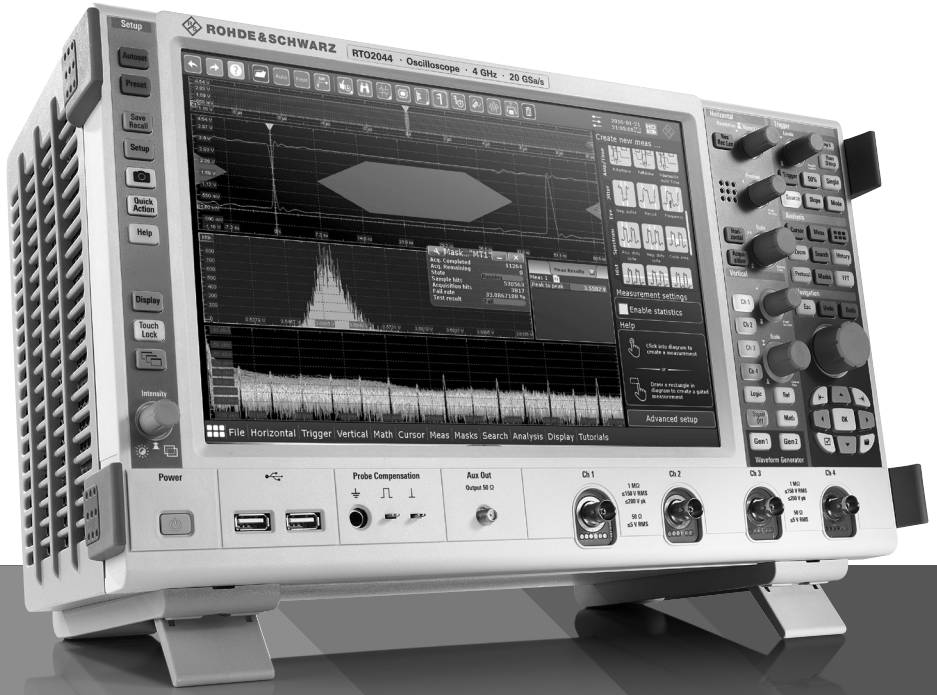
R&S®RTO OSCILLOSCOPE

Specifications



Data Sheet
Version 32.00

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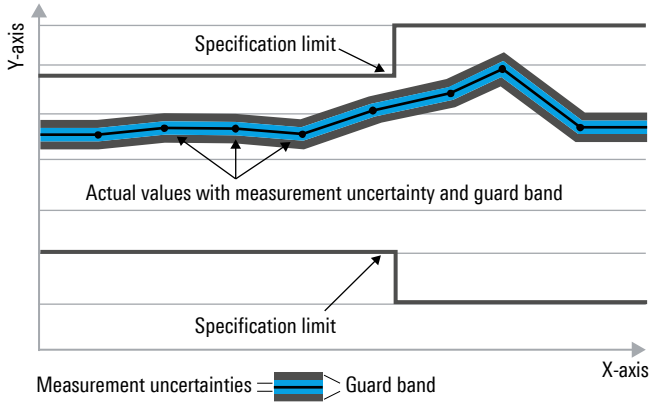
CONTENTS

Definitions

General
Product data applies under the following conditions:

- Three hours storage at ambient temperature followed by 30 minutes warm-up operation
- Specified environmental conditions met
- Recommended calibration interval adhered to
- All internal automatic adjustments performed, if applicable

Specifications with limits
Represent warranted product performance by means of a range of values for the specified parameter. These specifications are marked with limiting symbols such as <, ≤, >, ≥, ±, or descriptions such as maximum, limit of, minimum. Compliance is ensured by testing or is derived from the design. Test limits are narrowed by guard bands to take into account measurement uncertainties, drift and aging, if applicable.



Non-traceable specifications with limits (n. trc.)
Represent product performance that is specified and tested as described under “Specifications with limits” above. However, product performance in this case cannot be warranted due to the lack of measuring equipment traceable to national metrology standards. In this case, measurements are referenced to standards used in the Rohde & Schwarz laboratories.

Specifications without limits
Represent warranted product performance for the specified parameter. These specifications are not specially marked and represent values with no or negligible deviations from the given value (e.g. dimensions or resolution of a setting parameter). Compliance is ensured by design.

Typical data (typ.)
Characterizes product performance by means of representative information for the given parameter. When marked with <, > or as a range, it represents the performance met by approximately 80 % of the instruments at production time. Otherwise, it represents the mean value.

Nominal values (nom.)
Characterize product performance by means of a representative value for the given parameter (e.g. nominal impedance). In contrast to typical data, a statistical evaluation does not take place and the parameter is not tested during production.

Measured values (meas.)
Characterize expected product performance by means of measurement results gained from individual samples.

Uncertainties
Represent limits of measurement uncertainty for a given measurand. Uncertainty is defined with a coverage factor of 2 and has been calculated in line with the rules of the Guide to the Expression of Uncertainty in Measurement (GUM), taking into account environmental conditions, aging, wear and tear.

Device settings and GUI parameters are designated with the format “parameter: value”.

Non-traceable specifications with limits, typical data as well as nominal and measured values are not warranted by Rohde & Schwarz.

In line with the 3GPP standard, chip rates are specified in million chips per second (Mcps), whereas bit rates and symbol rates are specified in billion bit per second (Gbps), million bit per second (Mbps), thousand bit per second (kbps), million symbols per second (Msps) or thousand symbols per second (ksps), and sample rates are specified in million samples per second (Msample/s). Gbps, Mcps, Mbps, Msps, kbps, ksps and Msample/s are not SI units.

Base unit

Vertical system

Input channels	R&S®RTO2002	2 channels
	R&S®RTO2004	4 channels
	R&S®RTO2012	2 channels
	R&S®RTO2014	4 channels
	R&S®RTO2022	2 channels
	R&S®RTO2024	4 channels
	R&S®RTO2032	2 channels
	R&S®RTO2034	4 channels
	R&S®RTO2044	4 channels
	R&S®RTO2064	4 channels
Input impedance		50 Ω ± 3.5 % (50 Ω ± 1.5 % from +15 °C to +30 °C), 1 MΩ ± 1 % || 15 pF (meas.)
Analog bandwidth (–3 dB)	at 50 Ω input impedance	
	R&S®RTO2002 and R&S®RTO2004	≥ 600 MHz
	R&S®RTO2012 and R&S®RTO2014	≥ 1 GHz
	R&S®RTO2022 and R&S®RTO2024	≥ 2 GHz
	R&S®RTO2032 and R&S®RTO2034	≥ 3 GHz
	R&S®RTO2044	≥ 4 GHz
	R&S®RTO2064	≥ 6 GHz on 2 channels, ≥ 4 GHz on 4 channels
	at 1 MΩ input impedance	≥ 500 MHz (meas.)
Analog bandwidth limits	max. –1.5 dB, min. –4 dB	200 MHz, 20 MHz
Rise time/fall time	10 % to 90 % at 50 Ω (meas.)	
	R&S®RTO2002 and R&S®RTO2004	510 ps
	R&S®RTO2012 and R&S®RTO2014	280 ps
	R&S®RTO2022 and R&S®RTO2024	140 ps
	R&S®RTO2032 and R&S®RTO2034	116 ps
	R&S®RTO2044	100 ps
	R&S®RTO2064	76 ps
Input VSWR	input frequency	R&S®RTO2002, R&S®RTO2004, R&S®RTO2012, R&S®RTO2014, R&S®RTO2022, R&S®RTO2024, R&S®RTO2032, R&S®RTO2034, R&S®RTO2044
	≤ 2 GHz	1.25 (meas.)
	> 2 GHz	1.4 (meas.)
	input frequency	R&S®RTO2064
	≤ 2 GHz	1.25 (meas.)
	> 2 GHz to ≤ 4 GHz	1.6 (meas.)
	> 4 GHz	2.0 (meas.)
Vertical resolution		8 bit, 16 bit for high resolution decimation (with reduction of the sampling rate), 16 bit for high definition mode (without reduction of the sampling rate [1]
Effective number of bits of digitizer	for full-scale sine-wave signal with frequency equal to or lower than –3 dB bandwidth	> 7.0 bit (meas.)
DC gain accuracy	offset and position set to 0 V, after self-alignment	
	at 50 Ω, input sensitivity > 5 mV/div	±1.5 %
	at 50 Ω, input sensitivity ≤ 5 mV/div	±2 %
	at 1 MΩ	±2 %
Input coupling	at 50 Ω	DC, GND
	at 1 MΩ	DC, AC (> 7 Hz), GND

[1] The maximum realtime sampling rate in the high definition mode is 5 Gsample/s.

Input sensitivity	at 50 Ω	1 mV/div to 1 V/div, entire analog bandwidth supported for all input sensitivities
	at 1 MΩ	1 mV/div to 10 V/div, entire analog bandwidth supported for all input sensitivities
Maximum input voltage	at 50 Ω	5 V (RMS)
	at 1 MΩ	150 V (RMS), 200 V (V_p), derates at 20 dB/decade to 5 V (RMS) above 250 kHz
	at 1 MΩ with R&S®RT-ZP10 passive probe	400 V (RMS), 1650 V (V_p), 300 V (RMS) CAT II For derating and details, see R&S®RT-Zxx Standard Probes data sheet (PD 3607.3851.22)
Position range		±5 div
Offset range at 50 Ω	input sensitivity	
	> 316 mV/div to ≤ 1 V/div	±10 V
	> 100 mV/div to ≤ 316 mV/div	±3 V
	1 mV/div to ≤ 100 mV/div	±1 V
Offset range at 1 MΩ	input sensitivity	
	> 3.16 V/div to ≤ 10 V/div	±(115 V – input sensitivity × 5 div)
	> 1 V/div to ≤ 3.16 V/div	±100 V
	> 316 mV/div to ≤ 1 V/div	±(11.5 V – input sensitivity × 5 div)
	> 100 mV/div to ≤ 316 mV/div	±10 V
	> 31.6 mV/div to ≤ 100 mV/div	±(1.15 V – input sensitivity × 5 div)
	1 mV/div to ≤ 31.6 mV/div	±1 V
Offset accuracy		±(0.35 % × |net offset| + 2.5 mV + 0.1 div × input sensitivity) (net offset = offset – position × input sensitivity)
DC measurement accuracy	after adequate suppression of measurement noise using high-resolution sampling mode or waveform averaging or a combination of both	±(DC gain accuracy × |reading – net offset| + offset accuracy)
Channel-to-channel isolation (each channel at same input sensitivity)	input frequency	
	≤ 2 GHz	> 60 dB
	> 2 GHz to ≤ 4 GHz	> 50 dB
	> 4 GHz to ≤ 6 GHz	> 40 dB

RMS noise floor at 50 Ω (typ.)	input sensitivity	R&S®RTO2002, R&S®RTO2004	R&S®RTO2012, R&S®RTO2014
	1 mV/div	0.07 mV	0.10 mV
	2 mV/div	0.08 mV	0.10 mV
	5 mV/div	0.11 mV	0.13 mV
	10 mV/div	0.18 mV	0.22 mV
	20 mV/div	0.33 mV	0.40 mV
	50 mV/div	0.78 mV	0.95 mV
	100 mV/div	1.53 mV	1.88 mV
	200 mV/div	3.05 mV	3.75 mV
	500 mV/div	7.95 mV	9.60 mV
	1 V/div	15.3 mV	18.9 mV
	input sensitivity	R&S®RTO2022, R&S®RTO2024	R&S®RTO2032, R&S®RTO2034
	1 mV/div	0.16 mV	0.18 mV
	2 mV/div	0.16 mV	0.19 mV
	5 mV/div	0.20 mV	0.22 mV
	10 mV/div	0.32 mV	0.34 mV
	20 mV/div	0.59 mV	0.63 mV
	50 mV/div	1.45 mV	1.55 mV
	100 mV/div	2.85 mV	3.05 mV
	200 mV/div	5.50 mV	6.05 mV
	500 mV/div	14.2 mV	15.6 mV
	1 V/div	28.8 mV	31.2 mV
	input sensitivity	R&S®RTO2044	R&S®RTO2064
	1 mV/div	0.22 mV	0.33 mV
	2 mV/div	0.22 mV	0.33 mV
	5 mV/div	0.26 mV	0.34 mV
	10 mV/div	0.39 mV	0.47 mV
	20 mV/div	0.72 mV	0.80 mV
	50 mV/div	1.75 mV	1.90 mV
	100 mV/div	3.40 mV	3.55 mV
	200 mV/div	6.95 mV	7.20 mV
	500 mV/div	17.9 mV	18.9 mV
	1 V/div	35.6 mV	37.3 mV
RMS noise floor at 1 MΩ (meas.)	input sensitivity		
	1 mV/div	0.13 mV	
	2 mV/div	0.13 mV	
	5 mV/div	0.17 mV	
	10 mV/div	0.26 mV	
	20 mV/div	0.47 mV	
	50 mV/div	1.15 mV	
	100 mV/div	2.30 mV	
	200 mV/div	4.70 mV	
	500 mV/div	11.5 mV	
	1 V/div	23.0 mV	
	2 V/div	46.0 mV	
	5 V/div	115 mV	
	10 V/div	230 mV	

Horizontal system

Timebase range		selectable between 25 ps/div and 10 000 s/div, time per div settable to any value within range
Channel deskew		±100 ns
Reference position		00 % to 100 % of measurement display area
Trigger offset range	max.	+(memory depth/current sampling rate)
	min.	–10 000 s
Modes		normal, roll
Channel-to-channel skew		< 100 ps (meas.)
Timebase accuracy	standard	
	after delivery/calibration, at +23 °C	±5 ppm
	during calibration interval	±10 ppm
	with R&S®RTO-B4 option	
	after delivery/calibration, at +23 °C	±0.02 ppm
	during calibration interval	±0.2 ppm
	long-term stability (more than one year since calibration)	±(0.1 + 0.1 × years since calibration) ppm
Delta time accuracy	corresponds to time error between two edges on same acquisition and channel; signal amplitude greater than 5 divisions, measurement threshold set to 50 %, vertical gain 10 mV/div or greater; rise time lower than four sample periods; waveform acquired in realtime mode	±(K/realtime sampling rate + timebase accuracy × |reading|) (peak) (meas.) where K = 0.15 (R&S®RTO2002, R&S®RTO2004) K = 0.18 (R&S®RTO2012, R&S®RTO2014) K = 0.25 (R&S®RTO2022, R&S®RTO2024) K = 0.37 (R&S®RTO2032, R&S®RTO2034) K = 0.43 (R&S®RTO2044) K = 0.55 (R&S®RTO2064)

Acquisition system

Realtime sampling rate	R&S®RTO2002, R&S®RTO2004, R&S®RTO2012, R&S®RTO2014, R&S®RTO2022, R&S®RTO2024, R&S®RTO2032, R&S®RTO2034,	max. 10 Gsample/s on each channel
	R&S®RTO2044, R&S®RTO2064	max. 10 Gsample/s on 4 channels, max. 20 Gsample/s on 2 channels
Realtime waveform acquisition rate	max.	> 1 000 000 waveforms/s
Memory depth [2]	standard	
	R&S®RTO2002, R&S®RTO2012, R&S®RTO2022, R&S®RTO2032	50 Msample on 2 channels, 100 Msample on 1 channel
	R&S®RTO2004, R&S®RTO2014, R&S®RTO2024, R&S®RTO2034, R&S®RTO2044, R&S®RTO2064	50 Msample on 4 channels, 100 Msample on 2 channels, 200 Msample on 1 channel
	R&S®RTO-B101 option	
	R&S®RTO2002, R&S®RTO2012, R&S®RTO2022, R&S®RTO2032	100 Msample on 2 channels, 200 Msample on 1 channel
	R&S®RTO2004, R&S®RTO2014, R&S®RTO2024, R&S®RTO2034, R&S®RTO2044, R&S®RTO2064	100 Msample on 4 channels, 200 Msample on 2 channels, 400 Msample on 1 channel
	R&S®RTO-B102 option	
	R&S®RTO2002, R&S®RTO2012, R&S®RTO2022, R&S®RTO2032	200 Msample on 2 channels, 400 Msample on 1 channel
	R&S®RTO2004, R&S®RTO2014, R&S®RTO2024, R&S®RTO2034, R&S®RTO2044, R&S®RTO2064	200 Msample on 4 channels, 400 Msample on 2 channels, 800 Msample on 1 channel
	R&S®RTO-B104 option	
	R&S®RTO2002, R&S®RTO2012, R&S®RTO2022, R&S®RTO2032	400 Msample on 2 channels, 800 Msample on 1 channel
	R&S®RTO2004, R&S®RTO2014, R&S®RTO2024, R&S®RTO2034, R&S®RTO2044, R&S®RTO2064	400 Msample on 4 channels, 800 Msample on 2 channels (restriction: 400 Msample on 2 channels when Ch1 and Ch2 or Ch3 and Ch4 are turned on), 800 Msample on 1 channel
	R&S®RTO-B110 option	
	R&S®RTO2002, R&S®RTO2012, R&S®RTO2022, R&S®RTO2032	1 Gsample on 2 channels, 2 Gsample on 1 channel
	R&S®RTO2004, R&S®RTO2014, R&S®RTO2024, R&S®RTO2034, R&S®RTO2044, R&S®RTO2064	1 Gsample on 4 channels, 2 Gsample on 2 channels (restriction: 1 Gsample on 2 channels when Ch1 and Ch2 or Ch3 and Ch4 are turned on), 2 Gsample on 1 channel
Realtime digital filters	selectable for the data acquisition and/or the trigger system	
	lowpass	cutoff frequency selectable from 100 kHz to 50 % of analog bandwidth
Decimation modes	sample	first sample in decimation interval
	peak detect	largest and smallest sample in decimation interval
	high resolution	average value of samples in decimation interval
	root mean square	root of squared average of samples in decimation interval

[2] The maximum available memory depth depends on the bit depth of the acquired data and, therefore, on the settings of the acquisition system, such as decimation mode, waveform arithmetic, number of waveform streams or high definition mode.

Waveform arithmetic	off	no arithmetic
	envelope	envelope of acquired waveforms
	average	average of acquired waveforms, max. average depth depends on decimation mode [3]
	sample	max. 16 777 215
	high resolution	max. 65 535
	root mean square	max. 255
	reset condition	no reset (standard), reset by time, reset by number of processed waveforms
Waveform streams per channel		up to 3 with independent selection of decimation mode and waveform arithmetic
Sampling modes	realtime mode	max. sampling rate set by digitizer
	interpolated time	enhancement of sampling resolution by interpolation; max. equivalent sampling rate is 4 Tsample/s
Interpolation modes		linear, sin(x)/x, sample&hold
Fast segmentation mode	continuous recording of waveforms in acquisition memory without interruption due to visualization	
	max. realtime waveform acquisition rate	> 2 500 000 waveforms/s
	min. blind time between consecutive acquisitions	< 300 ns

Differential signals

General description	Calculation of differential and common mode signals from p part and n part connected to separate input channels. Because of the R&S®RTO digital trigger concept, these signals can be used as a trigger input.	
Input channels		channel 1, channel 2, channel 3, channel 4
Differential signal	difference between two input channels	channel 1 and channel 2, channel 3 and channel 4
Common mode signal	sum of two input channels	channel 1 and channel 2, channel 3 and channel 4
Maximum number of outputs	differential signals	2
	common mode signals	2

[3] Waveform averaging is not compatible with peak detect decimation.

High definition mode

General description	The high definition mode increases the numeric resolution of the waveform signal by using digital filtering, leading to a reduced noise. Because of the digital trigger concept of the R&S®RTO, the signals with increased numeric resolution are used as input for triggering.			
Numeric resolution	R&S®RTO2002/2004, R&S®RTO2012/2014, R&S®RTO2022/2024, R&S®RTO2032/2034, R&S®RTO2044			
	bandwidth		bit resolution	
	10 kHz to 50 MHz		16 bit	
	100 MHz		14 bit	
	200 MHz		13 bit	
	300 MHz		12 bit	
	500 MHz		12 bit	
	1 GHz		10 bit	
	R&S®RTO2064 (2 channels)			
	bandwidth		bit resolution	
	10 kHz to 200 MHz		16 bit	
	300 MHz		12 bit	
	500 MHz		12 bit	
	1 GHz		11 bit	
	2 GHz		10 bit	
	R&S® RTO2064 (4 channels)			
	bandwidth		bit resolution	
	10 kHz to 50 MHz		16 bit	
	100 MHz		14 bit	
	200 MHz		13 bit	
	300 MHz		12 bit	
	500 MHz		12 bit	
	1 GHz		10 bit	
Realtime sampling rate	R&S®RTO2002/2004, R&S®RTO2012/2014, R&S®RTO2022/2024, R&S®RTO2032/2034, R&S®RTO2044/2064 (4 channels)		max. 5 Gsample/s on each channel	
	R&S®RTO2044/2064 (2 channels)		max. 10 Gsample/s on each channel	
Input sensitivity			input sensitivity range is extended down to 500 µV/div; 500 µV/div is a magnification of the 1 mV/div setting.	
RMS noise floor at 50 Ω (meas.)	bandwidth	input sensitivity		
		1 mV/div	10 mV/div	100 mV/div
	10 MHz	10 µV	18 µV	150 µV
	100 MHz	31 µV	56 µV	470 µV
	500 MHz	63 µV	110 µV	960 µV
	1 GHz	92 µV	170 µV	1.41 mV
	2 GHz	140 µV	220 µV	1.78 mV

Trigger system

Sources	R&S®RTO2002, R&S®RTO2012, R&S®RTO2022, R&S®RTO2032	channel 1, channel 2
	R&S®RTO2004, R&S®RTO2014, R&S®RTO2024, R&S®RTO2034, R&S®RTO2044, R&S®RTO2064	channel 1, channel 2, channel 3, channel 4
Sensitivity		10^{-4} div, from DC to instrument bandwidth for all vertical scales
Trigger jitter	full-scale sine wave of frequency set to –3 dB bandwidth	< 1 ps (RMS) (meas.)
Coupling mode	standard	same as selected channel
	lowpass filter	cutoff frequency selectable from 100 kHz to 50 % of analog bandwidth
Sweep mode		auto, normal, single, n single
Event rate	max.	one event for every 400 ps time interval
Trigger level	range	±5 div from center of screen
Trigger hysteresis	modes	auto (standard) or manual
	sensitivity	10^{-4} div, from DC to instrument bandwidth for all vertical scales
Holdoff range	time	100 ns to 10 s, fixed and random
	events	1 event to 2 000 000 000 events

Main trigger modes		
Edge	triggers on specified slope (positive, negative or either) and level	
Glitch	triggers on glitches of positive, negative or either polarity that are shorter or longer than specified width	
	glitch width	100 ps to 1000 s
		50 ps to 1000 s (R&S®RTO2044, R&S®RTO2064)
Width	triggers on positive or negative pulse of specified width; width can be shorter, longer, inside or outside the interval	
	pulse width	100 ps to 1000 s
		50 ps to 1000 s (R&S®RTO2044, R&S®RTO2064)
Runt	triggers on pulse of positive, negative or either polarity that crosses one threshold but fails to cross a second threshold before crossing the first one again; runt pulse width can be arbitrary, shorter, longer, inside or outside the interval	
	runt pulse width	100 ps to 1000 s
		50 ps to 1000 s (R&S®RTO2044, R&S®RTO2064)
Window	triggers when signal enters or exits a specified voltage range; triggers also when signal stays inside or outside the voltage range for a specified period of time	
Timeout	triggers when signal stays high, low or unchanged for a specified period of time	
	timeout	100 ps to 1000 s
		50 ps to 1000 s (R&S®RTO2044, R&S®RTO2064)
Interval	triggers when time between two consecutive edges of same slope (positive or negative) is shorter, longer, inside or outside a specified range	
	interval time	100 ps to 1000 s
		50 ps to 1000 s (R&S®RTO2044, R&S®RTO2064)
Slew rate	triggers when the time required by a signal edge to toggle between user-defined upper and lower voltage levels is shorter, longer, inside or outside the interval; edge slope may be positive, negative or either	
	toggle time	100 ps to 1000 s
		50 ps to 1000 s (R&S®RTO2044, R&S®RTO2064)
Data2clock	triggers on setup time and hold time violations between clock and data present on any two input channels; monitored time interval may be specified by the user in the range from –100 ns to 100 ns around a clock edge and must be at least 100 ps wide	
Pattern	triggers when a logical combination (and, nand, or, nor) of the input channels stays true for a period of time shorter, longer, inside or outside a specified range	
State	triggers when a logical combination (and, nand, or, nor) of the input channels stays true at a slope (positive, negative or either) in one selected channel	

Serial pattern	triggers on serial data pattern up to 128 bit clocked by one input channel; pattern bits may be high (H), low (L) or don't care (X); clock edge slope may be positive, negative or either; hardware CDR selectable as clock source (requires R&S®RTO-K13 option)	
	max. data rate	< 2.50 Gbps
		< 5 Gbps (R&S®RTO2044, R&S®RTO2064)
TV/video	triggers on baseband analog progressive and interlaced video signals including NTSC, PAL, PAL-M, SECAM, EDTV and HDTV broadcast standards as well as custom bi-level and tri-level sync video standards	
	trigger modes	all fields, odd fields, even fields, all lines, line number

Advanced trigger modes		
Trigger qualification	trigger events may be qualified by a logical combination of unused channels	
	qualifiable events	edge, glitch, width, runt, window, timeout, interval
Sequence trigger (A/B/R trigger)	triggers on B event after occurrence of A event; delay condition after A event specified either as time interval or number of B events; an optional R event resets the trigger sequence to A	
	A event	any trigger mode
	B event	edge, glitch, width, runt, window, timeout, interval, slew rate
	R event	edge, glitch, width, runt, window, timeout, interval, slew rate
Zone trigger		with R&S®RTO-K19 option
Serial bus trigger	optional	see dedicated triggering and decoding options
NFC trigger		with R&S®RTO-K11 option
CDR trigger	triggers on clock signal recovered from the trigger source signal; phase of the trigger instant user-selectable as fraction of bit period; requires R&S®RTO-K13 option	
	CDR configuration parameters	PLL order (first or second), nominal bit rate, loop bandwidth, relative bandwidth, damping factor, unit interval offset
	CDR bit rate range	
	R&S®RTO2002, R&S®RTO2004, R&S®RTO2012, R&S®RTO2014, R&S®RTO2022, R&S®RTO2024	200 kbps to 2.5 Gbps
	R&S®RTO2044, R&S®RTO2064	200 kbps to 2.5 Gpbs standard, 400 kbps to 5.0 Gbps when operating at 20 Gsample/s realtime sampling rate [4]
External trigger input	input impedance	50 Ω ± 1.5 % or 1 MΩ ± 1 % || 20 pF (meas.)
	max. input voltage at 50 Ω	5 V (RMS)
	max. input voltage at 1 MΩ	30 V (RMS) derates at 20 dB/decade to 5 V (RMS) above 25 MHz
	trigger level	±5 V
	sensitivity	
	input frequency ≤ 100 MHz	300 mV (V_{pp})
	100 MHz < input frequency ≤ 500 MHz	600 mV (V_{pp})
	input coupling	AC, DC (50 Ω and 1 MΩ), GND, HF reject (attenuates > 50 kHz or > 50 MHz, user-selectable), LF reject (attenuates < 5 kHz or < 50 kHz, user-selectable)
	trigger modes	edge (rise or fall)

[4] The frontends of the R&S®RTO2044 and the R&S®RTO2064 sample at 20 Gsample/s when at most one channel from each pair {channel1, channel2} and {channel3, channel4} is active; and the user-selected sampling resolution in realtime sampling mode or interpolated time sampling mode is 50 ps or smaller.

Trigger out	functionality	a pulse is generated for every acquisition trigger event
	output voltage	0 V to 5 V at high impedance; 0 V to 2.5 V at 50 Ω
	pulse width	selectable between 50 ns and 60 ms
	pulse polarity	low active or high active
	output delay	depends on trigger settings
	jitter	±600 ps (RMS) (meas.)

RF characteristics [5]

Sensitivity/noise density	at 1.001 GHz (measurement of the power spectral density at 1.001 GHz at input sensitivity 1 mV/div, corresponding to –36 dBm input range of the oscilloscope, using the FFT with center frequency 1.001 GHz, span 500 kHz, RBW 3 kHz)	–159 dBm (1 Hz) (meas.)
	at 100 kHz (measurement of the power spectral density at 100 kHz at input sensitivity 1 mV/div, corresponding to –36 dBm input range of the oscilloscope, using the FFT with center frequency 100 kHz, span 20 kHz, RBW 200 Hz)	– 156 dBm (1 Hz) (meas.)
Noise figure	at 1.001 GHz (calculated based on the noise density above)	15 dB (meas.)
	at 100 kHz (calculated based on the noise density above)	18 dB (meas.)
Signal-to-noise ratio	measured for an input carrier with frequency 1 GHz and level 0 dBm at input sensitivity 70 mV/div, corresponding to 0 dBm input range of the oscilloscope, using the FFT with center frequency 1 GHz, span 100 MHz, RBW 400 Hz at +20 MHz from the center frequency	112 dB (meas.)
Absolute amplitude accuracy	0 to 5 GHz	±1 dB (meas.)
Spurious-free dynamic range	measured for an input carrier with frequency 950 MHz and level 0 dBm at input sensitivity 70 mV/div, corresponding to 0 dBm input range of the oscilloscope, using the FFT with center frequency 2 GHz, span 4 GHz, RBW 100 kHz	68 dBc (meas.)
Second harmonic distortion	measured for an input carrier with frequency 950 MHz and level 0 dBm at input sensitivity 70 mV/div, corresponding to 0 dBm input range of the oscilloscope, using the FFT with center frequency 950 MHz, span 4 GHz, RBW 100 kHz	–49 dBc (meas.)
Third harmonic distortion	measured for an input carrier with frequency 950 MHz and level 0 dBm at input sensitivity 70 mV/div, corresponding to 0 dBm input range of the oscilloscope, using the FFT with center frequency 950 MHz, span 4 GHz, RBW 100 kHz	–44 dBc (meas.)

[5] The RF characteristics are measured for an R&S®RTO2064 oscilloscope with 6 GHz bandwidth.

Waveform measurements

General features	measurement panels	up to 8 measurement panels; each panel may contain any number of automatic measurements of the same category
	gate	delimits the display region evaluated for automatic measurements
	reference levels	user-configurable vertical levels define support structures for automatic measurements
	statistics	displays maximum, minimum, mean, standard deviation, RMS and measurement count for each automatic measurement
	track	measurement results displayed as continuous trace that is time-correlated to the measurement source
	long-term analysis	history of selected measurements as trace against count index
	histogram	available for the main measurement of each measurement panel; automatic or manual selection of bin number and scale; counters for measurements under, within and over the histogram range
	limit check	measurements tested against user-defined margins and limits; pass or fail conditions may launch automatic response: acquisition stop, beep, print and save waveform

Measurement category	amplitude and time	amplitude, high, low, maximum, minimum, peak-to-peak, mean, RMS, sigma, overshoot, area, rise time, fall time, positive width, negative width, period, frequency, duty cycle, delay, phase, burst width, pulse count, positive switching, negative switching, cycle area, cycle mean, cycle RMS, cycle sigma, setup/hold time, setup/hold ratio, pulse train, slew rate rising, slew rate falling, DC voltmeter (requires Rohde & Schwarz active probe with R&S®ProbeMeter functionality)
	eye diagram	extinction ratio, eye height, eye width, eye top, eye base, crossing points, Q factor, S/N ratio, duty cycle distortion, eye rise time, eye fall time, eye bit rate, eye amplitude, jitter (peak-to-peak, 6-sigma, RMS)
	optical	optical average power, optical modulation amplitude
	spectrum	channel power, bandwidth, occupied bandwidth, harmonic search, total harmonic distortion THD in dB and % using power values, total harmonic distortion variants THD_a, THD_u and THD_r using voltage, overall voltage and overall voltage root means square, peak list (THD_a, THD_u, THD_r and peak list require R&S®RTO-K18 option)
	jitter	cycle-to-cycle jitter, N-cycle jitter, cycle-to-cycle width, cycle-to-cycle duty cycle, time-interval error, data rate, unit interval, skew delay, skew phase; requires R&S®RTO-K12 option
Cursors	setup	up to 4 cursor sets on screen, each set consisting of two horizontal and two vertical cursors
	target	acquired waveforms (input channels), math waveforms, reference waveforms, track waveforms, XY diagrams
	operating mode	vertical measurements, horizontal measurements or both; vertical cursors either set manually or locked to waveform
Histogram	source	acquired waveform (input channels), math waveform, reference waveform
	mode	vertical (for timing statistics), horizontal (for amplitude statistics)
	automatic measurements	waveform count, waveform samples, histogram samples, histogram peak, peak value, maximum, minimum, median, range, mean, sigma, mean ± 1, 2 and 3 sigma, marker ± probability

Mask testing

Test definition	number of masks	up to 8 simultaneously
	source	acquired waveforms (input channels), math waveforms
	fail condition	sample hit or waveform hit
	fail tolerance	minimum number of fail events for test fail in range from 0 to 4 000 000 000
	test rate	up to 600 000 waveforms per second
	action on error	acquisition stop, beep, print and save waveform
	save/load to file	test and mask settings (.xml format)
Mask definition with segments	number of independent segments	up to 8
	segment definition	array of points and connecting rule (upper, lower, inner) define segment region
	segment input	point and click on touchscreen, editable list
Mask definition with tolerance tube	input signal	acquired waveform
	definition of tolerance tube	horizontal width, vertical width, vertical stretch, vertical position
Mask definition with eye mask assistant (requires one of the following options: R&S®RTO-K12/-K91/-K133/-K134)	primary mask shape	
	type	diamond, square, hexagon, octagon
	dimensions	main and secondary height, main and secondary width, depending on selected shape
	position	vertical offset, horizontal offset
	secondary mask shapes	
	locations	any combination of left, right, top, bottom
	position	horizontal and vertical offset with respect to center of primary mask shape
Serial standard masks	multiple predefined protocol masks	D-PHY, M-PHY, C-PHY, PCIe, USB, HDMI™, JESD204C, ITU and Ethernet
Result statistics	category	completed acquisitions, remaining acquisitions, state, sample hits, mask hits, fail rate, test result (pass or fail)
Visualization options	waveform style	vectors, dots
	violation highlighting	hits (on/off), highlight persistence (50 ms to 50 s or infinite), waveform color (default: red)
	mask colors	configurable colors for mask without violation (default: translucent gray), mask with violation (default: translucent red), mask with contact (default: translucent pale red)

Waveform math

General features	number of math waveforms	up to 8
	number of reference waveforms	up to 4
	waveform arithmetic	user-selectable average or envelope of consecutive waveforms
Algebraic expressions	user may define complex mathematical expressions involving waveforms and measurement results	
	math functions	add, subtract, multiply, divide, absolute value, square, square root, integrate, differentiate, exp, $\log_{10}$, $\log_e$, $\log_2$, rescale, sin, cos, tan, arcsin, arccos, arctan, sinh, cosh, tanh, autocorrelation, crosscorrelation
	logical operators	not, and, nand, or, nor, xor, nxor
	relational operators	Boolean result of =, ≠, >, <, ≤, ≥
	frequency domain	spectral magnitude and phase, real and imaginary spectra, group delay
	digital filter	lowpass, highpass or user defined filter (specified by up to 1 million FIR filter coefficients)
	special functions	CDR transform; requires R&S®RTO-K12 option
Optimized math	operators	add, subtract, multiply, invert, absolute value, differentiate, $\log_{10}$, $\log_e$, $\log_2$, rescale, FIR, FFT magnitude

Spectrum analysis

General description	spectrum analysis allows signal analysis in the frequency domain.	
Spectrum	sources	channel 1, channel 2, channel 3, channel 4
	spectrum types	magnitude spectrum, phase spectrum
	setup parameters	center frequency, frequency span, automatic RBW, resolution bandwidth, gate position, gate width, vertical scale, vertical position, frame overlap
	scaling	
	magnitude spectrum	linear, dB, dBm, dBµV, dBmV, dBV, dBps, dBns, dBµs, dBms, dBs, dBHz, dBkHz, dBMHz, dBGHz, dBµA, dBmA, dBA
	phase spectrum	degrees, radians
	frequency range	DC to Nyquist frequency (1/2 sample rate, e.g. 10 GHz at 20 Gsample/s)
	frequency axis scaling	linear or logarithmic
	span	1 Hz to 10 GHz
	resolution bandwidth	≤ 1 Hz to 1 GHz
	window types	rectangular, Hamming, Hann, Blackman Harris, Gaussian, Flattop, Kaiser Bessel
	trace types	normal, envelope, average, RMS, min. hold, max. hold
	spectrum measurements	channel power, bandwidth, occupied bandwidth, various THD variants (total harmonic distortion), harmonic search, peak list (with user definable threshold)
	max. realtime waveform acquisition rate	> 1000 waveforms/s
	spectrogram	requires R&S®RTO-K18 option

Search and mark function

General description	scans acquired waveforms for occurrence of a user-defined set of events and highlights each occurrence	
Basic setup	source	all physical input channels, math waveforms, reference waveforms
	search panels	up to 8, where each panel may manage multiple event searches
	search mode	manually triggered or continuous
	search conditions	
	supported events	edge, glitch, width, runt, window, timeout, interval, slew rate, data2clock, state
	event configuration	identical to corresponding trigger event
	event selection	single or multiple events on same source
Search oscilloscope	mode	current waveform, gated time interval
Result visualization	table	
	sort mode	horizontal position or vertical value
	max. result count	specifies max. table size
	zoom window	centered on highlighted event

Display characteristics

Diagram types	Yt, XY, spectrum, long-term measurement, spectrogram (spectrogram requires R&S®RTO-K37 option)
Horizontal divisions	10
Vertical divisions	10
Display interface configuration	display area can be split up into separate diagram areas by dragging and dropping signal icons; each diagram area can hold any number of signals; diagram areas may be stacked on top of each other and later accessed via the dynamic tab menu
Signal icon	each active waveform is represented by a separate signal icon on the signal bar; the signal icon displays individual vertical and acquisition settings; a waveform can be minimized to signal icon to appears as a realtime preview in miniature; measurement results may also be minimized to a signal icon
Toolbar	quick access to 28 important tools; directly set most common parameters in a simple menu and access to more detailed parameters in main menu; user-defined selection of tools in toolbar
Upper menu	displays trigger, horizontal and acquisition settings; quick access to settings
Main menu	provides access to all instruments settings in compact menu
Axis label	X-axis ticks and Y-axis ticks labeled with tick value and physical unit
Diagram label	diagrams may be individually labeled with a descriptive user-defined name
Diagram layout	grid, crosshair, axis labels and diagram label may be switched on and off separately
Persistence	50 ms to 50 s, or infinite
Zoom	user-defined zoom window provides vertical and horizontal zoom; each diagram area supports multiple zoom windows; touchscreen interface simplifies resize and drag operations on zoom window
Signal colors	predefined or user-defined color tables for persistence display

Input and output

Front		
Channel inputs		BNC-compatible, for details see Vertical system
	probe interface	auto-detection of passive probes, Rohde & Schwarz active probe interface
Auxiliary output		SMA connector, for future use
Probe compensation output	signal shape	rectangle, V_{low} = 0 V, V_{high} = 1 V amplitude 1 V (V_{pp}) ± 5 %
	frequency	1 kHz ± 1 %
	impedance	nom. 50 Ω
Ground jack		connected to ground
USB interface		2 ports, type A plug, version 2.0

Rear		
External trigger input		BNC, for details see Trigger system
Trigger out		BNC, for details see Trigger system
USB interface		2 ports, type A plug and 1 port, type B plug, version 3.1 gen 1
LAN interface		RJ-45 connector, supports 10/100/1000BASE-T
External monitor interface		DVI-D and DisplayPort, output of oscilloscope display or extended desktop display
GPIB interface		see R&S®RTO-B10 option
Reference input		see R&S®RTO-B4 option
Reference output		see R&S®RTO-B4 option
Security slot		for standard Kensington style lock

General data

Display	type	12.1" LC TFT color display with capacitive touchscreen
	resolution	1280 × 800 pixel (WXGA)
Operating system		Windows 10 64-bit

Temperature		
Temperature loading	operating temperature range	0 °C to +45 °C
	storage temperature range	–40 °C to +70 °C
Temperature loading		in line with MIL-PRF-28800F section 4.5.5.1.1.1 class 3 tailored to +45 °C for operation
Climatic loading		+25° C/+40 °C at 85 % rel. humidity cyclic, in line with IEC 60068-2-30
		+30 °C/+40 °C/+45 °C at 95/75/45 % in line with MIL-PRF-28800F section 4.5.5.1.1.2 class 3 tailored to +45 °C for operation

Altitude		
Operating		up to 3000 m above sea level
Nonoperating		up to 4600 m above sea level

Mechanical resistance		
Vibration	sinusoidal	5 Hz to 150 Hz, max. 2 g at 55 Hz; 0.5 g from 55 Hz to 150 Hz; in line with EN 60068-2-6
		5 Hz to 55 Hz, in line with MIL-PRF-28800F section 4.5.5.3.2 class 3
	random	8 Hz to 500 Hz, acceleration 1.2 g (RMS), in line with EN 60068-2-64
		5 Hz to 500 Hz, acceleration 2.058 g (RMS), in line with MIL-PRF-28800F section 4.5.5.3.1 class 3
Shock		40 g shock spectrum, in line with MIL-STD-810E, method no. 516.4, procedure I
		30 g functional shock, halfsine, duration 11 ms, in line with MIL-PRF-28800F section 4.5.5.4.1

EMC		
RF emission		in line with CISPR 11/EN 55011 group 1 class A (for a shielded test setup); the instrument complies with the emission requirements stipulated by EN 55011, EN 61326-1 and EN 61326-2-1 class A, making the instrument suitable for use in industrial environments
Immunity		in line with IEC/EN 61326-1 table 2, immunity test requirements for industrial environment [6]

Certifications		VDE, $_{C}CSA_{US}$, CE, KC, UKCA, RCM

Calibration interval		1 year

[6] Test criterion is displayed noise level within ±1 div for input sensitivity of 5 mV/div.

Power supply		
AC supply		100 V to 240 V at 50 Hz to 60 Hz and 400 Hz, max. 5.5 A to 2.3 A, in line with MIL-PRF 28800F section 3.5
Power consumption		max. 450 W
Safety		in line with IEC 61010-1/61010-2-030, EN 61010-1/61010-2-030, CAN/CSA-C22.2 No. 61010-1/ 61010-2-030, UL 61010-1/61010-2-030

Mechanical data		
Dimensions	W × H × D	427 mm × 249 mm × 204 mm (16.81 in × 9.80 in × 8.03 in)
Weight	without options, nominal	9.6 kg (21.16 lb)

Options

R&S®RTO-B1 mixed signal option

Mixed signal option, additional 16 logic channels

Vertical system

Input channels		16 logic channels (D0 to D15)
Arrangement of input channels		arranged in two logic probes with 8 channels each, assignment of the logic probes to the channels (D0 to D7 or D8 to D15) is displayed on the probe
DC input resistance	at probe tips	100 kΩ ± 2 % (meas.)
Input capacitance		4 pF (meas.)
Maximum input frequency	signal with minimum input voltage swing and hysteresis setting: normal	400 MHz (meas.)
Maximum input voltage		±40 V (V_p)
Minimum input voltage swing		500 mV (V_{pp}) (meas.)
Threshold groups		D0 to D3, D4 to D7, D8 to D11 and D12 to D15
Threshold level	range	±8 V in 25 mV steps
	predefined	CMOS 5.0 V, CMOS 3.3 V, CMOS 2.5 V, TTL, ECL, PECL, LVPECL
Threshold accuracy	threshold setting between ±4 V	±(100 mV + 3 % of threshold setting) (meas.)
Comparator hysteresis		normal, robust, maximum

Horizontal system

Channel deskew	range for each channel	±200 ns
Channel-to-channel skew		< 500 ps (meas.)

Acquisition system

Sampling rate	max.	5 Gsample/s on each channel
Realtime waveform acquisition rate	max.	> 200 000 waveforms/s
Memory depth	at max. sampling rates	200 Msample for every channel
	at lower sampling rates	100 Msample for every channel
Decimation		pulses lost due to decimation are displayed

Trigger system

Holdoff range	time	100 ns to 10 s, fixed and random
	events	1 event to 2 000 000 000 events

Trigger modes		
Edge	triggers on specified slope (positive, negative or either) in the source signal	
	sources	any channel from D0 to D15 or any logical combination of D0 to D15
Width	triggers on positive or negative pulse of specified width in the source signal; width can be shorter, longer, equal, inside or outside the interval	
	sources	any channel from D0 to D15 or any logical combination of D0 to D15
	pulse width	200 ps to 10 s
Timeout	triggers when the source signal stays high, low or unchanged for a specified period of time	
	sources	any channel from D0 to D15 or any logical combination of D0 to D15
	timeout	200 ps to 10 s
Data2clock	triggers on setup time and hold time violations between a clock signal and a data signal; monitored time interval with a max. width of 200 ns and a position of max. ±1 µs relative to the clock edge	
	data signal	any subset of channels from D0 to D15 or any user-defined bus signal
	clock signal	any channel from D0 to D15

Pattern	triggers when the source goes true or stays true for a period of time shorter, longer, equal, inside or outside a specified range	
	sources	any logical combination of D0 to D15 or any user-defined bus signal
	pulse width	200 ps to 10 s
State	triggers on the slope (positive, negative or either) of the clock signal when data signal matches a user-defined logical state	
	data signal	any logical combination of D0 to D15 or any user-defined bus signal
	clock signal	any channel from D0 to D15
Serial pattern	triggers on a serial data pattern of up to 32 bit; pattern bits may be high (H), low (L) or don't care (X); clock edge slope may be positive, negative or either	
	data signal	any channel from D0 to D15 or any logical combination of D15 to D15
	clock signal	any channel from D0 to D15
	max. data rate	1 Gbps
Serial bus trigger	optional	see dedicated triggering and decoding options
	sources	any channel from D0 to D15

Waveform measurements

General features		measurement panels, gate, statistics, long-term analysis and limit check; see features of the base unit
Measurement sources		all channels from D0 to D15 or any logical combination of D0 to D15
Automatic measurements		positive pulse width, negative pulse width, period, frequency, burst width, delay, phase, positive duty cycle, negative duty cycle, positive pulse count, negative pulse count, rising edge count, falling edge count
Additional cursor function		display of decoded bus value at the cursor position

Display characteristics

Display of logical channels		selectable size and position on screen, diagram configuration by dragging and dropping signal icons
Bus decode	number of bus signals	4
	bus types	unclocked and clocked
	display types	decoded bus, logical signal, bus + logical signal, amplitude signal, amplitude + logical signal, tabulated list (decoded time interval selected with cursors)
	position and size	size and position on screen selectable
	data format of decoded bus	hex, unsigned integer, signed integer, fractional, binary
	data format of amplitude signal	unsigned integer, signed integer, fractional, binary offset
Channel activity display		independent of the oscilloscope acquisition, the state (stays low, stays high or toggles) of the channels from D0 to D15 is displayed in the signal icon

R&S®RTO-B4 OCXO 10 MHz

OCXO, precision reference frequency with reference input and output connectors		
Timebase accuracy	OCXO	see Horizontal system
Reference output	connector	BNC female
	impedance	nom. 50 Ω)
	output frequency with OCXO	nom. 10 MHz
	output frequency with auxiliary reference	same as auxiliary reference
	level	> 7 dBm
Auxiliary reference input	connector	BNC female
	impedance	nom. 50 Ω
	input frequency range	1 MHz ≤ f_{in} ≤ 20 MHz, in 1 MHz steps
	required level	≥ 0 dBm into 50 Ω

R&S®RTO-B6 arbitrary waveform generator

Arbitrary function/waveform generator, 2 analog channels, 8-bit pattern generator

Analog channels

General		
Output channel		2 channels
Vertical resolution		14 bit
Operating modes		function generator, arbitrary waveform generator, modulation, frequency sweep

Function generator	output of predefined waveforms	
Sample rate		500 Msample/s
Waveforms	sine, square/pulse, ramp, DC, noise, cardinal sine (sinc), Gaussian pulse, Lorentz, exponential fall, exponential rise, cardiac	
Sine	frequency range	1 mHz to 100 MHz
	amplitude flatness (relative to 1 kHz)	
	f ≤ 100 kHz	≤ ±0.1 dB
	100 kHz < f ≤ 60 MHz	≤ ±0.3 dB
	60 MHz < f ≤ 100 MHz	≤ ±0.5 dB
	total harmonic distortion (1 V (V_{pp}) into 50 Ω)	
	f ≤ 100 kHz	≤ –70 dBc (= THD ≤ 0.032 %)
	100 kHz < f ≤ 15 MHz	≤ –55 dBc
	15 MHz < f ≤ 35 MHz	≤ –40 dBc
	35 MHz < f ≤ 100 MHz	≤ –30 dBc
	nonharmonic spurious (1 V (V_{pp}) into 50 Ω)	–65 dBc (meas.)
	phase noise (meas.)	
	f ≤ 25 MHz	≤ –105 dBc (1 Hz) at 1 kHz offset, ≤ –115 dBc (1 Hz) at 10 kHz offset, ≤ –125 dBc (1 Hz) at 100 kHz offset
	25 MHz < f ≤ 100 MHz	≤ –105 dBc (1 Hz) at 1 kHz offset, ≤ –110 dBc (1 Hz) at 10 kHz offset, ≤ –115 dBc (1 Hz) at 100 kHz offset
Square/pulse	frequency range	1 mHz to 30 MHz
	duty cycle (if pulse width limit is not exceeded)	0.01 % to 99.99 %, 0.01 % resolution
	pulse width	≥ 16.5 ns, 0.1 ns resolution
	rise/fall time	
	f ≤ 10 Hz	90 µs (meas.)
	10 Hz < f ≤ 30 MHz	9 ns (meas.)
	overshoot	≤ 2 %
	jitter (cycle-to-cycle)	≤ 40 ps (RMS) (meas.)
Ramp (triangle, sawtooth)	frequency range	1 mHz to 1 MHz
	linearity	≤ 0.1 % (meas.)
	variable symmetry	0 % to 100 %, 0.1 % resolution
DC	level range	
	into 50 Ω	± [3 V – (noise amplitude [V_{pp}] / 2)]
	into open circuit	± [6 V – (noise amplitude [V_{pp}] / 2)]

Noise	amplitude	
	DC	0 V to 6 V (V_{pp}) (into 50 Ω) 0 V to 12 V (V_{pp}) (into open circuit) 4 digits resolution
	all other waveforms	0 % to 100 % of AC signal amplitude, 1 % resolution
	bandwidth	≥ 100 MHz
Cardinal sine (sinc)	frequency range	1 mHz to 5 MHz
Cardiac	frequency range	1 mHz to 1 MHz
Gauss (Gaussian pulse)	frequency range	1 mHz to 25 MHz
Lorentz	frequency range	1 mHz to 10 MHz
Exponential rise/fall	frequency range	1 mHz to 1 MHz

Arbitrary waveform generator	output of user-defined waveforms	
Waveform length		1 sample to 40 Msample on each channel
Sample rate		1 sample/s to 250 Msample/s
Filter bandwidth		100 MHz

Modulation		
Sample rate		500 Msample/s
Modulation types		amplitude modulation (AM), frequency modulation (FM), frequency-shift key modulation (FSK), pulse width modulation (PWM)
Carrier waveform	AM, FM, FSK	sine
	PWM	square/pulse
AM	modulation signals	sine, square, ramp (triangle, sawtooth)
	modulation frequency	1 mHz to 1 MHz
	depth	0 % to 100 %, 0.1 % resolution
FM	modulation signals	sine, square, ramp (triangle, sawtooth)
	modulation frequency	1 mHz to 1 MHz
	frequency deviation	1 mHz to 10 MHz
FSK	modulation signal	50 % duty cycle square wave
	range of frequency 1, frequency 2	1 mHz to 100 MHz
	hop rate	1 mHz to 1 MHz
PWM	modulation signals	sine, square, ramp (triangle, sawtooth)
	depth	0 % to 99.99 % of the duty cycle, 0.01 % resolution

Frequency sweep	output of a sinusoidal waveform with the frequency changing linearly between the start frequency and the stop frequency within the sweep time	
	sample rate	500 Msample/s
	waveform	sine
	frequency range	1 mHz to 100 MHz
	direction	up (start frequency < stop frequency)
		down (start frequency > stop frequency)
	sweep time	1 ms to 500 s

Two-channel operation	operating modes	independent channels, coupled parameters, differential
	parameter coupling	none, frequency and/or amplitude
	relative phase	–180° to 180°, 0.1° resolution
	channel-to-channel skew	≤ 200 ps (meas.)
	channel-to-channel isolation (each channel with same output amplitude)	
	f ≤ 10 MHz	≥ 60 dB (meas.)
	10 MHz < f ≤ 100 MHz	≥ 40 dB (meas.)

Outputs		
Connectors		BNC female on the rear panel
Function		on, off, inverted
Output impedance		nom. 50 Ω
Overload protection		a short-circuit to ground is tolerated indefinitely, automatic shutoff in case of voltages ≥ +7 V or ≤ –7 V (meas.), automatic shutoff in case of overcurrent, max. –20 V to +20 V without damage (meas.), ESD protection
Amplitude range [7]	sine, square, ramp, pulse, exponential rise, exponential fall	
	into 50 Ω	10 mV to 6 V (V_{pp}) (frequency ≤ 50 MHz), 10 mV to 4 V (V_{pp}) (frequency > 50 MHz)
	into open circuit	20 mV to 12 V (V_{pp}) (frequency ≤ 50 MHz), 20 mV to 8 V (V_{pp}) (frequency > 50 MHz)
	cardinal sine (sinc), cardiac	
	into 50 Ω	10 mV to 3 V (V_{pp})
	into open circuit	20 mV to 6 V (V_{pp})
	Gauss, Lorentz	
	into 50 Ω	10 mV to 2.5 V (V_{pp})
	into open circuit	20 mV to 5 V (V_{pp})
	arbitrary waveforms	
	into 50 Ω	10 mV to 6 V (V_{pp}) (sample rate ≤ 125 Msample/s), 10 mV to 4 V (V_{pp}) (sample rate > 125 Msample/s)
	into open circuit	20 mV to 12 V (V_{pp}) (sample rate ≤ 125 Msample/s), 20 mV to 8 V (V_{pp}) (sample rate > 125 Msample/s)
	resolution	1 mV
	accuracy	± [1% of control + 1 mV (V_{pp})] at 1 kHz
DC offset range	sine, square, ramp, pulse, exponential rise, exponential fall	
	into 50 Ω	± [3 V – (amplitude [V (V_{pp})] / 2)]
	into open circuit	± [6 V – (amplitude [V (V_{pp})] / 2)]
	cardinal sine (sinc), cardiac, Gauss, Lorentz	
	into 50 Ω	±0.5 V
	into open circuit	±1 V
	resolution	1 mV
	accuracy	± (2 % of control + 2 mV)
Frequency accuracy		| Δf | ≤ [(timebase accuracy) × (nominal frequency) + 1 µHz] (timebase accuracy: see Horizontal system)

[7] Amplitude is the sum of the AC amplitude and the noise amplitude.

8-bit pattern generator

Function		output of user-defined patterns
Output channels		8 channels, coupled w.r.t. pattern length and data output rate
Pattern length		1 bit to 40 Mbit on each channel
Bit rate		1 bit/s to 40 Mbit/s

Outputs		
Connector		16-pin double row connector, 2.54 mm pitch, located on an adapter board, which is connected via a removable ribbon cable to the R&S®RTO-B6
Output impedance		nom. 330 Ω
Overload protection	reverse input voltage without damage	–0.5 V to +6.5 V (meas.), ESD protection
Amplitude	low level output voltage (I = 100 µA)	
	output voltage	0 V + 0.15 V/– 0.02 V
	accuracy	≤ 0.15 V (meas.)
	high level output voltage	
	setting range	1.2 V to 5.0 V
	resolution	0.1 V
	accuracy	≤ 0.05 V
Rise/fall time		8 ns (meas.)
Overshoot		≤ 5 % (meas.)

R&S®RTO-B7 16 GHz differential pulse source

16 GHz differential pulse source with reference output

Output [8]

Output pulse		two complementary negative going square wave pulse train signals, single-ended or differential operation, fast transition on rising and falling edge, adjustable amplitude and timing parameters, free-running or phase-locked to base unit
Outputs	single-ended operation	single-ended output (OutP)
		single-ended reference output (RefP)
	differential operation	differential output (OutP, OutN)
		differential reference output (RefP, RefN)
Output connectors		SMA female connectors
Reverse DC voltage		0 V
Output impedance	single-ended outputs	nom. 50 Ω
	both differential pairs	nom. 100 Ω
Return loss	≤ 10 GHz	> 15 dB (meas.)
	≤ 20 GHz	> 12 dB (meas.)

DC characteristics [8]

Output high level		0 V ± 10 mV
Output low level setting range		–200 mV to –50 mV adjustable in 10 mV steps
Output low level error	OutP	±2 % of setting ±15 mV
Output low level imbalance	between OutP and RefP, OutN, RefN	±1 dB (meas.)

[8] All four outputs terminated with 50 Ω; all parameters are measured at all four single-ended outputs, unless noted.

Time domain characteristics [8]

Transition time	10 % to 90 %, rising and falling edge, calculated from 0.36/bandwidth	
	output low level: –120 mV to –50 mV	20 ps
	output low level: –200 mV to –130 mV	22 ps
Step response aberrations	for the first 100 ps after step transition	±10 % (meas.)
	for the first 1 ns after step transition	±4 % (meas.)
	until 100 ps before following step transition	±2 % (meas.)
Repetition rate	low frequency mode	5 Hz, 10 Hz, 20 Hz, 50 Hz, 100 Hz, 200 Hz, 500 Hz to 1 MHz
	high frequency mode, phase-locked to base unit	5 MHz, 10 MHz, 25 MHz, 50 MHz, 100 MHz, 250 MHz
	high frequency mode, free-running	5 MHz, 10 MHz, 25 MHz, 50 MHz
Positive duty cycle	measured at 50 % of transition	
	low frequency mode	10 % to 90 %, adjustable in 10 % steps
	high frequency mode	50 %
Duty cycle error	measured at 50 % of transition, at OutP and RefP outputs	
	low frequency mode	±2 % (meas.)
	high frequency mode	±0.1 % (meas.)
Skew	measured at 50 % of transition, between OutP and OutN output	< 0.5 ps (meas.)
Clock accuracy	free-running	±100 ppm (meas.)
	phase-locked to base unit	see Timebase accuracy of base unit

Frequency domain characteristics [8]

Analog bandwidth (–3 dB)	output low level: –120 mV to –50 mV	> 18 GHz (meas.)
	output low level: –200 mV to –130 mV	> 16.5 GHz (meas.)
Spectral magnitude error to ideal step spectrum	≤ 5 GHz	+0.5 dB to –1 dB (meas.)
	≤ 12 GHz	+0.5 dB to –2 dB (meas.)
	≤ analog bandwidth	+0.0 dB to –3 dB (meas.)

General

Accessories	The R&S®RTO-B7 contains an accessory bag with 2 SMA cables, 4 SMA terminations, 2 SMA(f) to SMA(f) adapters, 2 SMA shorts, 1 ESD wrist strap with grounding cord and 2 SMA(f) to BNC(m) adapters.

R&S®RTO-B10 GPIB interface

Function		interface in line with IEC 625-2 (IEEE 488.2)
Command set		SCPI 1999.0
Connector		24-pin Amphenol female
Interface functions		SH1, AH1, T6, L4, SR1, RL1, PP1, DC1, DT1, C0

R&S®RTO-B19 additional solid state disk

Disk type		solid state disk
Disk size		nom. ≥ 240 Gbyte
Firmware		installed upon delivery

R&S®RTO-K1 I²C/SPI serial triggering and decoding

I²C serial triggering and decoding		
Protocol configuration	bit rate	auto-detected
	auto threshold setup	assisted threshold configuration for I²C triggering and decoding
	device list	associate frame address with symbolic ID
Trigger	source (clock and data)	any input channel or logical channel
	bit rate	up to 6.5 Mbps
	trigger event setup	start, stop, restart, missing ACK, address, data, address + data
	address setup	7 bit or 10 bit address (value in hex, decimal, octal or binary); ACK, NACK or either; read, write or either; R/W bit included in address value or apart; condition =, ≠, ≥, ≤, in range, out of range
	data setup	data pattern up to 8 byte (hex, decimal, octal or binary); condition =, ≠, ≥, ≤, in range, out of range; offset within frame in range from 0 byte to 4095 byte
Decode	source (clock and data)	any input channel, math waveform, reference waveform, logical channel
	display type	decoded bus, logical signal, bus + logical signal, tabulated list, decode layers
	color coding	frame, start/restart, address, R/W bit, data, ACK/NACK, stop, error
	address and data format	hex, decimal, octal, binary, ASCII; symbolic names for user-defined subset of addresses
	decode layer	off, edges, bit
Search	search event setup	combination of start, stop, restart, missing ACK, address, data, address + data
	event settings	same as trigger event settings

SPI serial triggering and decoding		
Protocol configuration	type	2-wire, 3-wire and 4-wire SPI
	bit rate	auto-detected
	bit order	LSB first, MSB first
	word size	4 bit to 32 bit
	frame condition	SS, timeout
	polarity (MOSI, MISO, SS, CLK)	active high, active low
	phase (CLK)	first edge, second edge
	auto threshold setup	assisted threshold configuration for SPI triggering and decoding
Trigger	source (MOSI, MISO, SS, CLK)	any input channel or logical channel
	bit rate	up to 50 Mbps
	trigger event setup	start of frame, MOSI, MISO, MOSI + MISO
	data setup	data pattern up to 256 bit (hex or binary); condition =, ≠; offset within frame in range from 0 bit to 32767 bit
Decode	source (MOSI, MISO, SS, CLK)	any input channel, math waveform, reference waveform, logical channel
	display type	decoded bus, logical signal, bus + logical signal, tabulated list, decode layers
	color coding	frame, word, error
	data format	hex, decimal, octal, binary, ASCII
	decode layer	edges, bits, words
Search	search event setup	start of frame, MOSI, MISO, MOSI + MISO
	event settings	same as trigger event settings

R&S®RTO-K2 UART/RS-232/RS-422/RS-485 serial triggering and decoding

Protocol configuration	bit rate	300 bps to 20 Mbps
	signal polarity	idle low, idle high
	number of bits	5 bit to 9 bit
	bit order	LSB first, MSB first
	parity	odd, even, mark, space, none
	stop bit	1, 1.5 or 2 bit periods
	end of packet	word, timeout, none
	auto threshold setup	assisted threshold configuration for UART triggering and decoding
Trigger	source (TX and RX)	any input channel or logical channel
	trigger event setup	start bit, packet start, data, parity error, break condition
	data setup	data pattern up to 256 bit (hex, decimal, octal, binary or ASCII); condition =, ≠; offset within packet in range 0 bit to 32767 bit
Decode	source (TX and RX)	any input channel, math waveform, reference waveform, logical channel
	display type	decoded bus, logical signal, bus + logical signal, tabulated list
	color coding	packet, data payload, start error, parity error, stop error
	data format	hex, decimal, octal, binary, ASCII

R&S®RTO-K3 CAN/LIN serial triggering and decoding

CAN serial triggering and decoding		
Protocol configuration	signal type	CAN_H, CAN_L
	bit rate	100 bps to 1 Mbps
	sampling point	5 % to 95 % within bit period
	device list	associate frame identifier with symbolic ID, load DBC file content
	auto threshold setup	assisted threshold configuration for CAN triggering and decoding
Trigger	source	any input channel or logical channel
	trigger event setup	start of frame, frame type, identifier, identifier + data, symbolic, error condition (any combination of CRC error, bit stuffing error, form error and ACK error)
	identifier setup	frame type (data, remote or both), identifier type (standard or extended); condition =, ≠, ≥, ≤, in range, out of range
	data setup	data pattern up to 8 byte (hex, decimal, octal or binary); big-endian or little-endian; condition =, ≠, ≥, ≤, in range, out of range
	symbolic setup	message name, signal name; numeric signal condition =, ≠, ≥, ≤, in range, out of range; enumerated signal condition =, ≠, ≥, ≤
Decode	source	any input channel, math waveform, reference waveform, logical channel
	display type	decoded bus, logical signal, bus + logical signal, tabulated list
	color coding	start of frame, identifier, DLC, data payload, CRC, end of frame, error frame, overload frame, CRC error, bit stuffing error
	data format	hex, decimal, octal, binary, ASCII, symbolic

Search	source	any input channel or logical channel
	search event setup	combination of start of frame, frame type, identifier, identifier + data, error condition (any combination of CRC error, bit stuffing error, form error and ACK error) or only symbolic
	event settings	same as trigger event settings

LIN serial triggering and decoding		
Protocol configuration	version	1.3, 2.x or SAE J602; mixed traffic is supported
	bit rate	standard bit rate (1.2/2.4/4.8/9.6/10.417/ 19.2 kbps) or user-defined bit rate in range from 1 kbps to 20 kbps
	device list	associate frame identifier with symbolic ID, data length and protocol version
	auto threshold setup	assisted threshold configuration for LIN triggering and decoding
Trigger	source	any input channel
	trigger event setup	start of frame (sync break), identifier, identifier + data, wake-up frame, error condition (any combination of checksum error, parity error and sync field error)
	identifier setup	range from 0d to 63d; select condition =, ≠, ≥, ≤, in range, out of range for trigger “identifier”; select single identifier and condition = for trigger “identifier + data”
	data setup	data pattern up to 8 byte (hex, decimal, octal or binary); condition =, ≠, ≥, ≤, in range, out of range
Decode	source (TX and RX)	any input channel, math waveform, reference waveform
	display type	decoded bus, logical signal, bus + logical signal, tabulated list
	color coding	frame, frame identifier, data payload, checksum, error condition
	data format	hex, decimal, octal, binary, ASCII
Search	search event setup	combination of start of frame (sync break), identifier, identifier + data, wake-up frame, error condition (any combination of checksum error, parity error and sync field error)
	event settings	same as trigger event settings

R&S®RTO-K4 FlexRay™ serial triggering and decoding

Protocol configuration	signal type	single-ended, differential, logic
	channel type	channel A, channel B
	bit rate	standard bit rates (2.5/5.0/10.0 Mbps)
	device list	associate frame identifier with symbolic ID
	auto threshold setup	assisted threshold configuration for FlexRay™ triggering and decoding
	source	any input channel or logical channel
Trigger	trigger event setup	start of frame, header + data, symbol, wake-up, error condition (any combination of FSS error, BSS error, FES error, header CRC error and frame CRC error)
	header setup	indicator bits, identifier, payload length, cycle count
	indicator bits setup	payload preamble bit, null frame bit, sync frame bit and startup frame bit separately configurable (1, 0 or don't care)
	identifier setup	condition =, ≠, ≥, ≤, in range, out of range
	payload length setup	condition =, ≠, ≥, ≤, in range, out of range
	cycle count	condition =, ≠, ≥, ≤, in range, out of range; step parameter for selection of non-contiguous values within provided range
	data setup	data pattern up to 8 byte (hex, decimal, octal or binary); condition =, ≠, ≥, ≤, in range, out of range; offset within frame in range from 0 byte to 253 byte
Decode	source	any input channel, math waveform, reference waveform, logical channel
	display type	decoded bus, logical signal, bus + logical signal, tabulated list
	color coding	frame, frame header, identifier, payload length, header CRC, cycle count, data payload, frame CRC, error condition
	data format	hex, decimal, octal, binary, ASCII
Search	search event setup	combination of start of frame, header + data, symbol, wake-up, error condition (any combination of FSS error, BSS error, FES error, header CRC error and frame CRC error)
	event settings	same as trigger event settings

R&S®RTO-K5 I²S serial triggering and decoding

Protocol configuration	signal type	I²S standard, left justified, right justified, TDM
	auto threshold setup	assisted threshold configuration for I²S triggering and decoding
Trigger	source	any input channel or logical channel
	trigger event setup	data, window, frame condition, word select, error condition
	data setup	data pattern of an audio channel up to 4 byte (hex, signed decimal, unsigned decimal, octal or binary); condition =, ≠, ≥, ≤, <, >, in range, out of range
	window setup	word count of data pattern of an audio channel up to 4 byte (hex, signed decimal, unsigned decimal, octal or binary); condition =, ≠, ≥, ≤, <, >, in range, out of range
	frame condition setup	combination of audio channels in a frame, up to 4 byte (hex, signed decimal, unsigned decimal, octal or binary); condition =, ≠, ≥, ≤, <, >, in range, out of range
	word select setup	rising or falling edge of word select input channel
	error condition setup	source of word select
Decode	source	any input channel, math waveform, reference waveform, logical channel
	display type	decoded bus, logical signal, bus and logical signal, tabulated list
	color coding	audio frame, frame error, incomplete frame
	data format	hex, unsigned decimal, signed decimal (two's complement), octal, binary, ASCII
Protocol measurements	audio display	display of audio waveform for specified audio channels
	long-term display	history of selected audio data as trace against measurements, waveforms and time index

R&S®RTO-K6 MIL-STD-1553 serial triggering and decoding

Protocol configuration	signal type	single-ended
	bit rate	standard bit rate (1 Mbit/s)
	polarity	normal, inverted
	device list	associate frame identifier with symbolic ID
	auto threshold setup	assisted threshold configuration
	timing	min. gap (2 µs to 262 µs) or off; max. response (2 µs to 262 µs) or off
Trigger	trigger event setup	sync, word, data word, command/status word, command word, status word, error condition
	sync and word setup	all words, command/status word, data word
	data word setup	RTA (condition =, ≠, ≥, ≤, in range, out of range); data pattern (condition =, ≠, ≥, ≤, in range, out of range); payload data index (=, <, >, ≥, ≤, range); max length of data pattern is 4 byte
	command/status word setup	RTA (condition =, ≠, ≥, ≤, in range, out of range); 11 bit pattern (condition =, ≠, ≥, ≤, in range, out of range)
	command word setup	RTA (condition =, ≠, ≥, ≤, in range, out of range); subaddress/mode (condition =, ≠, ≥, ≤, in range, out of range); data word count/mode count (condition =, ≠, ≥, ≤, in range, out of range); direction (T/R)
	status word	RTA (condition =, ≠, ≥, ≤, in range, out of range); status flags (message error, instrumentation, service request, broadcast command, busy, subsystem flag, dynamic bus control, terminal flag)
	error condition	any combination of sync error, Manchester error, parity error, timing error (see protocol configuration)
Decode	source	any analog input channel, math waveform, reference waveform
	display type	decoded bus, logical signal, bus + logical signal, tabulated list
	color coding	frame (word), sync, RTA, status bit field, parity, data field, error condition
	data format	hex, octal, binary, ASCII, signed, unsigned
Search	search event setup	sync, word, data word, command/status word, command word, status word, error condition
	event settings	same as trigger event settings

R&S®RTO-K7 ARINC 429 serial triggering and decoding

Protocol configuration	signal type	single-ended
	bit rate	high (100 kbit/s)
		low (12 kbit/s to 14.5 kbit/s)
	polarity	A leg, B leg
	device list	associate frame identifier with symbolic ID
	auto threshold setup	assisted threshold configuration
	timing	min. gap (0 bit to 100 bit) or off; max. gap (0 bit to 1000 bit) or off
Trigger	trigger event setup	word start, word stop, label + data, error condition
	label + data setup	label (condition =, ≠, ≥, ≤, in range, out of range); data (condition =, ≠, ≥, ≤, in range, out of range); SDI/SSM
	error condition	any combination of coding error, parity error, timing error (see protocol configuration)
Decode	source	any analog input channel, math waveform, reference waveform
	display type	decoded bus, logical signal, bus + logical signal, tabulated list
	color coding	frame (word), label, SDI, data, SSM, parity, error condition
	data format	hex, octal, binary, ASCII, signed, unsigned
Search	search event setup	word start, word stop, label + data, error condition
	event settings	same as trigger event settings

R&S®RTO-K8 Ethernet (10BASE-T/100BASE-TX) serial triggering and decoding

Protocol configuration	signal type	one differential channel
	bit rate	auto-detected
	auto threshold setup	assisted threshold configuration
	full autoset	adjust horizontal and vertical resolution and perform auto threshold
	source (SDATA)	analog and math channels
	variants	10BASE-T, 100BASE-TX
Trigger	frame start	trigger at start of any MAC frame
	pattern	fast trigger for 10BASE-T MAC frames, 32 byte, index 0 to 65535
	frame	advanced trigger configuration for MAC frames only 48 bit destination address, 48 bit source address, 16 bit length/type, 32 bit frame check; conditions =, ≠, <, ≤, >, ≥, in range, out of range
	error	preamble error, length error, CRC error
Decode	display type	decoded bus, logical signal, bus + logical signal, tabulated list, details, decode layers
	color coding	preamble, frame, destination address, source address, data
	data format	hex, octal, binary, signed, unsigned
	decode layer	edges, binary
	result export	export of all result data into CSV, XML, HTM and PY file formats
Search	search event setup	frame, error
	event settings	same as trigger event settings

R&S®RTO-K9 CAN-FD serial triggering and decoding

Protocol configuration	signal type	CAN_H, CAN_L
	standard	ISO, non-ISO (Bosch)
	bit rate	
	arbitration rate	10 kbps to 1 Mbps
	data rate	10 kbps to 15 Mbps
	sampling point	5 % to 95 % within bit period; independent settings for arbitration phase and data phase
	device list	associate frame identifier with symbolic ID, load DBC file content
	auto threshold setup	assisted threshold configuration
Trigger	source	any input channel or logical channel
	trigger event setup	start of frame, frame type, identifier, identifier + data, symbolic, error condition (any combination of CRC error, bit stuffing error, form error and ACK error)
	identifier setup	frame type (data, remote or both), identifier type (standard or extended); condition =, ≠, ≥, ≤, in range, out of range
	FD bits	FDF, BRS and ESI (0, 1, X)
	data setup	data pattern up to 8 byte in the complete data range (hex, decimal, octal or binary); condition =, ≠, ≥, ≤, in range, out of range
	symbolic setup	message name, signal name; numeric signal condition =, ≠, ≥, ≤, in range, out of range; enumerated signal condition =, ≠, ≥, ≤
Decode	source	any input channel, math waveform, reference waveform, logical channel
	display type	decoded bus, logical signal, bus + logical signal, tabulated list
	color coding	start of frame, identifier, FD bits, DLC, data payload, CRC, end of frame, error frame, overload frame, CRC error, bit stuffing error
	data format	hex, decimal, octal, binary, ASCII, symbolic
	supported data length	64
Search	source	any input channel or logical channel
	search event setup	combination of start of frame, frame type, identifier, identifier + data, error condition (any combination of CRC error, bit stuffing error, form error and ACK error) or only symbolic
	event settings	same as trigger event settings

R&S®RTO-K10 SENT serial triggering and decoding

Protocol configuration	signal type	data signal
	clock period (clock tick)	1 µs to 100 µs
	clock tolerance	0 % to 25 %
	data nibbles	1 to 6
	serial message type	none, short serial message and enhanced serial message
	CRC version	Legacy (Feb 2008) and v2010 (Latest)
	CRC calculation	SAE J2716 standard and TLE 4998X
	pause pulse	no, yes, for constant frame length
	frame length in clock ticks (applicable only when pause pulse = constant frame length)	104 to 922
Trigger	source	any analog input channel
	trigger event setup	calibration or sync, transmission sequence, serial message and error condition
	transmission sequence status nibble setup	from 0 to F, condition =, ≠, ≥, ≤, in range, out of range
	transmission sequence data nibbles setup	each nibble value from 0 to F, condition =, ≠, ≥, ≤, in range, out of range
	serial message identifier setup	from 00 to FF, condition =, ≠, ≥, ≤, in range, out of range
	serial message identifier type setup (applicable only when the serial protocol = enhanced serial message in protocol configuration)	4 bit and 8 bit
	serial message data setup	00 to FF (short serial message) 000 to FFF (enhanced serial message with 8 bit ID) 0000 to FFFF (enhanced serial message with 4 bit ID)
	error condition setup	form error, calibration pulse error, pulse period error, CRC error and irregular frame length error
Decode	source	any analog input channel,
	display type	decoded bus, tabulated list
	color coding	transmission sequence: sync/calibration, status, data bits, CRC, pause pulse (optional), calibration pulse error, pulse period error, irregular frame length error and CRC error; serial message: identifier, data, CRC, form error, CRC error
	data format	hex, decimal, octal, binary, ASCII
Search	source	any analog input channel
	search event setup	calibration or sync, transmission sequence, serial message and error condition
	event settings	same as trigger event settings

R&S®RTO-K11 I/Q software interface

General	function		mixing, filtering, decimation and recording of RF or baseband signals as I/Q samples	
	input signals (2 channel models)		two real RF signals or one complex I/Q signal	
	input signals (4 channel models)		four real RF signals or two complex I/Q signals or two real RF signals and one complex I/Q signal	
	mixer frequency		between 100 Hz and 5 GHz (or mixer deactivated)	
	sampling rate of recorded I/Q samples		between 1 ksample/s and 10 Gsample/s	
	digital filter bandwidth (flat frequency response)		4 % to 80 % of sampling rate	
	sampling rate of recorded I/Q samples		between 1 ksample/s and 10 Gsample/s user-selectable	
	recording length			
			recording length independent of sampling rate	
	standard		max. 10 Msample with one or two input signals, max. 6 Msample with three or four input signals	
	R&S®RTO-B110 option		max. 40 Msample with one or two input signals, max. 24 Msample with three or four input signals	
Trigger	mode		auto or normal	
	operation		triggers on acquired signal after A/D conversion serial bus and MSO trigger not available	
	additional modes		NFC-A, 106 kbps, SENSA_REQ; NFC-B, 106 kbps, SENSB_REQ; NFC-F, 202 kbps or 404 kbps, start of sequence (SoS) length: 48 bit or 96 bit	
Display			magnitude of the downconverted signals	
Amplitude flatness with RF signal input (meas.)	R&S®RTO2002 and R&S®RTO2004	max. used center frequency	with I/Q bandwidth 100 MHz	with I/Q bandwidth 250 MHz
		≤ 100 MHz	±0.10 dB	
		≤ 200 MHz	±0.12 dB	±0.30 dB
		≤ 300 MHz	±0.20 dB	±0.50 dB
		≤ 400 MHz	±0.25 dB	±0.70 dB
		≤ 500 MHz	±0.35 dB	±1.00 dB
	R&S®RTO2012 and R&S®RTO2014	max. used center frequency	with I/Q bandwidth 100 MHz	with I/Q bandwidth 250 MHz
		≤ 100 MHz	±0.10 dB	
		≤ 200 MHz	±0.10 dB	±0.15 dB
		≤ 500 MHz	±0.10 dB	±0.25 dB
		≤ 750 MHz	±0.15 dB	±0.40 dB
		≤ 1 GHz	±0.30 dB	±0.90 dB
	R&S®RTO2022 and R&S®RTO2024	max. used center frequency	with I/Q bandwidth 100 MHz	with I/Q bandwidth 500 MHz
		≤ 100 MHz	±0.10 dB	
		≤ 500 MHz	±0.10 dB	±0.10 dB
		≤ 1 GHz	±0.17 dB	±0.35 dB
		≤ 1.5 GHz	±0.20 dB	±0.50 dB
		≤ 2 GHz	±0.35 dB	±1.00 dB
	R&S®RTO2032 and R&S®RTO2034	max. used center frequency	with I/Q bandwidth 100 MHz	with I/Q bandwidth 500 MHz
		≤ 100 MHz	±0.10 dB	
		≤ 500 MHz	±0.10 dB	±0.10 dB
		≤ 1 GHz	±0.10 dB	±0.35 dB
		≤ 2 GHz	±0.10 dB	±0.35 dB
		≤ 3 GHz	±0.30 dB	±1.30 dB
	R&S®RTO2044	max. used center frequency	with I/Q bandwidth 100 MHz	with I/Q bandwidth 500 MHz
		≤ 100 MHz	±0.10 dB	
		≤ 500 MHz	±0.10 dB	±0.10 dB
		≤ 1 GHz	±0.10 dB	±0.10 dB
		≤ 2 GHz	±0.10 dB	±0.15 dB
		≤ 3 GHz	±0.12 dB	±0.30 dB
		≤ 4 GHz	±0.30 dB	±0.75 dB

R&S®RTO-K12 jitter analysis

General description	The R&S®RTO-K12 jitter analysis option extends the functionality of the standard R&S®RTO firmware with a suite of measurement, analysis and visualization tools for signal integrity analysis and jitter characterization.	
Waveform measurements	category	jitter
	measurement functions	cycle-to-cycle jitter, N-cycle jitter, cycle-to-cycle width, cycle-to-cycle duty cycle, time-interval error, data rate, unit interval, skew delay, skew phase; the standard time measurements period, frequency and setup/hold are also available in the jitter category for convenience
	track	measurement results displayed as continuous trace that is time-correlated to the measurement source; applicable to time measurements from categories “jitter” and “amplitude and time”; track trace may be used as source for cursor measurements, automatic measurements, math waveforms and reference waveforms
Waveform math	FFT on track	FFT spectrum of the track trace of measurement results
	CDR transform	recovers clock timing from source waveform with software CDR and generates synthetic clock waveform that is time-correlated to source
Software clock data recovery (CDR)	number of CDR instances	up to 2; independently configurable
	algorithm	phase-locked loop (PLL), constant frequency
	configuration	nominal bit rate, PLL order (first or second), PLL loop bandwidth, PLL damping factor, initial phase alignment, result selection during initial synchronization
Mask testing with eye mask assistant	primary mask shape	
	type	diamond, square, hexagon, octagon
	dimensions	main and secondary height, main and secondary width, depending on selected shape
	position	vertical offset, horizontal offset
	secondary mask shapes	
	locations	any combination of left, right, top, bottom
	position	horizontal and vertical offset with respect to center of primary mask shape

R&S®RTO-K13 clock data recovery

General description	The R&S®RTO-K13 realtime clock data recovery (CDR) option activates the hardware CDR circuitry integrated into the R&S®RTO oscilloscope. It provides realtime clock recovery for non-return-to-zero (NRZ) serial data up to 5.0 Gbps. The recovered clock may be used for triggering and jitter analysis.	
Hardware clock data recovery (CDR)	description	fully digital implementation of PLL-based clock data recovery
	sources	
	R&S®RTO2002, R&S®RTO2012, R&S®RTO2022, R&S®RTO2032	channel 1, channel 2
	R&S®RTO2004, R&S®RTO2014, R&S®RTO2024, R&S®RTO2034, R&S®RTO2044	channel 1, channel 2, channel 3, channel 4
	configuration parameters	PLL order (first or second), nominal bit rate, loop bandwidth, relative bandwidth, damping factor, unit interval offset
	bit rate range	
	R&S®RTO2002, R&S®RTO2004, R&S®RTO2012, R&S®RTO2014, R&S®RTO2022, R&S®RTO2024, R&S®RTO2032, R&S®RTO2034	200 kbps to 2.5 Gbps
	R&S®RTO2044	200 kbps to 2.5 Gpbs standard, 400 kbps to 5.0 Gbps when operating at 20 Gsample/s realtime sampling rate [9]
	R&S®RTO2064	400 kbps to 5.0 Gbps standard, 200 kbps to 2.5 Gpbs when operating at 10 Gsample/s realtime sampling rate [10]
	relative bandwidth	1/500 to 1/3000 of the nominal bit rate
	damping factor	0.5 to 1.0; relevant for second order PLL only
	unit interval offset	0.0 to 1.0
Trigger modes	CDR	triggers on clock signal recovered from the trigger source signal; phase of the trigger instant user-selectable as fraction of bit period
	serial pattern	main trigger mode “serial pattern” supports the hardware CDR as additional clock source; sampling point user-selectable as fraction of bit period
Jitter analysis	The data and clock timing information of the hardware CDR may be acquired in realtime concurrently to the input data waveform. Analysis of the realtime CDR timing information is possible by means of compatible measurement, analysis and visualization tools provided in the R&S®RTO-K12 jitter analysis option. [11]	
	measurement functions	time-interval error (TIE), data rate, unit interval
	math functions	CDR transform interprets the acquired clock timing information and generates a synthetic clock waveform that is time-correlated to the input data waveform

[9] In general terms, the frontend of the R&S®RTO2044 samples at 20 Gsample/s when: at most one channel from each pair {channel1, channel2} and {channel3, channel4} is active; and the user-selected sampling resolution in realtime sampling mode or interpolated time sampling mode is 50 ps or smaller.

[10] In general terms, the frontend of the R&S®RTO2064 samples at 20 Gsample/s when at most one channel from each pair {channel1, channel2} and {channel3, channel4} is active, otherwise the sampling rate is 10 Gsample/s.

[11] Realtime CDR timing information can be acquired when the frontend is operating at 10 Gsample/s realtime sampling rate.

R&S®RTO-K18 spectrogram

General description	The R&S®RTO-K18 spectrum analysis allows advanced signal analysis in the frequency domain by visualization of the frequency spectrum versus time.	
Spectrogram	display characteristics	spectrogram display; a separate spectrogram can be created for each FFT display; each FFT segment of a captured acquisition is displayed in a separate spectrogram line
		support of logarithmic frequency x-axis
	number of spectrograms	up to 4
	signal colors	predefined or user-defined color tables for persistence display with the spectrogram
	time lines	in stop mode two separate time lines can be used to navigate through a spectrogram in time; for each time line the relevant FFT segment is displayed in a diagram; the difference in acquisition time between the timelines is displayed

R&S®RTO-K19 zone trigger

General description	The R&S®RTO-K19 zone trigger enables the triggering on user-defined zones drawn on the display.	
Source		acquired waveforms (input channels), math waveforms
Zone definition	number of zones	up to 8
	shapes	rectangles, polygones
	types	must intersect, must not intersect
	combination of zones	logical combination of zones of multiple sources using Boolean expressions
Trigger compatibility		compatible with the trigger modes edge, glitch, width, runt, window, timeout, interval, slew rate, data2clock, pattern, state, serial pattern, trigger qualification, and sequence trigger

R&S®RTO-K21 USB 2.0 compliance test

The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K21 performs USB 2.0 compliance test measurements with R&S®ScopeSuite, including tests for USB 2.0 (high speed), USB 1.1 (full speed) and USB 1.0 (low speed) with the R&S®RTO. R&S®ScopeSuite supports the R&S®RT-ZF1 USB 2.0 compliance test fixture set and the Allion USB test fixture solutions and the USB-IF signal quality board device/host; R&S®ScopeSuite supports Windows 7, 8 and 10.

Supported USB 2.0 compliance tests		
USB device test	high speed	signal quality (EL_2, 4, 5, 6, 7); packet parameters (EL_21, 22, 25); chirp timing (EL_28, 29, 31); suspend/resume/reset timing (EL_27, 28, 38, 39, 40); test J/K, SE0_NAK (EL_8, 9); receiver sensitivity (EL_16, 17, 18)
	full speed and low speed	full speed signal quality; back voltage; inrush current
USB host test	high speed	signal quality (EL_2, 3, 6, 7); packet parameters (EL_21, 22, 23, 25, 55); chirp timing (EL_33, 34, 35); suspend/resume/reset timing (EL_39, 41); test J/K, SE0_NAK (EL_8, 9)
	full speed and low speed	low speed signal quality downstream; full speed signal quality downstream; drop; droop
USB hub test	high speed	signal quality upstream (EL_2, 4, 6, 7); signal quality downstream (EL_2, 3, 6, 7); jitter downstream (EL_47); packet parameters upstream (EL_21, 22, 25); hub receiver sensitivity upstream (EL_16, 17, 18); repeater downstream (EL_42, 43, 44, 45, 48); repeater upstream (EL_42, 43, 44, 45); chirp timing upstream (EL_28, 29, 31); suspend/resume/reset timing upstream (EL_27, 28, 38, 39, 40); test J/K, SE0_NAK upstream (EL_8, 9); test J/K, SE0_NAK downstream (EL_8, 9)
	full speed and low speed	low speed signal quality downstream; full speed signal quality upstream; full speed signal quality downstream; inrush current upstream; drop downstream; droop downstream; back voltage

R&S®RTO-K22 Ethernet compliance test (10/100/1000BASE-T/EEE)

The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K22 performs Ethernet compliance test measurements with R&S®ScopeSuite, including tests for 10BASE-T, 100BASE-TX,1000BASE-T and Energy Efficient Ethernet (EEE) with the R&S®RTO. R&S®ScopeSuite supports the R&S®RT-ZF2 Ethernet compliance test fixture set as well as the R&S®RT-ZF4 and R&S®RT-ZF5 for EEE; R&S®ScopeSuite supports Windows 7, 8 and 10.

Supported Ethernet 10G compliance tests		
Standard reference		IEEE 802.3-2012
1000BASE-T	with/without disturber	with/without TX_CLK transmitter distortion (40.6.1.2.4)
		peak differential output voltage (40.6.1.2.1)
		maximum output droop (40.6.1.2.2)
		differential output templates (40.6.1.2.3)
	with TX_CLK	jitter master mode (40.6.1.2.5), jitter slave mode (40.6.1.2.5)
	without TX_CLK	jitter master mode (40.6.1.2.5)
	common	MDI return loss (40.8.3.1), common-mode output voltage (40.8.3.3)
100BASE-TX		amplitude domain tests (9.1.2.2, 9.1.3 and 9.1.4)
		rise and fall times (9.1.6)
		peak to peak duty cycle distortion (9.1.8)
		peak to peak transmitter jitter (9.1.9)
		active output interface template (annex J)
		transmitter return loss (9.1.5)
		receiver return loss (9.2.2)
10BASE-T	no TPM	link test pulse template (14.3.1.2.1)
		TP_IDL template (14.3.1.2.1)
		peak differential voltage (14.3.1.2.1)
		harmonic content (14.3.1.2.1)
		output timing jitter (14.3.1.2.3)
	with TPM	link test pulse template (14.3.1.2.1)
		TP_IDL template (14.3.1.2.1)
		MAU template (14.3.1.2.1)
		output timing jitter (14.3.1.2.3)
	common	transmitter return loss (14.3.1.2.2), receiver return loss (14.3.1.3.4)
		common-mode output voltage (14.3.1.2.5)

Supported EEE compliance tests		
Standard reference		IEEE 802.3-2012
1000BASE-T EEE (requires R&S®RT-ZF5)		quiet time (78.2)
		refresh time (master) (78.2)
		refresh time (slave) (78.2)
		wake state levels (40.6.1.2.7)
		transmitter timing jitter with TX_TCLK (master) (40.6.1.2.5)
		transmitter timing jitter with TX_TCLK (slave) (40.6.1.2.5)
		transmitter timing jitter without TX_TCLK (master) (40.6.1.2.5)
		transmitter timing jitter without TX_TCLK (master) (40.6.1.2.5)
100BASE-TX EEE (requires R&S®RT-ZF5)		sleep time (24.2.3.4 and 78.2)
		LPI quiet time (24.2.3.4 and 78.2)
		LPI refresh time (24.2.3.4 and 78.2)
		LPI transmitter timing jitter (24.2.3.4 and 78.2)
		transmit wake time (24.2.3.4 and 78.2)

10BASE-Te (requires R&S®RT-ZF4)	no TPM	link test pulse template (14.3.1.2.1)
		TP_IDL template (14.3.1.2.1)
		peak differential voltage (14.3.1.2.1)
		harmonic content (14.3.1.2.1)
		output timing jitter (14.3.1.2.3)
	with TPM	link test pulse template (14.3.1.2.1)
		TP_IDL template (14.3.1.2.1)
		MAU template (14.3.1.2.1)
		output timing jitter (14.3.1.2.3)
	common	transmitter return loss (14.3.1.2.2), receiver return loss (14.3.1.3.4)
		common mode output voltage (14.3.1.2.5)

R&S®RTO-K23 Ethernet compliance test (2.5/5/10GBASE-T)

The R&S®RTO-K23 option is available for R&S®RTO2022, R&S®RTO2024, R&S®RTO2032, R&S®RTO2034 and R&S®RTO2044 models only. The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K23 performs Ethernet compliance test measurements with R&S®ScopeSuite, including tests for 2.5GBASE-T, 5GBASE-T and 10GBASE-T with the R&S®RTO. R&S®ScopeSuite supports the R&S®RT-ZF2 Ethernet compliance test fixture set; R&S®ScopeSuite supports Windows 7, 8 and 10.

Supported Ethernet compliance tests		
Standard reference		IEEE 802.3-2012 and IEEE P802.3bz
2.5G/5GBASE-T		maximum output droop (126.5.3.1)
		transmitter nonlinear distortion (126.5.3.2)
		transmitter timing jitter master mode and clock frequency (126.5.3.3 and 126.5.3.5)
		transmitter timing jitter slave mode (126.5.3.3)
		transmitter power spectral density and power level (126.5.3.4)
		MDI return loss (126.6.2.1)
10GBASE-T		maximum output droop (55.5.3.1)
		transmitter linearity (55.5.3.2)
		transmitter timing jitter master mode (55.5.3.3)
		transmitter timing jitter slave mode (55.5.3.3)
		transmitter power spectral density (55.5.3.4) [12]
		transmitter power level (55.5.3.4) [12]
		transmitter clock frequency (55.5.3.5)
		MDI return loss (55.8.2.1)

[12] Requires an oscilloscope model with a bandwidth higher than or equal 3 GHz.

R&S®RTO-K24 Ethernet compliance test (100BASE-T1)

The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K24 performs 100BASE-T1 compliance test measurements with R&S®ScopeSuite. R&S®ScopeSuite supports the R&S®RT-ZF2, R&S®RT-ZF7A and R&S®RT-ZF8 Ethernet compliance test fixtures. The chapters after the test cases refer to IEEE 802.3-2018 and OPEN Alliance ECU specification version 2.0.

Supported 100BASE-T1 compliance tests		
100BASE-T1		transmitter output droop (96.5.4.1)
		transmitter distortion with and without disturber (96.5.4.2)
		transmitter timing jitter master mode (96.5.4.3)
		transmitter timing jitter slave mode (96.5.4.3)
		transmitter power spectral density (96.5.4.4)
		transmitter clock frequency (96.5.4.5)
		transmitter peak differential output (96.5.6)
		MDI return loss (96.7.1.3)
		MDI mode conversion Loss (96.8.2.2)
		MDI mode conversion Loss Adapter Verification (OABR_PMA_TX_06)
		MDI Common Mode Emission (OABR_PMA_TX_07)

R&S®RTO-K26 MIPI D-PHY compliance test

The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K26 performs D-PHY compliance test measurements with R&S®ScopeSuite. R&S®ScopeSuite supports Windows 7, 8 and 10. The numbers behind the test refer to the MIPI CTS for D-PHY V1.1.

Supported D-PHY compliance tests		
D-PHY	group 1 (7 tests): data lane LP-TX signaling requirements	data lane LP-TX Thevenin output high level voltage (V_{OH}) – 1.1.1
		data lane LP-TX Thevenin output low level voltage (V_{OL}) – 1.1.2
		data lane LP-TX from 15 % to 85 % rise time (T_{RLP}) – 1.1.3
		data lane LP-TX from 85 % to 15 % fall time (T_{FLP}) – 1.1.4
		data lane LP-TX slew rate versus C_{LOAD} ($\delta V/\delta t_{SR}$) – 1.1.5
		data lane LP-TX pulse width of exclusive-OR clock ($T_{LP\text{-}PULSE\text{-}TX}$) – 1.1.6
		data lane LP-TX period of exclusive-OR clock ($T_{LP\text{-}PER\text{-}TX}$) – 1.1.7
	group 2 (5 tests): clock lane LP-TX signaling requirements	clock lane LP-TX Thevenin output high level voltage (V_{OH}) – 1.2.1
		clock lane LP-TX Thevenin output low level voltage (V_{OL}) – 1.2.2
		clock lane LP-TX from 15 % to 85 % rise time (T_{RLP}) – 1.2.3
		clock lane LP-TX from 85 % to 15 % fall time (T_{FLP}) – 1.2.4
		clock lane LP-TX slew rate versus C_{LOAD} ($\delta V/\delta t_{SR}$) – 1.2.5
	group 3 (16 tests): data lane HS-TX signaling requirements	data lane HS entry: data lane T_{LPX} value – 1.3.1
		data lane HS entry: data lane $T_{HS\text{-}PREPARE}$ value – 1.3.2
		data lane HS entry: data lane $T_{HS\text{-}PREPARE} + T_{HS\text{-}ZERO}$ value – 1.3.3
		data lane HS-TX differential voltages $V_{OD(0)}$ and $V_{OD(1)}$ – 1.3.4
		data lane HS-TX differential voltage mismatch ΔV_{OD} – 1.3.5

		data lane HS-TX single-ended output voltages $V_{OHHS(DP)}$ and $V_{OHHS(DN)}$ – 1.3.6
		data lane HS-TX static common-mode voltages $V_{CMTX(1)}$ and $V_{CMTX(0)}$ – 1.3.7
		data lane HS-TX static common-mode voltage mismatch $\Delta V_{CMTX(1.0)}$ – 1.3.8
		data lane HS-TX dynamic common-level variations from 50 MHz to 450 MHz $\Delta V_{CMTX(LF)}$ – 1.3.9
		data lane HS-TX dynamic common-level variations above 450 MHz $\Delta V_{CMTX(HF)}$ – 1.3.10
		data lane HS-TX from 20 % to 80 % rise time t_R – 1.3.11
		data lane HS-TX from 80 % to 20 % fall time t_F – 1.3.12
		data lane HS exit: $T_{HS-TRAIL}$ value – 1.3.13
		data lane HS exit: from 30 % to 85 % post-EoT rise time T_{REOT} – 1.3.14
		data lane HS exit: T_{EOT} value – 1.3.15
		data lane HS exit: $T_{HS-EXIT}$ value – 1.3.16
D-PHY	group 4 (18 tests): clock lane HS-TX signaling requirements	clock lane HS entry: T_{LPX} value – 1.4.1
		clock lane HS entry: $T_{CLK-PREPARE}$ value – 1.4.2
		clock lane HS entry: $T_{CLK-PREPARE} + T_{CLK-ZERO}$ value – 1.4.3
		clock lane HS-TX differential voltages $V_{OD(0)}$ and $V_{OD(1)}$ – 1.4.4
		clock lane HS-TX differential voltage mismatch ΔV_{OD} – 1.4.5
		clock lane HS-TX single-ended output voltages $V_{OHHS(DP)}$ and $V_{OHHS(DN)}$ – 1.4.6
		clock lane HS-TX static common-mode voltages $V_{CMTX(1)}$ and $V_{CMTX(0)}$ – 1.4.7
		clock lane HS-TX static common-mode voltage mismatch $\Delta V_{CMTX(1,0)}$ – 1.4.8
		clock lane HS-TX dynamic common-level variations from 50 MHz to 450 MHz $\Delta V_{CMTX(LF)}$ – 1.4.9
		clock lane HS-TX dynamic common-level variations above 450 MHz $\Delta V_{CMTX(HF)}$ – 1.4.10
		clock lane HS-TX from 20 % to 80 % rise time t_R – 1.4.11
		clock lane HS-TX from 80 % to 20 % fall time t_F – 1.4.12
		clock lane HS exit: $T_{CLK-TRAIL}$ value – 1.4.13
		clock lane HS exit: from 30 % to 85 % post-EoT rise time T_{REOT} – 1.4.14
		clock lane HS exit: T_{EOT} value – 1.4.15
		clock lane HS exit: $T_{HS-EXIT}$ value – 1.4.16
		clock lane HS clock instantaneous: UI_{INST} value – 1.4.17
		clock lane HS clock delta UI: (ΔUI) value – 1.4.18
	group 5 (6 tests): HS-TX clock-to-data lane timing requirements	HS entry: $T_{CLK-PRE}$ value – 1.5.1
		HS exit: $T_{CLK-POST}$ value – 1.5.2
		HS clock rising edge alignment to first payload bit – 1.5.3
		data-to-clock skew ($T_{SKEW[TX]}$) – 1.5.4
		initial HS skew calibration burst $T_{SKEWCAL-SYNC}$ $T_{SKEWCAL}$– 1.5.5
		periodic HS skew calibration burst $T_{SKEWCAL-SYNC}$ $T_{SKEWCAL}$– 1.5.6

R&S®RTO-K27 MIPI D-PHY 2.5 compliance test

The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K27 performs D-PHY compliance test measurements with R&S®ScopeSuite. R&S®ScopeSuite supports Windows 7, 8 and 10. The numbers behind the test refer to the MIPI CTS for D-PHY V2.0, V2.1 and V2.5.

Supported D-PHY compliance tests		
D-PHY	group 1 (7 tests): data lane LP-TX signaling requirements	data lane LP-TX Thevenin output high level voltage (V_{OH}) – 1.1.1
		data lane LP-TX Thevenin output low level voltage (V_{OL}) – 1.1.2
		data lane LP-TX from 15 % to 85 % rise time (T_{RLP}) – 1.1.3
		data lane LP-TX from 85 % to 15 % fall time (T_{FLP}) – 1.1.4
		data lane LP-TX slew rate versus C_{LOAD} ($\delta V/\delta t_{SR}$) – 1.1.5
		data lane LP-TX pulse width of exclusive-OR clock ($T_{LP\text{-}PULSE\text{-}TX}$) – 1.1.6
		data lane LP-TX period of exclusive-OR clock ($T_{LP\text{-}PER\text{-}TX}$) – 1.1.7
	group 2 (5 tests): clock lane LP-TX signaling requirements	clock lane LP-TX Thevenin output high level voltage (V_{OH}) – 1.2.1
		clock lane LP-TX Thevenin output low level voltage (V_{OL}) – 1.2.2
		clock lane LP-TX from 15 % to 85 % rise time (T_{RLP}) – 1.2.3
		clock lane LP-TX from 85 % to 15 % fall time (T_{FLP}) – 1.2.4
		clock lane LP-TX slew rate versus C_{LOAD} ($\delta V/\delta t_{SR}$) – 1.2.5
	group 3 (16 tests): data lane HS-TX signaling requirements	data lane HS entry: data lane T_{LPX} value – 1.3.1
		data lane HS entry: data lane $T_{HS\text{-}PREPARE}$ value – 1.3.2
		data lane HS entry: data lane $T_{HS\text{-}PREPARE} + T_{HS\text{-}ZERO}$ value – 1.3.3
		data lane HS-TX differential voltages $V_{OD(0)}$ and $V_{OD(1)}$ – 1.3.4
		data lane HS-TX differential voltage mismatch ΔV_{OD} – 1.3.5
		data lane HS-TX single-ended output voltages $V_{OHHS(DP)}$ and $V_{OHHS(DN)}$ – 1.3.6
		data lane HS-TX static common mode voltages $V_{CMTX(1)}$ and $V_{CMTX(0)}$ – 1.3.7
		data lane HS-TX static common mode voltage mismatch $\Delta V_{CMTX(1.0)}$ – 1.3.8
		data lane HS-TX dynamic common-level variations from 50 MHz to 450 MHz $\Delta V_{CMTX(LF)}$ – 1.3.9
		data lane HS-TX dynamic common-level variations above 450 MHz $\Delta V_{CMTX(HF)}$ – 1.3.10
		data lane HS-TX from 20 % to 80 % rise time t_R – 1.3.11
		data lane HS-TX from 80 % to 20 % fall time t_F – 1.3.12
		data lane HS exit: $T_{HS\text{-}TRAIL}$ value – 1.3.13
		data lane HS exit: from 30 % to 85 % post-EoT rise time T_{REOT} – 1.3.14
		data lane HS exit: T_{EOT} value – 1.3.15
		data lane HS exit: $T_{HS\text{-}EXIT}$ value – 1.3.16

D-PHY	group 4 (19 tests): clock lane HS-TX signaling requirements	clock lane HS entry: T_{LPX} value – 1.4.1
		clock lane HS entry: $T_{CLK-PREPARE}$ value – 1.4.2
		clock lane HS entry: $T_{CLK-PREPARE}$ + $T_{CLK-ZERO}$ value – 1.4.3
		clock lane HS-TX differential voltages $V_{OD(0)}$ and $V_{OD(1)}$ – 1.4.4
		clock lane HS-TX differential voltage mismatch ΔV_{OD} – 1.4.5
		clock lane HS-TX single-ended output voltages $V_{OHHS(DP)}$ and $V_{OHHS(DN)}$ – 1.4.6
		clock lane HS-TX static common mode voltages $V_{CMTX(1)}$ and $V_{CMTX(0)}$ – 1.4.7
		clock lane HS-TX static common mode voltage mismatch $\Delta V_{CMTX(1, 0)}$ – 1.4.8
		clock lane HS-TX dynamic common-level variations from 50 MHz to 450 MHz $\Delta V_{CMTX(LF)}$ – 1.4.9
		clock lane HS-TX dynamic common-level variations above 450 MHz $\Delta V_{CMTX(HF)}$ – 1.4.10
		clock lane HS-TX from 20 % to 80 % rise time t_R – 1.4.11
		clock lane HS-TX from 80 % to 20 % fall time t_F – 1.4.12
		clock lane HS exit: $T_{CLK-TRAIL}$ value – 1.4.13
		clock lane HS exit: from 30 % to 85 % post-EoT rise time T_{REOT} – 1.4.14
		clock lane HS exit: T_{EOT} value – 1.4.15
		clock lane HS exit: $T_{HS-EXIT}$ value – 1.4.16
		clock lane HS clock instantaneous: UI_{INST} value – 1.4.17
		clock lane HS clock delta UI: (ΔUI) value – 1.4.18
		TX spread spectrum clocking (SSC) requirements (1.4.19)
	group 5 (9 tests): HS-TX clock-to-data lane timing requirements	HS entry: $T_{CLK-PRE}$ value – 1.5.1
		HS exit: $T_{CLK-POST}$ value – 1.5.2
		HS clock rising edge alignment to first payload bit – 1.5.3
		data-to-clock skew ($T_{SKEW[TX]}$) – 1.5.4
		initial HS skew calibration burst $T_{SKEWCAL-SYNC}$ $T_{SKEWCAL}$– 1.5.5
		periodic HS skew calibration burst $T_{SKEWCAL-SYNC}$ $T_{SKEWCAL}$– 1.5.6
		alternate calibration sequence $T_{ALTCAL-SYNC}$ and T_{ALTCAL} – 1.5.8
		preamble sequence $T_{PREAMBLE}$ and $T_{EXTSYNC}$ – 1.5.9
		clock and data lane TX HS-Idle $T_{HS-IDLE-POST}$, $T_{HS-IDLE-CLKHS0}$, $T_{HS-IDLE-PRE}$ – 1.5.10
	eye test (3 tests)	clock lane HS clock delta UI (ΔUI) –1.4.18
		clock lane HS clock period jitter –1.4.20
		HS-TX data and clock eye diagram –1.5.7

R&S®RTO-K31 power analysis

General description	The R&S®RTO-K31 power analysis option extends the R&S®RTO firmware with measurement functionality focused on switched mode power supplies (SMPS) and DC/DC converters.	
Input	quality	evaluation of power quality at an AC input; measures real power, apparent power, reactive power, power factor and phase angle of power, frequency, crest factor, RMS of voltage and current
	harmonics	measures up to the 40th harmonic of the incoming line frequency; precompliance checking for IEC 61000-3-2 (A, B, C, D), RTCA DO-160, MIL-STD-1399, max. limit checks
	inrush current	measures peak inrush current; multiple measurement zones configurable with analysis of the post-inrush behavior
Switching/control loop	slew rate	The slope of current or voltage is measured at start and end of the switching cycle.
	modulation	measures modulation of switching frequency and duty cycle under steady state and start-up conditions
	dynamic on-resistance	measures resistance of the switching transistor(s) in active state
Power path	efficiency (only for 4 channel devices)	measures input and output power to calculate the efficiency of an SMPS
	loss	measures switching loss and conduction loss of a power device
	safe operating area (SOA)	checks violation of voltage and current limits in which a power device can operate without damage; current versus voltage view (linear or log); violation mask is user-defined and editable in linear and log-log views
	turn on/off	measures relationship between AC and DC current, when turning the SMPS off and on
Output	ripple	measures AC components of output voltage and current, AC RMS, frequency, duty cycles, min./max./peak-to-peak amplitude
	spectrum	FFT analysis of output, measurement of frequency peaks
	transient response	This measurement captures the device behavior between the event of load changes and stabilization; includes peak (voltage, time), settling time, rise time, overshoot and delay
Deskew	automated	By using the R&S®RT-ZF20 probe deskew and calibration test fixture and Rohde & Schwarz voltage and current probes, the skew between the voltage and current signal is compensated automatically.
Reporting	easy reporting: Click to save a measurement. Report generation using user-selected test results from historical and currently active tests. Put repeated and/or different measurements in one report.	

R&S®RTO-K35 bus analysis

General description	The R&S®RTO-K35 bus analysis option adds bus measurements and analysis functions for dedicated protocols.	
	supported protocol options	R&S®RTO-K1 (I^2C, SPI), R&S®RTO-K2 (UART), R&S®RTO-K3 (CAN, LIN), R&S®RTO-K8 (Ethernet), R&S®RTO-K9 (CAN-FD), R&S®RTO-K10 (SENT), R&S®RTO-K40 (RFFE), R&S®RTO-K57 (100BASE-T1)
Measurements	field value	allows for the selection of frame types and displays the value of a specified field; the value can be displayed as track and histogram
	frame to frame	measures the distance between the starts of two selectable frame types in seconds
	trigger to frame	measures the distance between the trigger event and the start of a selectable frame type in seconds; alternatively, it measures the distance between the start of a selectable frame type and the trigger event
	frame count	counts the total number of frames in each acquisition
	gap time	measures the distance between the end of a selectable frame type to the start of another selectable frame type in seconds
	bus idle ratio	measures the percentage of idle time on a bus; idle time is defined as the time where the bus is not occupied by frames
	main bit rate	measures the main bit rate of a protocol based on the relevant bits in a frame; if a protocol provides multiple bit rates, the most relevant bit rate is being measured
	secondary bit rate	for protocols with multiple bit rates, the secondary bit rate is available
	frame error count	counts the total number of erroneous frames in each acquisition
	frame error rate	measures the percentage of erroneous frames in relation to the total frames
	consecutive frame error rate	measures the percentage of follow up (consecutive) frame errors, ignoring all single frame errors

R&S®RTO-K39 user-defined math

General description	The R&S®RTO-K39 user-defined math option provides a Python interface to apply user functions defined by Python scripts to the waveform processing. The output can be visualized as a waveform math signal.

R&S®RTO-K40 MIPI RFFE serial triggering and decoding

Protocol configuration	signal type	two channel, single-ended
	bit rate	auto-detected
	auto threshold setup	assisted threshold configuration
	full autoset	full autoset of horizontal and vertical settings and auto threshold setup
	source (SCLK, SDATA)	any two input channels, math waveforms, reference waveforms, or logical channels
	supported version	1.X, 2.0,2.1 and 3.0
	read mode	standard or sRead mode
	glitch filter	configurable glitch filter
	gap detection	detect gaps between sequences

Trigger	trigger event setup	sequence start, sequence stop, register 0 write, register write, register read, extended register write, extended register read, extended register write long, extended register read long, error condition types
	sequence start setup	4 bit slave address; conditions =, ≠, <, ≤, >, ≥, in range, out of range
	sequence stop setup	4 bit slave address; conditions =, ≠, <, ≤, >, ≥, in range, out of range
	register 0 write setup	4 bit slave address, 7 bit data word; conditions =, ≠, <, ≤, >, ≥, in range, out of range for each of these options
	register write/read	4 bit slave address, 5 bit register address, 8 bit data word; conditions =, ≠, <, ≤, >, ≥, in range, out of range for each of these options
	extended register write/read	4 bit slave address; 8 bit address, byte count: 0 to 15 (inclusive), data pattern: 1 to 16 byte (hex or binary); conditions =, ≠, <, ≤, >, ≥, in range, out of range for each of these options; index: 1 to 16 selects the specific data frame byte; conditions =, ≠, <, ≤, >, ≥, in range
	extended register write long/read long	4 bit slave address, 8 bit address, byte count: 0 to 7 (inclusive), data pattern: 0 to 8 byte (hex or binary); conditions =, ≠, <, ≤, >, ≥, in range, out of range for each of these options; index: 1 to 8 selects the specific data frame byte; conditions =, ≠, <, ≤, >, ≥, in range
	interrupt summary and notification	4 bit slave address, bit count 0 to 32, notification and interrupt bits
	masked write	4 bit slave address; 8 bit address, 8 bit mask, 8 bit data pattern; conditions =, ≠, <, ≤, >, ≥, in range, out of range for each of these options; frame byte; conditions =, ≠, <, ≤, >, ≥, in range
	master ownership handover	2 bit MID; conditions =, ≠, <, ≤, >, ≥, in range, out of range for each of these options; frame byte; conditions =, ≠, <, ≤, >, ≥, in range
	master write/read	2 bit MID, 8 bit address, 16 bit data pattern; conditions =, ≠, <, ≤, >, ≥, in range, out of range for each of these options; frame byte; conditions =, ≠, <, ≤, >, ≥, in range
	master context transfer write/read	2 bit MID, 8 bit byte count, 8 bit address, data pattern: 1 to 8 byte (hex or binary); conditions =, ≠, <, ≤, >, ≥, in range, out of range for each of these options; index: 1 to 256 selects the specific data frame byte; conditions =, ≠, <, ≤, >, ≥, in range
	error condition	SSC error; length error, bus park error, parity error, no response, unknown sequence, version error, min. gap between frames: 1 ns to 10 us

Decode	display type	decoded bus, logical signal, bus + logical signal, tabulated list, decode layers
	color coding	sequence, frame, error
	data format	hex, octal, binary, ASCII, signed, unsigned
	decode layer	off, edges, bit
Search	search event setup	sequence start, sequence stop, register 0 write, register write, register read, extended register write, extended register read, extended register write long, extended register read long, master read, master write, master ownership handover, interrupt summary and notification, error condition types
	event settings	same as trigger event settings

R&S®RTO-K42 MIPI D-PHY serial triggering and decoding

Protocol configuration	signal type	clock, data (differential or single-ended)
	bit rate	selectable without clock lane (1 Mbps to 2.5 Gbps), auto detect with clock lane
	source	any input channels, math waveforms, reference waveforms
	variants	D-PHY v. 1.2, CSI-2 v.1.2, DSI v. 1.3
Trigger	trigger event setup	HS start of packet, HS end of packet, HS packet header, HS data, LP escape mode, LP lane turnaround, LP HS request
	HS packet header setup	virtual channel, data type, word count; conditions =, ≠, <, ≤, >, ≥, in range, out of range for data and word count
	HS data	virtual channel, data type, word count, data value, data index; conditions =, ≠, <, ≤, >, ≥, in range, out of range for data count, word count, data value
	LP escape mode	escape mode, data value, data index; conditions =, ≠, <, ≤, >, ≥, in range, out of range for escape mode and data value
Decode	display type	decoded bus, tabulated list, details, decode layers
	color coding	high speed: frames according to trace, cells; low power: escape word, data word
	data format	hex, octal, binary, signed, unsigned
	decode layer	off, HS edges, HS binary, HS burst bits, HS burst bytes, HS merged bytes, HS merged words, LP edges, LP states, LP active states, LP binary
	result export	export of all result data into CSV, XML, HTM and PY file formats
Search	search event setup	HS start of packet, HS end of packet, HS packet header, HS data, LP escape mode, LP lane turnaround, LP HS request
	event settings	same as trigger event setup

R&S®RTO-K44 MIPI M-PHY serial triggering and decoding

Protocol configuration	signal type	up to 4 channels, differential
	bit rate	clock recovery
	source (SDATA)	analog and math channels, reference waveforms
	variants	UniPro 1.6 and M-PHY 4.0
Trigger	trigger event setup	M-PHY burst, M-PHY adapt, M-PHY LCC, UniPro DL_PDU frames, UniPro PACP frames, UniPro trigger upper frames, M-PHY/UniPro errors
Decode	display type	decoded bus, logical signal, bus + logical signal, tabulated list, details, decode layers
	color coding	for different cells/frame types
	data format	K/D symbols; with UniPro additionally: hex, octal, binary, signed, unsigned
	decode layer	off, edges, bit, 8b/10b symbols, LCC bits; with UniPro additionally: filter/descrambler, lane merge, byte
Search	search event setup	M-PHY burst, M-PHY adapt, M-PHY LCC, UniPro DL_PDU frames, UniPro PACP frames, UniPro trigger upper frames, M-PHY/UniPro errors

R&S®RTO-K50 Manchester and NRZ serial triggering and decoding

Protocol configuration	signal type	selectable, one channel, differential or single-ended, two channel, differential or single-ended
	bit rate	auto detected, adjustable
	auto threshold setup	assisted threshold configuration
	source	analog, math. channels, logical (only NRZ)
	bit encoding variants	Manchester, Manchester II, NRZ clocked, NRZ unclocked
	properties	active state (high/low), idle state (high/low), clock edge (first/second)
	frame separation	gap, enable signal (only NRZ)
Frame format	frame	multiple frame management, frame identification and sync, variable length frames, variable number of cells
	cells	name, size (bits), numeric format, bit order, color
	file storage of frame format	save/load as xml files
Trigger	variants	all supported bit encodings
	trigger event setup	frame start, pattern, advanced trigger
	frame start	gap, start bit
	pattern	up to 256 bit pattern within 65 535 bit frame [13]
	advanced trigger	frame type (with OR combinations), frame fields (with AND combinations), frame field data; conditions =, ≠, <, ≤, >, ≥, in range, out of range for data count, word count, data value; error types
Decode	display type	decoded bus, logical signal, bus signal, tabulated list, result details, decode layers
	color coding	according to cell configuration table
	data format	according to cell configuration table
	decode layer	edges, binary
Search	event settings	same as advanced trigger settings
Filter	The filter function selects those decode events that shall be shown in the result table. Events that do not match the criteria set will not be displayed in the table when the filter is turned on.	
	settings	same as advanced trigger settings

[13] The pattern trigger will not be effective after Manchester violations.

R&S®RTO-K52 8b10b serial triggering and decoding

8b10b decoding		
Protocol configuration	signal type	one/two channel, differential, single-ended
	bit rate	selectable/adjustable auto configuration, ideal for bitrate up to 6.25 Gbit/s
	auto threshold setup	assisted threshold configuration
	one click setup	convenient way for perfect decode results; auto scaling of waveforms, auto threshold and bitrate estimation on one click
	source (differential, single-ended D+/D–)	full combination of either analog, math, reference channels
	variants	all layer 1 (physical layer) encoded 8b/10b protocols, recommended for Ethernet, FibreChannel 1G, 2G, PCI Express, Serial ATA, Serial Rapid IO (SRIO), XAUI
Trigger	trigger event setup	symbols, errors
	symbols	K/D symbol (8 bit/10 bit), complex expression (combination of K/D symbols, wildcards, disparity)
	errors	disparity, glitching and unknown symbol
Decode	display type	decoded bus, bus signal, tabulated list, details, decode layers
	color coding	sync symbol, K symbols, data (Dx.y) coding and error coding
	data format	hex, 10bit and K/D representation
	decode layer	edges, bit
Search	search event setup	symbols, errors
	event settings	same as trigger event settings

R&S®RTO-K55 MDIO serial triggering and decoding

Protocol configuration	bit rate	up to 5 Mbps (auto-detected)
	auto threshold setup	assisted threshold configuration for MDIO triggering and decoding
	device list	associate frame address with symbolic ID
Trigger	source (clock and data)	any input channel or logical channel
	trigger event setup	start, stop, ST, OP, PHY address, register address, data
	ST setup	01 (clause 22), 00 clause 45, any
	OP setup	address, write, post read, read, any
	PHY address setup	5 bit address (hex, decimal, octal or binary); equal
	PHY register (clause 22)/device type (clause 45) setup	5 bit value (hex, decimal, octal or binary); equal
	data (clause 22)/data/address (clause 45)	16 bit value (hex, decimal, octal or binary); equal
Decode	source (clock and data)	any input channel, math waveform, reference waveform, logical channel
	display type	decoded bus, logical signal, bus + logical signal, tabulated list, decode layers
	color coding	frame, PHY address, PHY register, address, data, turnaround
	PHYAD/PRTAD	symbolic names for user-defined addresses
	address/data field format	hex, decimal, octal, binary, ASCII
	decode layer	edges, binary
Search	source (clock and data)	any input channel, math waveform, reference waveform, logical channel
	search event setup	start, stop, ST, OP, PHY address, register address, data
	event settings	same as trigger event settings

R&S®RTO-K57 Ethernet (100BASE-T1) serial triggering and decoding

Protocol configuration	signal type	one channel differential, two channels single-ended, optional additional use of reverse channels for signal improvement: one channel differential, two channels single-ended
	symbol rate	66.667 Msymbol/s, adjustable for testing
	thresholds	upper/lower, assisted threshold configuration
	source	any analog input channels, math waveforms, reference waveforms
	polarity	normal, inverted
	mode	slave, master
Trigger	trigger event setup	frame start, MAC frame, idle frame, error conditions
	MAC frame setup	destination address (condition =, ≠, <, >, ≥, ≤, in range, out of range), source address (condition =, ≠, <, >, ≥, ≤, in range, out of range), length/type (condition =, ≠, <, >, ≥, ≤, in range, out of range), frame check (condition =, ≠, <, >, ≥, ≤, in range, out of range), data (condition =, ≠, <, >, ≥, ≤, in range, out of range), data index (condition =, <, >, ≥, ≤, range)
	error condition setup	preamble error, CRC error, SFD error
Decode	display type	decoded bus, tabulated list, details, decode layers
	color coding	for different cells types
	data format	hex, octal, binary, signed, unsigned
	decode layer	reversed bits, descrambled bits, scrambled bits, ternary symbols
	result export	export of all result data into CSV, XML, HTM and PY file formats
Search	search event setup	frame start, MAC frame, idle frame, error conditions
	event settings	same as trigger event settings

R&S®RTO-K58 Ethernet (1000BASE-T1) serial triggering and decoding

Protocol configuration	signal type	one channel differential, two channels single-ended, optional additional use of reverse channels for signal improvement: one channel differential, two channels single-ended
	symbol rate	750 Msymbol/s, adjustable for testing
	thresholds	automatically adjusted during decoding
	source	any analog input channels, math waveforms, reference waveforms
	polarity	normal, inverted
	mode	slave, master
Trigger	trigger event setup	frame start, MAC frame, idle frame, error conditions
	MAC frame setup	destination address (condition =, ≠, <, >, ≥, ≤, in range, out of range), source address (condition =, ≠, <, >, ≥, ≤, in range, out of range), length/type (condition =, ≠, <, >, ≥, ≤, in range, out of range), frame check (condition =, ≠, <, >, ≥, ≤, in range, out of range), data (condition =, ≠, <, >, ≥, ≤, in range, out of range), data index (condition =, <, >, ≥, ≤, range)
	error condition setup	RS-FEC error, out of range error, CRC error, SFD error
Decode	display type	decoded bus, tabulated list, details, decode layers
	color coding	for different cells types
	data format	hex, octal, binary, signed, unsigned
	decode layer	ternary symbols, scrambled bits, descrambled bits, corrected RS-FEC symbols
	result export	export of all result data into CSV, XML, HTM and PY file formats
Search	search event setup	frame start, MAC frame, idle frame, error conditions
	event settings	same as trigger event settings

R&S®RTO-K60 USB 1.0/1.1/2.0 serial triggering and decoding

Protocol configuration	signal type	single-ended, differential
	protocol type	low, full, high speed and HSIC
	bit rate	standard bit rates (1.5/12/480 Mbit/s)
	source	any input channel
	probe type	
	for low and full speed	single-ended probe
	for high speed	differential probe (R&S®RT-ZDx)
	for HSIC	single-ended probe(R&S®RT-ZSx)
	auto threshold setup	assisted threshold configuration for USB triggering and decoding
Trigger	trigger event setup	start of packet, end of packet, PID token (IN, OUT, SETUP, SOF), PID data (Data0, Data1, Data2 [14], MData [14]), PID handshake (ACK, NAK, STALL, NYET [14]), PID special (PRE [15], ERR [14], SPLIT [14], PING [14]); bus state (reset [15], resume [15], suspend [15]); error condition
	address, endpoint and frame setup SC, port, SEU, ET check (SPLIT) [15]	condition =, ≠, ≥, ≤, in range, out of range
	data setup	data pattern up to 4 byte (hex, decimal, octal, binary or ASCII), bit separately configurable (1, 0 or don't care); condition =, ≠; position based or window based triggering (first occurrence in packet payload)
	error condition	any error, PID error, CRC5 error, CRC16 error, bit stuffing error, unexpected PID, SE1 error [15] and glitching error
Decode	source	any input channel, math waveform
	display type	decoded bus, logical signal, bus + logical signal, tabulated list
	color coding	packet identifier, payload length, frame, address, endpoint, data payload, CRC5, CRC16, error condition
	data format	hexadecimal, decimal, octal, binary, ASCII, unsigned
Search	search event setup	combination of start of packet, PID token (IN, OUT, SETUP, SOF), PID data (Data0, Data1, Data2 [14], MData [14]), PID handshake (ACK, NAK, STALL, NYET [14]), PID special (PRE [15], ERR [14], SPLIT [14], PING [14]); error condition (any error, PID error, CRC5 error, CRC16 error, bit stuffing error, unexpected PID, SE1 error [15] and glitching error)
	address, endpoint and frame setup SC, port, SEU, ET check (SPLIT)	condition =, ≠, ≥, ≤, in range, out of range
	data setup	data pattern up to 4 byte (hex, decimal, octal, binary or ASCII), bit separately configurable (1, 0 or don't care); condition =, ≠; position based or window based triggering (first occurrence in packet payload)
	error condition	any error, PID error, CRC5 error, CRC16 error, bit stuffing error, unexpected PID, SE1 error [15] and glitching error

[14] Only available in high speed and HSIC.

[15] Only available in low and full speed.

R&S®RTO-K61 USB 3.1 Gen 1 serial triggering and decoding

The R&S®RTO-K61 is suitable for R&S®RTO2064 models only.

Protocol configuration	signal type	one channel
	bit rate	auto detected
	auto threshold setup	supported
	source	any analog input channels, math channels, reference channels
	scrambling	selectable
	digital signal processing	CTLE continuous time equalizer; DFE decision feedback equalizer
Trigger	trigger event setup	frame start, frame content, errors
	frame content	USB packet types: TSEQ, TSET1, TSET2, set link function, U2 inactivity timeout, vendor device test, port capability, port configuration, port, config. resp., link delay meas, ACK, NRDY, ERDY, STATUS, STALL, function wake, latency tolerance, bus interval, adjust, host role request, sublink speed, ping, ping response, data packet header, data packet payload, DPP aborted, isochronous timestamp, link command, info, BRST, BDAT, BERC, BCNT, idle; fields according to selected USB packet with content conditions =, ≠, <, >, ≥, ≤, in range, out of range
	errors	CRC, length, value out of range
Decode	display type	decoded bus, tabulated list, details, decode layers
	color coding	cell and frame types
	data format	hexadecimal, octal, binary, ASCII, signed, unsigned, 8b/10b symbols
	decode layer	edges, bit, scrambled symbols, descrambled symbols, byte
	result export	export of all result data into CSV, XML, HTM and PY file formats
Search	search event setup	frame start, frame content, errors
	event settings	same as trigger event settings

R&S®RTO-K63 USB power delivery serial triggering and decoding

Protocol configuration	signal type	one channel
	bit rate	auto detected
	source	any analog input channel, logical channels, math channels, reference channels
	thresholds	data, advertisements
	data details	detailed breakdown selectable
Trigger	trigger event setup	frame start
		frame content
		errors
	frame content	extended, NumDataObjs, MsgID, PwrRole/Plug, Rev, DataRole, MsgType, voltage advertisements (content conditions =, ≠, <, >, ≥, ≤, in range, out of range)
	errors	4b/5b, preamble, CRC, length, SOP warning
Decode	display type	decoded bus, logical signal, bus + logical signal, tabulated list, details, decode layers
	color coding	cell and frame types
	data format	hex, octal, binary, signed, unsigned
	decode layer	edges, bits, 4b5b symbols
Search	search event setup	frame start
		frame content
		errors
	event settings	same as trigger event settings

R&S®RTO-K64 USB 3.1 SSIC serial triggering and decoding

Protocol configuration	signal type	up to 4 lanes differential
	bit rate	auto detected
	source	any analog input channels, math channels, reference channels
	scrambling	selectable
	digital signal processing	CTLE continuous time equalizer; DFE decision feedback equalizer
Trigger	trigger event setup	frame start, frame content, errors
	frame content	USB packet types: TSEQ, TSET1, TSET2, set link function, U2 inactivity timeout, vendor device test, port capability, port configuration, port, config. resp., link delay meas, ACK, NRDY, ERDY, STATUS, STALL, function wake, latency tolerance, bus interval, adjust, host role request, sublink speed, ping, ping response, data packet header, data packet payload, DPP aborted, isochronous timestamp, link command, info, BRST, BDAT, BERC, BCNT, idle; fields according to selected USB packet with content conditions =, ≠, <, >, ≥, ≤, in range, out of range
	errors	CRC, length, value out of range
Decode	display type	decoded bus, tabulated list, details, decode layers
	color coding	cell and frame types
	data format	hex, octal, binary, signed, unsigned
	decode layer	edges, bit, byte, 8b/10b symbols, LCC bits, descrambler, lane merge
Search	search event setup	frame start, frame content, errors
	event settings	same as trigger event settings

R&S®RTO-K65 SpaceWire serial triggering and decoding

Protocol configuration	signal type	two channels: strobe and data (differential or single-ended)
	bit rate	auto adjust (strobe + data)
	source	any analog input channels, logical channels [16], math channels, reference channels
Trigger	trigger event setup	control frame, data pattern, null frame, time code, error condition
	control frame setup	any, FCT, EOP, EEP
	data pattern setup	8 bit (condition =, ≠, <, >, ≥, ≤, in range, out of range)
	time code setup	8 bit (condition =, ≠, <, >, ≥, ≤, in range, out of range)
	errors condition setup	parity, ESC
Decode	display type	decoded bus, logical signal, bus + logical signal, tabulated list, decode layers
	color coding	control frame, data frame, null frame, time code
	data format	hex, octal, binary, signed, unsigned
Search	search event setup	control frame, data pattern, null frame, time code, error
	event settings	same as trigger event settings

[16] SpaceWire protocol trigger on logical channels is not available.

R&S®RTO-K72 PCI Express 1.1/2.0 serial triggering and decoding

The R&S®RTO-K72 is suitable for R&S®RTO2064 models only.

Protocol configuration	signal type	up to four channels (×1, ×2, ×4 link size) differential signals
	bit rate	predefined 2.5 Gbit/s for Gen 1 and 5 Gbit/s for Gen 2
	source	any analog input channels, math channels, reference channels
	digital signal processing	CTLE continuous time equalizer; DFE decision feedback equalizer
Trigger	trigger event setup	TLP (transaction layer packets), DLLP (data layer packets), ordered sets, errors
	transaction layer packets (TLP)	any type, memory request (32/64 bit, R/W, ordering, snoop, seq. number, requester ID), I/O transactions, configuration requests, message requests (incl. routing and message code), completion packets (status, completer ID), atomic operation (FetchAdd, SWAP, CAS) for 32/64 bit
	data layer packets (DLLP)	any type, Ack and Nak (seq. number), InitFC1, InitFC2, updateFC (credit type C, NP, Cpl and virtual channel), power management with PM type, vendor packet format. multi-root I/O virtualization (MRDLLP): MRInit (phase, VH FC, mixed type, authorized, device/port type), MRReset (A, VH Group), MRUpdateFC, MRInitFC1 and MRInitFC2 (VL number, VH absent, TLP type, credit type)
	ordered sets	SKP OS, training sequence (TS1, TS2), fast training sequence (FTS), electrical idle OS, electrical idle exit OS, compliance and modified compliance pattern
	errors condition setup	CRC16, ECRC, LCRC, disparity, invalid packets (corrupt header or length errors)
Decode	display type	decoded bus, tabulated list, decode layers, detailed result display for packets
	color coding	TLP, DLLP, K-code, D-code, ordered sets, errors
	data format	K/D symbol, 8 bit format (hex)
	decode layer	8b10b, descrambled 8b10b, bit
	result export	export of all result data into CSV, XML, HTM and PY file formats
Search	search event setup	TLP, DLLP, ordered sets, errors
	event settings	same as trigger event settings

R&S®RTO-K76 CXPI serial triggering and decoding

Protocol configuration	signal type	one channel
	bit rate	auto-detected/adjustable
	auto threshold setup	assisted threshold configuration
	source (SDATA)	any input channels, math waveforms, reference waveforms or logical channels
Trigger	trigger event setup	frame start, frame types with frame content, error condition
	frame types	normal, normal poll, sleep, long, long poll, PID, PTYPE, PTYPE+PID
	frame content (depending on frame type)	frame ID, NW, CT, DLC, data pattern
	data pattern setup	up to 8 byte (condition =, ≠, <, >, ≥, ≤, in range, out of range), payload data index (=, <, >, ≥, ≤, range)
	error condition setup	IFS, IBS, CRC, length, parity, UART, DLC
Decode	display type	decoded bus, logical signal, bus + logical signal, tabulated list, details, decode layers
	color coding	for different cell types
	data format	hex, octal, binary, signed, unsigned
Search	search event setup	frame start, frame types with data, error types
	event settings	same as trigger event settings

R&S®RTO-K81 PCI Express 1.1/2.0 compliance test

The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K81 performs PCIe 1.x/2.0 (up to 2.5GT/s) compliance test measurements with R&S®ScopeSuite. R&S®ScopeSuite supports Windows 7, 8 and 10. The option can only be used with an R&S®RTO2064. The chapters after the category refer to PCI Express Base Specification Revision 1.1 and 2.1.

Supported PCIe compliance tests		
PCIe 1.1	signal quality (4.3.3)	mean unit interval
		data rate
		template tests
		min eye width
		median to max jitter
		differential output voltage
	reference clock (1.32)	differential input high voltage
		differential input low voltage
		duty cycle
		average clock period
		rising edge rate
		falling edge rate
PCIe 2.0	signal quality (4.3.3)	mean unit interval
		data rate
		template tests
		min eye width
		median to max jitter
		differential output voltage

R&S®RTO-K87 Ethernet compliance test (1000BASE-T1)

The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K87 performs 1000BASE-T1 compliance test measurements with R&S®ScopeSuite. R&S®ScopeSuite supports the R&S®RT-ZF6 frequency converter and R&S®RT-ZF7A and R&S®RT-ZF8 test fixtures; R&S®ScopeSuite supports Windows 7, 8 and 10. The option can only be used with an R&S®RTO with a bandwidth ≥ 2 GHz. The chapters in front of the test cases refer to IEEE 802.3-2018 OPEN Alliance ECU specification supported, where applicable.

Supported 1000BASE-T1 compliance tests	
1000BASE-T1	97.5.3.3 transmitter timing jitter master mode
	97.5.3.3 transmitter timing jitter slave mode
	97.5.3.3 transmitter timing MDI jitter
	97.5.3.6 transmitter clock frequency
	97.5.3.2 transmitter distortion
	97.5.3.4 transmitter power spectral density (PSD)
	97.5.3.4 transmitter power level
	97.5.3.5 transmitter peak differential output
	97.5.3.1 maximum output droop
	97.7.2.1 MDI return loss
	97.7.2.2 MDI mode conversion loss
	MDI adapter verification

R&S®RTO-K88 Ethernet compliance test (MGBASE-T1)

The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K88 performs MGBASE-T1 compliance test measurements with R&S®ScopeSuite. R&S®ScopeSuite supports R&S®RT-ZF7A and R&S®RT-ZF8 test fixtures; R&S®ScopeSuite supports Windows 7, 8 and 10. The chapters in front of the test cases refer to IEEE P802.3ch.

Supported MGBASE-T1 compliance tests	
MGBASE-T1 (2.5/5/10G)	149.5.2.1 maximum output droop
	149.5.2.2 transmitter linearity
	149.5.2.3 transmitter timing jitter master
	149.5.2.3 transmitter timing jitter slave
	149.5.2.3.1 transmit MDI random jitter in master mode
	149.5.2.3.2 transmit MDI deterministic jitter in master mode
	149.5.2.4 transmitter power spectral density (PSD) and power level
	149.5.2.5 transmitter peak differential output
	149.5.2.6 transmitter clock frequency
	149.8.2.1 MDI return loss

R&S®RTO-K89 Ethernet compliance test (10BASE-T1)

The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K89 performs 10BASE-T1 compliance test measurements with R&S®ScopeSuite. R&S®ScopeSuite supports the R&S®RT-ZF7A and R&S®RT-ZF8 test fixtures; R&S®ScopeSuite supports Windows 7, 8 and 10. The chapters in front of the test cases refer to IEEE P802.3cg.

Supported 10BASE-T1 compliance tests	
10BASE-T1S	147.5.4.1 transmitter output voltage
	147.5.4.3 transmitter timing jitter
	147.5.4.2 transmitter output droop
	147.5.4.4 transmitter power spectral density (PSD)
	147.7.2 MDI return loss
	147.7.3 MDI mode conversion
10BASE-T1L	146.5.4.1 transmitter output voltage
	146.5.4.3 transmitter timing jitter
	146.5.4.5 transmitter clock frequency
	146.5.4.4 transmitter power spectral density (PSD) and power level
	146.8.3 MDI return loss
	146.8.4 MDI mode conversion

R&S®RTO-K91 DDR3/DDR3L/LPDDR3 signal integrity debug and compliance test

The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K91 performs DDR3 (JESD79-3F), DDR3L(JESD79-3-1A.01) and LPDDR3 (JEDS209-3C) compliance test measurements with R&S®ScopeSuite. Furthermore, it enables the DDR3 decode capability to separate read and write bursts as well as the eye analysis function for mask testing on the oscilloscope. R&S®ScopeSuite supports Windows 7, 8 and 10.

Supported DDR3 compliance tests		
Timing tests	clock timing (12.1)	tCK(avg) (12.1.1)
		tCK(abs) (12.1.2)
		tCL(avg) (12.1.3)
		tCH(avg) (12.1.3)
		tJIT(per) (12.1.4)
		tJIT(duty) (12.1.4)
		tJIT(cc) (12.1.5)
		tERR(nper) (12.1.6)
	data timing (4.13.2, 13.4, 13.6)	tDS(base) (13.6)
		tDH(base) (13.6)
		tDS(derate) (13.6)
		tDH(derate) (13.6)
		tHZ (4.13.2)
		tLZ (4.13.2)
		tDIPW (13.4 note 28)
		tDQSQ (4.13.2)
		tQH (4.13.2)
	strobe timing (4.13, 4.14, 8.3.1)	tDQSCK (4.13.2)
		tLZ (4.13.2)
		tHZ (4.13.2)
		tRPRE (4.13.2)
		tRPST (4.13.2)
		tQSH (4.13.2)
		tQSL (4.13.2)
		tDQSS (4.14.2)
		tDQSH (4.14.2)
		tDQSL (4.14.2)
		tDSS (4.14.2)
		tDSH (4.14.2)
		tWPST (4.14.2)
		tWPRE (4.14.2)
		tDVAC (strobe) (8.3.1)
		tDVAC (clock) (8.3.1)
	command timing (13.5)	tIS (13.5)
		tIS (derated) (13.5)
		tIH (13.5)
		tIH (derated) (13.5)
		tIPW (13.5)
		tVAC (CA) (13.5)
	address timing (13.5) DDR3 and DDR3L	tIS (13.5)
		tIS (derated) (13.5)
		tIH (13.5)
		tIH (derated) (13.5)
		tIPW (13.5)
		tVAC (CA) (13.5)
	address timing (4.2) LPDDR3	tISCA (4.2)
		tIHCA (4.2)
		tIPWCA (4.2)
		tVAC (CA) (13.5)
	chip select timing (13.5) DDR3 and DDR3L	tIS (13.5)
		tIS (derated) (13.5)
		tIH (13.5)
		tIH (derated) (13.5)
		tIPW (13.5)
	chip select timing (4.2) LPDDR3	tISCS (4.2)
		tIHCS (4.2)
		tIPWCS (4.2)
		tVAC(CS) (11.5)

Electrical tests single-ended measurements	input slew rate for ADD and CMD DDR3 and DDR3L (8.5, 13.5) LPDDR3 (7.6, 11.5)	SR(tIS) rising
		SR(tIS) falling
		SR(tIH) rising
		SR(tIH) falling
	input slew rate for DQ and DM DDR3 and DDR3L (8.5, 13.6) LPDDR3 (7.6, 11.6)	SR(tIS) rising
		SR(tIS) falling
		SR(tIH) rising
		SR(tIH) falling
	AC and DC input levels for ADD and CMD DDR3(8.1.1) DDR3L(3.1) LPDDR3(7.1.1)	VIH (AC)
		VIL (AC)
		VIH (DC)
		VIL (DC)
	AC and DC input levels for DQ and DM (8.1.2)	VIH (AC)
		VIL (AC)
		VIH (DC)
		VIL (DC)
	AC input levels for CK and DQS (8.3.3)	VSEH (AC)
		VSEL (AC)
	output slew rate for DQ (9.3)	SRQse rising
		SRQse falling
	AC and DC output levels for DQ (9.2)	VOH(AC)
		VOL(AC)
		VOH(DC)
		VOL(DC)
	AC overshoot and undershoot for ADD and CMD (9.6.1)	overshoot amplitude
		overshoot area
		undershoot amplitude
		undershoot area
	AC overshoot and undershoot for CK, DQ, DQS and DM (9.6.2)	overshoot amplitude
		overshoot area
		undershoot amplitude
		undershoot area
Electrical tests differential measurements	AC input levels for CK and DQS (8.3)	VIHdiff (AC)
		VILdiff (AC)
	AC differential cross point voltage for CK and DQS (8.4)	VIX (AC)
	differential output slew rate for DQS (9.4)	SRQdiff rising
		SRQdiff falling
	differential AC output levels for DQS (9.2)	VOHdiff(AC)
		VOLdiff(AC)
Debug	trigger write cycle	configures the oscilloscope to trigger on a write cycle
	trigger read cycle	configures the oscilloscope to trigger on a read cycle
DDR3 decoding		
Protocol configuration	signal type	DQ, DQS
	bit rate	adjustable
	threshold setup	manual threshold/hysteresis configuration
	source	analog channels
Decode	display type	decoded bus, tabulated list, details
	color coding	read frame, write frame
	data format	hex, octal, binary, signed, unsigned
	decode layer	edges, bit, words
Search	search event setup	frame content, error
	frame content	data; conditions =, ≠, <, ≤, >, ≥, in range, out of range
	error	length, frame incomplete

DDR3 eye diagram		
General description	The DDR3 eye diagram allows the user to generate eye diagrams from long multi-period acquisitions of clock signals and serial data signals. It allows the fine control of the signal content that contributes to the eye diagram and enables the development advanced analysis, measurement, mask test and navigation functions.	
General configuration	number of eye diagram instances	up to 4; independently configurable
	main source	analog channels, differential channels, math channels, reference channels, track channels
	timing reference source	analog channels, differential channels, math channels, reference channels, track channels
	horizontal settings	range, position; expressed in absolute time or relative to user-defined bit rate
Display	persistence	50 ms to 50 s, or infinite
	trace colors	predefined or user-defined color tables
	eye stripe	displays position of eye diagram slices and masks violations time-correlated to the main source waveform; always enabled, for mask tests only, disabled.
Qualification	gate	
	position	start, stop; absolute time or relative to display in percent
	coupling	none, cursor #, zoom #
	signal	
	source	analog channels, math channels, reference channels
	condition	greater than, less than, in range, out of range; relative to selected reference level
Filter	DDR3 protocol	
	frame type	any, read frame, write frame
	error	length
	bit sequence	
	mode	all, level transition, constant level, bit pattern
	bit pattern setup	up to 8 prefix bits and up to 5 suffix bits with respect to central eye diagram bit
Mask testing	mask test results	
	counters	acquisitions, slices, sample hits, slice hits, fail rate
	violation details	number and position of mask violation, expressed as time instant and slice index
	navigation and zoom	use zoom coupling to navigate to violation upon clicking the corresponding table item

R&S®RTO-K92 eMMC compliance test

The R&S®RTO-K92 option is available for R&S®RTO2004, R&S®RTO2014, R&S®RTO2024, R&S®RTO2034, R&S®RTO2044 and R&S®RTO2064 models only. The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. R&S®RTO-K92 performs eMMC (HS200, HS400) compliance test measurements with R&S®ScopeSuite. R&S®ScopeSuite supports Windows 7, 8 and 10.

Supported eMMC compliance tests		
HS200 (JESD84-B50)	CLK (10.5.2, 10.8.1)	bus signal levels tests (VIH, VIL)
		interface timing tests (t_{Period}, rise time, fall time, duty cycle)
	CMD push pull (10.5.2, 10.8.1)	bus signal levels tests (VIH, VIL, VOH, VOL)
		interface timing tests (setup time, hold time)
	CMD open drain (10.5.1)	bus signal levels tests (VOH, VOL)
	DAT data write (10.5.2, 10.8.1)	bus signal levels tests (VIH, VIL)
		interface timing tests (setup time, hold time)
	DAT data read (10.5.2, 10.8.1)	bus signal levels tests (VOH, VOL)
HS400 (JESD84-B50)	CLK (10.5.2, 10.10.1)	bus signal levels tests (VIH, VIL)
		interface timing tests (t_{Period}, slew rate, duty cycle distortion, minimum pulse width)
	CMD push pull (10.5.2, 10.10.1)	bus signal levels tests (VIH, VIL, VOH, VOL)
		interface timing tests (setup time, hold time)
	CMD open drain (10.5.1)	bus signal levels tests (VOH, VOL)
	DAT data write (10.5.2, 10.10.1)	bus signal levels tests (VIH, VIL)
		interface timing tests (setup time, hold time, slew rate)
	DAT data read (10.5.2, 10.10.2)	bus signal levels tests (VOH, VOL)
		interface timing tests (output skew, output hold skew, slew rate)
	data strobe for data read (10.5.2, 10.10.1)	bus signal levels tests (VOH, VOL)
		interface timing tests (t_{Period}, slew rate, duty cycle distortion, minimum pulse width)

R&S®RTO-K99 R&S®ScopeSuite automation

The option is used in combination with the free-of-charge R&S®ScopeSuite PC software, which can be downloaded from the Rohde & Schwarz website. It requires matching compliance test options (see below). R&S®RTO-K99 makes it possible to automate the supported compliance options remotely. After remote execution of a test case the user can collect the results to process them in a proprietary software to create own reports.

Remote API to execute test cases of R&S®ScopeSuite		
API language		C#
Supported options	R&S®RTO-K22	100BASE-TX, 1000BASE-T
	R&S®RTO-K24	100BASE-T1
	R&S®RTO-K87	1000BASE-T1
	R&S®RTO-K91	DDR3, DDR3L, LPDDR3

R&S®RTO-K121 deembedding base option

General description	The R&S®RTO-K121 deembedding base option allows waveform correction based on S-parameters of the involved measurement blocks. The R&S®RTO-K121 option is available for R&S®RTO2022, R&S®RTO2024, R&S®RTO2032, R&S®RTO2034, R&S®RTO2044 and R&S®RTO2064 models only.	
Source		channel 1, channel 2, channel 3, channel 4,
Signal types		single-ended signals
		differential signals based on two separate cables by using two channels
		full differential signals based on differential probes
S-parameter files		s2p-files and s4p-files
Types of blocks		cables, connectors, fixtures and customer defined blocks
Maximum number of blocks		10

Proven cable/proven probe

General description	The proven probe/proven cable is a part of the R&S®RTO-K121 deembedding base option. This function enables the user to determine the correction parameters of a cable or a modified probe based on the differential pulse source R&S®RTO-B7.	
Mode		proven cable proven probe (Rohde & Schwarz probes, user defined)
Configurations	proven cable	single ended
	proven probe	single ended, differential
Correction method	cable, user-defined probe	transmission (magnitude and phase)
	Rohde & Schwarz probe	transmission (magnitude and phase)
Maximal group delay of DUT		20 ns
Maximal length of cables (setup)		3 m
Source		step with amplitude of –200 mV

R&S®RTO-K130 TDR/TDT analysis

Time domain reflexion/time domain transmission analysis option		
General description	The R&S®RTO-K130 TDR/TDT option is a measurement technique used to determine the characteristics of electrical lines by observing reflected and/or transmitted waveforms. Together, they provide a powerful means of analyzing electrical transmission media. The R&S®RTO-K130 option is available for R&S®RTO2022, R&S®RTO2024, R&S®RTO2032, R&S®RTO2034, R&S®RTO2044 and R&S®RTO2064 models only.	
Mode		TDR, TDT, TDR/TDT
Configuration		single ended
Signals		impedance/reflection coefficient
Domain		time/distance
Bandwidth	TDR and/or TDT, single ended	
	R&S®RTO2022, R&S®RTO2024	2 GHz
	R&S®RTO2032, R&S®RTO2034	3 GHz
	R&S®RTO2044	4 GHz
	R&S®RTO2064	6 GHz
Step amplitude		200 mV
Repetition rate		50 Hz to 500 kHz (depends on horizontal scale)
Length of cable	max.	15 ns (~ 3.2 m at ε_r = 2)
	min.	2 ns (~ 0.4 m at ε_r = 2)
Electrical length of short	range, adjustable by user	0 ns to 2 ns
Reference impedance	single ended	50 Ω
	differential	100 Ω

R&S®RTO-K133 advanced jitter analysis

General description	The R&S®RTO-K133 option provides advanced jitter measurements and enables jitter separation. R&S®RTO-K133 option includes R&S®RTO-K12 option.	
Jitter separation	total jitter (TJ), deterministic jitter (DJ), data dependent jitter (DDJ), periodic jitter (PJ), data dependent jitter plus periodic jitter (DDJ+PJ), random jitter (RJ), (other) bounded uncorrelated jitter ((O)BUJ), random jitter plus (other) bounded uncorrelated jitter (RJ+(O)BUJ)	
Accepted input signals	clock signals or data signals (NRZ)	
Reference clock	internal clock recovery (PLL first or second order, constant clock or feed forward) or explicit clock signal	
Basic measurements	symbol rate, symbol duration, event count	
Jitter measurements	total jitter at bit error rate (TJ@BER)	value in seconds or unit interval BER value selectable between 10^{-32} and 10^{-1}
	deterministic jitter (DJ, dual-dirac)	value in seconds or unit interval
	duty cycle distortion (DCD)	value in seconds or unit interval
	inter symbol interference (ISI)	value in seconds or unit interval
	total jitter (TJ) corresponds to time interval error (TIE)	peak-to-peak value and RMS value in seconds or unit interval
	deterministic jitter (DJ)	peak-to-peak value and RMS value in seconds or unit interval
	data dependent jitter (DDJ)	peak-to-peak value and RMS value in seconds or unit interval
	periodic jitter (PJ)	peak-to-peak value and RMS value in seconds or unit interval
	data dependent jitter plus periodic jitter (DDJ+PJ)	peak-to-peak value and RMS value in seconds or unit interval
	periodic jitter components	amplitude, frequency, direction (vertical or horizontal)
	random jitter (RJ)	RMS value in seconds or unit interval
	(other) bounded uncorrelated jitter ((O)BUJ)	peak-to-peak value and RMS value in seconds or unit interval
	(other) bounded uncorrelated jitter ((O)BUJ, dual-dirac)	value in seconds or unit interval
	random jitter plus (other) bounded uncorrelated jitter (RJ+(O)BUJ)	peak-to-peak value and RMS value in seconds or unit interval
Statistics	max. and min. values for each jitter measurement type	
Jitter result plots	histogram (rising edges only)	TJ, DJ, DDJ, PJ, RJ+OBUJ
	histogram (falling edges only)	TJ, DJ, DDJ, PJ, RJ+OBUJ
	histogram (both edges)	TJ, DJ, DDJ, PJ, RJ+OBUJ
	TIE track	TJ, DDJ, PJ, RJ+OBUJ
	power spectral density (PSD)	TJ, DDJ, PJ, RJ+OBUJ
Additional result plots	step response	
	bathtub	PJ and (O)BUJ removable from noise bathtub
	synthetic eye diagram	DD only, DD+P(h), DD+P(v), DD+P

R&S®RTO-K134 advanced jitter and noise analysis

General description	The R&S®RTO-K134 option provides advanced jitter and noise measurements and separation. R&S®RTO-K134 option includes advanced jitter analysis R&S®RTO-K133 option and basic jitter analysis R&S®RTO-K12 option.	
Noise separation	total noise (TN), deterministic noise (DN), data dependent noise (DDN), periodic noise (PN), data dependent noise plus periodic noise (DDN+PN), random noise (RN), (other) bounded uncorrelated noise ((OBUN), random noise plus other (other) bounded uncorrelated noise (RN+(O)BUN)	
Accepted input signals	clock signals or data signals (NRZ)	
Reference clock	internal clock recovery (PLL first or second order, constant clock or feed forward) or explicit clock signal	
Basic measurements	symbol rate, symbol duration, event count	
Noise measurements	eye height at bit error rate (EN@BER)	absolute or relative, BER value selectable between 10^{-32} and 10^{-1}
	level distortion (LD)	absolute or relative value
	inter symbol interference noise (ISIN)	absolute or relative value
	total noise (TN)	peak-to-peak value and RMS value, absolute or relative
	deterministic noise (DN)	peak-to-peak value and RMS value, absolute or relative
	data dependent noise (DDN)	peak-to-peak value and RMS value, absolute or relative
	periodic noise (PN)	peak-to-peak value and RMS value, absolute or relative
	data dependent noise plus periodic noise (DDN+PN)	peak-to-peak value and RMS value, absolute or relative
	periodic noise components	amplitude, frequency, direction (vertical or horizontal)
	random noise (RN)	RMS value, absolute or relative
	(other) bounded uncorrelated noise ((O)BUN)	peak-to-peak value and RMS value, absolute or relative
	(other) bounded uncorrelated noise ((O)BUN, dual-dirac)	absolute or relative value
	random noise plus (other) bounded uncorrelated noise (RJ+(O)BUN)	peak-to-peak value and RMS value, absolute or relative
Statistics	max. and min. values for each noise measurement type	
Noise result plots	histogram (level 0)	TN, DN, DDN, PN, RN+OBUN
	histogram (level 1)	TN, DN, DDN, PN, RN+OBUN
	histogram (both levels)	TN, DN, DDN, PN, RN+OBUN
	TIE track	TN, DDN, PN, RN+OBUN
	power spectral density (PSD)	TN, DDN, PN, RN+OBUN
Additional result plots	step responses	
	noise bathtub	PN and (O)BUN removable from noise bathtub
	synthetic eye diagram	DD only, DD+P(h), DD+P(v), DD+P

Ordering information

Designation	Type	Order No.
Base unit (including standard accessories: 500 MHz passive probe (10:1) per channel, accessories bag, quick start guide, CD with manual, power cord)		
Oscilloscope		
600 MHz, 10 Gsample/s, 50/100 Msample, 2 channels	R&S®RTO2002	1329.7002.02
600 MHz, 10 Gsample/s, 50/200 Msample, 4 channels	R&S®RTO2004	1329.7002.04
1 GHz, 10 Gsample/s, 50/100 Msample, 2 channels	R&S®RTO2012	1329.7002.12
1 GHz, 10 Gsample/s, 50/200 Msample, 4 channels	R&S®RTO2014	1329.7002.14
2 GHz, 10 Gsample/s, 50/100 Msample, 2 channels	R&S®RTO2022	1329.7002.22
2 GHz, 10 Gsample/s, 50/200 Msample, 4 channels	R&S®RTO2024	1329.7002.24
3 GHz, 10 Gsample/s, 50/100 Msample, 2 channels	R&S®RTO2032	1329.7002.32
3 GHz, 10 Gsample/s, 50/200 Msample, 4 channels	R&S®RTO2034	1329.7002.34
4 GHz, 20 Gsample/s, 50/200 Msample, 4 channels	R&S®RTO2044	1329.7002.44
6 GHz, 20 Gsample/s, 50/200 Msample, 4 channels	R&S®RTO2064	1329.7002.64
Hardware options (plug-in)		
Mixed signal option, 400 MHz, 5 Gsample/s, 16 channels	R&S®RTO-B1	1326.3558.02
Digital extension port for R&S®RT-ZVC usage with R&S®RTO oscilloscope, included in R&S®RTO-B1	R&S®RTO-B1E	1333.0738.02
OCXO 10 MHz	R&S®RTO-B4	1304.8305.02
Arbitrary waveform generator, 100 MHz, 2 analog channels, 8-bit pattern generator	R&S®RTO-B6	1329.7054.02
16 GHz differential pulse source	R&S®RTO-B7	1333.2030.02
GPIB interface	R&S®RTO-B10	1304.8311.03
Additional solid state disk	R&S®RTO-B19	1329.7048.02
Memory upgrade, 100 Msample per channel	R&S®RTO-B101	1329.7060.02
Memory upgrade, 200 Msample per channel	R&S®RTO-B102	1329.7077.02
Memory upgrade, 400 Msample per channel	R&S®RTO-B104	1329.7083.02
Memory upgrade, 1 Gsample per channel, for R&S®RTO2002/12/22/32	R&S®RTO-B110	1329.7090.02
Memory upgrade, 1 Gsample per channel, for R&S®RTO2004/14/24/34/44/64	R&S®RTO-B110	1329.7090.04
Bandwidth upgrades [17]		
Upgrade of the R&S®RTO2002/4 to 1 GHz bandwidth	R&S®RTO-B201	1329.7102.02
Upgrade of the R&S®RTO2002/4 to 2 GHz bandwidth	R&S®RTO-B202	1329.7119.02
Upgrade of the R&S®RTO2002/4 to 3 GHz bandwidth	R&S®RTO-B203	1329.7125.02
Upgrade of the R&S®RTO2004 to 4 GHz bandwidth	R&S®RTO-B204	1329.7131.02
Upgrade of the R&S®RTO2004 to 6 GHz bandwidth	R&S®RTO-B206	1329.7148.02
Upgrade of the R&S®RTO2012/4 to 2 GHz bandwidth	R&S®RTO-B212	1329.7154.02
Upgrade of the R&S®RTO2012/4 to 3 GHz bandwidth	R&S®RTO-B213	1329.7160.02
Upgrade of the R&S®RTO2014 to 4 GHz bandwidth	R&S®RTO-B214	1329.7177.02
Upgrade of the R&S®RTO2014 to 6 GHz bandwidth	R&S®RTO-B216	1329.7183.02
Upgrade of the R&S®RTO2022/4 to 3 GHz bandwidth	R&S®RTO-B223	1329.7190.02
Upgrade of the R&S®RTO2022/4 to 4 GHz bandwidth	R&S®RTO-B224	1329.7202.02
Upgrade of the R&S®RTO2024 to 6 GHz bandwidth	R&S®RTO-B226	1329.7219.02
Upgrade of the R&S®RTO2034 to 4 GHz bandwidth	R&S®RTO-B234	1329.7225.02
Upgrade of the R&S®RTO2034 to 6 GHz bandwidth	R&S®RTO-B236	1329.7231.02
Upgrade of the R&S®RTO2044 to 6 GHz bandwidth	R&S®RTO-B246	1329.7248.02
Software options		
Serial triggering and decoding		
I^2C/SPI serial triggering and decoding	R&S®RTO-K1	1329.7260.02
UART/RS-232/RS-422/RS-485 serial triggering and decoding	R&S®RTO-K2	1329.7277.02
CAN/LIN serial triggering and decoding	R&S®RTO-K3	1329.7283.02
FlexRay™ serial triggering and decoding	R&S®RTO-K4	1329.7290.02
I^2S serial triggering and decoding	R&S®RTO-K5	1329.7302.02
MIL-STD-1553 serial triggering and decoding	R&S®RTO-K6	1329.7319.02
ARINC 429 serial triggering and decoding	R&S®RTO-K7	1329.7325.02
Ethernet (10BASE-T/100BASE-TX) serial triggering and decoding	R&S®RTO-K8	1329.7331.02
CAN-FD serial triggering and decoding	R&S®RTO-K9	1329.7348.02
SENT serial triggering and decoding	R&S®RTO-K10	1329.7354.02
MIPI RFFE serial triggering and decoding	R&S®RTO-K40	1329.7519.02
MIPI D-PHY serial triggering and decoding	R&S®RTO-K42	1329.7525.02
MIPI M-PHY serial triggering and decoding	R&S®RTO-K44	1333.0267.02
Manchester and NRZ serial triggering and decoding	R&S®RTO-K50	1329.7531.02
8b10b serial triggering and decoding	R&S®RTO-K52	1329.7548.02
MDIO serial triggering and decoding	R&S®RTO-K55	1329.7554.02

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

Designation	Type	Order No.
Ethernet (100BASE-T1) serial triggering and decoding	R&S®RTO-K57	1333.0596.02
Ethernet (1000BASE-T1) serial triggering and decoding	R&S®RTO-K58	1801.4503.02
USB 1.0/1.1/2.0/HSIC serial triggering and decoding	R&S®RTO-K60	1329.7560.02
USB 3.1 Gen 1 serial triggering and decoding	R&S®RTO-K61	1326.3112.02
USB power delivery serial triggering and decoding	R&S®RTO-K63	1326.3135.02
USB 3.1 SSIC serial triggering and decoding	R&S®RTO-K64	1337.9123.02
SpaceWire serial triggering and decoding	R&S®RTO-K65	1326.2868.02
PCI Express 1.1/2.0 serial triggering and decoding	R&S®RTO-K72	1326.3741.02
CXPI serial triggering and decoding	R&S®RTO-K76	1326.3170.02
Compliance tests		
USB 2.0 compliance test	R&S®RTO-K21	1329.7454.02
Ethernet compliance test (10/100/1000BASE-T/EEE)	R&S®RTO-K22	1329.7460.02
Ethernet compliance test (2.5/5/10GBASE-T)	R&S®RTO-K23	1329.7477.02
Ethernet compliance test (100BASE-T1)	R&S®RTO-K24	1329.7483.02
MIPI D-PHY compliance test	R&S®RTO-K26	1329.7490.02
MIPI D-PHY 2.5 compliance test	R&S®RTO-K27	1803.6584.02
PCI Express 1.1/2.0 compliance test	R&S®RTO-K81	1326.0920.02
Ethernet compliance test (1000BASE-T1)	R&S®RTO-K87	1337.8591.02
Ethernet compliance test (MGBASE-T1)	R&S®RTO-K88	1801.4526.02
Ethernet compliance test (10BASE-T1)	R&S®RTO-K89	1801.4510.02
DDR3/DDR3L/LPDDR3 signal integrity debug and compliance test	R&S®RTO-K91	1337.8891.02
eMMC compliance test	R&S®RTO-K92	1333.0444.02
R&S®ScopeSuite automation	R&S®RTO-K99	1326.4419.02
Analysis		
I/Q software interface	R&S®RTO-K11	1329.7360.02
Jitter analysis	R&S®RTO-K12	1329.7377.02
Clock data recovery	R&S®RTO-K13	1329.7383.02
Spectrogram	R&S®RTO-K18	1329.7425.02
Zone trigger	R&S®RTO-K19	1329.7431.02
Power analysis	R&S®RTO-K31	1329.7502.02
Bus analysis	R&S®RTO-K35	1801.2846.02
User-defined math	R&S®RTO-K39	1803.6784.02
Deembedding base option	R&S®RTO-K121	1326.3058.02
TDR/TDT analysis	R&S®RTO-K130	1326.3087.02
Advanced jitter analysis	R&S®RTO-K133	1801.4832.02
Advanced jitter and noise analysis	R&S®RTO-K134	1802.9450.02
Windows 10 upgrade	R&S®RTO-U2	1801.3836.02
Probes		
500 MHz, passive, 10:1, 1 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, transmission line, 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
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)	R&S®RT-ZC10	1409.7750.02
100 MHz, current, AC/DC, 0.1 V/A, 30 A (RMS)	R&S®RT-ZC20	1409.7766.02
120 MHz, AC/DC, 1 V/A, 5 A (RMS)	R&S®RT-ZC30	1409.7772K02
2 MHz, current, AC/DC, 0.01 V/A, 500 A (RMS), Rohde & Schwarz probe interface	R&S®RT-ZC05B	1409.8204.02
10 MHz, current, AC/DC, 0.01 V/A, 150 A (RMS), Rohde & Schwarz probe interface	R&S®RT-ZC10B	1409.8210.02
50 MHz, AC/DC, 0.1 V/A, 30 A (RMS), Rohde & Schwarz probe interface	R&S®RT-ZC15B	1409.8227.02
100 MHz, current, AC/DC, 0.1 V/A, 30 A (RMS), Rohde & Schwarz probe interface	R&S®RT-ZC20B	1409.8233.02
Multi-channel power probe, 2 × 4 voltage/current channels, for R&S®RTO2000/R&S®RTE	R&S®RT-ZVC04	1326.0259.04
Multi-channel power probe, 2 × 2 voltage/current channels, for R&S®RTO2000/R&S®RTE	R&S®RT-ZVC02	1326.0259.02
Probe set for E and H near-field measurements, two passive E and three passive H near-field proves, 30 MHz to 3 GHz	R&S®HZ-15	1147.2736.02
Probe set for H near-field measurements, two passive H near-field probes, 30 MHz to 3 GHz	R&S®HZ-17	1339.4141.02

Designation	Type	Order No.
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
Probe box to N/USB adapter	R&S®RT-ZA9	1417.0909.02
Adapter SMA(f) to BNC(m)	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
Extended cable set for R&S®RT-ZVC, PCB probing, 1 current and voltage lead, length: 32 cm	R&S®RT-ZA30	1333.1686.02
Extended cable set for R&S®RT-ZVC, 4 mm probing, 1 current and voltage lead, length: 32 cm	R&S®RT-ZA31	1333.1692.02
Oscilloscope interface cable for R&S®RT-ZVC (included in R&S®RT-ZVC02/-ZVC04, 1326.0259.02/.04)	R&S®RT-ZA33	1333.1770.02
Extended cable set for R&S®RT-ZVC, 4 mm probing, 1 current and voltage lead, length: 1 m	R&S®RT-ZA34	1333.1892.02
Extended cable set for R&S®RT-ZVC, PCB probing, 1 current and voltage lead, length: 1 m	R&S®RT-ZA35	1333.1905.02
Solder-in cable set for R&S®RT-ZVC, 4 current and voltage solder-in cables, solder-in pins	R&S®RT-ZA36	1333.1911.02
Extended cable set for R&S®RT-ZVC, BNC connector, 1 current and voltage lead, length: 16 cm	R&S®RT-ZA37	1337.9130.02
Adapter, Rohde & Schwarz probe interface to 2.92 mm/3.5 mm/SMA, incl. USB-C port	R&S®RT-ZA50	1803.5265.02
Adapter, 2.92 mm/3.5 mm/SMA to Rohde & Schwarz probe interface, incl. USB-C port	R&S®RT-ZA51	1803.5365.02
Accessories		
Front cover, for R&S®RTO oscilloscopes	R&S®RTO-Z1	1333.0096.02
Soft case, for R&S®RTO oscilloscopes and accessories	R&S®RTO-Z3	1304.9118.02
Transit case, for R&S®RTO/RTE oscilloscopes and accessories	R&S®RTO-Z4	1317.7025.02
Probe pouch, for R&S®RTO 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
Ethernet 1000BASE-T1 jitter test cable	R&S®RT-ZF2C	1317.5639.02
Frequency converter (100BASE-T1)	R&S®RT-ZF3	5025.0670.02
Ethernet 10BASE-Te fixture	R&S®RT-ZF4	1333.0915.02
Ethernet Probe fixture	R&S®RT-ZF5	1333.0938.02
Frequency converter (1000BASE-T1)	R&S®RT-ZF6	1337.8579.02
Automotive Ethernet T&D fixture	R&S®RT-ZF7	1801.3688.02
SMA adapter	R&S®RT-ZF7A	1801.4126.02
SMA adapter for PoDL	R&S®RT-ZF7P	1802.9680.02
Automotive Ethernet compliance fixture	R&S®RT-ZF8	1801.3694.02
Probe deskew and calibration test fixture	R&S®RT-ZF20	1800.0004.02
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 oscilloscopes, 6 HU resulting height	R&S®ZZA-RTO	1304.8286.00

Warranty		
Base unit		3 years
All other items [18]		1 year
Service options		
Extended warranty, one year	R&S®WE1	Contact your local Rohde & Schwarz sales office.
Extended warranty, two years	R&S®WE2	
Extended warranty with calibration coverage, one year	R&S®CW1	
Extended warranty with calibration coverage, two years	R&S®CW2	
Extended warranty with accredited calibration coverage, one year	R&S®AW1	
Extended warranty with accredited calibration coverage, two years	R&S®AW2	

Extended warranty with a term of one and two years (WE1 and WE2)
Repairs carried out during the contract term are free of charge [19]. Necessary calibration and adjustments carried out during repairs are also covered.

Extended warranty with calibration coverage (CW1 and CW2)
Enhance your extended warranty by adding calibration coverage at a package price. This package ensures that your Rohde & Schwarz product is regularly calibrated, inspected and maintained during the term of the contract. It includes all repairs [19] and calibration at the recommended intervals as well as any calibration carried out during repairs or option upgrades.

Extended warranty with accredited calibration (AW1 and AW2)
Enhance your extended warranty by adding accredited calibration coverage at a package price. This package ensures that your Rohde & Schwarz product is regularly calibrated under accreditation, inspected and maintained during the term of the contract. It includes all repairs [19] and accredited calibration at the recommended intervals as well as any accredited calibration carried out during repairs or option upgrades.

[18] For options installed, the remaining base unit warranty applies if longer than 1 year. Exception: all batteries have a 1 year warranty.

[19] Excluding defects caused by incorrect operation or handling and force majeure. Wear-and-tear parts are not included.

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