> index of the word

Return values:
<FormattedMOSIVal>

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:WORD<w>:MISO?

Returns the data value of the specified word on the MISO line.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

<w> index of the word

Return values:
<MISOValue> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:WORD<w>:MOSI?

Returns the data value of the specified word on the MOSI line.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame
<w>	index of the word

Return values:

<MOSIValue>
Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:WORD<w>:STARt?

Returns the start time of the specified data word.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame
<w>	index of the word

Return values:

<FrameWordStart>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only

SBUS<m>:SPI:FRAMe<fr>:WORD<w>:STOP?

Returns the end time of the specified data word.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame
<w>	index of the word

Return values:

<FrameWordStop>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only

17.16.3 I²C (option R&S MXO4-K510)

17.16.3.1 Configuration

SBUS<m>:I2C:SCL:HYSTeresis <Hysteresis>

Sets a hysteresis value for the clock line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Manual operation: See "Threshold" on page 269

SBUS<m>:I2C:SCL:SOURce SCLSource

Selects the waveform source of the clock line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
SCLSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4

Usage: Asynchronous command

Manual operation: See "SCL source" on page 269

SBUS<m>:I2C:SCL:THReshold <Threshold>

Sets a user-defined threshold value for the clock line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Threshold>

Manual operation: See "Threshold" on page 269

SBUS<m>:I2C:SDA:HYSTeresis <Hysteresis>

Sets a hysteresis value for the data line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Manual operation: See "Threshold" on page 269

SBUS<m>:I2C:SDA:SOURce SDASource

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

Suffix:
<m> 1...4, index of the serial bus

Parameters:
SDASource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4

Usage: Asynchronous command

Manual operation: See "SDA source" on page 269

SBUS<m>:I2C:SDA:THReshold <Threshold>

Sets a user-defined threshold value for the data line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Threshold>

Manual operation: See "Threshold" on page 269

17.16.3.2 Trigger

Trigger commands for serial buses affect the current trigger source. Therefore, set the trigger source to the required serial bus with `TRIGger:EVENt<m>:SOURce` before sending the bus-specific trigger commands.

TRIGger:I2C:TYPE <Type>

Selects the trigger type for I²C analysis.

Parameters:

<Type> STARt | REPStart | STOP | NACK | ADDRess | DATA | ADAT

STARt
Start condition

REPStart
Repeated start - the start condition occurs without previous stop condition.

STOP
Stop condition, end of frame

NACK
Missing acknowledge bit. To localize specific missing acknowledge bits, use:
`TRIGger:I2C:ADNack`
`TRIGger:I2C:DWNack`
`TRIGger:I2C:DRNack`

ADDRess
Triggers on one specific address

DATA
Triggers on a specific data

ADAT
Triggers on a combination of address and data condition.

*RST: STARt

Usage: Asynchronous command

Manual operation: See "Type" on page 273

TRIGger:I2C:ACCess <RWBitAddress>

Toggles the trigger condition between read and write access of the primary. Select "Either" if the transfer direction is not relevant for the trigger condition.

Parameters:
<RWBitAddress> READ | WRITe | EITHer
*RST: EITHer

Usage: Asynchronous command

Manual operation: See "R/W bit" on page 276

TRIGger:I2C:ACONdition <AddrOptor>

Sets the operator to set a specific address or an address range. The address values are set with `TRIGger:I2C:ADDRess` and `TRIGger:I2C:ADDTo`.

Parameters:
<AddrOptor> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange
*RST: EQUal

TRIGger:I2C:ADDRess <Address>

Triggers on the specified address, or sets the start value of an address range depending on the condition set with `TRIGger:I2C:ACONdition`.

Parameters:
<Address> List of comma-separated values

Manual operation: See "Address" on page 276

TRIGger:I2C:ADDTo <AddressTo>

Sets the end value of an address range if the condition is set to an address range with `TRIGger:I2C:ACONdition`.

Parameters:
<AddressTo> Llist of comma-separated values

Manual operation: See "Address" on page 276

TRIGger:I2C:ADNack <AddressNack>

Triggers if the address acknowledge bit is missing - no slave recognizes the address.

Parameters:
<AddressNack> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "No Ack conditions" on page 275

TRIGger:I2C:AMODe <AddressType>

Sets the address length to be triggered on: 7 bit or 10 bit.

Parameters:
<AddressType> BIT7 | BIT10
*RST: BIT7

Usage: Asynchronous command

Manual operation: See "Address type" on page 275

TRIGger:I2C:DCONdition <DataOperator>

Sets the operator to set a specific data value or a data range.

Parameters:
<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
*RST: EQUal

Manual operation: See "Data" on page 276

TRIGger:I2C:DMIN <Data>

Specifies the data bit pattern, or sets the the start value of a data pattern range. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Parameters:
<Data>

Usage: Asynchronous command

Manual operation: See "Data" on page 276

TRIGger:I2C:DPOSition <DataPosition>

Sets the number of data bytes to be skipped after the address.

Parameters:
<DataPosition> Range: 0 to 4095
Increment: 1
*RST: 0

Manual operation: See "Index" on page 276

TRIGger:I2C:DRNack <DataReadNack>

Triggers on the end of the read process when the master reads data from the slave. This Nack is sent according to the protocol definition, it is not an error.

Parameters:
<DataReadNack> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "No Ack conditions" on page 275

TRIGger:I2C:DWNack <DataWriteNack>

Triggers if a date acknowledge bit is missing - the addressed slave does not accept the data.

Parameters:
<DataWriteNack> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "No Ack conditions" on page 275

17.16.3.3 Filter

There are two commands for each parameter, that you can use for defining the I2C settings.

For example, to set the *Frame type =WRITe > Field =Address >Data* value you can use one of the following commands:

- `SBUS:I2C:FILTer:FRAMe1:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SBUS:I2C:FILTer:DMIN "WRITe", "Address", 01100`
  Defines the parameter by using the frame and field name.

SBUS<m>:I2C:FILTer:ENABle <Enable>

Enables the filtering on I2C frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<m> 1...4, index of the serial bus

Parameters:

<Enable> ON | OFF

*RST: OFF

Manual operation: See "Enable" on page 271

SBUS<m>:I2C:FILTer:FRENable <Frame>,<Enabler>
SBUS<m>:I2C:FILTer:FRAMe<fr>:ENABle <Enable>

Enables or disables the specific frame to be filtered on.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Parameters:

<Enable> ON | OFF

*RST: ON

Manual operation: See "Frame type" on page 271

SBUS<m>:I2C:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<Data_Max>

Manual operation: See "Edit" on page 272

SBUS<m>:I2C:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<Data_Min>

Manual operation: See "Edit" on page 272

SBUS<m>:I2C:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<Data_Operator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Manual operation: See "Edit" on page 272

SBUS<m>:I2C:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<m>:I2C:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:

<m> 1...4, index of the serial bus

<n> index of the error

Parameters:

<Enable> ON | OFF

*RST: ON

SBUS<m>:I2C:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Manual operation: See "Edit" on page 272

SBUS<m>:I2C:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Manual operation: See "Edit" on page 272

SBUS<m>:I2C:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Manual operation: See "Edit" on page 272

SBUS<m>:I2C:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame
<fl>	index of the field

Parameters:

<BitState>	ONE | ZERO *RST: ZERO

Manual operation: See "Edit" on page 272

SBUS<m>:I2C:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<m>:I2C:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame
<fl>	index of the field

Parameters:

<CondEnabler>	ON | OFF *RST: OFF

Manual operation: See "Edit" on page 272

17.16.3.4 Decode results

SBUS<m>:I2C:FCOunt?

Returns the number of decoded frames.

Suffix:

<m> 1..4
Selects the serial bus.

Return values:

<Count> Total number of decoded frames.

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:AACCess?

Returns the address acknowledge bit value for the indicated frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<AddressAckBit> INComplete | ACK | NACK | EITHer
*RST: INComplete

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:ACCess?

Returns the value of the R/W bit of the indicated frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<RWBit> UNDefined | READ | WRITe | EITHer
*RST: UNDefined

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:ACOMplete?

Returns if the address is completely contained in the acquisition.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:
<AddrComplete> ON | OFF
*RST: OFF

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:ADBStart?

Returns the start time of the address acknowledge bit.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:
<AddrAckBtStrt> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:ADDRess?

Returns the device address value of the indicated frame. That is, the address value that is shown in the decoded cells and in the decode results table.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:
<AddressValue> Range: 0 to 2047
Increment: 1
*RST: 0

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:ADEVice?

Returns the pure device address of the indicated frame *without* the R/W bit.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:
<DeviceAddress> Range: 0 to 1023
Increment: 1
*RST: 0

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:AMODe?

Returns the address length.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<AddressType> BIT7 | BIT7RW | BIT7_RW | BIT10 | AUTO | ANY
*RST: BIT7

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:ASTart?

Returns the start time of the address for the indicated frame.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<AddressStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:BCOunt?

Returns the number of bytes in the specified frame.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<Count>

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:BITRate?

Returns the primary bit rate.

Suffix:

<m>	1...4, index of the serial bus

<fr> index of the frame

Return values:

<PrimaryBitRate> Range: 0 to 100000000000
Increment: 1
*RST: 0
Default unit: bps

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:BYTE<o>:ACCess?

Returns the acknowledge bit value of the specified data byte.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<o> index of the byte number

Return values:

<AckBit> INComplete | ACK | NACK | EITHer
*RST: INComplete

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:BYTE<o>:ACKStart?

Returns the start time of the acknowledge bit of the specified byte.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<o> index of the byte number

Return values:

<AckBitStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:BYTE<o>:COMPlete?

Returns if the indicated byte is completely contained in the acquisition.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<o> index of the byte number

Return values:

<ValueComplete> ON | OFF

*RST: OFF

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:BYTE<o>:STARt?

Returns the start time of the specified data byte.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<o> index of the byte number

Return values:

<FrameByteStart> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:BYTE<o>:VALue?

Returns the data value of the specified byte.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<o> index of the byte number

Return values:

<Value> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:DATA?

Returns the data words of the specified frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Example:

```
BUS:I2C:FRAMe4:DATA?
<-- 3,74,164,18
```

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:RWBStart?

Returns the start time of the R/W bit

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<RWBitStart>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:STARt?

Returns the start time of the specified frame.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<FrameStart>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:STATus?

Returns the overall state of the frame.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<FrameState>
NOSTopbit | OK | INComplete | ADDifferent

INComplete
The stop bit is missing.

OK
The frame is valid.

UNEXpstop
A stop bit was detected but clock and data are continued.

INSufficient
The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

ADDifferent
Error in 10 bit address. In case of a read access on a 10 bit address, the first address byte is sent twice, first as write, the second as read. The first seven bits of the byte must be identical. If they are not identical, the ADDiffernt error is indicated.

*RST: OK

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:STOP?

Returns the end time of the specified frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<FrameStop> Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only

SBUS<m>:I2C:FRAMe<fr>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<Translation> String with symbolic name of the address

Usage: Query only

17.16.4 UART / RS232 (option R&S MXO4-K510)

17.16.4.1 Configuration

SBUS<m>:UART:BITRate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:

<m>	1...4, index of the serial bus

Parameters:

<Bitrate>	Range: 300 to 20000000 Increment: 1 *RST: 9600 Default unit: bps

Usage: Asynchronous command

Manual operation: See "Bit rate" on page 281

SBUS<m>:UART:EWORd <EndWord>

Sets the end pattern of the packets. A new packet starts with the first start bit after the defined end pattern.

The command is relevant if `SBUS<m>:UART:PACKets` is set to `EWORd`.

Suffix:

<m>	1...4, index of the serial bus

Parameters:
<EndWord>

Usage: Asynchronous command

Manual operation: See "Packets" on page 281

SBUS<m>:UART:PACKets <FrmSeparation>

Defines the method of packet separation. A packet is a number of subsequent words in a date stream.

Suffix:

<m> 1...4, index of the serial bus

Parameters:

<FrmSeparation> NONE | TOUT

NONE
Packets are not considered.

EWORd
End word, the end condition of a packet is a pattern. To define the end word, use `SBUS<m>:UART:EWORd`.

TOUT
Defines a timeout between the packets. To set the timeout, use `SBUS<m>:UART:TOUT`.

*RST: NONE

Manual operation: See "Packets" on page 281

SBUS<m>:UART:PARity <Parity>

Defines the optional parity bit that is used for error detection.

Suffix:

<m> 1...4, index of the serial bus

Parameters:

<Parity> NONE | ODD | EVEN | MARK | SPC | DC

MARK
The parity bit is always a logic 1.

SPC
SPaCe: The parity bit is always a logic 0.

DC
Don't Care: the parity is ignored.

*RST: NONE

Usage: Asynchronous command

Manual operation: See "Parity" on page 281

SBUS<m>:UART:POLarity <Polarity>

Defines the logic levels of the bus. The idle state corresponds to a logic 1. The start bit corresponds to a logic 0. "Idle high" (high=1) is used, for example, for control signals, while "Idle low" (low=1) is defined for data lines (RS-232).

Suffix:

<m> 1...4, index of the serial bus

Parameters:
<Polarity> IDLLow | IDLHigh
*RST: IDLHigh

Usage: Asynchronous command

Manual operation: See "Polarity" on page 281

SBUS<m>:UART:RX:HYSTeresis <Rx hysteresis>

Sets the hysteresis for the Tx line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Rx hysteresis>

Manual operation: See "Threshold" on page 282

SBUS<m>:UART:RX:SOURce RXSource

Selects the input channel for the receiver signal.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
RXSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4

Usage: Asynchronous command

Manual operation: See "Source: Tx, Rx" on page 280

SBUS<m>:UART:RX:THReshold <Rx threshold>

Sets a user-defined threshold value for the Rx line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Rx threshold>

Manual operation: See "Threshold" on page 282

SBUS<m>:UART:SBIT <StopBits>

Sets the number of stop bits: 1 or 1.5 or 2 stop bits are possible.

Suffix:
<m> 1...4, index of the serial bus

Parameters:

<StopBits> B1 | B15 | B2

*RST: B1

Usage: Asynchronous command

Manual operation: See "Stop bits" on page 281

SBUS<m>:UART:SSIZe <DataBits>

Sets the number of data bits of a word in a range from 5 bits to 8 bits. If no parity bit is used, then 9 data bits are possible.

Suffix:

<m> 1...4, index of the serial bus

Parameters:

<DataBits> Range: 5 to 9
Increment: 1
*RST: 8

Usage: Asynchronous command

Manual operation: See "Data bits" on page 281

SBUS<m>:UART:TOUT <Timeout>

Sets the timeout between packets in a UART data stream. A new packet starts with the first start bit after the timeout.

The command is relevant if `SBUS<m>:UART:PACKets` is set to `TOUT`.

Suffix:

<m> 1...4, index of the serial bus

Parameters:

<Timeout> Range: 1E-06 to 1
Increment: 1
*RST: 0.001
Default unit: s

Usage: Asynchronous command

Manual operation: See "Packets" on page 281

SBUS<m>:UART:TX:HYSTeresis <Tx hysteresis>

Sets the hysteresis for the Tx line.

Suffix:

<m> 1...4, index of the serial bus

Parameters:

<Tx hysteresis>

Manual operation: See "Threshold" on page 282

SBUS<m>:UART:TX:SOURce TXSource

Selects the input channel for the transmitter signal.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
TXSource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4

Usage: Asynchronous command

Manual operation: See "Source: Tx, Rx" on page 280

SBUS<m>:UART:TX:THReshold <Tx threshold>

Sets a user-defined threshold value for the Tx line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Tx threshold> User-defined clock threshold

Manual operation: See "Threshold" on page 282

17.16.4.2 Trigger

Trigger commands for serial buses affect the current trigger source. Therefore, set the trigger source to the required serial bus with `TRIGger:EVENt<m>:SOURce` before sending the bus-specific trigger commands.

TRIGger:UART:DATA <DataPattern>

Specifies the data pattern to be found on the specified trigger source. Enter the words in msb first bit order.

Parameters:
<DataPattern>

Manual operation: See "Pattern" on page 286

TRIGger:UART:DPOSition <DataPosition>

Sets the number of words before the first word of interest. These offset words are ignored.

Parameters:

<DataPosition>	Range:	0 to 4095
	Increment:	1
	*RST:	0

Manual operation: See "Index min" on page 286

TRIGger:UART:FCONdition <DataOperator>

Selects the operator for the "Data" pattern.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan

*RST: EQUal

Manual operation: See "Data" on page 286

TRIGger:UART:OPERator <DataOperator>

Sets the operator for the data pattern in the selected field of the selected frame.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan

*RST: EQUal

TRIGger:UART:SOURce <Source>

Selects the transmitter or receiver line as trigger source.

Parameters:

<Source> TX | RX

*RST: TX

Manual operation: See "Trigger source" on page 286

TRIGger:UART:TYPE <Type>

Selects the trigger condition.

Parameters:

<Type> STBT | PCKS | DATA | PRER | BRKC | STPerror

STBT: Start bit
PCKS: Packet start
DATA: Serial pattern
BRKC: Break condition
STPerror: Stop error

*RST: STBT

Manual operation: See "Type" on page 285

17.16.4.3 Filter

SBUS<m>:UART:FILTer:ENABle <Enable>

Enables the filtering on UART frames. Only the frames that match the selected filter conditions are displayed.

Suffix:

<m> 1...4, index of the serial bus

Parameters:

<Enable> ON | OFF

*RST: OFF

Manual operation: See "Enable" on page 283

SBUS<m>:UART:FILTer:IMIN <Frame>,<Field>,<Data>
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:IMIN <Index_Min>

Specifies the index, or sets the start value of an index range.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:
<Index_Min> Range: 1 to 65535
Increment: 1
*RST: 1

Manual operation: See "Edit" on page 284

SBUS<m>:UART:FILTer:IMAX <Frame>,<Field>,<Data>
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:IMAX <Index_Max>

Sets the end value of an index range if the operator is set to `INRange`.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:
<Index_Max> Range: 1 to 65535
Increment: 1
*RST: 65535

Manual operation: See "Edit" on page 284

SBUS<m>:UART:FILTer:IOPerator <Frame>,<Field>,<Operator>
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:IOPerator <Index_Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:
<Index_Operator> EQUal | INRange | RANGe
*RST: INRange

Manual operation: See "Edit" on page 284

SBUS<m>:UART:FILTer:ERENable <ErrorName>,<Enabler>
SBUS<m>:UART:FILTer:ERRor<n>:ENABle <Enable>

Defines the error type to be filtered on.

Suffix:
<m> 1...4, index of the serial bus

<n> index of the error

Parameters:

<Enable>	ON | OFF *RST: ON

Manual operation: See "Error type" on page 285

SBUS<m>:UART:FILTer:DOPerator <Frame>,<Field>,<Operator>
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:DOPerator <Data_Operator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame
<fl>	index of the field

Parameters:

<Data_Operator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange *RST: EQUal

Manual operation: See "Edit" on page 284

SBUS<m>:UART:FILTer:DMIN <Frame>,<Field>,<Data>
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:DMIN <Data_Min>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<m>	1..4 Selects the serial bus.
<fr>	* Specifies the frame number.
<fl>	* Specifies the field number within the frame.

Parameters:

<Data_Min>

Manual operation: See "Edit" on page 284

SBUS<m>:UART:FILTer:DMAX <Frame>,<Field>,<Data>
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:DMAX <Data_Max>

Sets the end value of a data pattern range if the operator is set to `INRange` or `OORANGe`.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

<fl> index of the field

Parameters:
<Data_Max>

Manual operation: See "Edit" on page 284

SBUS<m>:UART:FILTer:BIT <Frame>,<Field>,<Bit>
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<BitState> ONE | ZERO
*RST: ZERO

Manual operation: See "Edit" on page 284

SBUS<m>:UART:FILTer:FRENable <Frame>,<Enabler>
SBUS<m>:UART:FILTer:FRAMe<fr>:ENABle <Enable>

Enables or disables the checking condition for the selected frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Parameters:

<Enable> ON | OFF
*RST: ON

Manual operation: See "Frame Ttype" on page 284

SBUS<m>:UART:FILTer:FIENable <Frame>,<Field>,<Enabler>
SBUS<m>:UART:FILTer:FRAMe<fr>:FLD<fl>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

<fl> index of the field

Parameters:

<CondEnabler> ON | OFF
*RST: OFF

Manual operation: See "Edit" on page 284

17.16.4.4 Decode results

SBUS<m>:UART:WORD<w>:BITRate?

Returns the primary bit rate.

Suffix:

<m> — 1...4, index of the serial bus

<w> — index of the word

Return values:

<PrimaryBitRate> — Range: 0 to 100000000000
Increment: 1
*RST: 0
Default unit: bps

Usage: Query only

SBUS<m>:UART:WORD<w>:COUNt?

Returns the number of words in the acquisition.

Suffix:

<m> — 1...4, index of the serial bus

<w> — *
The suffix is irrelevant.

Return values:

<Count> — Number of words

Usage: Query only

SBUS<m>:UART:WORD<w>:RXValue?

Returns the value of the specified word on the Rx line.

Suffix:

<m> — 1...4, index of the serial bus

<w> — index of the word

Return values:

<RxValue>	Range:	0 to 511
	Increment:	1
	*RST:	0

Usage: Query only

SBUS<m>:UART:WORD<w>:SOURce?

Returns the line on which the specified word was transferred.

Suffix:

<m> 1...4, index of the serial bus

<w> index of the word

Return values:

<WordSource> TX | RX

*RST: TX

Usage: Query only

SBUS<m>:UART:WORD<w>:STARt?

Returns the start time of the specified word.

Suffix:

<m> 1...4, index of the serial bus

<w> index of the word

Return values:

<WordStart>	Range:	-1E+26 to 1E+26
	Increment:	1E-10
	*RST:	0
	Default unit:	s

Usage: Query only

SBUS<m>:UART:WORD<w>:STATe?

Returns the status of the specified word.

Suffix:

<m> 1...4, index of the serial bus

<w> index of the word

Return values:

<WordState> OK | FRSTart | FRENd | FRME | BREak | STERror | SPERror | PRERror | INComplete

*RST: OK

Usage: Query only

SBUS<m>:UART:WORD<w>:TXValue?

Returns the value of the specified word on the Tx line.

Suffix:

<m>	1...4, index of the serial bus
<w>	index of the word

Return values:

<TxValue>
Range: 0 to 511
Increment: 1
*RST: 0

Usage: Query only

17.16.5 CAN / CAN-FD (option R&S MXO4-K520)

17.16.5.1 Configuration

SBUS<m>:CAN:BITRate <BitStuffError>

Sets the number of transmitted bits per second.

Suffix:

<m> 1...4, index of the serial bus

Parameters:

<BitStuffError>
Range: 100 to 5000000
Increment: 1
*RST: 100000
Default unit: bps

Usage: Asynchronous command

Manual operation: See "Bit rate" on page 290

SBUS<m>:CAN:DATA:HYSTeresis <Hysteresis>

Sets a hysteresis value for the data line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Hysteresis>

Usage: Asynchronous command

SBUS<m>:CAN:DATA:SOURce DATASource

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

Suffix:
<m> 1...4, index of the serial bus

Parameters:
DATASource C1 | C2 | C3 | C4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | M1 | M2 | M3 | M4 | M5 | R1 | R2 | R3 | R4

Usage: Asynchronous command

Manual operation: See "Data" on page 289

SBUS<m>:CAN:DATA:THReshold <Threshold>

Sets a user-defined threshold value for the data line.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<Threshold>

Usage: Asynchronous command

Manual operation: See "Threshold" on page 290

SBUS<m>:CAN:FDATa:DBITrate <FDBitrate>

Sets the bit rate of the data phase.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<FDBitrate> Range: 100 to 15000000
Increment: 1
*RST: 1000000
Default unit: bps

Usage: Asynchronous command

SBUS<m>:CAN:FDATa:SAMPlepoint <FDSamplePoint>

Sets the position of the sample point within the bit in percent of the nominal bit time.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<FDSamplePoint> Range: 12 to 96
Increment: 5
*RST: 66
Default unit: %

Usage: Asynchronous command

Manual operation: See "Sample point" on page 290

SBUS<m>:CAN:TYPE <SignalType>

Selects the CAN-High or CAN-Low line. Both lines are required for differential signal transmission used by CAN.

Suffix:
<m> 1...4, index of the serial bus

Parameters:
<SignalType> CANH | CANL
*RST: CANL

Usage: Asynchronous command

Manual operation: See "Type" on page 290

17.16.5.2 Trigger

Trigger commands for serial buses affect the current trigger source. Therefore, set the trigger source to the required serial bus with `TRIGger:EVENt<m>:SOURce` before sending the bus-specific trigger commands.

TRIGger:CAN:TYPE <Type>

Selects the trigger type for CAN analysis.

Parameters:

<Type> STOF | EDOF | FTYP | ID | IDDT | ERRC

STOF
STart Of Frame: triggers on the first edge of the dominant SOF bit (synchronization bit).

FTYP
Frame TYPe: triggers on a specified frame type (data, remote, error, or overload) and on the identifier format.
To set the frame type, use `TRIGger:CAN:FTYPe`. Set the identifier format with `TRIGger:CAN:ITYPe`.

ID
IDentifier: Sets the trigger to one specific identifier or an identifier range. To set the identifier, use `TRIGger:CAN:ICONdition`,`TRIGger:CAN:IMAX`, and `TRIGger:CAN:IMIN`.

IDDT
IDentifier and DaTa: Combination of identifier and data conditions To set the identifier condition, use `TRIGger:CAN:ICONdition`, `TRIGger:CAN:IMIN`, and `TRIGger:CAN:IMAX`.
To set the data condition, use `TRIGger:CAN:DCONdition` and `TRIGger:CAN:DMIN`.

ERRC
ERRor Condition: Define the error types with:
`TRIGger:CAN:ACKerror`
`TRIGger:CAN:BITSterror`
`TRIGger:CAN:CRCerror`
`TRIGger:CAN:FORMerror`
`TRIGger:CAN:FDATa:SCERror`

*RST: STOF

Usage: Asynchronous command

Manual operation: See "Type" on page 293

TRIGger:CAN:ACKerror <AckError>

Triggers when the transmitter does not receive an acknowledgment - a dominant bit during the Ack Slot.

The trigger type has to be set before: TRIGger:CAN:TYPE to ERRC.

Parameters:

<AckError> ON | OFF

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 296

TRIGger:CAN:BITSterror <BitStuffError>

Triggers if a stuff error occurs - when the 6th consecutive equal bit level in the mentioned fields is detected.

The trigger type has to be set before: TRIGger:CAN:TYPE to ERRC.

Parameters:

<BitStuffError> ON | OFF

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 296

TRIGger:CAN:BORDer <Endianness>

Sets the byte order (endianness) of the data transfer. Only for CAN protocol.

Parameters:

<Endianness> BENDian | LENDian

BENDian
Big endian, data is analyzed and evaluated in the order of reception.

LENDian
Little endian, the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

*RST: BENDian

Usage: Asynchronous command

TRIGger:CAN:CRCerror <ChecksumError>

Triggers on CRC errors. A CRC error occurs when the CRC calculated by the receiver differs from the received value in the CRC sequence.

The trigger type has to be set before: TRIGger:CAN:TYPE to ERRC.

Parameters:

<ChecksumError> ON | OFF

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 296

TRIGger:CAN:DCONdition <DataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:
<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `TRIGger:CAN:DMIN`.

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Data pattern" on page 296

TRIGger:CAN:DLC <WordCount>

Sets the Data Length Code, the number of data bytes to be found. For complete definition, set also the operator with `TRIGger:CAN:DLCCondition`.

Parameters:
<WordCount> Range: CAN: 1 to 8, CAN FD: 1 to 15 (64 bytes)
Increment: 1
*RST: 8

Usage: Asynchronous command

Manual operation: See "DLC" on page 296

TRIGger:CAN:DLCCondition <DLCOperator>

Operator to set the data length code for triggering on CAN and CAN FD data.

The number of data bytes to be found is set with `TRIGger:CAN:DLC`.

See also: `TRIGger:CAN:BORDer`.

Parameters:
<DLCOperator> EQUal | GETHan

For little endian transfer direction, EQUal must be set.

*RST: GETHan

Usage: Asynchronous command

Manual operation: See "DLC" on page 296

TRIGger:CAN:DMIN <DataPattern>

Sets a data pattern, or sets the start value of a data pattern range.

Parameters:

<DataPattern> Numeric or string pattern. The string parameter accepts the bit value X (don't care).

Usage: Asynchronous command

Manual operation: See "Data pattern" on page 296

TRIGger:CAN:FDATa:BRS <BRS_Bit>

Sets the bit rate switch bit.

Parameters:

<BRS_Bit> ONE | ZERO | DC

ONE: the bit rate switches from the bit rate of the arbitration phase to the faster data rate.

*RST: ONE

Usage: Asynchronous command

Manual operation: See "BRS, ESI" on page 298

TRIGger:CAN:FDATa:DPOSition <DataPosition>

Defines the number of the first data byte at which the data pattern may start.

The setting is available for CAN FD option.

Parameters:

<DataPosition> Range: 1 to 2048
Increment: 1
*RST: 1

Usage: Asynchronous command

TRIGger:CAN:FDATa:ESI <ESI_Bit>

Sets the error state indicator bit.

Parameters:

<ESI_Bit> ONE | ZERO | DC

DC: don't care, bit is nor relevant

*RST: DC

Usage: Asynchronous command

Manual operation: See "BRS, ESI" on page 298

TRIGger:CAN:FDATa:FDF <FDF_Bit>

Sets the CAN FD frame format. It corresponds to the EDL bit (extended data length), which only exists in CAN FD format.

Parameters:

<FDF_Bit> ONE | ZERO | DC

ONE: CAN FD.
ZERO: CAN.
DC: don't care, the format is not relevant.

*RST: DC

Usage: Asynchronous command

TRIGger:CAN:FDATa:SCERror <StuffCntErr>

Triggers on stuff count errors. A stuff count error occurs if th received stuff count value does not match the value calculated from the own stuff bit count.

The trigger type `TRIGger:CAN:TYPE` must be set to `ERRC`.

Only relevant for CAN FD signals in ISO standard.

Parameters:

<StuffCntErr> ON | OFF

*RST: ON

Usage: Asynchronous command

TRIGger:CAN:FDATa:STANdard <Standard>

Selects the CAN standard. Use `ANY` if the standard of the signal is unknown.

Parameters:

<Standard> ANY | CAN | CANFd

*RST: CAN

Usage: Asynchronous command

Manual operation: See "Standard" on page 297

TRIGger:CAN:FORMerror <FormError>

Triggers when a fixed-form bit field contains one or more illegal bits.

The trigger type has to be set before: `TRIGger:CAN:TYPE` to `ERRC`.

Parameters:

<FormError> ON | OFF

*RST: ON

Usage: Asynchronous command

Manual operation: See "Error conditions" on page 296

TRIGger:CAN:FTYPe <FrameType>

Sets the CAN frame type.

Parameters:

<FrameType> ANY | DATA | REMote | ERRor | OVERload

Available values depend on the CAN standard setting:
Remote frames are not available in the CAN FD protocol.
If the trigger type is set to FTYP (frame type), you can set the values `DATA | REMote | ERRor | OVERload`.
If the trigger type is set to ID (identifier), you can set the values `ANY | DATA | REMote`.

*RST: ANY

Usage: Asynchronous command

Manual operation: See "Frame type" on page 295

TRIGger:CAN:ICONdition <IdOperator>

Sets the operator to set a specific identifier or an identifier range.

Parameters:

<IdOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one identifier pattern to be set with `TRIGger:CAN:IMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `TRIGger:CAN:IMIN` and `TRIGger:CAN:IMAX`.

*RST: EQUal

Usage: Asynchronous command

Manual operation: See "Identifier" on page 296

TRIGger:CAN:IMAX <IdPattern>

Sets the end value of an identifier range if `TRIGger:CAN:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<IdPattern> Numeric or string pattern.

Usage: Asynchronous command

Manual operation: See "Identifier" on page 296

TRIGger:CAN:IMIN <IdPattern>

Specifies a message identifier pattern, or sets the start value of an identifier range.

Parameters:
<IdPattern> Numeric or string pattern.

Usage: Asynchronous command

Manual operation: See "Identifier" on page 296

TRIGger:CAN:ITYPe <IdentifierType>

Selects the format of data and remote frames.

Remote frames are not available in the CAN FD protocol.

Parameters:
<IdentifierType> ANY | B11 | B29

B11
11 bit identifier (standard format). The instrument triggers on the sample point of the IDE bit.

B29
29 bit identifier (extended format). The instrument triggers on the sample point of the RTR bit.

ANY
The ID type and ID pattern are not relevant for the trigger condition.

*RST: ANY

Usage: Asynchronous command

Manual operation: See "ID type" on page 295

17.16.5.3 Decode results

SBUS<m>:CAN:FRAMe<fr>:ACKState?

Return the states of the acknowledgement field.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<FrameAckState> OK | ERRor | UNDF
UNDF: Undefined
*RST: OK

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:ACKValue?

Returns the value of the acknowledge slot for the selected frame.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<FrameAckValue> Range: 0 to 1
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:BSEPosition?

Returns the location of a bit stuffing error.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:
<BtStuffErrPos> Time when the error occurred.

Range: 0 to 5000
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:BYTE<o>:STATe?

Returns the state of the specified byte.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

<o> *
Selects the byte number.

Return values:
<State> OK | ERRor | UNDF

UNDF: Undefined

*RST: OK

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:BYTE<o>:VALue?

Returns the value of the specified byte.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

<o> *
Selects the byte number.

Return values:
<Value> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:CSSTate?

Return the states of the checksum field (CRC).

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<ChecksumState> OK | ERRor | UNDF

*RST: OK

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:CSValue?

Returns the CRC sequence value of the selected frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<ChecksumValue> Range: 0 to 2097151
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:DATA?

Returns the data of the specified frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<FrameData> Comma-separated list of values. The first value is the number of bytes, followed by the values of the data bytes.

Example:

```
BUS1:CAN:FRAMe2:DATA?
--> 3,208,231,32
```

Returns the data of the second frame: the number of bytes is 3 data (first value).

Usage: Query only

SBUS<m>:CAN:FRAMe<fr>:DLCState?

Return the states of the state of data length code.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:
<FrameDLCState> OK | ERRor | UNDF
*RST: OK

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:DLCValue?

Returns the data length code of the selected frame - the number of data bytes in the frame.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:
<FrameDLCValue> Range: 0 to 15
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:FERCause?

Returns information on a form error, if the frame status query (`SBUS<m>:CAN:FRAMe<fr>:STATus?`) returned a FORM error.

Suffix:
<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:
<FormErrorCause> NONE | CRCDerror | ACKDerror | FSBE | RESerror
`CRCDerror` = CRC delimiter error
`ACKDerror` = ACK delimiter error
`FSBE` = Fixed stuff bit error (CAN-FD ISO only)
`RESerror` = Reserved bit error
*RST: NONE

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:IDSTate?

Return the states of the identifier state.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<IdtfSt>	OK | ERRor | UNDF UNDF: Undefined *RST: OK

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:IDTYpe?

Returns the identifier type of the selected frame, the identifier format of data and remote frames.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<IdentifierType>	ANY | B11 | B29 B11: standard format, 11 bit B29: extended format, 29 bit *RST: B11

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:IDValue?

Returns the identifier value of the selected frame.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<IdtfVal>	Range: 0 to 536870911 Increment: 1 *RST: 0

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:NDBYtes?

Returns the number of data bytes.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<NDBytes> Range: 1 to 64
Increment: 1
*RST: 1

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:PDATa?

Returns a list of comma-separated pattern data values.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<NDBytes>

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:SDATa?

Returns the symbolic data of the specified frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<SymbolicData> Comma-separated list of values. The first value is the number of bytes, followed by the values of the data bytes.

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:SDEXport?

Returns the symbolic data of the frame in export format.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<SymbolicData>

Usage:	Query only Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:STANdard?

Returns the CAN standard.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<Standard>	ANY | CAN | CANFd | CANXI *RST: CAN
Usage:	Query only Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:STARt?

Return the start time of the selected frame.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<FrameStart>	Range: -1E+26 to 1E+26 Increment: 1E-10 *RST: 0 Default unit: s
Usage:	Query only Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:STATus?

Returns the overall state of the selected frame.

Suffix:

<m>	1...4, index of the serial bus
<fr>	index of the frame

Return values:

<FrameState>	OK | FORM | BTST | CRC | CRCD | NOACk | ACKD | EOFD | CAERror | FCERor | INComplete | SERRror | SFERror | SCERror | SAERror | SCAE | SCFE `OK`: the frame is valid. `FORM`: Fixed-bit form error. `BTST`: Bit stuffing error occured.

CRC: Cyclic redundancy check failed.
CRCD: Wrong CRC delimiter occurred.
NOACK: Acknowledge is missing.
ACKD: Wrong ACK delimiter occurred.
EOFD: Wrong end of frame.
CAERror: CRC error followed by an acknowledgement error (missing acknowledge).
FCERor: CRC error followed by a form error (wrong CRC delimiter or wrong ACK delimiter).
INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.
SERRror: Stuff count error (CAN-FD ISO only).
SFER: Stuff count error and FORM error (CAN-FD ISO only).
SCER: Stuff count error and CRC error (CAN-FD ISO only).
SAER: Stuff count error and ACK error (CAN-FD ISO only).
SCAE: Stuff count error and CRC error and ACK error (CAN-FD ISO only).
SCFE: Stuff count error and CRC error and FORM error (CAN-FD ISO only).

*RST: OK

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:STOP?

Return the stop time of the selected frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<FrameStop>
Range: -1E+26 to 1E+26
Increment: 1E-10
*RST: 0
Default unit: s

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:STUFf?

Returns the value of the stuff count field.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<StuffCount> Range: 0 to 7
Increment: 1
*RST: 0

Usage: Query only
Asynchronous command

SBUS<m>:CAN:FRAMe<fr>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<Label> String with symbolic label of the identifier

Example: `BUS:CAN:FRAMe:SYMBol?`
Response: `Temperature`

Usage: Query only

SBUS<m>:CAN:FRAMe<fr>:TYPE?

Returns the frame type of the selected frame.

Suffix:

<m> 1...4, index of the serial bus

<fr> index of the frame

Return values:

<FrameType> DATA | REMote | ERR | OVLD | CBFFdata | CBFFremote | CEFFdata | CEFFremote | FBFF | FEFF | XLFF

Data, remote, error or overload frame.

*RST: DATA

Usage: Query only
Asynchronous command

17.17 Mixed signal option (option R&S MXO4-B1)

This chapter describes the remote commands of MSO option R&S MXO4-B1.

Some of the commands in the following chapter are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, chapter "Command Sequence and Synchronization"

17.17.1 Digital channels

All `DIGital:` commands affect only the settings of the first MSO bus (Logic1). The settings of all other logic groups (Logic 2, 3,4) remain unchanged.

DIGital<m>:LABel <Label>

Sets a name for the indicated digital channel. The name is displayed in the diagram.

The setting affects only the settings of the first MSO bus (Logic1).

You can set the label for all buses with `PBUS<m>:BIT<n>:LABel`

Suffix:

<m>	0..15 Selects the digital channel.

Parameters:

<Label>	String containing the channel name

Usage: Asynchronous command

DIGital<m>:SIZE <Size>

Suffix:

<m>	0..15 The suffix is irrelevant.

Parameters:

<Size>

Usage: Asynchronous command

DIGital<m>:SKEW <Skew>

Sets an individual delay for each digital channel to time-align it with other digital channels. The skew value compensates delays that are known from the circuit specifics or caused by the different length of cables.

The setting affects only the settings of the first MSO bus (Logic1).

You can set the skew for all buses with `PBUS<m>:BIT<n>:SKEW`.

Suffix:

<m> 0..15
Selects the digital channel.

Parameters:

<Skew>

Usage: Asynchronous command

DIGital<m>:STATe <State>

Enables or disables the indicated digital channel, displays it, and enables the Logic 1 if the bus was disabled.

If another active bus already uses the selected digital channel, the instrument disables the other bus to avoid conflicts.

For Logic 1, the `DIG::STAT` command has the same effect as `PBUS<m>:STATe`. To enable digital channels for buses 2, 3 and 4, use the `PBUS:BIT[:STAT]` command.

Suffix:

<m> 0..15
Selects the digital channel.

Parameters:

<State> ON | OFF

Usage: Asynchronous command

DIGital<m>:TECHnology <Technology>

Selects the threshold voltage for various types of integrated circuits and applies it to all digital channels.

The setting affects only the settings of the first MSO bus (Logic1).

You can set the technology value for all buses with `PBUS<m>:TECHnology`.

Suffix:

<m> 0..15
The suffix is irrelevant.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MANual
See `PBUS<m>:TECHnology`.

Usage: Asynchronous command

DIGital<m>:THCoupling <State>

Sets the threshold and the hysteresis for all digital channels of Logic1 to the same value.

Suffix:
<m> 0..15
The suffix is irrelevant.

Parameters:
<State> ON | OFF

Usage: Asynchronous command

DIGital<m>:THReshold <Value>

Sets the logical threshold for the channel group to which the indicated digital channel belongs.

The setting affects only the settings of the first MSO bus (Logic1).

You can set the threshold for all buses with `PBUS<m>:TECHnology` or `PBUS<m>:THReshold<n>`

See also: `DIGital<m>:THCoupling` on page 597

Suffix:
<m> 0..15
Number of the digital channel.
Channel groups: 0..3; 4..7; 8..11; 12..15

Parameters:
<Value>

Usage: Asynchronous command

17.17.2 Logic configuration

The following commands configure the four logic groups of R&S MXO4-B1.

PBUS<m>:BIT<n>:LABel <Label>

Sets a name for the indicated digital channel. The name is displayed in the diagram.

Suffix:

<m> 1..4
Selects the logic.

<n> 0..15
Selects the bit of the bus word. Each bit corresponds to a digital channel.

Parameters:

<Label> String containing the channel name

Usage: Asynchronous command

PBUS<m>:BIT<n>:SKEW <Skew>

Sets an individual delay for each digital channel to time-align it with other digital channels.

The skew value compensates delays that are known from the circuit specifics or caused by the different length of cables. The skew between the probe boxes of the digital channels and the probe connectors of the analog channels is automatically aligned by the instrument.

Suffix:

<m> 1..4
Selects the logic.

<n> 0..15
Selects the bit of the bus word. Each bit corresponds to a digital channel.

Parameters:

<Skew> Range: -2E-07 to 2E-07
Increment: 2E-10
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "D0-D15" on page 306

PBUS<m>:BIT<n>[:STATe] <Assigned>

Enables the selected logic group. The corresponding signal icon appears on the signal bar.

If another active bus already uses the selected digital channel, the instrument disables the other bus to avoid conflicts.

Suffix:

<m>	1..4 Selects the logic.
<n>	0..15 Selects the bit of the bus word. Each bit corresponds to a digital channel.

Parameters:

<Assigned>	ON | OFF *RST: OFF

Usage: Asynchronous command

PBUS<m>:CLEar

Removes all assigned digital channels from the bus.

Suffix:

<m>	1..4 Selects the logic.

Usage: Setting only
Asynchronous command

PBUS<m>:CLOCk <ClockSource>

Selects the digital channel used as clock.

Suffix:

<m>	1 | 2 Selects the logic. The clocked bus is available on Logic 1 and 2.

Parameters:

<ClockSource>	D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 Clock channel *RST: D0

Usage: Asynchronous command

Manual operation: See "Clock source" on page 304

PBUS<m>:CLON <Clocked>

Defines if the bus is a clocked bus - one of the digital channels serves as clock of the bus.

Suffix:
<m> 1 | 2
Selects the logic. The clocked bus is available on Logic 1 and 2.

Parameters:
<Clocked> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Bus clocked" on page 304

PBUS<m>:CLSLope <ClockSlope>

Selects the slope of the clock signal at which all digital channels of the bus are analyzed.

Suffix:
<m> 1 | 2
Selects the logic. The clocked bus is available on Logic 1 and 2.

Parameters:
<ClockSlope> POSitive | NEGative | EITHer
*RST: POSitive

Usage: Asynchronous command

Manual operation: See "Clock slope" on page 304

PBUS<m>:DISPlay:SHBU <ShowBus>

If enabled, the resulting bus signal and bus values are displayed in the diagram.

Suffix:
<m> 1..4
Selects the logic.

Parameters:
<ShowBus> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show bus" on page 303

PBUS<m>:DISPlay:SHDI <ShwDigSigns>

If enabled, the selected digital channels are shown in the diagram. Each channel is displayed as a logic signal.

Suffix:
<m> 1..4
Selects the logic.

Parameters:

<ShwDigSigns> ON | OFF

*RST: OFF

Usage: Asynchronous command

Manual operation: See "Show dig. signals" on page 301

PBUS<m>:HYSTeresis<n> <Hysteresis>

Defines the size of the hysteresis for the respective channels.

Suffix:

<m> 1..4
Selects the logic.

<n> 1..4
Selects the channel group:
1 = digital channels 0..3
2 = digital channels 4..7
3 = digital channels 8..11
4 = digital channels 12..15

Parameters:

<Hysteresis> MAXimum | ROBust | NORMal

MAXIMUM = MAXimum
Maximum value that is possible and useful for the signal and its settings

ROBUST = ROBust
Different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system.

NORMAL = NORMal
The instrument sets a value suitable for the signal and its settings.

Usage: Asynchronous command

Manual operation: See "Hysteresis" on page 302

PBUS<m>:SKEW <SkewOffset>

Sets a general delay for all digital channels.

Suffix:

<m> 1..4
Selects the logic.

Parameters:

<SkewOffset> Range: -2E-07 to 2E-07
Increment: 2E-10
*RST: 0
Default unit: s

Usage: Asynchronous command

Manual operation: See "Skew" on page 306

PBUS<m>:STATe <State>

Enables the selected logic group. The corresponding signal icon appears on the signal bar.

Dependencies: At least one digital channel must be enabled for the selected bus, otherwise the command does not work.

The bus is enabled automatically if the first digital channel is enabled with `PBUS<m>:BIT<n>[:STATe]`.

Suffix:
<m> 1..4
Selects the logic.

Parameters:
<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "State" on page 301

PBUS<m>:TECHnology <Technology>

Selects the threshold voltage for various types of integrated circuits and applies it to all digital channels.

Suffix:
<m> 1..4
Selects the logic.

Parameters:
<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MANual

V15: TTL
V25: CMOS 5.0 V
V165: CMOS 3.3 V
V125: CMOS 2.5 V
V09: CMOS 1.85 V
VM13: ECL, -1.3 V
V38: PECL
V20: LVPECL
V0: Ground
MANual: Set a user-defined threshold value with `DIGital<m>:THReshold` on page 597.

*RST: V165

Usage: Asynchronous command

Manual operation: See "Technology,Threshold" on page 302

PBUS<m>:THCoupling <LevelCoupling>

Sets the threshold and the hysteresis for all digital channels and all buses to the same value.

For Logic 1, the command `DIGital<m>:THCoupling` has the same effect.

Suffix:

<m> 1..4
The suffix is irrelevant.

Parameters:

<LevelCoupling> ON | OFF
*RST: ON

Usage: Asynchronous command

Manual operation: See "Level coupling" on page 302

PBUS<m>:THReshold<n> <Threshold>

Sets the logical threshold for the indicated channel group.

Alternatively you can use the following commands:

- To select from a list of predefined technologies: `PBUS<m>:TECHnology`
- For logic 1: `DIGital<m>:THReshold`

See also `DIGital<m>:THCoupling` on page 597.

Suffix:

<m> 1..4
Selects the logic.

<n> 1..4
Selects the channel group:
1 = digital channels 0..3;
2 = digital channels 4..7
3 = digital channels 8..11
4 = digital channels 12..15

Parameters:

<Threshold>

Usage: Asynchronous command

Manual operation: See "Technology,Threshold" on page 302

17.17.3 MSO data

The remote data transfer from the instrument to the controlling computer is performed using the following commands:

DIGital<m>:DATA:HEADer?

Returns the header of digital channel data

Table 17-6: Header data

Position	Meaning	Example
1	XStart, acquisition time before trigger, in s	-5E-008 = - 50 ns
2	XStop, acquisition time after trigger, in s	5E-008 = 50 ns
3	Record length of the waveform in Samples	1000
4	Number of values per sample interval. For digital data, the result is 1.	1

Suffix:
<m> 0..15
Selects the digital channel.

Usage: Query only
Asynchronous command

DIGital<m>:DATA[:VALues] [<start>],[<size>]

Returns the data of the indicated digital channel for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

Suffix:
<m> 0..15
Selects the digital channel.

Setting parameters:
<start> List of data (0 and 1)

<size>

Usage: Asynchronous command

PBUS<m>:DATA:FORMat <DataFormat>

Sets the data format of bus values, which are displayed in the decode table and on the comb bus display.

It also sets the format for the number representation for remote data transfer with PBUS<m>:DATA[:VALues]?.

Suffix:

<m> 1..4
Selects the logic.

Parameters:

<DataFormat> HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG
*RST: HEX

Usage: Asynchronous command

Manual operation: See "Data format" on page 303

PBUS<m>:DATA:HEADer?

Returns the header data of the indicated bus.

For a detailed description, see DIGital<m>:DATA:HEADer?.

Suffix:

<m> 1..4
Selects the logic.

Usage: Query only
Asynchronous command

Manual operation: See "Data format" on page 303

PBUS<m>:DATA[:VALues]?

Returns the data of the indicated logic.

Requirements:

- PBUS<m>:STATe is set to ON.
- PBUS<m>:DISPlay:SHBU is set to ON.
- A number format is set with PBUS<m>:DATA:FORMat.

Suffix:

<m> 1..4
Selects the logic.

Example:

```
PBUS:STAT ON
PBUS:DISP:SHBU ON
PBUS:DISP:BTYP COMB
PBUS:DATA:FORMat HEX
PBUS:DATA:VAL?
```

Usage: Query only
Asynchronous command

Manual operation: See "Data format" on page 303

17.18 Waveform generator (option R&S MXO4-B6)

This chaptes decribes the remote commands of the waveform generator.

The instrument preset does not affect the generator settings. Each generator has its own preset: `WGENerator<wg>:PRESet`.

Some of the commands in the following chapter are asynchronous. An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially.

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used after the command or a command set.

For more information, see:

- www.rohde-schwarz.com/rc-via-scpi, chapter "Command Sequence and Synchronization"

17.18.1 Waveform generator setup

17.18.1.1 General settings

WGENerator<wg>:ACOPy

Copies all settings from Gen1/Gen2 and applies them to Gen2/Gen1.

Suffix:

<wg> 1..2

Usage: Setting only

WGENerator<wg>:FREQuency <Frequency>

Sets the frequency of the waveform.

Suffix:

<wg> 1..2

Parameters:

<Frequency> Range: 0.001 to 100000000
Increment: 1
*RST: 10000000
Default unit: Hz

Manual operation: See "Frequency" on page 320

WGENerator<wg>:FUNCtion:PULSe[:WIDTh] <PulseWidth>

Sets the pulse width, the pulse duration of the generated pulse waveform.

Suffix:

<wg> 1..2

Parameters:

<PulseWidth> Range: 1.65E-08 to 90000
Increment: 1
*RST: 5E-07
Default unit: s

Manual operation: See "Pulse width" on page 322

WGENerator<wg>:FUNCtion:RAMP[:SYMMetry] <RampSymmetry>

Sets the symmetry of a ramp waveform, the percentage of time the waveform is rising. By changing the symmetry of the ramp, you can create, for example, triangular waveforms.

Suffix:

<wg> 1..2

Parameters:

<RampSymmetry> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Manual operation: See "Symmetry" on page 322

WGENerator<wg>:FUNCtion[:SELect] <FunctionType>

Selects the type of waveform to be generated.

Suffix:

<wg> 1...2, index of the waveform generator

Parameters:

<FunctionType> SINusoid | SQUare | RAMP | DC | PULSe | SINC | CARDiac | GAUSs | LORNtz | EXPRise | EXPFall | ARBitrary

SINC: Cardial sine

*RST: SINusoid

Manual operation: See "Function type" on page 309

WGENerator<wg>:FUNCtion[:SQUare]:DCYCle <SquareDutyCycle>

Sets the duty cycle for the pulse function.

Suffix:

<wg> 1..2

Parameters:

<SquareDutyCycle> Range: 0.01 to 99.99
Increment: 1
*RST: 50
Default unit: %

Manual operation: See "Duty cycle" on page 322

WGENerator<wg>:OUTPut[:LOAD] <Load>

Select the user load, the load of the DUT at its connection.

Suffix:

<wg> 1..2

Parameters:

<Load> FIFTy | HIZ

`FIFTy`: 50Ω
`HIZ`: High-Z (high input impedance)

*RST: HIZ

Manual operation: See "User load" on page 321

WGENerator<wg>:PERiod <Period>

Sets the period of the pulse waveform, if `WGENerator<wg>:FUNCtion[:SELect]` is set to `PULSe`.

Suffix:

<wg> 1..2

Parameters:

<Period> Range: 1E-08 to 1000
Increment: 1
*RST: 1E-06
Default unit: s

Manual operation: See "Period" on page 322

WGENerator<wg>:PRESet

Presets the generator to a default setup. The default includes the following settings:

- "Function type" = "Sine"
- "Frequency" = "1 MHz"
- "Amplitude" = "1 Vpp"

Suffix:
<wg> 1..2

Usage: Setting only

Manual operation: See "Default setup" on page 322

WGENerator<wg>:VOLTage:DCLevel <DCLevel>

Sets the level for the DC signal, if `WGENerator<wg>:FUNCtion[:SELect]` is set to `DC`.

Suffix:
<wg> 1..2

Parameters:
<DCLevel> Range: -5 to 5
Increment: 0.1
*RST: 0
Default unit: V

Manual operation: See "DC level" on page 322

WGENerator<wg>:VOLTage:HIGH <High>

Sets the high signal level of the output waveform.

Suffix:
<wg> 1..2

Parameters:
<High> Range: -5.99 to 6
Increment: 0.1
*RST: 0.5
Default unit: V

WGENerator<wg>:VOLTage:INVersion <Inversion>

Inverts the waveform at the offset level.

Suffix:
<wg> 1..2

Parameters:

<Inversion> ON | OFF

*RST: OFF

Manual operation: See "Inversion" on page 309

WGENerator<wg>:VOLTage:LOW <Low>

Sets the low signal level of the output waveform.

Suffix:

<wg> 1..2

Parameters:

<Low> Range: -6 to 5.99
Increment: 0.1
*RST: -0.5
Default unit: V

WGENerator<wg>:VOLTage:OFFSet <Offset>

Sets the vertical offset of the generated waveform.

Suffix:

<wg> 1..2

Parameters:

<Offset> Range: -5.995 to 5.995
Increment: 0.1
*RST: 0
Default unit: V

Manual operation: See "Offset" on page 321

WGENerator<wg>:VOLTage[:VPP] <Amplitude>

Sets the amplitude of the waveform.

Suffix:

<wg> 1..2

Parameters:

<Amplitude> Range: 0.01 to 12
Increment: 0.1
*RST: 0.4
Default unit: Vpp

Manual operation: See "Amplitude" on page 321

WGENerator<wg>[:ENABle] <State>

Enables the function generator.

Suffix:
<wg> 1..2

Parameters:
<State> ON | OFF
*RST: OFF

Usage: Asynchronous command

Manual operation: See "State" on page 309

17.18.1.2 Modulation settings

WGENerator<wg>:MODulation:AM:DCYCle <SquareDutyCycle>

Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Suffix:
<wg> 1..2

Parameters:
<SquareDutyCycle> Range: 10 to 90
Increment: 1
*RST: 50
Default unit: %

Manual operation: See "Duty cycle" on page 324

WGENerator<wg>:MODulation:AM:DEPTh <Depth>

Sets the modulation depth, the percentage of the amplitude range that is used for AM modulation.

Suffix:
<wg> 1..2

Parameters:
<Depth> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Manual operation: See "Depth" on page 324

WGENerator<wg>:MODulation:AM:FREQuency <Frequency>

Sets the frequency of the modulation waveform for AM frequency modulation.

Suffix:
<wg> 1..2

Parameters:
<Frequency> Range: 0.001 to 1000000
Increment: 1
*RST: 1000
Default unit: Hz

Manual operation: See "Frequency" on page 324

WGENerator<wg>:MODulation:AM:SYMMetry <RampSymmetry>

Sets the symmetry for the AM ramp modulation waveform, the percentage of time that the waveform is rising.

Suffix:
<wg> 1..2

Parameters:
<RampSymmetry> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Manual operation: See "Symmetry" on page 324

WGENerator<wg>:MODulation:AM[:FUNCtion] <SignalType>

Selects the type of the modulating signal for AM modulation.

Suffix:

<wg>	1..2

Parameters:

<SignalType> SINusoid | SQUare | RAMP

*RST: SINusoid

Manual operation: See "Signal type" on page 323

WGENerator<wg>:MODulation:CARRier:FREQuency <FreqCarrierAlias>

Sets the frequency of the carrier signal for a modulation waveform.

Suffix:

<wg>	1..2

Parameters:

<FreqCarrierAlias>

Range: 0.001 to 100000000
Increment: 10
*RST: 1000000
Default unit: Hz

WGENerator<wg>:MODulation:CARRier:PERiod <PeriodCarrierAlias>

Sets the period of the carrier signal for a modulation waveform.

Suffix:

<wg>	1..2

Parameters:

<PeriodCarrierAlias>

Range: 1E-08 to 1000
Increment: 1
*RST: 1E-06
Default unit: s

WGENerator<wg>:MODulation:FM:DCYCle <SquareDutyCycle>

Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Suffix:

<wg>	1..2

Parameters:

<SquareDutyCycle>

Range: 10 to 90
Increment: 1
*RST: 50
Default unit: %

Manual operation: See "Duty cycle" on page 324

WGENerator<wg>:MODulation:FM:DEViation <Deviation>

Sets the frequency deviation, the maximum difference between the FM modulated signal and the carrier signal.

Suffix:
<wg> 1..2

Parameters:
<Deviation> Range: 0.001 to 10000000
Increment: 1
*RST: 1000
Default unit: Hz

Manual operation: See "Deviation" on page 324

WGENerator<wg>:MODulation:FM:FREQuency <Frequency>

Sets the frequency of the modulating waveform for FM modulation.

Suffix:
<wg> 1..2

Parameters:
<Frequency> Range: 0.001 to 1000000
Increment: 1
*RST: 1000
Default unit: Hz

Manual operation: See "Frequency" on page 324

WGENerator<wg>:MODulation:FM:SYMMetry <RampSymmetry>

Sets the symmetry for the FM ramp modulation waveform, the percentage of time that the waveform is rising.

Suffix:
<wg> 1..2

Parameters:
<RampSymmetry> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Manual operation: See "Symmetry" on page 324

WGENerator<wg>:MODulation:FM[:FUNCtion] <SignalType>

Selects the type of the modulating signal for FM modulation.

Suffix:
<wg> 1..2

Parameters:

<SignalType>	SINusoid | SQUare | RAMP *RST: SINusoid

Manual operation: See "Signal type" on page 323

WGENerator<wg>:MODulation:FSK:FONE <Frequency1>
WGENerator<wg>:MODulation:FSK:FTWO <Frequency2>

Sets the frequency of the first /second signal in FSK modulated signal.

Suffix:

<wg>	1..2

Parameters:

<Frequency2>	Range: 0.001 to 100000000 Increment: 1 *RST: 1000 Default unit: Hz

Manual operation: See "Frequency 1/Frequency 2" on page 325

WGENerator<wg>:MODulation:FSK[:RATE] <Rate>

Sets the frequency at which signal switches between `WGENerator<wg>:MODulation:FSK:FONE` and `WGENerator<wg>:MODulation:FSK:FTWO`.

Suffix:

<wg>	1..2

Parameters:

<Rate>	Range: 0.001 to 1000000 Increment: 1 *RST: 1000 Default unit: Hz

Manual operation: See "FSK rate" on page 325

WGENerator<wg>:MODulation:NDCLevel <LevelDC>

Sets the DC noise level, if `WGENerator<wg>:FUNCtion[:SELect]` is set to `DC`.

Suffix:

<wg>	1..2

Parameters:

<LevelDC>	Range: 0 to 10 Increment: 0.1 *RST: 0 Default unit: Vpp

WGENerator<wg>:MODulation:NLABsolute?

Queries the level of the noise in volts.

Suffix:

<wg> 1...2, index of the waveform generator

Return values:

<LevAbs> Range: 0 to 12
Increment: 0.1
*RST: 0
Default unit: Vpp

Usage: Query only

WGENerator<wg>:MODulation:NLPCent <LevelPct>

Sets the level of the noise in percentage of the set "Amplitude" output of the signal.

Suffix:

<wg> 1..2

Parameters:

<LevelPct> Range: 0 to 100
Increment: 1
*RST: 0
Default unit: %

Manual operation: See "Noise level in %" on page 321

WGENerator<wg>:MODulation:PWM:DCYCle <SquareDutyCycle>

Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Suffix:

<wg> 1..2

Parameters:

<SquareDutyCycle> Range: 10 to 90
Increment: 1
*RST: 50
Default unit: %

Manual operation: See "Duty cycle" on page 324

WGENerator<wg>:MODulation:PWM:DEPTh <Depth>

Sets the modulation depth, the percentage of the amplitude range that is used for PWM modulation.

Suffix:

<wg> 1..2

Parameters:

<Depth> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Manual operation: See "Modulation depth" on page 324

WGENerator<wg>:MODulation:PWM:FREQuency <Frequency>

Sets the frequency of the modulating waveform for PWM modulation.

Suffix:

<wg> 1..2

Parameters:

<Frequency> Range: 0.001 to 1000000
Increment: 1
*RST: 1000
Default unit: Hz

Manual operation: See "Frequency" on page 324

WGENerator<wg>:MODulation:PWM:SYMMetry <RampSymmetry>

Sets the symmetry for the PWM ramp modulation waveform, the percentage of time that the waveform is rising.

Suffix:

<wg> 1..2

Parameters:

<RampSymmetry> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

Manual operation: See "Symmetry" on page 324

WGENerator<wg>:MODulation:PWM[:FUNCtion] <SignalType>

Selects the type of the modulating signal for PWM modulation.

Suffix:

<wg> 1..2

Parameters:

<SignalType> SINusoid | SQUare | RAMP
*RST: SINusoid

Manual operation: See "Signal type" on page 323

WGENerator<wg>:MODulation:TYPE <ModulationType>

Selects the modulation type, which defines how the carrier signal is modified.

Suffix:
<wg> 1..2

Parameters:
<ModulationType> NONE | AM | FM | PWM | ASK | FSK
*RST: AM

Manual operation: See "Modulation type" on page 323

17.18.1.3 ARB settings

WGENerator<wg>:ARBGen:NAME <FilePath>

Sets the file path and the file for an arbitrary waveform, if `WGENerator<wg>:ARBGen[:SOURce]` is set to `ARBitrary`.

Suffix:
<wg> 1..2

Parameters:
<FilePath>

Manual operation: See "Load signal" on page 328

WGENerator<wg>:ARBGen:OPEN

Loads the arbitrary waveform, which is selected with the `WGENerator<wg>:ARBGen:NAME` command.

Suffix:
<wg> 1..2

Usage: Setting only
Asynchronous command

Manual operation: See "Load signal" on page 328

WGENerator<wg>:ARBGen:RUNMode <RunMode>

Sets the duration for which the signal of the arbitrary generator will be output after the trigger event.

Suffix:
<wg> 1..2

Parameters:
<RunMode> SINGle | REPetitive
*RST: REPetitive

WGENerator<wg>:ARBGen:SAMPles?

Sets the sample rate for the arbitrary waveform.

Suffix:
<wg> 1..2

Return values:
<NumSamples> Range: 0 to 128000000
Increment: 10
*RST: 0
Default unit: pts

Usage: Query only

Manual operation: See "Number of samples" on page 327

WGENerator<wg>:ARBGen:SELect <SignalSource>

Selects the oscilloscope source, from which the arbitrary signal is loaded, if `WGENerator<wg>:ARBGen[:SOURce]` is set to `SCOPe`.

Suffix:
<wg> 1..2

Parameters:
<SignalSource> C1 | C2 | C3 | C4 | R1 | R2 | R3 | R4
*RST: C1

WGENerator<wg>:ARBGen:SRATe <SampleRate>

Sets the sample rate for the arbitrary waveform.

Suffix:
<wg> 1..2

Parameters:
<SampleRate> Range: 1 to 312500000
Increment: 10
*RST: 1000000
Default unit: Sa/s

Manual operation: See "Sample rate" on page 327

WGENerator<wg>:ARBGen[:SOURce] <WaveformSource>

Selects the source of the arbitrary waveform.

Suffix:
<wg> 1..2

Parameters:
<WaveformSource> ARBitrary | SCOPe | ERINjection
*RST: ARBitrary

Manual operation: See "Arb wfm source" on page 326

17.18.1.4 Sweep settings

WGENerator<wg>:SWEep[:STATe] <Sweep>

Enables or disables the sweeping.

Suffix:
<wg> 1..2

Parameters:
<Sweep> ON | OFF
*RST: OFF

Manual operation: See "Sweep state" on page 325

WGENerator<wg>:SWEep:TYPE <Type>

Sets the type of the sweep, a linear or logarithmic change of the frequency.

Suffix:
<wg> 1..2

Parameters:
<Type> LIN | LOG
*RST: LIN

Manual operation: See "Sweep type" on page 326

WGENerator<wg>:SWEep:FSTart <StartFrequency>

Sets the start frequency of the sweep signal.

Suffix:
<wg> 1..2

Parameters:

<StartFrequency>	Range:	0.001 to 100000000
	Increment:	1
	*RST:	1000
	Default unit:	Hz

Manual operation: See "Start frequency" on page 326

WGENerator<wg>:SWEep:TIME <Time>

Sets the duration of the sweep.

Suffix:
<wg> 1..2

Parameters:

<Time>	Range:	0.001 to 500
	Increment:	1
	*RST:	0.001
	Default unit:	s

Manual operation: See "Sweep time" on page 326

WGENerator<wg>:SWEep:FEND <StopFrequency>

Sets the stop frequency of the sweep signal.

Suffix:
<wg> 1..2

Parameters:

<StopFrequency>	Range:	0.001 to 100000000
	Increment:	1
	*RST:	1000000
	Default unit:	Hz

Manual operation: See "Stop frequency" on page 326

17.18.2 Synchronize settings

WGENerator<wg>:COUPling:ALL <CoupleAll>

Enables the coupling of the generators, with the selected set of parameters: amplitude, frequency and noise.

Suffix:

<wg>	1..2

Parameters:

<CoupleAll>	ON | OFF *RST: OFF

Manual operation: See "Generator enable" on page 328

WGENerator<wg>:COUPling:AMPLitude <CplAmplitude>

Enables the coupling of all amplitude parameters of the generators.

Suffix:

<wg>	1..2 Specifies the master generator.

Parameters:

<CplAmplitude>	ON | OFF *RST: OFF

Manual operation: See "Frequency parameters" on page 329

WGENerator<wg>:COUPling:PHASeshift <PhaseShift>

Sets the phase shift between the waveform of Gen1 and Gen2 when the frequency parameters of the two waveforms are coupled.

Suffix:

<wg>	1..2 Specifies the master generator.

Parameters:

<PhaseShift>	Range: -180 to 180 Increment: 1 *RST: 0 Default unit: °

Manual operation: See "Phase Gen1 - Gen2" on page 329

WGENerator<wg>:COUPling[:FREQuency] <CplFreq>

Enables the coupling of all frequency parameters of the generators.

Suffix:

<wg>	1..2 Specifies the master generator.

Parameters:

<CplFreq>	ON | OFF *RST: OFF

Manual operation: See "Amplitude parameters" on page 329

GENerator:SYNC[:COMBination] <Combination>

Sets which signals generated from the waveform generator are synchronized.

Parameters:

<Combination>	NONE | GEN12
	*RST: NONE

Manual operation: See "Synchron start" on page 328

17.19 Status reporting

This chapter describes the remote commands that are used to read the status registers.

For information on structure, hierarchy, and contents of the status registers, see Chapter 16.5, "Remote control - status reporting system", on page 342.

17.19.1 General commands

STATus:PRESet

Resets the status registers.

All `PTRansition` bits are set to 1, i.e. all transitions from 0 to 1 are detected.

All `NTRansition` bits are set to 0, i.e. a transition from 1 to 0 in a `CONDition` bit is not detected.

All `EVENt` bits are set to 0.

The `ENABle` bits of `STATus:OPERation` and `STATus:QUEStionable` are set to 0, i.e. all events in these registers are not passed on.

Usage: Setting only
SCPI confirmed
Asynchronous command

17.19.2 STATus:OPERation register

`STATus:OPERation` commands provide information on the activity of the instrument.

See also: Chapter 16.5.3.3, "STATus:OPERation register", on page 347.

STATus:OPERation:CONDition?
STATus:OPERation[:EVENt]?

The `CONDition` command returns information on actions the instrument is currently executing. The contents of the register is retained.

The `EVENt` command returns information on actions the instrument has executed since the last reading. Reading the `EVENt` register deletes its contents.

Bits:

- 0 = ALIGnment
- 2 = AUToset
- 3= WTRIgger (wait for trigger)
- 4= MEASuring

Usage: Query only

STATus:OPERation:ENABle <Enable>

Controls the ENABle part of the STATus:OPERation register. The ENABle defines which events in the EVENt part of the status register are forwarded to the OPERation summary bit (bit 7) of the status byte. The status byte can be used to create a service request.

Parameters:

<Enable> Range: 1 to 65535
Increment: 1

Example: `STATus:OPERation:ENABle 5`
The ALIGnment event (bit 0) and AUToset event (bit 2) are forwarded to the OPERation summary bit of the status byte.

17.19.3 STATus:QUEStionable registers

The commands of the `STATus:QUEStionable` subsystem control the status reporting structures of the `STATus:QUEStionable` registers.

See also: Chapter 16.5.3.4, "STATus:QUEStionable register", on page 348.

The query of the `[:EVENt]` and `[:ENABLe]` commands, return a list of the affected sources:

Table 17-7: Source values for the STATus:QUEStionable:...:[:EVENt] and STATus:QUEStionable:...:[:ENABLe]

Bits	Source values	Description
For all bits	NONE	
	ALL	All available sources are activated
PPSupply	PRobe<m>	Active probe
POVerload	PRobe<m>	Active probe
COVerload	CHAN<m>	Analog channels
	WARNCHAN<m>	Warning overload channels
	EXTTRIGGERIN	External analog signal connected to the external trigger input
	TRIGGEROUT	Trigger out signal
TEMPerature	TEMPWARN	Temperature warning: indicates that the device is getting hot and should be cooled.
	TEMPERROR	Temperature error: the device is too hot and will automatically shut down in a few seconds.
ADCState	CPCHAN<m>	Positive clipping for analog channels
	CNCHAN<m>	Negative clipping for analog channels
	CPPRobe<m>	Positive clipping for probes
	CNPRobe<m>	Negative clipping for probes
GOVerload	WGENerator<m>	Available generators
NOALigndata	HCHannel<m>	Horizontal channels
	VCHannel<m>	Vertical channels
	PROBe<m>	Probes channels
	LPRObes<m>	Logic probes
	WGENerator<m>	Available generators
LIMit	MEAS<m>	Enabled measurements
MARGin	MEAS<m>	Enabled measurements
IMPRecise	MEAS<m>	Enabled measurements

Some of the status commands can be used interchangeably:

Table 17-8: Overview STATus:QUEStionable and respective CHANnel,MEASurement commands

STATus:QUEStionable register	,MEASurement
STATus:QUEStionable:COVerload Bit: CHANnel<ch>	CHANnel<ch>:OVERload:STATus:
STATus:QUEStionable:COVerload Bit: WCHannel<ch>	CHANnel<ch>:WARNoverload:STATus

STATus:QUEStionable register	,MEASurement
STATus:QUEStionable:ADCState Bit: CPCHannel<ch>	CHANnel<ch>:ADCState:STATus:PCLipping
STATus:QUEStionable:ADCState Bit: CNCHannel<ch>	CHANnel<ch>:ADCState:STATus:NCLipping
STATus:QUEStionable:LIMit Bit: MEASurement<mg>	MEASurement<mg>:LIMit:STATus
STATus:QUEStionable:MARGin Bit: MEASurement<mg>	MEASurement<mg>:MARGin:STATus
STATus:QUEStionable:IMPRecise Bit: MEASurement<mg>	MEASurement<mg>:IMPRecise:STATus

---

STATus:QUEStionable:ADCState:CONDition?
STATus:QUEStionable:COVerload:CONDition?
STATus:QUEStionable:GOVerload:CONDition?
STATus:QUEStionable:IMPRecise:CONDition?
STATus:QUEStionable:LIMit:CONDition?
STATus:QUEStionable:MARGin:CONDition?
STATus:QUEStionable:PLL:CONDition?
STATus:QUEStionable:PPSupply:CONDition?
STATus:QUEStionable:TEMPerature:CONDition?

Returns the contents of the `CONDition` part of the status register to check for questionable instrument or measurement states. This part contains information on the action currently being performed in the instrument.

Reading the `CONDition` registers does not delete the contents since it indicates the current hardware status.

Usage: Query only

STATus:QUEStionable:ADCState:ENABle <Value>
STATus:QUEStionable:COVerload:ENABle <Value>
STATus:QUEStionable:GOVerload:ENABle <Value>
STATus:QUEStionable:IMPRecise:ENABle <Value>
STATus:QUEStionable:LIMit:ENABle <Value>
STATus:QUEStionable:MARGin:ENABle <Value>
STATus:QUEStionable:PLL:ENABle <Value>
STATus:QUEStionable:PPSupply:ENABle <Value>
STATus:QUEStionable:TEMPerature:ENABle <Value>

Sets the `ENABle` part that allows true conditions in the EVENt part to be reported for the summary bit in the status byte.

These events can be used for a service request. If a bit in the `ENABle` part is 1, and the corresponding `EVENt` bit is true, a positive transition occurs in the summary bit. This transition is reported to the next higher level.

See Source values for the STATus:QUEStionable:...:[:EVENt] and STATus:QUEStionable:...:[:ENABLe] for a list of the return values.

Parameters:
<Value> bit dependent

STATus:QUEStionable:ADCState:NTRansition <Value>
STATus:QUEStionable:COVerload:NTRansition <Value>
STATus:QUEStionable:GOVerload:NTRansition <Value>
STATus:QUEStionable:IMPRecise:NTRansition <Value>
STATus:QUEStionable:LIMit:NTRansition <Value>
STATus:QUEStionable:MARGin:NTRansition <Value>
STATus:QUEStionable:PLL:NTRansition <Value>
STATus:QUEStionable:PPSupply:NTRansition <Value>
STATus:QUEStionable:TEMPerature:NTRansition <Value>

Sets the negative transition filter.

If a bit is set, a transition from 1 to 0 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Parameters:
<Value> WGENerator<g>

STATus:QUEStionable:ADCState:PTRansition <Value>
STATus:QUEStionable:COVerload:PTRansition <Value>
STATus:QUEStionable:GOVerload:PTRansition <Value>
STATus:QUEStionable:IMPRecise:PTRansition <Value>
STATus:QUEStionable:LIMit:PTRansition <Value>
STATus:QUEStionable:MARGin:PTRansition <Value>
STATus:QUEStionable:PLL:PTRansition <Value>
STATus:QUEStionable:PPSupply:PTRansition <Value>
STATus:QUEStionable:TEMPerature:PTRansition <Value>

Sets the positive transition filter.

If a bit is set, a transition from 0 to 1 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Parameters:
<Value> WGENerator<g>

STATus:QUEStionable:ADCState[:EVENt]?
STATus:QUEStionable:COVerload[:EVENt]?
STATus:QUEStionable:GOVerload[:EVENt]?
STATus:QUEStionable:IMPRecise[:EVENt]?
STATus:QUEStionable:LIMit[:EVENt]?
STATus:QUEStionable:MARGin[:EVENt]?
STATus:QUEStionable:PLL[:EVENt]?
STATus:QUEStionable:PPSupply[:EVENt]?
STATus:QUEStionable:TEMPerature[:EVENt]?

Returns the contents of the `EVENt` part of the status register to check if an event has occurred since the last reading.

Reading an `EVENt` register deletes its contents.

Parameters:
<Value> See Source values for the STATus:QUEStionable:...:[:EVENt] and STATus:QUEStionable:...:[:ENABLe] for a list of the return values.

Usage: Query only

17.19.4 Measurement status register

This chapter describes the remote commands for querying the status of the measurements.

You can also use the `STATus:QUEStionable` register interchangeably with the measurement status commands, see Overview STATus:QUEStionable and respective CHANnel,MEASurement commands.

MEASurement<mg>:IMPRecise:STATus:CONDition?

Returns the contents of the `CONDition` part of the measurement status, to check if a limit value is imprecise (the magnitude of the signal is too low to get reliable measurement results).

Reading the `CONDition` registers does not delete the contents.

Suffix:
<mg> 1...16, index of the measurement

Usage: Query only

MEASurement<mg>:IMPRecise:STATus:ENABle <Value>

Sets the `ENABle` part that allows true conditions in the EVENt part to be reported.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<Value> ON | OFF

MEASurement<mg>:IMPRecise:STATus:NTRansition <Value>

Sets the negative transition filter for imprecise measurements (the magnitude of the signal is too low to get reliable measurement results).

If a bit is set, a transition from 1 to 0 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<Value> ON | OFF

MEASurement<mg>:IMPRecise:STATus:PTRansition <Value>

Sets the positive transition filter for imprecise measurements (the magnitude of the signal is too low to get reliable measurement results).

If a bit is set, a transition from 0 to 1 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Suffix:
<mg> 1...16, index of the measurement

Parameters:
<Value> ON | OFF

MEASurement<mg>:IMPRecise:STATus[:EVENt]?

Returns the contents of the `EVENt` part of the measurement status, to check if an imprecise measurement has occurred since the last reading.

Reading an `EVENt` deletes its contents.

Suffix:
<mg> 1...16, index of the measurement

Usage: Query only

MEASurement<mg>:LIMit:STATus:CONDition?

Returns the contents of the `CONDition` part of the measurement status, to check if a limit value is violated.

Reading the `CONDition` registers does not delete the contents.

Suffix:

<mg> 1...16, index of the measurement

Usage: Query only

MEASurement<mg>:LIMit:STATus:ENABle <Value>

Sets the `ENABle` part that allows true conditions in the EVENt part to be reported.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<Value> ON | OFF

MEASurement<mg>:LIMit:STATus:NTRansition <Value>

Sets the negative transition filter if a limit value of a measurement is violated.

If a bit is set, a transition from 1 to 0 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<Value> ON | OFF

MEASurement<mg>:LIMit:STATus:PTRansition <Value>

Sets the positive transition filter if a limit value of a measurement is violated.

If a bit is set, a transition from 0 to 1 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<Value> ON | OFF

MEASurement<mg>:LIMit:STATus[:EVENt]?

Returns the contents of the `EVENt` part of the measurement status, to check if a limit violation has occurred since the last reading.

Reading an `EVENt` deletes its contents.

Suffix:

<mg> 1...16, index of the measurement

Usage: Query only

MEASurement<mg>:MARGin:STATus:CONDition?

Returns the contents of the `CONDition` part of the measurement status, to check if a margin value is violated.

Reading the `CONDition` registers does not delete the contents.

Suffix:

<mg> 1...16, index of the measurement

Usage: Query only

MEASurement<mg>:MARGin:STATus:ENABle <Value>

Sets the `ENABle` part that allows true conditions in the EVENt part to be reported.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<Value> ON | OFF

MEASurement<mg>:MARGin:STATus:NTRansition <Value>

Sets the negative transition filter if a margin value of a measurement is violated.

If a bit is set, a transition from 1 to 0 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<Value> ON | OFF

MEASurement<mg>:MARGin:STATus:PTRansition <Value>

Sets the positive transition filter if a margin value of a measurement is violated.

If a bit is set, a transition from 0 to 1 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Suffix:

<mg> 1...16, index of the measurement

Parameters:

<Value> ON | OFF

MEASurement<mg>:MARGin:STATus[:EVENt]?

Returns the contents of the `EVENt` part of the measurement status, to check if a margin violation has occurred since the last reading.

Reading an `EVENt` deletes its contents.

Suffix:
<mg> 1...16, index of the measurement

Usage: Query only

17.19.5 Channel status register

This chapter describes the remote commands for querying the status of the channels.

You can also use the `STATus:QUEStionable` register interchangeably with the channel status commands, see Overview STATus:QUEStionable and respective CHANnel,MEASurement commands.

CHANnel<ch>:ADCState:STATus:NCLipping:CONDition?
CHANnel<ch>:ADCState:STATus:PCLipping:CONDition?

Returns the contents of the `CONDition` part of the channel status, to check if a negative/positive clipping value is violated.

Reading the `CONDition` registers does not delete the contents.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Query only

CHANnel<ch>:ADCState:STATus:NCLipping:ENABle <Value>
CHANnel<ch>:ADCState:STATus:PCLipping:ENABle <Value>

Sets the `ENABle` part that allows true conditions in the EVENt part to be reported.

Suffix:
<ch> 1 to 4, index of the analog channel

Parameters:
<Value> ON | OFF

CHANNel<ch>:ADCState:STATus:NCLipping:NTRansition <Value>
CHANNel<ch>:ADCState:STATus:PCLipping:NTRansition <Value>

Sets the negative transition filter if a negative/positive clipping value of a channel is violated.

If a bit is set, a transition from 1 to 0 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Suffix:

<ch>	1 to 4, index of the analog channel

Parameters:

<Value>	ON | OFF

CHANNel<ch>:ADCState:STATus:NCLipping:PTRansition <Value>
CHANNel<ch>:ADCState:STATus:PCLipping:PTRansition <Value>

Sets the positive transition filter if a negative/positive clipping value of a channel is violated.

If a bit is set, a transition from 0 to 1 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Suffix:

<ch>	1 to 4, index of the analog channel

Parameters:

<Value>	ON | OFF

CHANNel<ch>:ADCState:STATus:NCLipping[:EVENt]?
CHANNel<ch>:ADCState:STATus:PCLipping[:EVENt]?

Returns the contents of the `EVENt` part of the channel status, to check if a negative/positive clipping channel violation has occurred since the last reading.

Reading an `EVENt` deletes its contents.

Suffix:

<ch>	1 to 4, index of the analog channel
Usage:	Query only

CHANNel<ch>:OVERload:STATus:CONDition?

Returns the contents of the `CONDition` part of the channel status, to check if an overload for the 50 Ω terminator has occurred.

Reading the `CONDition` registers does not delete the contents.

Suffix:

<ch>	1 to 4, index of the analog channel
Usage:	Query only

CHANnel<ch>:OVERload:STATus:ENABle <Value>

Sets the `ENABle` part that allows true conditions in the EVENt part to be reported.

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<Value> ON | OFF

CHANnel<ch>:OVERload:STATus:NTRansition <Value>

Sets the negative transition filter if an overload for the 50 Ω terminator has occurred.

If a bit is set, a transition from 1 to 0 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<Value> ON | OFF

CHANnel<ch>:OVERload:STATus:PTRansition <Value>

Sets the positive transition filter if an overload for the 50 Ω terminator has occurred.

If a bit is set, a transition from 0 to 1 in the condition part causes an entry to be made in the corresponding bit of the `EVENt` part of the register.

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<Value> ON | OFF

CHANnel<ch>:OVERload:STATus[:EVENt] <Value>

Returns the contents of the `EVENt` part of the channel status, to check if an overload for the 50 Ω terminator has occurred since the last reading.

Reading an `EVENt` deletes its contents.

Suffix:

<ch> 1 to 4, index of the analog channel

Parameters:

<Value> ON | OFF

CHANnel<ch>:WARNoverload:STATus[:EVENt]?

Returns the contents of the `EVENt` part of the channel status, to check if an overload has occurred since the last reading.

Reading an `EVENt` deletes its contents.

Suffix:
<ch> 1 to 4, index of the analog channel

Usage: Query only

17.19.6 Programming tips and examples

Example: Observing the limits violation of a measurement

The following example describes how to use the status register commands to observe, if a violation of a measurement limit has occurred.

```
*SRE 8
// Enables the STATus:QUEStionable bit in the service-request (SRE)

STATus:QUEStionable:ENABle 512
// Enables the LIMIt bit of the STATus:QUEStionable register

MEASurement1:ENABle ON
MEASurement2:ENABle ON
MEASurement3:ENABle ON
// Enables measurement 1,2,3


STATus:QUEStionable:LIMit:ENABle ALL
// Enables the limit check for all active measurements

STATus:QUEStionable:LIMit:ENABle?
MEAS1,MEAS2,MEAS3
//Queries which measurement were active at the time the
//STATus:QUEStionable:LIMit:ENABle was send

*SRQ?
// A service request was sent

*STB?
72
// STATus:QUEStionable is set:
// #72= 64 + 8 = 2^6 + 2^3
// 64 : bit 6 is awlays on when a SRQ is sent
// 8: bit 3 for STATus:QUEStionable

STATus:QUEStionable:EVENt?
512
// 512= 2^9,

STATus:QUEStionable:LIMit:EVENt?
MEAS1,MEAS2
// Measurements 1 and 2 have exceeded the limit
// The event register is cleared after the query


STATus:QUEStionable:LIMit:EVENt?
NONE
// The event bit has been set to 0 after the first query
```

```
STATus:QUEStionable:LIMit:CONDition?
MEAS1,MEAS2
// Measurements 1 and 2 are still exceeding the limit


STATus:QUEStionable:EVENt?
0

// Waiting for an event
*SRQ?

// Measurement 3 exceeds the limit

STATus:QUEStionable:LIMit:CONDition?
MEAS1,MEAS2,MEAS3
// Measurements 1,2 and 3 are currently exceeding the limit


STATus:QUEStionable:LIMit:EVENt?
MEAS3
// Measurement 3 has newly  exceeded the limit
// The event register is cleared after the query
```

Query OPC status in the event status register

If you activate a time-consuming operation and wait for completion with `*OPC?`, a time-out could occur before the operation is finished and you do not receive the returned “1”. In addition, the test program is blocked while waiting with `*OPC?`. It is not possible to process other (not interdependent) commands in the meantime or to communicate with other instruments.

Thus, for time-consuming operations, you can avoid blocking the communication by sending the operation complete command `*OPC`:

```
*CLS
*OPC
```

Afterwards you can poll the operation complete status in the event status register with `*ESR?`.

This query returns the content of the event status register and afterwards clears the content. See also Chapter 16.5.3.2, "Event status register (ESR) and event status enable register (ESE)", on page 346.

18 Maintenance and support

The instrument does not need periodic maintenance. Only the cleaning of the instrument is essential.

To protect the front panel and to transport the instrument to another workplace safely and easily, various accessories are provided. Refer to the data sheet for available covers and cases and their order numbers.

18.1 Cleaning

How to clean the product is described in "Cleaning the product" on page 19.

Do not use any liquids for cleaning. Cleaning agents, solvents, acids and bases can damage the front panel labeling, plastic parts and display.

18.2 Changing fuses

If the product does not start, it is possible that a blown fuse is the cause.

The product is protected by 2 fuses of type Size 5x20 mm, 250V~, T5H (slow-blow), IEC 60127-2 (order no. 0099.6735.00).

1. **WARNING!** The fuse is part of the main power supply. Handling the fuse while the power is on can lead to electric shock.

   Before changing the fuse:

   a) Set the switch on the power supply to position [0].
   b) Disconnect the product from the power source.

2. The fuse slot is on the rear panel between the main power switch and AC power supply connector.
   Pull out the fuse holder out of its slot.
3. Check the condition of the fuse.
4. Replace the blown fuse. Only use a fuse of the specified type.
5. Insert the fuse holder into its slot until it latches.

18.3 Contacting customer support

Technical support – where and when you need it

For quick, expert help with any Rohde & Schwarz product, contact our customer support center. A team of highly qualified engineers provides support and works with you to find a solution to your query on any aspect of the operation, programming or applications of Rohde & Schwarz products.

Contact information

Contact our customer support center at www.rohde-schwarz.com/support, or follow this QR code:

Figure 18-1: QR code to the Rohde & Schwarz support page

18.4 Data security

If you have to send the instrument to the service, or if the instrument is used in a secured environment, consider the document "Instrument Security Procedures" that is delivered on the R&S MXO 4 web page.

18.5 Transporting

Lifting and carrying

See: "Lifting and carrying the instrument" on page 16

Packing

Use the original packaging material. It consists of antistatic wrap for electrostatic protection and packing material designed for the product.

If you do not have the original packaging, use similar materials that provide the same level of protection.

Securing

When moving the R&S MXO 4 in a vehicle or using transporting equipment, make sure that the R&S MXO 4 is properly secured. Only use items intended for securing objects.

Transport altitude

The maximum transport altitude without pressure compensation is specified in the data sheet.

18.6 Storage

Protect the product against dust. Ensure that the environmental conditions, e.g. temperature range and climatic load, meet the values specified in the data sheet.

18.7 Disposal

Rohde & Schwarz is committed to making careful, ecologically sound use of natural resources and minimizing the environmental footprint of our products. Help us by disposing of waste in a way that causes minimum environmental impact.

Disposing electrical and electronic equipment

A product that is labeled as follows cannot be disposed of in normal household waste after it has come to the end of its service life. Even disposal via the municipal collection points for waste electrical and electronic equipment is not permitted.

Figure 18-2: Labeling in line with EU directive WEEE

Rohde & Schwarz has developed a disposal concept for the eco-friendly disposal or recycling of waste material. As a manufacturer, Rohde & Schwarz completely fulfills its obligation to take back and dispose of electrical and electronic waste. Contact your local service representative to dispose of the product.

List of commands

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