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R&S®RTO
Digital Oscilloscope
At a glance

R&S®RTO oscilloscopes combine excellent signal fidelity, high acquisition rate and the world's first realtime digital trigger system with a compact device format in the 600 MHz to 4 GHz class. They offer an extensive set of measurement and analysis functions. The fully optimized touchscreen operation is amazingly simple.

R&S®RTO oscilloscopes are optimized to perform precise measurements at a high input sensitivity and very low inherent noise. With an acquisition rate of one million waveforms per second, R&S®RTO oscilloscopes detect signal faults lightning fast. The world's only realtime digital trigger system precisely correlates the trigger event to the measurement signal.

R&S®RTO oscilloscopes are equipped with over 90 measurement functions for debugging complex designs. Rare signal faults are found using the rapid mask test or the powerful FFT analysis function. The history function can be used to look back in time to identify the actual cause of a fault. For challenging analysis tasks, the oscilloscopes can be extended with options for protocol decoding, jitter and compliance testing and vector signal analysis.

R&S®RTO oscilloscopes have been optimized for touchscreen operation, making them easy and intuitive to use.

R&S®RTO Digital Oscilloscope Benefits and key features

Truly uncompromised performance
▪ Precise measurements due to very low noise level: 1% of full scale at 1 mV/div and 1 GHz
▪ High dynamic range due to single-core A/D converter
▪ High definition with up to 16-bit resolution and 500 µV/div
▪ Full measurement bandwidth even at 1 mV/div
▪ Low crosstalk even with high-frequency signals due to 60 dB channel-to-channel isolation
▪ Accurate highly sensitive triggering
▪ Find rare signal faults quickly thanks to industry-leading one million waveforms per second
▪ High measurement speed, even for complex analysis functions
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Outstanding range of capabilities
▪ Wide selection of measurement functions: over 90 automated measurements
▪ QuickMeas: key measurement results at the push of a button
▪ Search and navigation: finding faults fast
▪ History function: looking back in time
▪ Industry-leading mask test: quick configuration – reliable results with up to 600 000 tests per second
▪ FFT-based spectrum analysis: powerful, fast and user-friendly
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Optimized user interface
▪ High-resolution touchscreen for ease of use
▪ Color coding for clear overview
▪ Fully customizable display
▪ Fast access to important tools
▪ Signal details at your fingertip
▪ Easy selection of instrument setup
▪ Documentation at the press of a button
▷ page 13

Master sophisticated applications
▪ Class-leading 400 MHz logic analysis: 5 Gsample/s and 200 Msample memory on 16 channels
▪ High definition: see more with up to 16-bit vertical resolution
▪ Serial protocols: easy triggering and decoding
▪ Analysis of power electronics with the power analysis option
▪ Jitter analysis
▪ Automatic compliance tests
▪ EMI debugging with oscilloscopes
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Models					
Base unit	**Channels**	**Sampling rate**	**Acquisition memory**	**Acquisition rate**	**Mixed signal analysis (MSO)**
R&S®RTO1044 (4 GHz bandwidth)	4	20 Gsample/s	20 Msample per channel, max. 800 Msample	1 million wave-forms per second	400 MHz bandwidth, 5 Gsample/s sampling rate, 200 Msample memory depth
R&S®RTO1024 (2 GHz bandwidth)	4	10 Gsample/s			
R&S®RTO1022 (2 GHz bandwidth)	2				
R&S®RTO1014 (1 GHz bandwidth)	4				
R&S®RTO1012 (1 GHz bandwidth)	2				
R&S®RTO1004 (600 MHz bandwidth)	4				
R&S®RTO1002 (600 MHz bandwidth)	2				

Truly uncompromised performance
Precise measurements

l **Very low inherent noise of 100 µV at 1 mV/div and 1 GHz**
l **High dynamic range due to single-core A/D converter**
l **Full measurement bandwidth up to 4 GHz for 1 mV/div**
l **High definition mode for up to 16-bit vertical resolution**
l **Deep memory up to 800 Msample**
l **Channel-to-channel isolation of > 60 dB prevents crosstalk from high-frequency signals**

Precise measurements due to very low noise level

Minimizing noise was a key goal when designing the R&S®RTO. All aspects were considered, from balanced BNC-compatible inputs with 18 GHz bandwidth to extremely low-noise frontends to high-precision A/D converters. The low inherent noise of the oscilloscopes enables precise measurements, even at the smallest vertical resolutions.

## High dynamic range due to single-core A/D converter

developed a monolithic A/D converter for the R&S®RTO oscilloscopes. This chip's single-core archi-tecture minimizes signal distortion and achieves more than seven effective bits over the entire signal range. The min-imized signal distortion is an excellent foundation for pre-cision signal analysis in the optional high definition mode. This unique mode further reduces noise, making acquisi-tions with up to 16-bit resolution possible.

Full measurement bandwidth even at 1 mV/div

With their input sensitivity of up to 1 mV/div, R&S®RTO oscilloscopes offer high vertical resolution. Other oscillo-scopes attain such high input sensitivity only by employing software-based zooming or by limiting the bandwidth. In contrast, the R&S®RTO oscilloscopes show the signal's real test points, even at 1 mV/div. And their full measurement bandwidth can be used. With the high definition option, the R&S®RTO is the first instrument in its class to offer ver-tical scaling of 500 µV/div at a bandwidth of 1 GHz.

Fast acquisition even with deep memory

Many applications require long record lengths, for instance for analyzing serial buses or switched-mode power sup-plies. The signal processing in the R&S®RTO oscilloscope is optimized to achieve high acquisition rates, even during long recordings. Users benefit from smooth operation and fast results.

10 Gsample/s single-core A/D converter from .
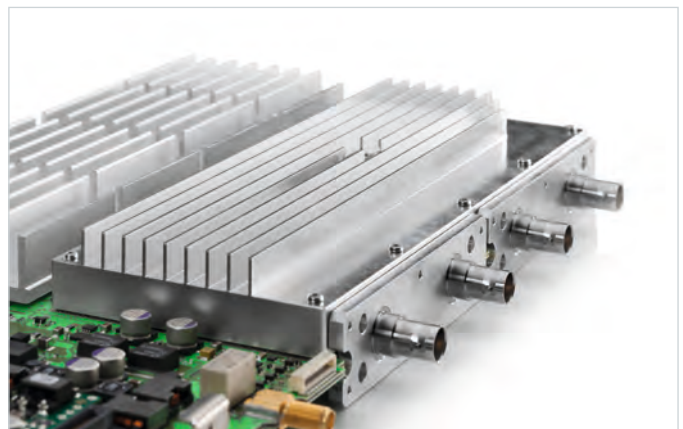
Excellent shielding for optimum channel-to-channel isolation.

Flat frequency response for accurate measurement results

For accurate signal acquisition, R&S®RTO oscilloscopes feature a flat frequency response over the oscilloscope's entire specified bandwidth, ensuring accurate measurement results regardless of the signal's frequency components. The Gaussian falloff in frequency response leads to low overshoot and precise acquisition of signal edges.
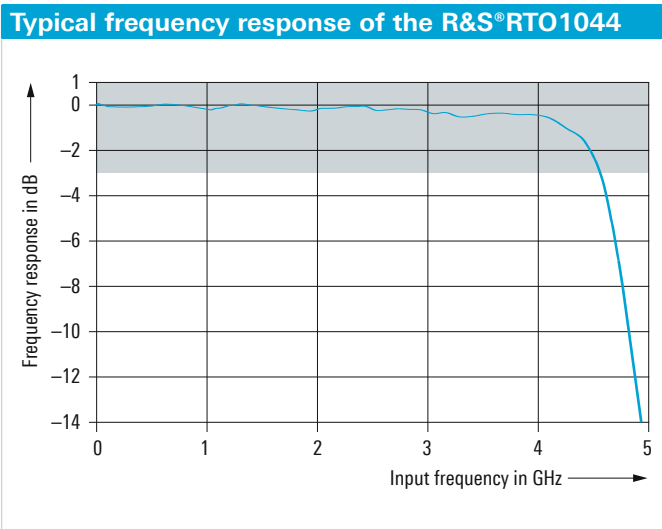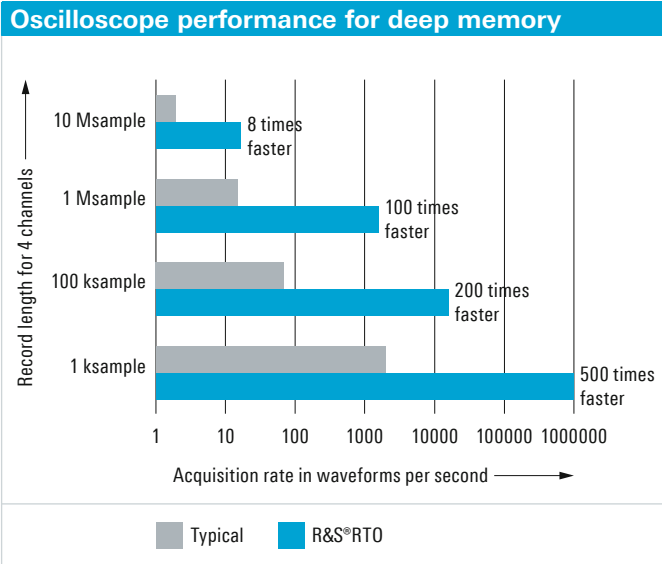
Low gain and offset errors

oscilloscopes are known for their accu-rate measurements, even at different amplitude and offset settings and varying ambient temperatures. The amplifiers and attenuator pads in the frontend are very precisely matched. The sophisticated temperature control ensures high temperature stability within the instrument. Excellent prerequisites for continuous operation without annoying interruptions caused by automatic compensation processes.

Low crosstalk even with high-frequency signals

The excellent channel-to-channel isolation in R&S®RTO oscilloscopes ensures that the measurement signal from one channel has the least possible influence on the signals from the other channels. Their characteristic of > 60 dB up to 2 GHz is outstanding.

R&S®ProbeMeter: voltmeter with 0.1% accuracy integrated into the probe

Active probes from have an integrated voltmeter (R&S®ProbeMeter) that displays the DC value of a measurement signal, irrespective of the oscilloscope scaling. The R&S®RT-ZD10/20/30/40 differential probes additionally display the common mode voltage.

Oscilloscope performance for deep memory

Record length for 4 channels / Acquisition rate in waveforms per second

- 10 Msample — 8 times faster
- 1 Msample — 100 times faster
- 100 ksample — 200 times faster
- 1 ksample — 500 times faster

Typical   R&S®RTO

Typical frequency response of the R&S®RTO1044

Frequency response in dB vs. Input frequency in GHz

Oscilloscope measurement range and bandwidth	RMS noise floor at 50 Ω (typ.)	RMS noise floor at 50 Ω (typ.) in % of measurement range
10 mV measurement range (1 mV/div), 1 GHz bandwidth	100 µV	1%
100 mV measurement range (10 mV/div), 1 GHz bandwidth	200 µV	0.2%
1 V measurement range (100 mV/div), 4 GHz bandwidth	3.6 mV	0.36%

Digital trigger: exceptional precision

ı **Minimal trigger jitter of < 1 ps without subsequent software correction**
ı **High trigger sensitivity at the oscilloscope's full bandwidth**
ı **User-selectable hysteresis and trigger filters**
ı **Optional hardware clock data recovery for triggering on serial interfaces with embedded clock signals**

Accurate highly sensitive triggering

The unique digital trigger system from uses a common path for the measurement signal and the trigger. The oscilloscopes determine if the trigger condi-tion has been met by directly analyzing the digitized signal independently of the current sampling rate. As a result, oscilloscopes have an extremely low trigger jitter and high measurement accuracy. With the optional R&S®RTO-B4 oven-controlled crystal oscillator (OCXO), time stability can be improved to up to 0.02 ppm, for deep memory acquisition and for acquisition with high trigger offset.

High trigger sensitivity at full bandwidth

The digital trigger validates every acquired sample against the trigger definition. For this reason, R&S®RTO oscillo-scopes trigger on even the smallest signal amplitudes. In order to achieve stable triggering regardless of signal noise levels, the user can set the trigger hysteresis for the oscilloscopes. And thanks to the low-noise frontends, the oscilloscopes can also trigger on signals with verti-cal input sensitivities of < 10 mV/div at full measurement bandwidth.

Trigger hysteresis

Adjustable trigger hysteresis
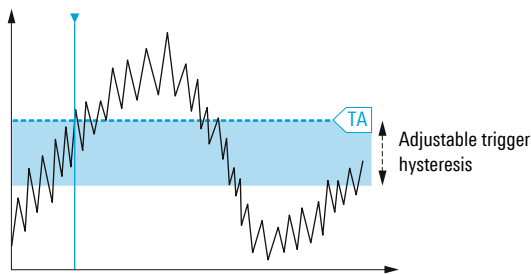
The hysteresis of the digital trigger can be set automatically or manually from 0 div to 5 div.

Comparison of digital and analog triggering architecture
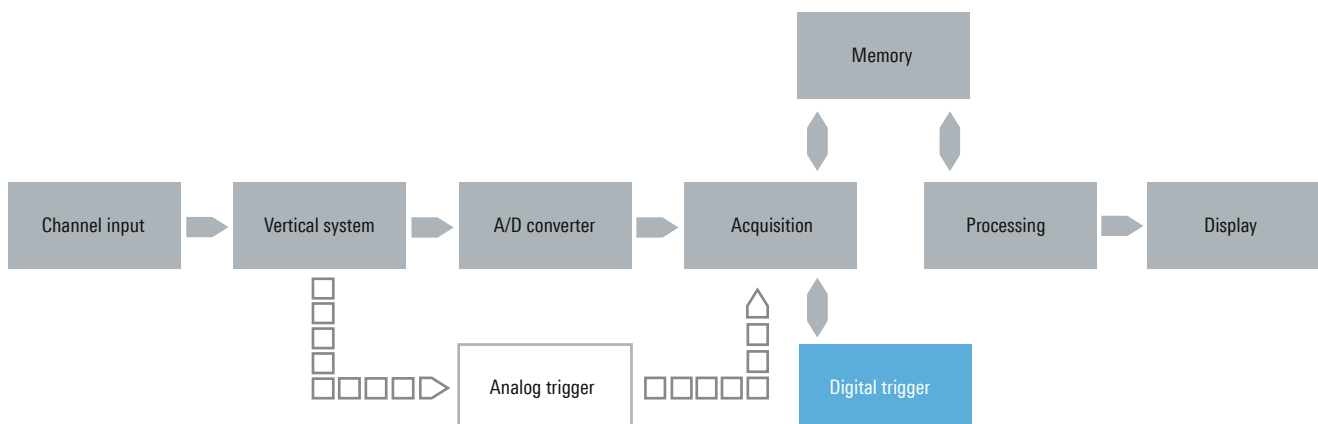
Adjustable digital filter for the trigger signal

The digital trigger architecture used by the R&S®RTO oscilloscopes makes it possible to adapt the cutoff frequency of the digital lowpass filter to the signal to be measured. The same filter settings can be used for both the trigger signal and the measurement signal. As a result, RF noise on the trigger signal can be suppressed, for instance while simultaneously capturing and displaying the unfiltered measurement signal.

Serial pattern trigger for all protocols

The serial pattern trigger allows users to detect defined sequences of up to 128 bit, making it possible to acquire and analyze special protocol patterns, such as headers or protocol data from serial interfaces. Either a separate clock signal can be used, or the hardware clock data recovery option can be used for embedded clock signals.
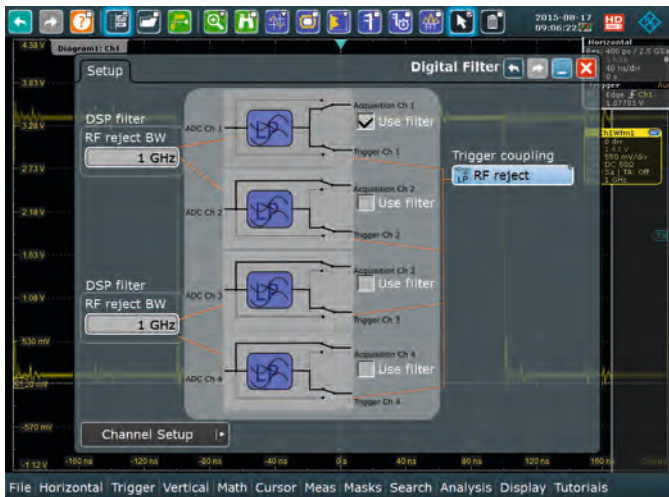
Setting the digital filter.

Serial pattern trigger set for a specific bit sequence with the R&S®RTO-K13 clock data recovery option.

The unique architecture of the digital trigger permits stable triggering, even on signal details such as this 0.4% overshoot (high definition option).

Find rare signal faults quickly

ı **One million waveforms per second make signal faults visible fast**
ı **600 000 mask tests per second**
ı **Hardware-accelerated FFT analysis detects even sporadic faults**

One million waveforms per second: fault finding instead of guesswork

A digital oscilloscope acquires signals in two steps. First, it samples the measurement signal for a defined period of time and stores the samples. It then processes the values and displays them graphically. During this period, the oscilloscope is "blind" to the measurement signal. For conventional digital oscilloscopes, this blind time is more than 99.5 % of the total time at a maximum sampling rate. Measurements take place in less than 0.5 % of the total time, while signal faults occurring during this blind time remain hidden to the user. The less often the faults occur, the less likely they are to be discovered.

Compared with conventional oscilloscopes, the blind time of the R&S®RTO oscilloscopes is up to 500 times shorter. This is due to the core component of the instrument – an ASIC designed specifically for intensive parallel processing that can process the input signal in a minimum amount of time and quickly prepare it for display on the screen. R&S®RTO oscilloscopes acquire, analyze and display up to one million waveforms per second. As a result, these instruments find faults significantly faster and more reliably.

Acquisition cycle with blind time comparison (R&S®RTO versus conventional architecture)
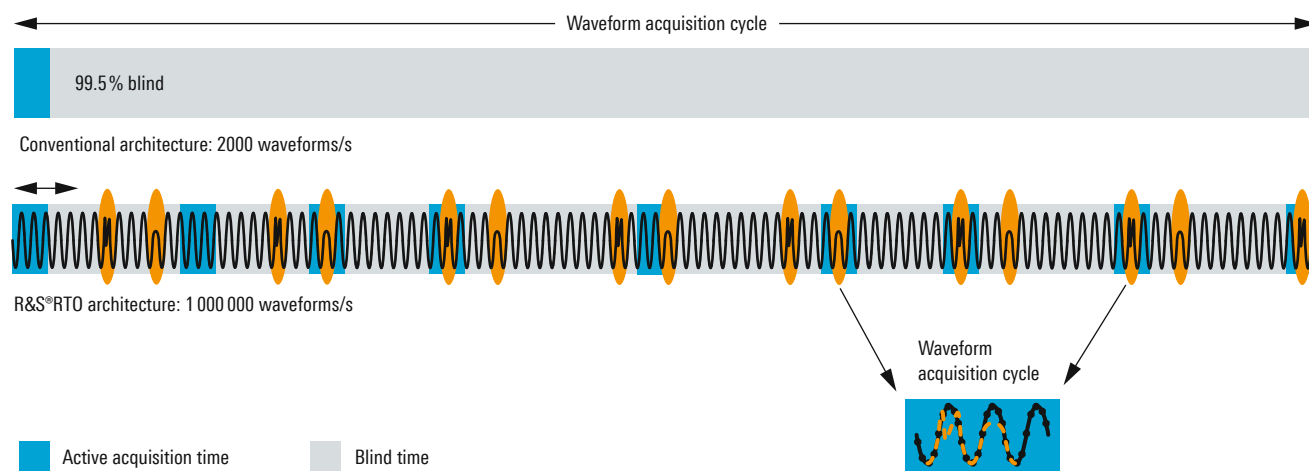
A digital oscilloscope is not able to acquire signal faults that occur during the blind time.
Due to their very short blind time, the R&S®RTO oscilloscopes look at the measured signal over 500 times more often.

High measurement speed, even for complex analysis functions

Many analysis functions are implemented in hardware:
- Histogram
- Spectrum display
- Mask test
- Cursor measurements
- Selected automatic measurement functions
- Selected mathematical operations

The resulting high acquisition and processing rates ensure smooth operation and fast, conclusive results, even during complex analyses.

Max. acquisition rates for analysis functions	
Analysis function	**Maximum acquisition rate**
None	> 1 000 000
Histogram	> 1 000 000
Mask test	> 600 000
Cursor measurements	> 1 000 000
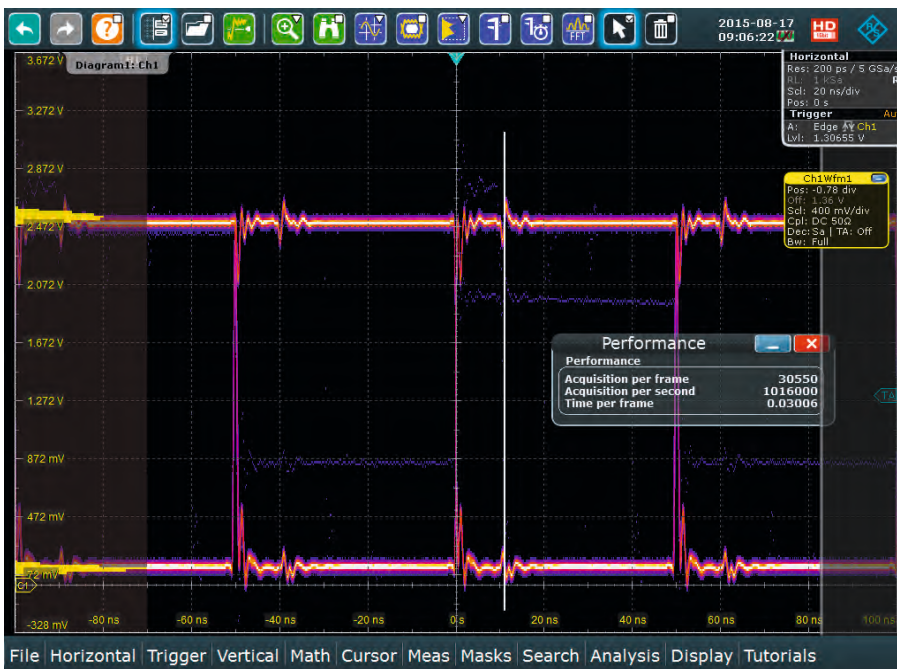
Due to the high acquisition rate of one million waveforms per second, R&S®RTO oscilloscopes find rare signal faults very quickly.

Outstanding range of capabilities
For fast results

- Over 90 automated measurements
- Display of measurement results as trend, track or histogram
- QuickMeas for fast results
- History function for looking back in time
- Powerful FFT-based spectrum analysis
- 100 acquisitions per second, with continuous transfer via Ethernet

Wide selection of measurement functions

R&S®RTO oscilloscopes offer over 90 measurement functions. The automated measurements are organized by type into amplitude and time measurements, jitter, eye, histogram and spectral measurements.

QuickMeas: key measurement results at the push of a button

The QuickMeas function, which simultaneously displays the results of several measurement functions for the current signal, is unique for an instrument in this class. The set of functions can be individually defined with up to eight measurements and saved for later analysis. The QuickMeas function is quickly and easily accessed via the toolbar.

Available analysis options	
Statistics	display of average value, minimum/maximum value and standard deviation
Histogram	graphic display of events as histogram; definition of measurement range and resolution for the histogram (manual or automatic)
Trend	long-term trend function for analyzing slowly developing variations in measurement results (easy identification of thermal dependencies within measurement results)
Track (optional)	analysis of rapidly changing measurement results, e.g. periods; display of results over the entire acquisition period
Gating	restriction of the measurement range to a specific signal range (manually defined or linked to existing cursor or zoom ranges)
Reference lines	definition of reference lines (manual, automatic or averaged); optional display in the waveform
Waveform	graphic display of the results on the waveform, e.g. for documentation purposes
Multiple measurements	definition of the maximum number of measurements per waveform

Measurement display with statistics (bottom), histogram and long-term trend.
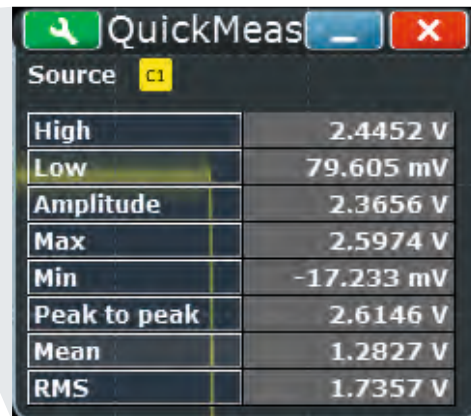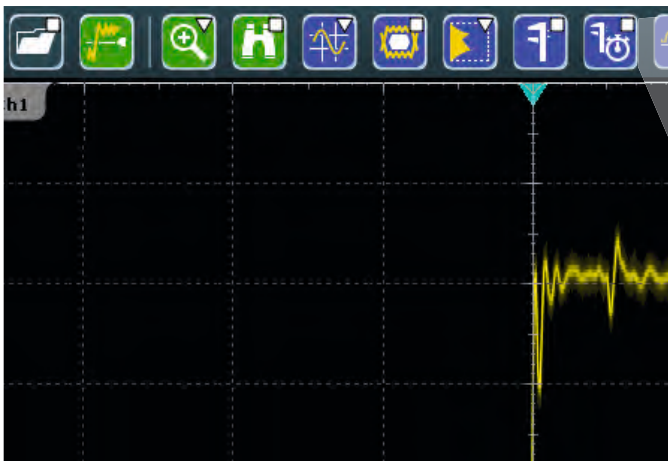
Activation of QuickMeas to display key signal characteristics.

Search and navigation: finding faults fast

Comprehensive search functions simplify the analysis of long signal sequences. Users can search waveforms based on different criteria, such as signal fault, signal pattern and protocol contents. Depending on the specific application, users can search on analog or digital channels, on reference or math waveforms and on serial, protocol-based buses. All events are shown in a table with timestamps. The user can then examine the individual events in a zoom window and navigate between the events. For example, it is possible to view the number of glitch errors in a table, with each individual glitch in the waveform correlated against other signals.

History function: looking back in time

Where does the interference pulse in the signal come from? What caused the loss of a data bit? Finding the real cause of a problem is often only possible by looking at the history of a signal sequence.

The R&S®RTO history function provides access to previously acquired waveforms at the press of a button. This allows users to analyze the measurement data stored in memory. They can scroll through the individual acquisitions with the history player or use the persistence mode to display them superimposed. This powerful function facilitates searches for signal faults over all acquisitions. One timestamp per waveform clearly identifies when events took place. Various analysis tools such as automatic measurements, FFT, mask tests and a search function are available for analyzing past acquisitions.

Industry-leading mask test: quick configuration – reliable results

Mask tests quickly reveal whether a specific signal lies within defined tolerance limits, providing a pass/fail evaluation to assess the quality and stability of a device under test. Signal anomalies and unexpected results are easy to identify by stopping the measurement if the mask is violated. Defining masks is easy and flexible with the R&S®RTO. With just a few keystrokes, the user can generate a mask from a reference signal or define masks consisting of up to eight segments. To get started quickly, the mask segments can be generated on the screen using the mouse or a finger. The positions of the mask points can be optimized later in the mask test dialog box.

Powerful search function for detailed display of events.

History function for looking back in time.

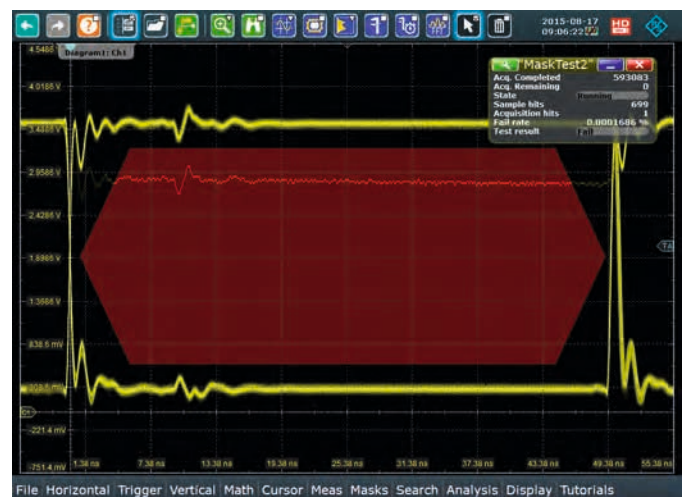Fast mask test: Within ten seconds, more than six million waveforms are acquired, evaluated and displayed.

FFT-based spectrum analysis: powerful, fast and user-friendly

The FFT in the R&S®RTO is hardware accelerated and fast. It conveys the impression of a live spectrum. Using the persistence mode, rapid signal changes, signal interferers and weak superimposed signals can easily be made visible. The low-noise frontend and the A/D converter's high effective number of bits (> 7) provide an outstanding dynamic range, so that even weak signal faults can be identified without difficulty. The ability to overlap FFT frames enables the R&S®RTO to detect intermittent signals such as pulsed interferers. Like in spectrum analyzers, FFT operation is based on entering the center frequency, span and resolution bandwidth. Measurements such as total harmonic distortion (THD) and power spectrum density (PSD) can also be performed.

The ability to perform a mask test in the FFT frequency spectrum is unique. This is useful for finding rare events such as sporadic EMI interferers and correlating them to the time domain signal.

Save results fast

Waveforms can be saved in various file formats or downloaded via Ethernet for later analysis using MATLAB® or Excel, for example. The screen content can also be printed or saved. The download feature on the R&S®RTO is unique. When set to a special operating mode, the oscilloscopes continuously acquire 100 waveforms per second, evaluate the waveforms and transmit them to a PC via Ethernet.

Sophisticated analysis with up to three waveforms per channel

R&S®RTO oscilloscopes simultaneously provide different displays of up to three waveforms per measurement channel. The type of data decimation and the waveform arithmetics can be combined. Users can, for example, effectively debug by comparing the original sample points directly against the averaged waveform and the envelope.

Storage options		
Contents	waveform	complete
		selection (zoom, cursor, gate, manual)
		number of acquisitions
		history memory
Evaluation		histograms
		measurement results
		long-term trend
Format	measurement data	binary, .XLS, .CSV, 1 to 4 channels
	graphics	.PNG, .JPG, .BMP, .TIF, .PDF
Drivers		VXi, LabView, LabWindows, .NET

Up to three waveforms per channel

The R&S®RTO oscilloscopes are the first to allow users to configure the type of data decimation and the waveform arithmetics and to display up to three waveforms simultaneously.
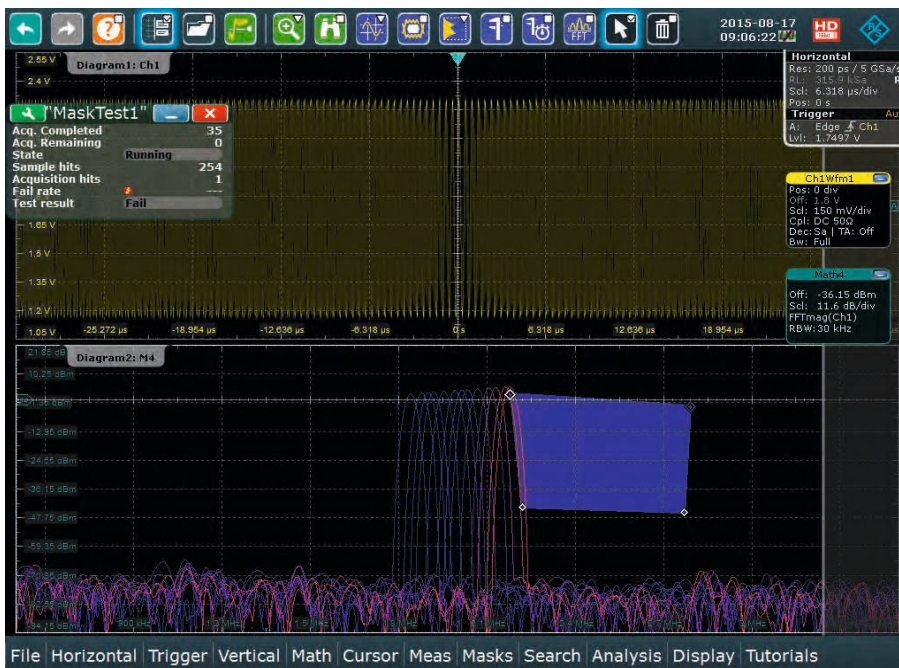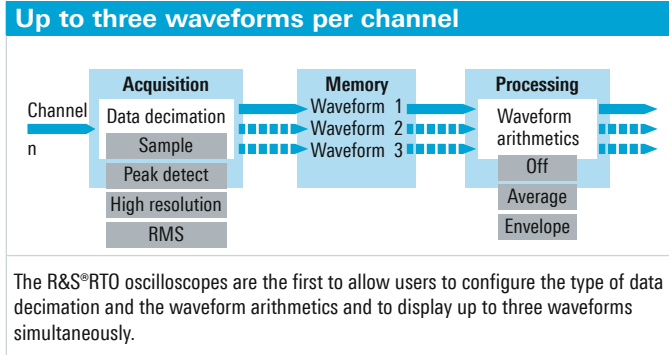
The FFT function stands out in terms of accuracy, speed, functionality and usability.

Optimized user interface

ı **Touch-optimized**
ı **High-resolution XGA screen**
ı **Flexible split screen for waveforms and results**
ı **New tools, including undo/redo, fingertip zoom and QuickMeas**

High-resolution touchscreen

The high-resolution 10.4" XGA touchscreen is one of the highlights of the R&S®RTO. The oscilloscope is optimized for touchscreen operation:
ı Arrange signal and measurement result windows by drag & drop
ı Optimize the screen display by moving the window borders
ı Define zoom and measurement ranges
ı Move cursor, offset or trigger level simply by touching the line
ı Activate and configure measurements, histograms and FFT analyses
ı Create masks in only seconds

Additional applications such as compliance tests can be displayed on an externally connected monitor.

Color coding for clear overview

The controls for vertical settings and the trigger are color-coded. Multicolor LEDs around the rotary knobs visualize the channel that is currently in focus. The color coding corresponds to the signal display on the screen. This clear mapping allows smooth work, even during complex tests and measurements.

Fully customizable display

The R&S®RTO SmartGrid function helps users keep the screen well organized:
ı Drag & drop waveforms and event windows onto the main screen
ı Divide the screen into different diagram, waveform and result windows
ı Stack multiple tabs
ı Display waveforms, buses and results in realtime as a signal icon on the edge of the screen

The high-resolution touchscreen permits smooth operation. The SmartGrid function from permits the user to flexibly arrange wave-forms using drag & drop.

Dialog boxes with signal flow diagrams

Signal flow diagrams in the dialog boxes visualize the signal processing, making it easier to configure measurements. Crosslinks take you directly to logically related settings. Forward/back buttons help you navigate quickly between dialog boxes. Semi-transparent dialog boxes are an elegant way of keeping everything in view. The measurement diagrams always maintain their original size. The level of transparency can be set via the intensity button. You can also scale the dialog boxes, minimize them to the active input field and position them anywhere on the screen.

Fast access to important tools

A toolbar at the upper edge of the screen provides access to frequently used functions such as measurements, zoom, FFT and the recycle bin. The toolbar can be customized to contain your favorite tools. There are just two steps involved in using a function: selecting the tool and applying it to the waveform.

Signal details at your fingertip

R&S®RTO oscilloscopes offer extended zoom functionality:
ı Zoom range selection and navigation by touch in the zoom window
ı Hardware zoom function to adjust vertical and horizontal scaling for analysis of signal details
ı Fingertip zoom to open a horizontal zoom range in the signal; use a finger or the mouse to move the zoom window along the signal for an overview of the signal characteristics; use the keep function to open a standard zoom for detailed analysis of anomalies in the signal

R&S®RTO toolbar

←	undo	Ref 1	update reference waveform
→	redo		label
?	show help	Preset	preset
	graphical recall	Auto	autoset
	show signalbar		find trigger level
	selection tool	Single	run single
	zoom	Run Cont	run/stop
	cursor		save waveform
	mask test		clear screen
	histogram		save settings
	measurement		save settings
	quick meas		recycle bin
FFT	FFT		search
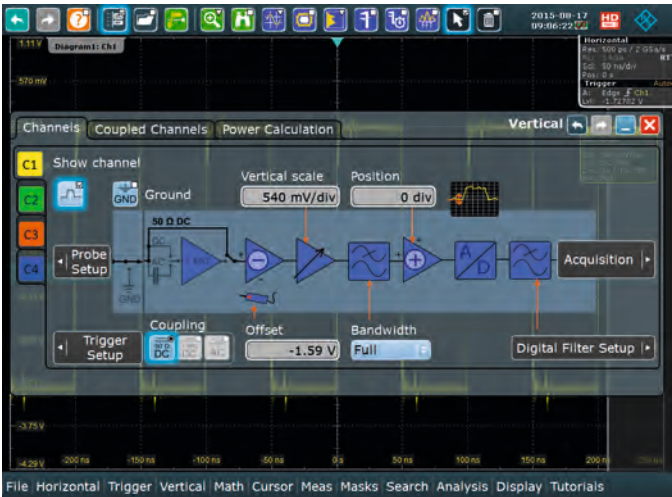
Dialog box for vertical settings in a signal flow diagram.

The fingertip zoom simplifies detailed analysis.

Easy selection of instrument setup

The R&S®RTO can save instrument setups for repetitive measurements. It is unique in how it helps the user select the correct configuration – each instrument setup is saved along with a screenshot of the most recent oscilloscope display. Users can simply scroll through the screenshots to find the right configuration.

Remote control access, anytime

The R&S®RTO can be remote controlled using a PC or another device via remote desktop or VNC. The user sees the same user interface as on the oscilloscope itself. All oscilloscope functions are also available remotely.

Documentation at the press of a button

R&S®RTO oscilloscopes help you document measurements:
❙ Print screenshots of the screen content, including waveforms and results
❙ Easily read signal characteristics thanks to clear grid annotations
❙ Use color-coded labels to highlight anomalies in the diagram
❙ Save waveforms, histograms and measurement results in binary, .XLS or .CSV format for signal analysis on a PC

Selection of languages

The R&S®RTO oscilloscope's user interface supports multiple languages. The language can be changed in just a few seconds while the instrument is running, making the oscilloscope a true international instrument.

Easy access to various instrument setups.

Content is documented using the print dialog box, which offers a wide range of configuration options.
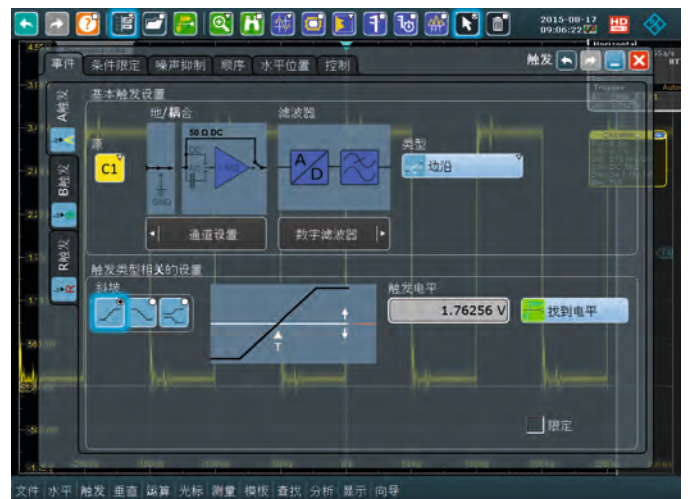
The user interface can be set to Chinese.

Overview of the R&S®RTO oscilloscope

Control elements

Savesets for direct access to saved instrument setups

Rise time histogram: labels facilitate documentation of results

Views are organized into multiple tabs

Toolbar for fast access to frequently used functions

Preset to return to default or user-defined settings

Clear grid annotation for easy reading of measured values

Print or save results at the push of a button

SmartGrid function from for fast positioning of waveforms

Knob for setting the level of transparency of the dialog boxes or the intensity of the waveforms

Menu bar on the bottom edge of the screen – even visible during touchscreen operation

USB interfaces for mouse, keyboard, data exchange, documentation or firmware updates

Continuous update of displayed
measurement results

Continuous update of minimized
signal

HORIZONTAL

RESOLUTION · RECORD LENGTH

RES
REC LEN

POSITION · REF POINT

SCALE

HORI-
ZONTAL

ACQUI-
SITION

TRIGGER

LEVELS

TRIGGER

RUN
CONT

SOURCE | SLOPE | MODE | RUN Nx
SINGLE

ANALYSIS

CURSOR | MEAS | MASKS | SEARCH

ZOOM | PROTOCOL | USER | HISTORY

VERTICAL

POSITION · OFFSET

CH 1

CH 2

SCALE

CH 3

CH 4

SIGNAL
OFF | REF | MATH

NAVIGATION

ESC

ENTER

UNDO

REDO

FIELD | FIELD

Direct access to
frequently required
analysis functions

Signal icons show import-
ant settings or a miniature
view of the real signal

Multilevel undo/redo
function to easily restore
previous settings

Color-coded controls
indicate the currently
selected channel

Display | Tutorials

CH 1

CH 2

CH 3

CH 4

1 MΩ
≤ 150 V RMS
≤ 200 V pk

50Ω
≤ 5 V RMS

1 MΩ
≤ 150 V RMS
≤ 200 V pk

50Ω
≤ 5 V RMS

Tutorials to learn how to operate
the oscilloscope

Probe interface supports
all probes

BNC connector, channel 1, 2, 3 or 4:
high-precision 18 GHz BNC inputs with excellent
impedance matching

Master sophisticated applications

ı **Logic analysis, memory expansions and hardware/ software options can be upgraded on site**
ı **Regular firmware updates for enhanced functionality are available free of charge**
ı **Bandwidth upgrades up to 4 GHz**

No tools are needed to remove the hard disk.

On-site configuration of hardware options

The R&S®RTO can be quickly adapted to new requirements. The unique plug & play concept makes upgrading and retrofitting of options easy. All hardware options, such as the digital channels for logic analysis or the 10 MHz OCXO reference clock, can be inserted into the slots on the rear panel without opening the oscilloscope. This approach has many advantages:
ı Easy extensibility for future tasks
ı On-site installation of options in minutes
ı No need for alignment or recalibration after installation of options

Software applications on demand

The base unit features all functions of a state-of-the-art oscilloscope for general applications. For special requirements, the base unit can be extended with software options at any time:
ı Triggering and decoding of serial protocols such as I^{2}C, SPI or CAN
ı Automatic compliance tests on fast interfaces, including USB or Ethernet
ı Detailed options for jitter analysis, power analysis and RF analysis

Always up-to-date

 continually offers regular firmware up-dates to add additional basic functions to the R&S®RTO oscilloscopes. The oscilloscope's firmware can be updated using a USB storage device or the LAN port. Free firmware updates can be simply downloaded from the Internet. Your R&S®RTO oscilloscope al-ways remains up to date.

Exchangeable hard disk or solid state disk

The R&S®RTO hard disk can be exchanged without any tools. Confidential data remains protected. Depending on the particular application, either a conventional hard disk drive (HDD) or a solid state disk (SSD) can be chosen.

Memory upgrades to up to 800 Msample for long acquisition times

In the standard configuration, R&S®RTO oscilloscopes permit the analysis of up to 20 Msample deep signal sequences per channel, or a maximum of 80 Msample with only one channel, making the oscilloscopes ideal for general applications. Some special analyses, such as seamless recordings of long pulse sequences, require an even deeper acquisition memory. For these applications, options are available to expand the memory to 50/100/200/400 Msample per channel and up to 800 Msample for two channels. Users enable the options on site, eliminating the need to send in their oscilloscopes.

Easy bandwidth upgrading for faster signals

Sometimes investment budgets are limited, or not all future bandwidth requirements are known at the time of purchase. Options are available for upgrading the bandwidth of all R&S®RTO oscilloscopes. An R&S®RTO1004 oscilloscope with 600 MHz bandwidth, for example, can be upgraded to 4 GHz. All upgrade options include a complete check of the instrument and calibration at a service center.

Ready for sophisticated applications

Time domain analysis	Logic analysis
General debugging	**Debugging embedded designs**
Power analysis	**System test**
▪ Switched mode power supplies	**ADC test**
Signal analysis	**Time-correlated digital and**
▪ Jitter analysis	**analog signal analysis**
▪ Compliance tests (e.g. USB 2.0, Ethernet)	

Scope of the art

Triggering and decoding	EMI debugging
▪ Embedded (I²C, SPI, Ethernet, 8b10b)	**Spectral analysis**
▪ Computer (UART, RS-232)	**Vector signal analysis**
▪ Automotive (CAN, CAN-FD, LIN, FlexRay™, SENT)	▪ NFC analysis
	▪ LTE (MIMO) analysis
▪ Audio serial (I²S, LJ, RJ, TDM)	▪ General OFDM analysis
▪ A&D (MIL-STD-1553, ARINC 429)	
▪ Configurable (Manchester, NRZ)	

Protocol analysis	Frequency domain analysis

Logic analysis: fast and precise testing of embedded designs

ı **Every R&S®RTO can be expanded to include a mixed signal option**
ı **400 MHz, 5 Gsample/s sampling rate and 200 Msample memory**
ı **Comprehensive trigger options with 200 ps resolution**
ı **History function for looking back in time at digital signals**
ı **Many analysis tools, including automatic measurements and bus display as an analog waveform**

The R&S®RTO-B1 option turns the R&S®RTO into a mixed signal oscilloscope.

More signal details thanks to high time resolution over the entire memory depth

With a sampling rate of 5 Gsample/s, the R&S®RTO-B1 mixed signal option (MSO) provides a maximum time resolution of 200 ps for all digital channels. This sampling rate is available over the entire memory depth of 200 Msample per channel. As a result, the MSO option is capable of detecting critical events such as narrow or widely separated glitches.

Precise triggering on signal events

The R&S®RTO-B1 option offers numerous triggers for debugging and analysis, such as edge, width, pattern and serial pattern. These triggers can be combined with holdoff conditions. For the trigger source, the user can choose between individual digital channels or bus signals. The digital channel resolution of 200 ps makes these channels a precise trigger source.

High acquisition and analysis rate for fast fault finding

The hardware-based signal processing of the digital measurement waveforms extends from acquisition and triggering to analysis functions such as cursor functions and measurements, and even includes the visualization of the results. This enables an acquisition and analysis rate of more than 200 000 waveforms per second, ensuring that rare events are detected quickly and reliably.

Straightforward display of digital signals

The R&S®RTO-B1 option supports 16 digital channels and simultaneous decoding of up to four parallel buses. Each bus is represented by an icon on the edge of the screen. The icons can be dragged and dropped onto the screen using the SmartGrid function. The icon clearly shows the current status of all activated logic chan-nels (high, low, toggle) irrespective of the other oscillo-scope settings.

The user configures the parallel buses according to the actual bus topology. The decoded buses are displayed in a bus format or as an analog waveform. For clocked buses, the decoded contents can also be displayed in a table.

Processing and analysis functions

For efficient analysis of measurement waveforms, the R&S®RTO-B1 option offers a wide selection of automatic time measurements, including statistical evaluation. Automatic measurements can be performed on all digital channels and their logical combinations. In addition to time measurements, the cursor also supports the decoding of the bus value at the cursor position. The history function enables the user to access and analyze specific measurement waveforms in the acquisition memory.

Analysis of serial protocols with digital channels

The digital channels of the R&S®RTO-B1 option support triggering and decoding of serial interface protocols, including I²C, SPI and CAN.

Low test point loading due to active probe solution

The 16 digital inputs are grouped into two logic probes with eight channels each. High input impedance combined with low input capacitance of 100 kΩ || 4 pF ensures low loading of the test points.

The signal activity of the digital channels is displayed in the signal icon independently of the oscilloscope settings.

Ramp signal of a 4-bit ADC with analog and digital channels, and an SPI bus signal with digital channels.

MSO option	Digital channels	Input impedance	Max. signal frequency	Max. sampling rate	Max. acquisition memory
R&S®RTO-B1	16 channels (2 logic probes)	100 kΩ || 4 pF	400 MHz	5 Gsample/s per channel	200 Msample per channel

High definition: see more with up to 16-bit vertical resolution

ı **Upgrade to high definition oscilloscope**
ı **Increased vertical resolution of up to 16 bit**
ı **Sharper waveforms and more signal details for even more precise analysis**

Resolution as a function of the filter bandwidth

Filter	Resolution
Inactive	8 bit
1 GHz	10 bit
500 MHz	12 bit
300 MHz	12 bit
200 MHz	13 bit
100 MHz	14 bit
50 MHz to 10 kHz	16 bit

Noise reduction

Noise of the R&S®RTO1044 oscilloscope (4 GHz model) as a function of the set filter bandwidth of the R&S®RTO-K17 high definition option; a reduction in noise leads to an increase in the signal-to-noise ratio, which improves the vertical resolution.

Increased resolution for precise measurement of small signal amplitudes

High definition describes the capability of R&S®RTO oscilloscopes to work with applications for which a high vertical resolution is essential. This is especially the case when low-voltage components on a signal that also exhibits high-voltage components need to be analyzed in detail. One example is the characterization of switched-mode power supplies. The voltages across the switching device must be determined during the off and on times within the same acquisition. Because the voltage variations can be several hundred volts, a high resolution of more than 8 bit is essential for precise measurement of small voltage components. Another example is amplitude-modulated signals with low modulation index as can be found in radar applications.

16-bit vertical resolution available

The R&S®RTO-K17 software option increases the vertical resolution of the R&S®RTO oscilloscopes to up to 16 bit – a 256-fold improvement over 8-bit resolution. To achieve this higher resolution, the signal is lowpass filtered after the A/D converter. The filter reduces the noise, thereby increasing the signal-to-noise ratio. Users can adjust the bandwidth of the lowpass filter from 10 kHz to 1 GHz to match the characteristics of the applied signal. The lower the filter bandwidth, the higher the resolution.

The increase in resolution leads to sharper waveforms, showing signal details that would otherwise be masked by noise. To be able to analyze these signals in detail, the input sensitivity of the oscilloscopes is increased to 500 µV/div. Thanks to the low-noise frontend and the highly accurate single-core A/D converter, R&S®RTO oscilloscopes have an excellent dynamic range and measurement accuracy. Switching on high definition mode allows users to benefit from even more precise measurement results.

The high definition mode offers crucial advantages over high resolution decimation (also supported by the R&S®RTO oscilloscopes). First, the user knows exactly what signal bandwidth is available due to explicit lowpass filtering. Second, there are no unexpected aliasing effects. Since the high definition mode is not based on decimation, the increase in resolution is not accompanied by a reduction in the sampling rate. When the high definition mode is on, the full sampling rate can be used, ensuring the best possible time resolution. The high definition mode also permits users to trigger on the signals with increased resolution, whereas high resolution decimation only takes place after the trigger unit.
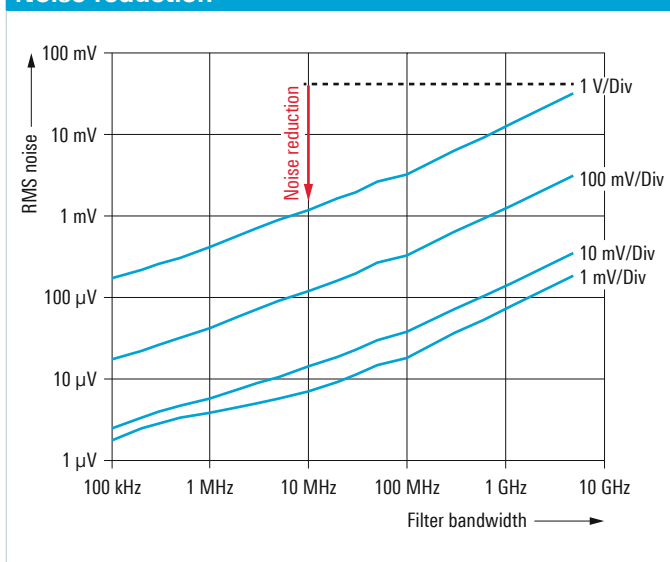
Realtime triggering on smallest signal details

The increased resolution in high definition mode makes it possible to reveal even the smallest signal details. The next step in the debugging process is to trigger on these details for in-depth analysis. Whether this is possible depends greatly on the capabilities of the trigger system. Is it sensitive enough to benefit from the high-resolution signal? The unique digital trigger system offers the required sensitivity. Each of the up to 16-bit samples is checked against the trigger condition and can initiate a trigger. This means that R&S®RTO oscilloscopes are able to trigger on even the smallest signal amplitudes and isolate relevant signal events.

High acquisition rate and full functionality for fast measurement results

Switching on the high definition mode does not compromise measurement speed or functions. Since the lowpass filtering, which improves resolution and noise suppression, is implemented in realtime in the oscilloscope's ASIC, the acquisition and processing rates remain high. The oscilloscope enables smooth operation and measurement results are available quickly.

All analysis tools, such as automatic measurements, FFT and the history mode, can also be used in high definition mode.
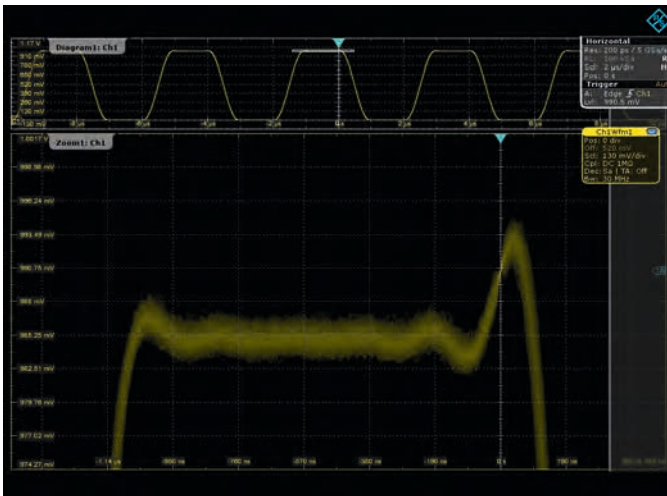
The high sensitivity of the digital trigger makes it pos-sible to trigger on signal overshoots of less than 9 mV, as can be seen in this example. At a vertical scale of 130 mV/div, this corresponds to only a fraction of one display division.
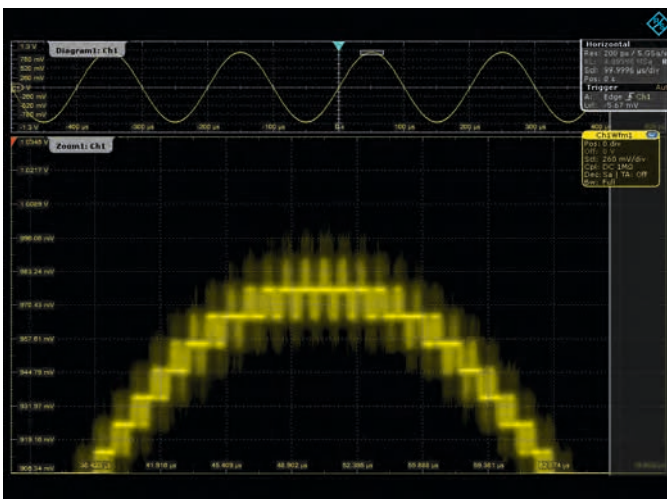
Zoomed-in peak of a sine wave: the high definition mode is not activated. Only the quantization levels can be seen in the zoom window.
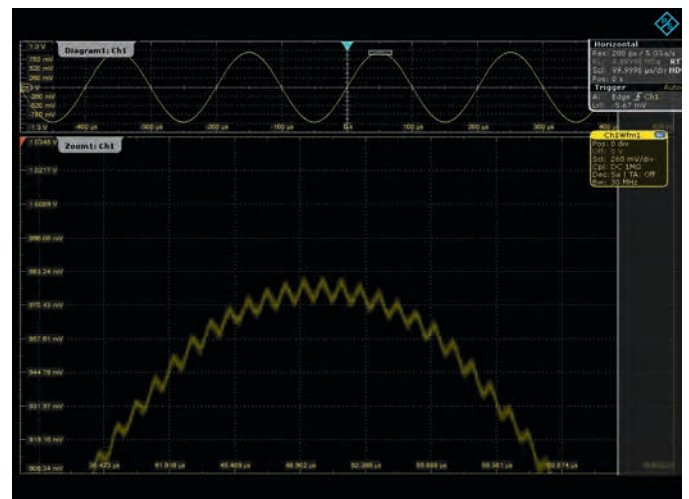
When the high definition mode is switched on, the zoom window shows that another very low-amplitude sine wave is superimposed on the signal.

Serial protocols: easy triggering and decoding

ı **Hardware-based triggering and decoding for rapid analysis**
ı **Color-coded telegram data in the waveform diagram or in a table**
ı **Symbol display supports standard CAN-dbc or FIBEX formats**
ı **Triggering and decoding of Manchester and NRZ coded serial protocols**
ı **Decoding of up to four serial buses**
ı **Comprehensive search functions for easier analysis of long and complex signal sequences**

Easy configuration

R&S®RTO oscilloscopes offer a variety of tools for serial interface analysis. The configuration for any given protocol is quickly accomplished. Navigation between the individual dialog boxes is smooth thanks to crosslinks. The Find Reference Levels function makes it particularly easy to define the decision level for the logical signals.

Isolating protocol events

Protocol-specific definition of the trigger conditions is very important for tracking down protocol errors. The R&S®RTO enables triggering on specific protocol content, e.g. addresses or data, as well as on protocol errors.

Clear display of data

When displaying decoded data, the individual protocol areas within the logical signals are color-coded, and address and data content can be displayed in hex, bin or ASCII format. The SmartGrid function supports flexible placement of the signals in a suitable diagram. Telegrams can additionally be displayed in a user-designed table.

Support of labels

For some standards, labels make complex protocol data easier to comprehend. R&S®RTO oscilloscopes support the industry standards CAN-dbc and FIBEX for CAN and FlexRay™. The symbols are displayed both on the waveform and in the table. The CAN bus permits additional trigger settings based on these symbols.

## High acquisition rate for finding errors quickly

Data errors at serial interfaces are frequently the result of sporadic signal faults caused by borderline timing of logic components. High acquisition rates are a key prerequisite for detecting such errors quickly. oscillo-scopes are ideal for these tasks because they hardware decode the protocol-specific trigger results. Errors are found reliably and quickly and displayed immediately.

## Options for triggering and decoding

Application	Serial standard	Option
Embedded	I²C/SPI	R&S®RTO-K1
	UART/RS-232/422/458	R&S®RTO-K2
	Ethernet	R&S®RTO-K8
	8b10b	R&S®RTO-K52
	MDIO	R&S®RTO-K55
	USB 2.0/HSIC	R&S®RTO-K60
Automotive, industrial	CAN/LIN (CAN-dbc)	R&S®RTO-K3
Automotive	CAN-FD (CAN-dbc)	R&S®RTO-K9
	FlexRay™ (FIBEX)	R&S®RTO-K4
	SENT	R&S®RTO-K10
Audio	I²S/LJ/RJ/TDM	R&S®RTO-K5
Aerospace and defense	MIL-STD-1553	R&S®RTO-K6
	ARINC 429	R&S®RTO-K7
	SpaceWire	R&S®RTO-K65
Mobile communications	MIPI RFFE	R&S®RTO-K40
	MIPI D-PHY	R&S®RTO-K42
Configurable	Manchester, NRZ	R&S®RTO-K50

Rapid telegram data search

Comprehensive search functions simplify the analysis of long signal sequences. They permit users to quickly track down specific telegram types, content and errors. All detected events are shown in a table with timestamps. The user can then examine the individual events in a zoom window with the proper timing correlation and navigate between the events.
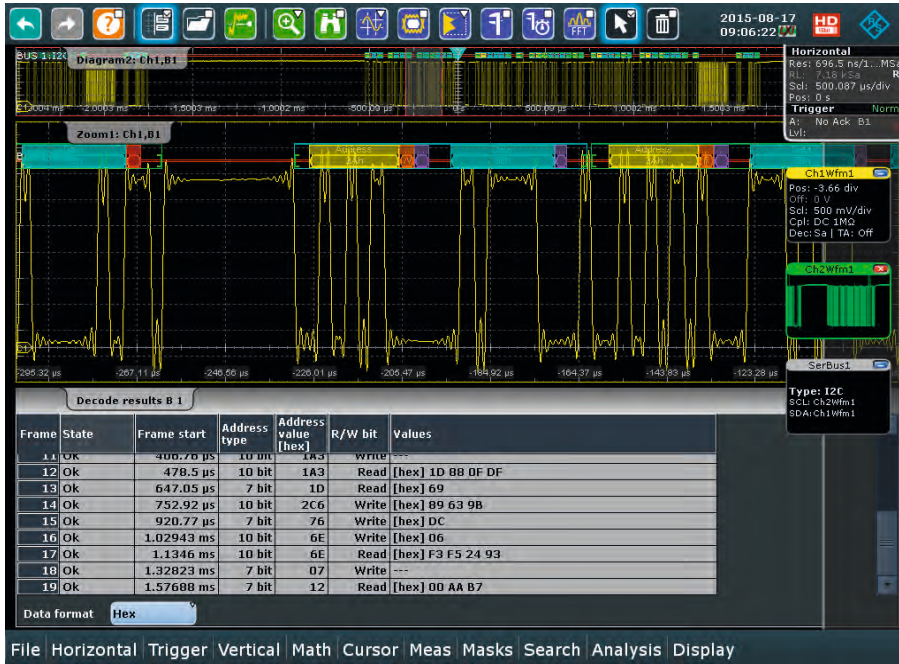
The individual areas of the decoded protocol frame are color-coded to provide a clear overview. The details can also be displayed in a table.
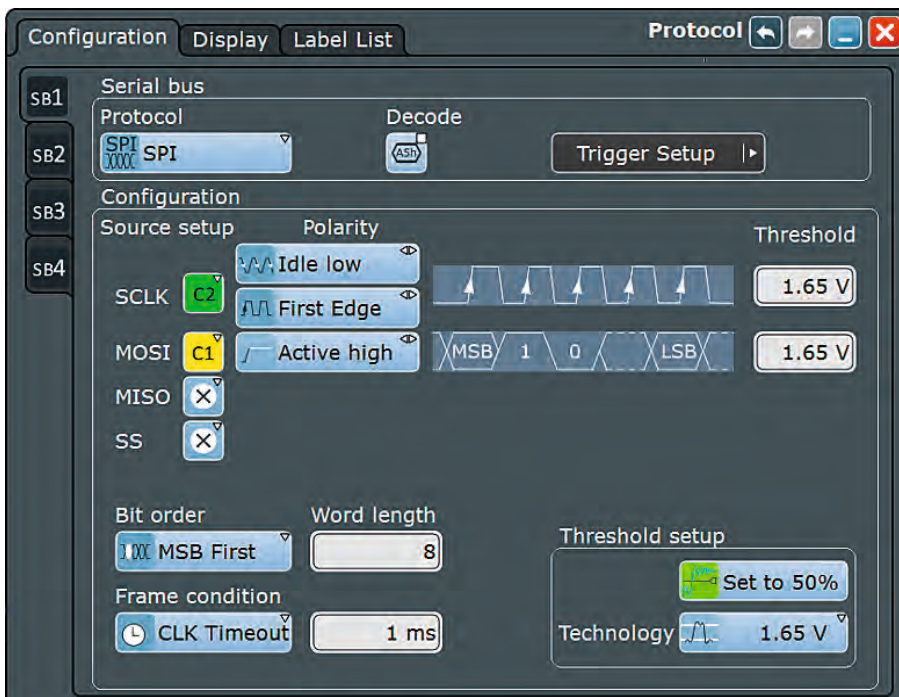
The user conveniently configures the serial buses according to the actual protocol topology.

Analysis of power electronics with the power analysis option

ı **Analysis of the input and output as well as the transfer function in switched-mode power supplies**
ı **Measurement wizard for fast results**
ı **Documentation at the push of a button**
ı **Harmonic current analysis in line with conventional EN, MIL and RTCA standards**

Special measurement functions and measurement wizard for fast results

For characterizing switched-mode power supplies and power electronics, the R&S®RTO-K31 power analysis option provides automated measurement functions, guides the user through the test sequence and documents the measurement results. This option facilitates the analysis of the turn on/turn off behavior, the internal transfer function, the safe operating area (SOA), the output signal quality and switching losses.

After a measurement function is selected, the measurement wizard guides the user through the test setup. Detailed illustrations help the user make the correct connections. The oscilloscope then configures itself automatically and delivers quick results. The configuration can be modified or the oscilloscope can be fully manually configured in order to document specific signal details.

Standards for limiting the harmonic current

Depending on the application, different standards for limiting the harmonic current must be met when developing switched-mode power supplies. The R&S®RTO-K31 option supports the user during testing of all conventional standards: EN 61000-3-2 classes A, B, C, D, MIL-STD-1399 and RTCA DO-160.

Easy and clear documentation of measurement results

Each result can be added to the test report simply by pressing a button. The test report documents the setup and configuration. Users can flexibly define the level of detail for the report and customize the layout, for example by adding a company logo. The available output formats are PDF and RTF.

Extensive accessories for contacting and delay compensation

A wide range of passive and active probes permits measurements in common voltage and current ranges. The R&S®RT-ZF20 probe deskew and calibration test fixture can be used to time-synchronize the measurement signals from the current and voltage probes. The R&S®RTO-K31 power analysis option automatically deskews the current probe and voltage probe signals at the push of a button.

Measurement functions		
Measurement	**Measurement functions**	
Input	current harmonics	EN 61000-3-2 class A, B, C, D
		MIL-STD-1399
		RTCA DO-160
	inrush current	
	power quality	
	power consumption	
Power converter control	modulation analysis	
	slew rate	
	dynamic on-resistance	
Power path	safe operating area (SOA mask editor)	
	turn on/turn off	
	switching loss	
	power efficiency	
Output	output ripple	
	transient response	
	output spectrum	

Measurement wizard for fast and easy testing.

Harmonics

Measurement setup:

Settings:

Standard:	EN61000-3-2 Class D
Frequency:	50Hz
Autoscale signal:	Yes

Vertical setup:

Probes:	Source	Name	Unit	Gain/Att.		
	Voltage Channel 1	None	Volt	10V/V		
	Current Channel 3	RT-ZC20	Ampere	10A/V		

Channels:	Source	Scale	Offset	Coupling	Deskew	Bandwidth
	Voltage Channel 1	82V/div	0V	1MOhm DC	0s	Full
	Current Channel 3	130mA/div	0A	1MOhm DC	-8.8ns	Full

Trigger setup:

Type	Source	Level	Slope
Edge	Channel 3	-1300mV	Positive

Horizontal setup:

Time scale	Record length	Resolution	Reference	ADC rate	Acq. time	Sample rate
400ms/div	5MSa	800ns	50%	10GHz	4s	1.25MSa/s

Measured signals:

Results:

Harmonic order n	Frequency	Harmonic current	Maximum permissible harmonic current	
2	100.3Hz	603µA	166.85mA	Pass
3	150.4Hz	112.97#mA	88.83mA	Fail
4	200.5Hz	1393µA	166.85mA	Pass
5	250.6Hz	62.36mA	49.64mA	Fail
6	300.8Hz	1025µA	166.85mA	Pass
7	350.90Hz	9200µA	26.13mA	Pass
8	401Hz	932µA	166.85mA	Pass

Extensive result documentation.

Jitter analysis

ı **Automatic jitter measurements**
ı **Jitter wizard for easy configuration of jitter measurements**
ı **Display of measurement results as track, long-term trend or histogram**
ı **Unique FFT on track for detailed analysis**
ı **Clock data recovery of embedded clocks in realtime using the R&S®RTO-K13 option**

Precise results

R&S®RTO oscilloscopes are ideally suited for jitter measurements. The sensitive, broadband, low-noise frontend combined with the high-precision, single-core A/D converter ensures exact results. Another strength of R&S®RTO oscilloscopes lies in their wide range of analysis options. For example, FFT analysis of the track for the cycle-cycle jitter makes it possible to determine interference frequencies.

Wizard for easy test configuration

All automatic jitter measurements are combined into a single group. By using the jitter wizard, typical measurements can be configured in just seconds. The user can select how the results will be displayed, e.g. as a histogram.

Powerful analysis options

R&S®RTO oscilloscopes simplify detailed investigation of signals by providing a variety of graphical display options. The following displays and analysis options are available:
ı Long-term trend: display of measurement results from different acquisitions in a separate figure to permit detection of slowly developing trends, such as thermal changes (automatic or manual scaling)
ı Track: graphic display of a measurement over the entire acquisition time, e.g. frequency; display of results versus acquisition time
ı Histogram: summation of measurement results in a bar graph; automatic or manual setting of number of histogram bins
ı FFT on track: FFT analysis on the track curve of a measurement result; derivation of additional information such as the frequency of interference sources through jitter analysis

| Jitter measurement functions	
Standard functions	**R&S®RTO-K12 option**
Period	cycle-cycle jitter
Frequency	N-cycle jitter
Setup	cycle-to-cycle width
Setup/hold time	cycle-cycle duty cycle
Setup/hold ratio	time interval error
	data rate
	unit interval
	skew delay
	skew phase
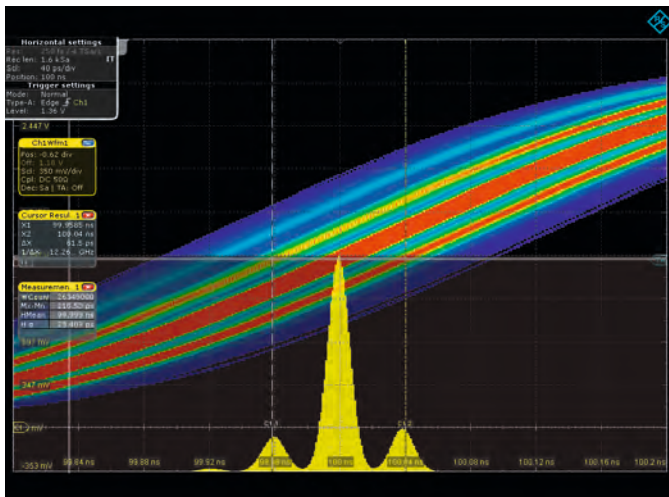
Histogram of the rising edge of a clock signal.

Jitter wizard for easy and quick configuration of the jitter measurement.

## Clock data recovery for analyzing embedded clock signals

A number of serial interfaces use an embedded clock. The receiver must recover the clock signal from the transmitted signal using clock data recovery. The R&S®RTO-K13 clock data recovery option simplifies characterization of these types of signals. It is part of the unique digital trigger architecture of the R&S®RTO and permits realtime clock recovery. As a result, eye and histogram measurements can be run continuously over a long period of time without postprocessing. The advantage: the hardware-based clock data recovery functions at the full acquisition rate without any restriction of the oscilloscope functions. A unique feature is the option to display the recovered embedded clock and analyze it in detail using all jitter measurements.

Serial pattern trigger

By combining the R&S®RTO with the optional hardware-based clock data recovery or the parallel clock signal, the user can trigger on any serial interface telegram pattern of up to 16 byte with bit rates between 100 kbit and 2.5 Gbit. All analysis options remain available. For example, users can use jitter measurements to determine the influence of specific bit sequences on the protocol clock.
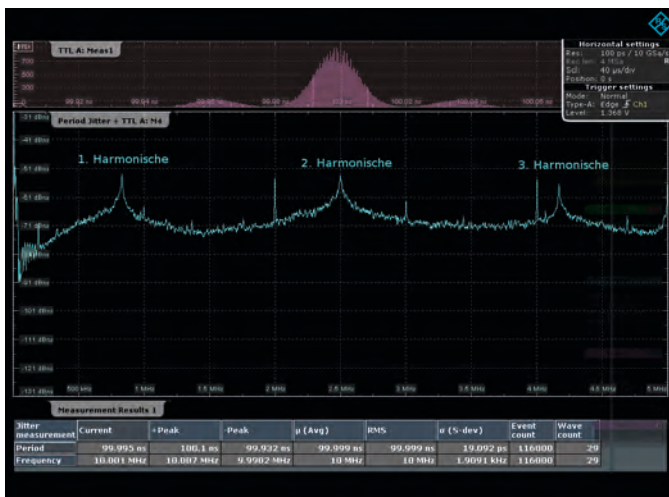
Track spectrum (cycle-cycle jitter) for identifying interference frequencies.
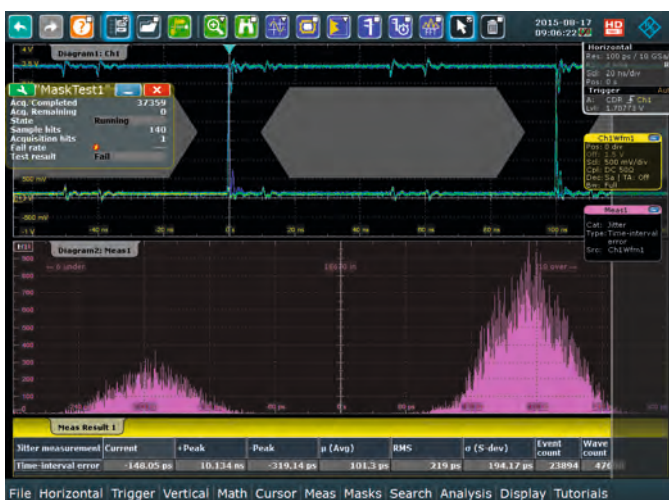
The clock data recovery option permits a continuous mask test on serial interfaces with an embedded clock.

Measurement of the time interval error (TIE) of the embedded clock for different bit sequences (010000X10000001). The lower histogram shows that the TIE differs based on the bit sequence.

Automatic compliance tests

- **High measurement accuracy with reliable results**
- **Test wizard for easy test selection and configuration**
- **Automatic control of the R&S®RTO oscilloscope and other measuring instruments**
- **Compliance test software that runs on the R&S®RTO or on a separate PC with Windows 7**
- **Comprehensive documentation of test results as PDF, DOC or HTML file**

Easy configuration and automatic control

R&S®ScopeSuite is generic compliance test software that runs on the R&S®RTO oscilloscope or on a separate PC with Windows 7.

User data, all test setup settings and measurement report definitions are easy to configure. The limit editor allows the user to individually adjust standard-specific test limits. R&S®ScopeSuite controls the measurement settings and test sequence on the R&S®RTO and guides the user through all selected tests based on the test setup. Detailed, image-based instructions make it easy to correctly connect the oscilloscope and the probes to the test fixture and the device under test.

Flexible test execution

For debugging during development or for stability tests, the user can repeat tests as often as required using the Repeat – Keep Previous function. The results are documented in the measurement report. In the case of an operating error, the user can discard the measurement result and repeat the test sequence using the Repeat – Discard Previous function.
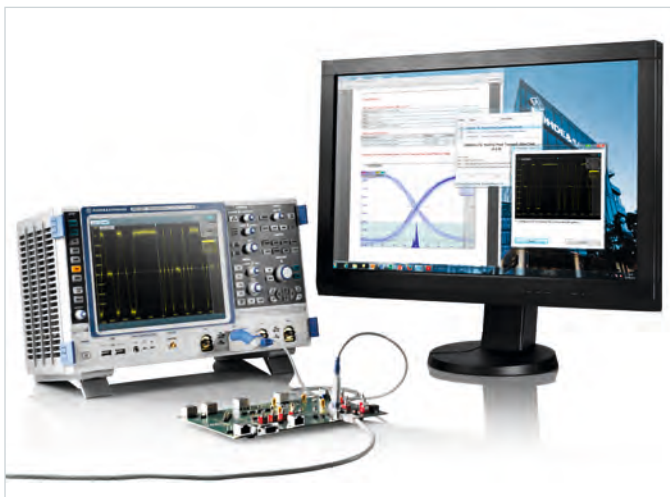
The R&S®ScopeSuite software can be launched on the R&S®RTO oscilloscope. The display is output to the oscilloscope screen or an external monitor.
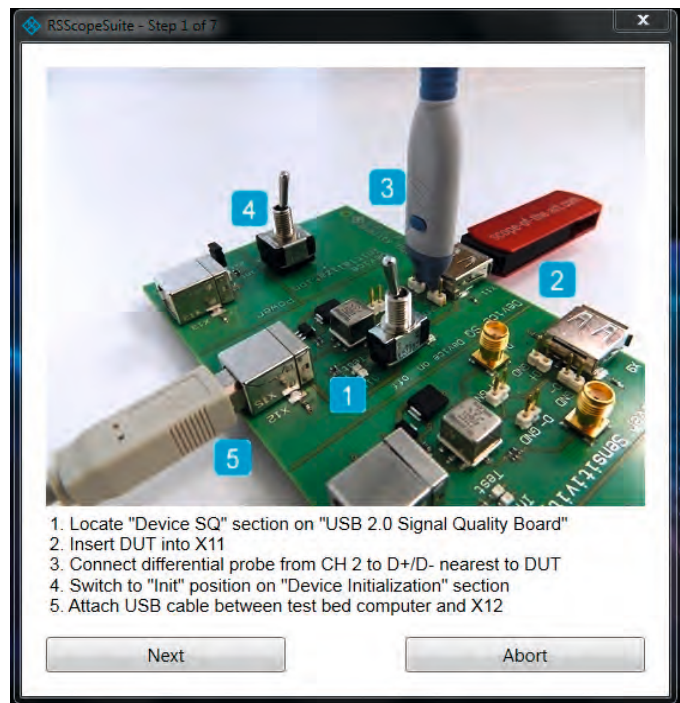

Detailed step-by-step instructions.

Straightforward, configurable reports

Documenting the measurement results is an essential part of compliance tests. R&S®ScopeSuite offers a wide variety of documentation functions. Users can add measurement details and screenshots to the pass/fail results. The available output formats are PDF, DOC and HTML.

Test fixture sets made by

The different interface standards define the connection between the measuring equipment and the device under test. offers the right test fixture set for every compliance test.
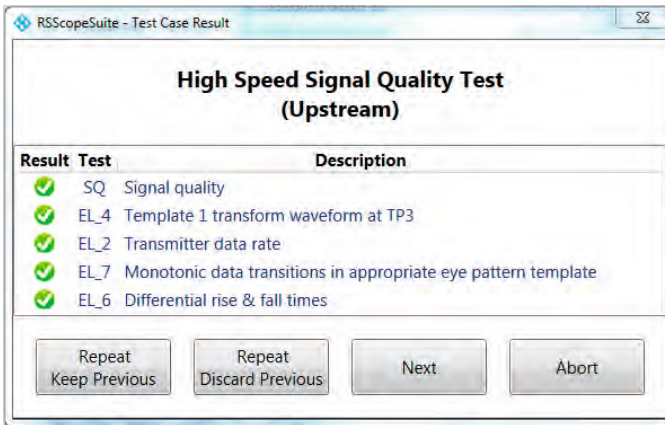
The test execution control allows tests to be repeated for multiple tests (Repeat – Keep Previous) and to be redone in case of operating errors (Repeat – Discard Previous).
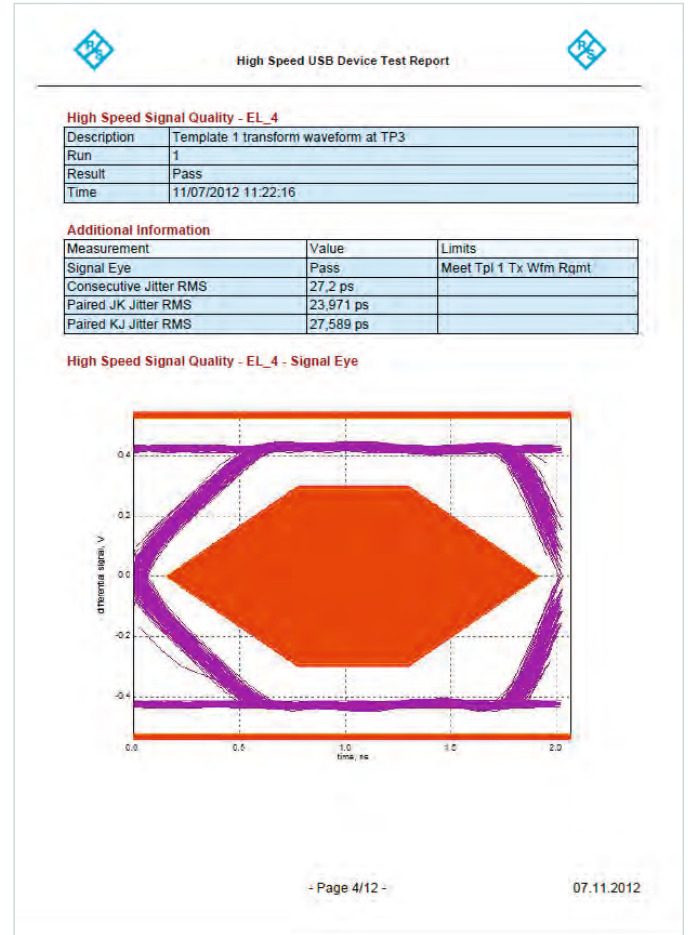
Detailed report of the measurement results.

Interface standard	Compliance test option	Test fixture set	Recommended base unit
USB 1.0/USB 1.1	R&S®RTO-K21	R&S®RT-ZF1	R&S®RTO100x or higher bandwidth
USB 2.0	R&S®RTO-K21	R&S®RT-ZF1	R&S®RTO102x or higher bandwidth
10/100 Mbit Ethernet	R&S®RTO-K22	R&S®RT-ZF2	R&S®RTO100x or higher bandwidth
1 Gbit Ethernet	R&S®RTO-K22	R&S®RT-ZF2, R&S®RT-ZF2C	R&S®RTO100x or higher bandwidth
10 Gbit Ethernet	R&S®RTO-K23	R&S®RT-ZF2	R&S®RTO102x or higher bandwidth
BroadR-Reach® Ethernet	R&S®RTO-K24	R&S®RT-ZF2, R&S®RT-ZF3	R&S®RTO100x or higher bandwidth
MIPI D-PHY	R&S®RTO-K26	–	R&S®RTO1044
eMMC (HS200, HS400)	R&S®RTO-K92	–	R&S®RTO1014 or higher bandwidth

EMI debugging with oscilloscopes

❙ **High input sensitivity and high dynamic range for reliable detection of unwanted emissions**
❙ **Easy navigation in the frequency spectrum**
❙ **Overlap FFT analysis with information on the frequency of occurrence of spectral components**
❙ **Gated FFT for analyzing the correlation between the time and frequency spectrum**
❙ **Mask test in the spectrum for targeted analysis of sporadic emissions**

EMI tests during development

When debugging EMI problems in electronic circuits, development engineers face the challenging problem of quickly and accurately identifying and eliminating the sources of unwanted emissions. One of the most important test instruments during circuit development is the oscilloscope. Many problems can be eliminated during development by using oscilloscopes for EMI debugging.

High dynamic range and sensitivity

The R&S®RTO oscilloscope is a powerful tool for EMI debugging. Its high dynamic range and input sensitivity of 1 mV/div at full measurement bandwidth make it possible to detect even weak emissions. The powerful FFT implementation is well suited for the required analysis in the frequency domain thanks to its easy operation, high acquisition rate and functions such as color coding of the spectral display according to the frequency of occurrence. In combination with a near-field probe, EMI problems can be quickly located and analyzed.

Together with the R&S®HZ-15 near-field probe set, R&S®RTO oscilloscopes are ideal for EMI tests during development.

Visualizing sporadic emissions

One special feature is overlap FFT. The oscilloscope splits the captured time domain signal into overlapping segments and calculates an individual spectrum for each segment. These spectra are then color-coded according to their frequency of occurrence and combined to a complete spectrum. The complete spectrum provides a very good overview of the type and frequency of occurrence of EMI emissions. Even sporadic signals are visible.

Another highlight is the flexible definition of masks in the frequency domain using the mask function. The stop-on-violation condition stops the acquisition exactly at the signal that violated the frequency mask. This solves the most challenging EMI problem – detecting and analyzing sporadic emissions.

Correlation between frequency and time

The gated FFT function of the R&S®RTO oscilloscopes makes it possible to restrict FFT analysis to a user-defined region of the captured time domain signal. Users can move this time window across the entire signal to determine which segments of the time domain signal correlate to which events in the spectrum. This makes it possible, for example, to correlate unwanted emissions from switched-mode power supplies with overshoots from the switching transistor.

Overlap FFT processing

Conventional, non-overlapping FFT processing without pulse peaks that cause broadband interference
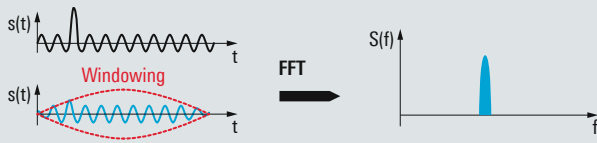
The R&S®RTO uses overlap FFT processing, captures small pulse peaks and uses color coding to display them
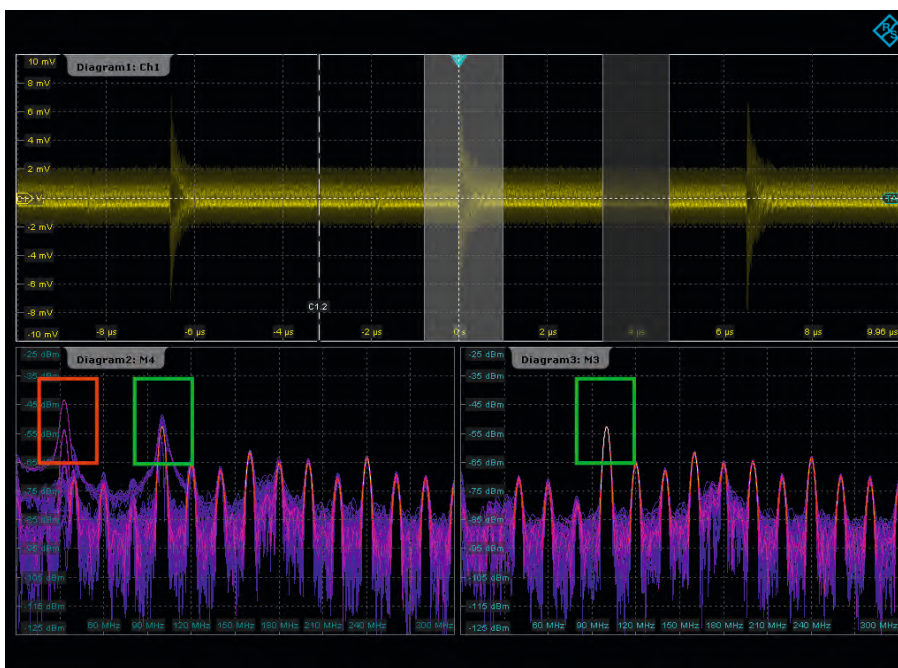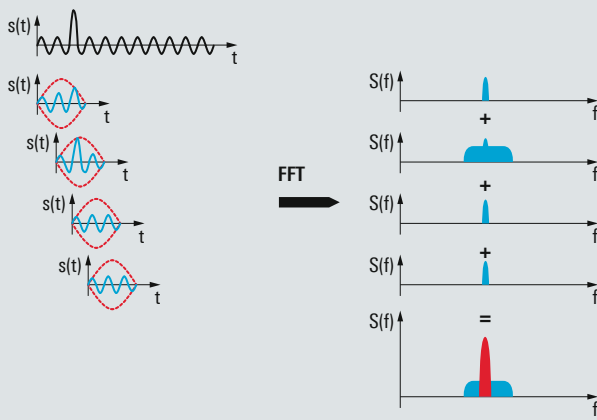
Gated FFT displays the spectrum for defined time segments of the acquired signal. The two time segments that have undergone FFT processing are highlighted in gray (the resulting spectra are displayed on the left and right below). Gated FFT makes it possible to correlate intermittent EMI emissions to the time domain signal. The red box shows the part of the spectrum caused by an unwanted emission, and the green boxes show a part of the spectrum that is constant and therefore present in both spectra.

R&S®RTO Digital Oscilloscope **33**

Powerful probes

- **Comprehensive probe portfolio for all measurement tasks**
- **High signal fidelity thanks to excellent specifications**
- **R&S®ProbeMeter with 0.01% measurement accuracy**
- **Active probes with micro button for instrument control**

Practical design: micro button for convenient instrument control. Diverse probe tips and ground cables are included as standard.
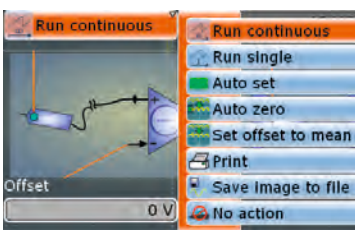
Menu for configuring the micro button.

The R&S®RTO probe family

Passive probes are suited for general measurements on low-frequency signals with less stringent accuracy requirements. An R&S®RT-ZP10 passive probe for each oscilloscope channel is included as standard. The passive R&S®RT-ZH10/-ZH11 high-voltage probes are used for voltages over 400 V.

Active probes are used whenever the load on the device under test must be low, or when the measurement signal contains high-frequency components that must not be distorted. Even signals in the kilohertz range can contain high-frequency components of well over 100 MHz on their edges. offers an entire family of high-quality, single-ended and differential active probes.

High-voltage measurements are often required when analyzing power electronics. The R&S®RT-ZD01 probe permits differential measurements up to 1.4 kV. Several current probes are available for current measurements, to meet the demands of the different applications.

High signal fidelity due to excellent specifications

Besides bandwidth, the crucial parameters for probes are input impedance and dynamic range. With an input impedance of 1 MΩ, the active probes put only a minimum load on a signal source's operating point. And the very large vertical dynamic range, even at high frequencies, prevents signal distortion – for example: 16 V (V_{pp}) at 1 GHz for the single-ended probes. Measurements are not interrupted for compensation processes since the probes' offset and gain errors are nearly independent of temperature (e.g. zero drift < 90 µV/°C for single-ended probes).

Micro button for convenient instrument control

The situation is all too familiar. The user has carefully positioned the probes on the device under test and now wants to start the measurements – but does not have a hand free. This will not happen with the ac-tive probes. They are equipped with a micro button on the probe tip. Different functions such as run/stop, autoset or adjust offset can be assigned to this button.

R&S®ProbeMeter: integrated voltmeter for precise DC measurements

Is the supply voltage correct? Is DC voltage superimposed? These questions from everyday practice are answered by the active probes' integrated voltmeter (R&S®ProbeMeter). It always shows the DC value of a measurement signal with the full dynamic range – regardless of the other instrument settings. The R&S®ProbeMeter offers a much higher DC measurement accuracy than a

traditional oscilloscope channel. It provides many advantages that make everyday measurement tasks easier:

I Fast verification of supply voltages and signal levels without changing the oscilloscope settings

I Automatic compensation of the DC component for AC measurements with optimal dynamic range

I DC value of a measurement signal as a reference for trigger level setting

I Significantly higher DC measurement accuracy compared to a traditional oscilloscope channel

I DC common mode and differential voltage on the R&S®RT-ZD10/20/30/40

▷ For more information, see the product brochure: Digital oscilloscopes from , Probes and accessories (PD 3606.8866.12).
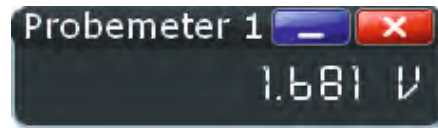
R&S®ProbeMeter: high DC measurement accuracy, independent of instrument settings and in parallel with the measurement channel.

R&S®RT-ZC20B current probe (100 MHz, 30 A (RMS)).

R&S®RT-ZD01 high-voltage differential probe (100 MHz, 1 kV (RMS)).

active probes (1.0 GHz to 6.0 GHz).

R&S®RT-ZS10/20/30.

R&S®RT-ZS60/-ZZ80.

R&S®RT-ZD10/20/30.

R&S®RT-ZD40.

Probe	Bandwidth	Attenuation factor	Input impedance	Input capacitance	Dynamic range	Extras
Passive probes						
R&S®RT-ZP10	500 MHz	10:1	10 MΩ	≈ 10 pF	400 V (RMS)	
Passive broadband probes						
R&S®RT-ZZ80	8.0 GHz	10:1	500 Ω	0.3 pF	20 V (RMS)	
Active broadband probes						
Single-ended						
R&S®RT-ZS10E	1.0 GHz	10:1	1 MΩ	0.8 pF	±8 V	
R&S®RT-ZS10	1.0 GHz					R&S®ProbeMeter and micro button for instrument control
R&S®RT-ZS20	1.5 GHz					
R&S®RT-ZS30	3.0 GHz					
R&S®RT-ZS60	6.0 GHz			0.3 pF		
Differential						
R&S®RT-ZD10	1.0 GHz	10:1/100:1	1 MΩ	0.6 pF/1.3 pF	±5 V/70 V DC, 46 V AC (peak)	R&S®ProbeMeter and micro button for instrument control
R&S®RT-ZD20	1.5 GHz	10:1		0.6 pF	±5 V	
R&S®RT-ZD30	3.0 GHz					
R&S®RT-ZD40	4.5 GHz			0.4 pF		
High-voltage probes						
Single-ended						
R&S®RT-ZH10	400 MHz	100:1	50 MΩ	7.5 pF	1 kV (RMS)	
R&S®RT-ZH11	400 MHz	1000:1				
Differential						
R&S®RT-ZD01	100 MHz	100:1/1000:1	8 MΩ	3.5 pF	±140 V/±1400 V	

Probe	Bandwidth	Max. current (RMS/peak)	Rise time	Sensitivity error	Max. input voltage	Extras
Current probes						
R&S®RT-ZC05B	2 MHz	500 A/±700 A	175 ns	±1 % up to 500 A (RMS)	600 V (CAT II), 300 V (CAT III)	power supply via probe interface
R&S®RT-ZC10	10 MHz	150 A/±300 A	35 ns	±1 % up to 150 A (RMS)	600 V (CAT II), 300 V (CAT III)	external power supply required, e.g. R&S®RT-ZA13
R&S®RT-ZC10B						power supply via probe interface
R&S®RT-ZC20	100 MHz	30 A/±50 A	3.5 ns	±1 % up to 30 A (RMS)	300 V (CAT I)	external power supply required, e.g. R&S®RT-ZA13
R&S®RT-ZC20B						probe interface for probe detec-tion and power supply
EMC near-field probes						
R&S®HZ-14	9 kHz to 1 GHz	–	–	–	–	passive and active E and H near-field probe for EMC debugging
R&S®HZ-15	30 MHz to 3 GHz					E and H near-field probe for EMC debugging, 20 dB gain with R&S®HZ-16

Extensive range of accessories

Safe transport and easy rackmounting

Thanks to an extensive selection of storage and transport accessories, the R&S®RTO is always fully protected and easy to transport. The rackmount kit makes it easy to install the oscilloscope in systems. Active, passive and logic probes can be stored in a special pouch on the rear panel of the R&S®RTO for easy accessibility.

Accessories	
Front cover, for R&S®RTO/RTE digital oscilloscopes	R&S®RTO-Z1
Soft case, for R&S®RTO/RTE digital oscilloscopes and accessories	R&S®RTO-Z3
Transit case, with trolley function, for R&S®RTO/RTE digital oscilloscopes and accessories	R&S®RTO-Z4
Probe pouch, for R&S®RTO/RTE digital oscilloscopes	R&S®RTO-Z5
19" rackmount kit, for R&S®RTO/RTE digital oscilloscopes with 6 HU	R&S®ZZA-RTO

Specifications in brief

Specifications in brief		
Vertical system		
Number of channels	R&S®RTO1002/1012/1022	2
	R&S®RTO1004/1014/1024/1044	4
Analog bandwidth (–3 dB) at 50 Ω	R&S®RTO1002 and R&S®RTO1004	600 MHz
	R&S®RTO1012 and R&S®RTO1014	1 GHz
	R&S®RTO1022 and R&S®RTO1024	2 GHz
	R&S®RTO1044	4 GHz
Rise time	R&S®RTO1002 and R&S®RTO1004	583 ps
	R&S®RTO1012 and R&S®RTO1014	350 ps
	R&S®RTO1022 and R&S®RTO1024	175 ps
	R&S®RTO1044	100 ps
Impedance		50 Ω ± 1.5%, 1 MΩ ± 1% at 15 pF (meas.)
Input sensitivity	max. bandwidth in all ranges	50 Ω: 1 mV/div to 1 V/div, 1 MΩ: 1 mV/div to 10 V/div
ENOB of A/D converter	full-scale sine wave, < –3 dB frequency bandwidth	> 7 bit (meas.)
Acquisition system		
Realtime sampling rate	R&S®RTO1002/1004/1012/1014/1022/1024	max. 10 Gsample/s on each channel
	R&S®RTO1044	max. 10 Gsample/s on 4 channels, max. 20 Gsample/s on 2 channels
Acquisition memory	standard configuration, per channel/1 channel active	R&S®RTO 2-channel model: 20/40 Msample, R&S®RTO 4-channel model: 20/80 Msample
	max. upgrade (R&S®RTO-B104 option), per channel/1 channel active	R&S®RTO 2-channel model: 400/800 Msample, R&S®RTO 4-channel model: 400/800 Msample
Max. acquisition rate	continuous acquisition and display, 10 Gsample/s, 1 ksample	1 000 000 waveforms/s
	ultra-segmented mode	< 300 ns blind time
Decimation modes	any combination of decimation mode and waveform arithmetics on up to 3 waveforms per channel	sample, peak detect, high resolution, root mean square
Waveform arithmetics		off, envelope, average
Interpolation modes		linear, sin(x)/x, sample & hold
Horizontal system		
Timebase range		25 ps/div to 10 000 s/div
Timebase accuracy	after delivery/calibration	±5 ppm
	R&S®RTO-B4 option	±0.02 ppm
Channel deskew		±100 ns (realtime deskew, channel-to-channel triggers (e.g. state) detect deskew)
Trigger system		
Trigger types		edge, glitch, width, runt, window, timeout, interval, slew rate, data2clock, pattern, state, serial pattern, TV/video, serial bus trigger (optional), SENT
Sensitivity	definition of trigger hysteresis	can be set automatically or manually from 0 div to 5 div
Min. detectable glitch	R&S®RTO1002/1004/1012/1014/1022/1024	100 ps
	R&S®RTO1044	50 ps
Waveform math		
Algebraic categories		mathematics, logical operations, comparison, frequency domain, digital filters
Hardware-accelerated mathematics		+, –, *, 1/x, |x|, derivative, $\log_{10}$, ln, $\log_2$, scaling, FIR, FFT magnitude
Analysis and measurement functions		
Hardware-accelerated analysis		spectrum, histogram, mask test, cursor
Hardware-accelerated measurements		amplitude measurements, time measurements

Specifications in brief

General data		
Dimensions	W × H × D	427 mm × 249 mm × 204 mm (16.81 in × 9.8 in × 8.03 in)
Weight	R&S®RTO1024	9.6 kg (21.16 lb)
Screen		10.4" LC TFT color touchscreen, 1024 × 768 pixel (XGA)
Interfaces		1 Gbit/s LAN, 4 × USB 2.0, GPIB (optional), DVI for external monitor, external trigger, trigger output

Ordering information

Designation	Type	Order No
Base unit (including standard accessories: per channel: R&S®RT-ZP10, accessories bag, quick start guide, CD with manual, power cord)		
Digital Oscilloscope		
600 MHz, 10 Gsample/s, 20/40 Msample, 2 channels	R&S®RTO1002	1316.1000.02
600 MHz, 10 Gsample/s, 20/80 Msample, 4 channels	R&S®RTO1004	1316.1000.04
1 GHz, 10 Gsample/s, 20/40 Msample, 2 channels	R&S®RTO1012	1316.1000.12
1 GHz, 10 Gsample/s, 20/80 Msample, 4 channels	R&S®RTO1014	1316.1000.14
2 GHz, 10 Gsample/s, 20/40 Msample, 2 channels	R&S®RTO1022	1316.1000.22
2 GHz, 10 Gsample/s, 20/80 Msample, 4 channels	R&S®RTO1024	1316.1000.24
4 GHz, 20 Gsample/s, 20/80 Msample, 4 channels	R&S®RTO1044	1316.1000.44
Hardware options (plug-in)		
Mixed Signal Option, 400 MHz	R&S®RTO-B1	1304.9901.03
OCXO 10 MHz	R&S®RTO-B4	1304.8305.02
GPIB Interface	R&S®RTO-B10	1304.8311.03
Solid-State Drive (Windows 7)	R&S®RTO-B18	1317.6993.03
Replacement Hard Disk (Windows 7)	R&S®RTO-B19	1304.8328.03
Memory Upgrade, 50 Msample per channel	R&S®RTO-B101	1304.8428.02
Memory Upgrade, 100 Msample per channel	R&S®RTO-B102	1304.8434.02
Memory Upgrade, 200 Msample per channel (instruments with Windows 7 Embedded operating system)	R&S®RTO-B103	1304.8440.02
Memory Upgrade, 400 Msample per channel (instruments with Windows 7 Embedded operating system)	R&S®RTO-B104	1304.8457.02
Windows 7 Upgrade Kit	R&S®RTO-U1	1317.7048.02
Bandwidth upgrades [1]		
Upgrade of the R&S®RTO1002/4 to 1 GHz bandwidth	R&S®RTO-B200	1316.1323.02
Upgrade of the R&S®RTO1002/4 to 2 GHz bandwidth	R&S®RTO-B201	1316.1330.02
Upgrade of the R&S®RTO1004 to 4 GHz bandwidth	R&S®RTO-B202	1316.1346.02
Upgrade of the R&S®RTO1012/4 to 2 GHz bandwidth	R&S®RTO-B203	1316.1352.02
Upgrade of the R&S®RTO1014 to 4 GHz bandwidth	R&S®RTO-B204	1316.1369.02
Upgrade of the R&S®RTO1024 to 4 GHz bandwidth	R&S®RTO-B205	1316.1375.02
Operating system upgrade from Windows XP Embedded to Windows 7 Embedded	R&S®RTO-U1	1317.7048.02

Designation	Type	Order No
Software options		
Serial triggering and decoding		
I²C/SPI Serial Triggering and Decoding	R&S®RTO-K1	1304.8511.02
UART/RS-232/RS-422/RS-485 Serial Triggering and Decoding	R&S®RTO-K2	1304.8528.02
CAN/LIN Serial Triggering and Decoding	R&S®RTO-K3	1304.8534.02
FlexRay™ Serial Triggering and Decoding	R&S®RTO-K4	1304.8540.02
I²S/LJ/RJ/TDM Serial Triggering and Decoding	R&S®RTO-K5	1317.3620.02
MIL-STD-1553 Serial Triggering and Decoding	R&S®RTO-K6	1317.7419.02
ARINC 429 Serial Triggering and Decoding	R&S®RTO-K7	1317.7425.02
Ethernet Serial Decoding	R&S®RTO-K8	1326.0220.02
CAN-FD Serial Triggering and Decoding	R&S®RTO-K9	1325.9881.02
SENT Serial Triggering and Decoding	R&S®RTO-K10	1326.1549.02
MIPI RFFE Serial Triggering and Decoding	R&S®RTO-K40	1325.9900.02
MIPI D-PHY Serial Triggering and Decoding	R&S®RTO-K42	1326.2668.02
Manchester and NRZ Serial Triggering and Decoding	R&S®RTO-K50	1326.0236.02
8b10b Serial Decoding	R&S®RTO-K52	1326.0894.02
MDIO Serial Triggering and Decoding	R&S®RTO-K55	1326.0713.02
USB 1.0/1.1/2.0/HSIC Serial Triggering and Decoding	R&S®RTO-K60	1320.6690.02
SpaceWire Serial Triggering and Decoding	R&S®RTO-K65	1326.2851.02
Compliance tests		
USB 2.0 Compliance Test	R&S®RTO-K21	1317.4103.02
Ethernet Compliance Test (10/100/1000BASE-T)	R&S®RTO-K22	1317.4678.02
10G Ethernet Compliance Test	R&S®RTO-K23	1320.6261.02
BroadR-Reach® Compliance Test	R&S®RTO-K24	1320.6684.02
MIPI D-PHY Compliance Test	R&S®RTO-K26	1317.5668.02
eMMC Compliance Test	R&S®RTO-K92	1329.6958.02
Analysis		
I/Q Software Interface	R&S®RTO-K11	1317.2975.02
Jitter Analysis	R&S®RTO-K12	1317.4690.02
Clock Data Recovery	R&S®RTO-K13	1317.4703.02
High Definition Mode	R&S®RTO-K17	1326.0536.02
Power Analysis	R&S®RTO-K31	1317.5739.02
Probes		
500 MHz, passive, 10:1, 10 MΩ ‖ 9.5 pF, max. 400 V	R&S®RT-ZP10	1409.7550.00
400 MHz, passive, high-voltage, 100:1, 50 MΩ ‖ 7.5 pF, 1 kV (RMS)	R&S®RT-ZH10	1409.7720.02
400 MHz, passive, high-voltage, 1000:1, 50 MΩ ‖ 7.5 pF, 1 kV (RMS)	R&S®RT-ZH11	1409.7737.02
8.0 GHz, passive, Z0, 10:1, 500 Ω ‖ 0.3 pF, 20 V (RMS)	R&S®RT-ZZ80	1409.7608.02
1.0 GHz, active, 1 MΩ ‖ 0.8 pF	R&S®RT-ZS10E	1418.7007.02
1.0 GHz, active, 1 MΩ ‖ 0.8 pF, R&S®ProbeMeter, micro button	R&S®RT-ZS10	1410.4080.02
1.5 GHz, active, 1 MΩ ‖ 0.8 pF, R&S®ProbeMeter, micro button	R&S®RT-ZS20	1410.3502.02
3.0 GHz, active, 1 MΩ ‖ 0.8 pF, R&S®ProbeMeter, micro button	R&S®RT-ZS30	1410.4309.02
6.0 GHz, active, 1 MΩ ‖ 0.3 pF, R&S®ProbeMeter, micro button	R&S®RT-ZS60	1418.7307.02
100 MHz, high-voltage, active, differential, 8 MΩ ‖ 3.5 pF, 1 kV (RMS) (CAT III)	R&S®RT-ZD01	1422.0703.02
1.0 GHz, active, differential, 1 MΩ ‖ 0.6 pF, R&S®ProbeMeter, micro button, including 10:1 external attenuator, 1.3 pF, 70 V DC, 46 V AC (peak)	R&S®RT-ZD10	1410.4715.02
1.5 GHz, active, differential, 1 MΩ ‖ 0.6 pF, R&S®ProbeMeter, micro button	R&S®RT-ZD20	1410.4409.02
3.0 GHz, active, differential, 1 MΩ ‖ 0.6 pF, R&S®ProbeMeter, micro button	R&S®RT-ZD30	1410.4609.02
4.5 GHz, active, differential, 1 MΩ ‖ 0.4 pF, R&S®ProbeMeter, micro button	R&S®RT-ZD40	1410.5205.02
10 MHz, current, AC/DC, 0.01 V/A, 150 A (RMS), BNC	R&S®RT-ZC10	1409.7750K02
100 MHz, current, AC/DC, 0.1 V/A, 30 A (RMS), BNC	R&S®RT-ZC20	1409.7766K02
120 MHz, AC/DC, 1 V/A, 5 A (RMS)	R&S®RT-ZC30	1409.7772K02

Designation	Type	Order No
2 MHz, current, AC/DC, 0.01 V/A, 500 A (RMS), probe interface	R&S®RT-ZC05B	1409.8204.02
10 MHz, current, AC/DC, 0.01 V/A, 150 A (RMS), probe interface	R&S®RT-ZC10B	1409.8210.02
50 MHz, AC/DC, 0.1 V/A, 30 A (RMS), probe interface	R&S®RT-ZC15B	1409.8227.02
100 MHz, current, AC/DC, 0.1 V/A, 30 A (RMS), probe interface	R&S®RT-ZC20B	1409.8233.02
Probe accessories		
Accessory Set for R&S®RT-ZP10 passive probe (2.5 mm probe tip)	R&S®RT-ZA1	1409.7566.00
Spare Accessory Set for R&S®RT-ZS10/10E/20/30	R&S®RT-ZA2	1416.0405.02
Pin Set for R&S®RT-ZS10/10E/20/30	R&S®RT-ZA3	1416.0411.02
Mini Clips	R&S®RT-ZA4	1416.0428.02
Micro Clips	R&S®RT-ZA5	1416.0434.02
Lead Set	R&S®RT-ZA6	1416.0440.02
Pin Set for R&S®RT-ZD20/30	R&S®RT-ZA7	1417.0609.02
Pin Set for R&S®RT-ZD40	R&S®RT-ZA8	1417.0867.02
SMA Adapter	R&S®RT-ZA10	1416.0457.02
Probe Power Supply	R&S®RT-ZA13	1409.7789.02
External Attenuator, 10:1, 2.0 GHz, 70 V DC, 46 V AC (peak)	R&S®RT-ZA15	1410.4744.02
Accessories		
Front Cover, for R&S®RTO/RTE digital oscilloscopes	R&S®RTO-Z1	1317.6970.02
Soft Case, for R&S®RTO digital oscilloscopes and accessories	R&S®RTO-Z3	1304.9118.02
Transit Case, for R&S®RTO/RTE digital oscilloscopes and accessories	R&S®RTO-Z4	1317.7025.02
Probe Pouch, for R&S®RTO digital oscilloscopes	R&S®RTO-Z5	1317.7031.02
USB 2.0 Compliance Test Fixture Set	R&S®RT-ZF1	1317.3420.02
Ethernet Compliance Test Fixture Set	R&S®RT-ZF2	1317.5522.02
1000BASE-T Jitter Test Cable	R&S®RT-ZF2C	1317.5639.02
Frequency Converter	R&S®RT-ZF3	5025.0670.02
Probe Deskew and Calibration Test Fixture	R&S®RT-ZF20	1800.0004.02
Probe Set for E and H Near-Field Measurements, 9 kHz to 1 GHz	R&S®HZ-14	1026.7744.03
Compact Probe Set for E and H Near-Field Measurements, 30 MHz to 3 GHz	R&S®HZ-15	1147.2736.02
3 GHz, 20 dB Preamplifier, 100 V to 230 V Power Adapter, for R&S®HZ-15	R&S®HZ-16	1147.2720.02
19" Rackmount Kit, for R&S®RTO/RTE digital oscilloscopes with 6 HU	R&S®ZZA-RTO	1304.8286.00

[1] The bandwidth upgrade is performed at a service center, where the oscilloscope will also be calibrated.

Service options		
Extended Warranty, one year	R&S®WE1	Please contact your local sales representative.
Extended Warranty, two years	R&S®WE2	
Extended Warranty, three years	R&S®WE3	
Extended Warranty, four years	R&S®WE4	
Extended Warranty with Calibration Coverage, one year	R&S®CW1	
Extended Warranty with Calibration Coverage, two years	R&S®CW2	
Extended Warranty with Calibration Coverage, three years	R&S®CW3	
Extended Warranty with Calibration Coverage, four years	R&S®CW4	

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