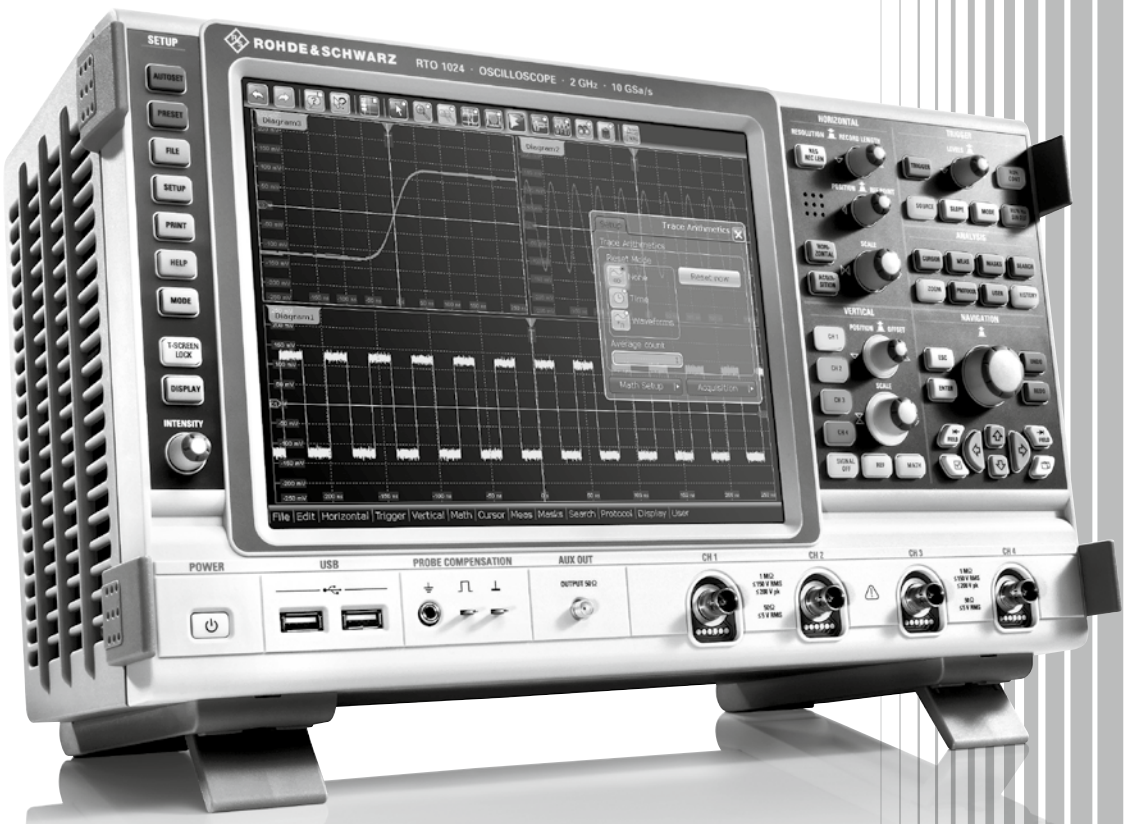
R&S®RTO
Digital Oscilloscope
Specifications



ROHDE&SCHWARZ

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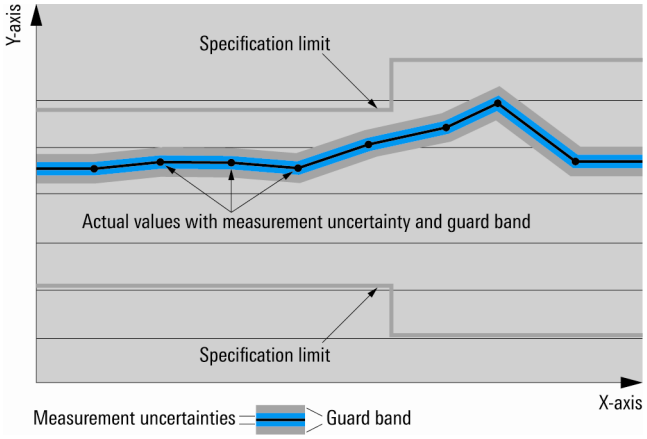
Definitions

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.



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.

Typical data as well as nominal and measured values are not warranted by Rohde & Schwarz.

Base unit

Vertical system

Input channels	R&S®RTO1002	2 channels
	R&S®RTO1004	4 channels
	R&S®RTO1012	2 channels
	R&S®RTO1014	4 channels
	R&S®RTO1022	2 channels
	R&S®RTO1024	4 channels
	R&S®RTO1044	4 channels
Input impedance		50 Ω ± 2 % (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®RTO1002 and R&S®RTO1004	600 MHz
	R&S®RTO1012 and R&S®RTO1014	1 GHz
	R&S®RTO1022 and R&S®RTO1024	2 GHz
	R&S®RTO1044	4 GHz
	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 (calculated)	
	R&S®RTO1002 and R&S®RTO1004	583 ps
	R&S®RTO1012 and R&S®RTO1014	350 ps
	R&S®RTO1022 and R&S®RTO1024	175 ps
	R&S®RTO1044	100 ps
Input VSWR	input frequency ≤ 2 GHz	1.25 (meas.)
	input frequency > 2 GHz	1.4 (meas.)
Vertical resolution		8 bit
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 and GND
	at 1 MΩ	DC, AC and GND
Input sensitivity	at 50 Ω	1 mV/div to 1 V/div
	at 1 MΩ	1 mV/div to 10 V/div
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
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
	input frequency > 2GHz	> 50 dB

RMS noise floor at 50 Ω (typ.)	input sensitivity	R&S®RTO1002, R&S®RTO1004	R&S®RTO1012, R&S®RTO1014
	1 mV/div	0.08 mV	0.10 mV
	2 mV/div	0.08 mV	0.10 mV
	5 mV/div	0.11 mV	0.12 mV
	10 mV/div	0.17 mV	0.20 mV
	20 mV/div	0.28 mV	0.36 mV
	50 mV/div	0.70 mV	0.85 mV
	100 mV/div	1.30 mV	1.65 mV
	200 mV/div	2.70 mV	3.30 mV
	500 mV/div	7.00 mV	8.70 mV
	1 V/div	13.7 mV	17.0 mV
	input sensitivity	R&S®RTO1022, R&S®RTO1024	R&S®RTO1044 (meas.)
	1 mV/div	0.15 mV	0.24 mV
	2 mV/div	0.15 mV	0.25 mV
	5 mV/div	0.18 mV	0.28 mV
	10 mV/div	0.28 mV	0.42 mV
	20 mV/div	0.50 mV	0.72 mV
	50 mV/div	1.22 mV	1.80 mV
	100 mV/div	2.39 mV	3.60 mV
	200 mV/div	4.80 mV	7.20 mV
	500 mV/div	12.0 mV	18.0 mV
	1 V/div	23.9 mV	36.0 mV

Horizontal system

Timebase range		selectable between 25 ps/div and 50 s/div, time per div settable to any value within range
Channel deskew		±100 ns
Reference position		10 % to 90 % 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®RTO1002, R&S®RTO1004) K = 0.18 (R&S®RTO1012, R&S®RTO1014) K = 0.25 (R&S®RTO1022, R&S®RTO1024) K = 0.43 (R&S®RTO1044)

Acquisition system

Realtime sampling rate	R&S®RTO1002, R&S®RTO1004, R&S®RTO1012, R&S®RTO1014, R&S®RTO1022, R&S®RTO1024	max. 10 Gsample/s on each channel
	R&S®RTO1044	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	standard	
	R&S®RTO1002, R&S®RTO1012, R&S®RTO1022	20 Msample on 2 channels, 40 Msample on 1 channel
	R&S®RTO1004, R&S®RTO1014, R&S®RTO1024, R&S®RTO1044	20 Msample on 4 channels, 40 Msample on 2 channels, 80 Msample on 1 channel
	R&S®RTO-B101 option	
	R&S®RTO1002, R&S®RTO1012, R&S®RTO1022	50 Msample on 2 channels, 100 Msample on 1 channel
	R&S®RTO1004, R&S®RTO1014, R&S®RTO1024, R&S®RTO1044	50 Msample on 4 channels, 100 Msample on 2 channels, 200 Msample on 1 channel
	R&S®RTO-B102 option	
	R&S®RTO1002, R&S®RTO1012, R&S®RTO1022	100 Msample on 2 channels, 200 Msample on 1 channel
	R&S®RTO1004, R&S®RTO1014, R&S®RTO1024, R&S®RTO1044	100 Msample on 4 channels, 200 Msample on 2 channels, 400 Msample on 1 channel
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
Waveform arithmetic	off	no arithmetic
	envelope	envelope of acquired waveforms
	average	average of acquired waveforms, max. average depth depends on decimation mode [1]
	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
	equivalent time	enhancement of sampling resolution by repetitive acquisition; max. equivalent sampling rate is 4 Tsample/s
Interpolation modes		linear, sin(x)/x, sample&hold
Ultra segmented mode		continuous recording of waveforms in acquisition memory without interruption due to visualization; blind time between consecutive acquisitions less than 300 ns

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

Trigger system

Sources	R&S®RTO1002, R&S®RTO1012, R&S®RTO1022	channel 1, channel 2
	R&S®RTO1004, R&S®RTO1014, R&S®RTO1024, R&S®RTO1044	channel 1, channel 2, channel 3, channel 4
Sensitivity	trigger hysteresis mode	auto (standard) or manual
	range	0 V to 5 div × input sensitivity
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
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®RTO1044 only)
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®RTO1044 only)
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®RTO1044 only)
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®RTO1044 only)
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®RTO1044 only)
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®RTO1044 only)
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	
	max. data rate	< 2.50 Gbps
		< 5 Gbps (R&S®RTO1044 only)

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
	R event	edge, glitch, width, runt, window, timeout, interval, slew rate
Serial bus trigger	basic	I^2C, SPI, UART/RS-232-C
	optional	LIN, CAN and FlexRay with dedicated software options
NFC trigger		with R&S®RTO-K11 option
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	< 300 mV (V_p) (meas.)
	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)
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 (meas.)

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
	long-term analysis	history of selected measurements as trace against count index
	histogram	available for one measurement per measurement panel
	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, DC voltmeter (requires Rohde & Schwarz active probe with R&S®ProbeMeter functionality)
	eye diagram	extinction ratio, eye height, eye width, eye top, eye base, 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)
	spectrum	channel power, bandwidth, occupied bandwidth, total harmonic distortion
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, XY diagrams
	operating mode	vertical measurements, horizontal measurements or both; vertical cursors either set manually or track 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 16
	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
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 4
	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, $\log_{10}$, $\log_e$, $\log_2$, 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
Optimized math	operators	add, subtract, multiply, invert, absolute value, differentiate, $\log_{10}$, $\log_e$, $\log_2$, rescale, FIR, FFT magnitude
Spectrum analysis	FFT magnitude spectrum	
	setup parameters	center frequency, frequency span, frame overlap, frame window (rectangular, Hamming, Hann, Blackman, Gaussian, Flattop, Kaiser Bessel), user-selectable spectrum averaging and envelope

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 scope	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
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 bar	accommodates timebase settings, trigger settings and signal icons; signal bar may be docked to left or right side of display area or hidden
Signal icon	each active waveform is represented by a separate signal icon on the signal bar; the signal icon displays the individual vertical and acquisition settings; a waveform can be minimized to its signal icon so that it appears as a realtime preview in miniature form; dialog boxes and measurement results may also be minimized to a signal icon
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 (meas.)
	frequency	1 kHz ± 1 %
	impedance	50 Ω (nom.)
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, version 2.0
LAN interface		RJ-45 connector, supports 10/100/1000BaseT
External monitor interface		DVI-D connector, output of scope 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	10.4" LC TFT color display with touchscreen
	resolution	1024 × 768 pixel (XGA)

Temperature		
Temperature loading	operating temperature range	0 °C to +45 °C
	storage temperature range	–40 °C to +70 °C
Climatic loading		+40 °C at 85 % rel. humidity, in line with IEC 60068-2-30

Altitude		
Operating		up to 3000 m above sea level
Non-operating		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
	random	10 Hz to 300 Hz, acceleration 1.2 g (RMS), in line with EN 60068-2-64
Shock		40 g shock spectrum, in line with MIL-STD-810E, method no. 516.4, procedure I

EMC		
RF emission	in line with EN 55011 class A, operation in residential, commercial and business areas or in small-size companies is not covered; therefore the instrument may not be operated in residential, commercial and business areas or in small-size companies unless additional measures are taken to ensure that EN 55011 class B is complied with	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 [2]

Certifications		VDE-GS, $_{C}$CSA$_{US}$

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

Calibration interval		1 year

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
Power consumption		max. 450 W
Safety		in line with IEC 61010-1, EN 61010-1, CAN/CSA-C22.2 No. 61010-1-04, UL 61010-1

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

MSO, 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
Input impedance		100 kΩ ± 2 % || ~4 pF (meas.) at probe tips
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		±(100 mV + 3 % of threshold setting)
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 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 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 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 D0 to D15 or any user-defined bus signal
	clock signal	any channel 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 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 D0 to D15 or a any logical combination of D15 to D15
	clock signal	any channel D0 to D15
	max. data rate	1 Gbps
Serial bus trigger	basic	I^2C, SPI, UART/RS-232-C
	optional	LIN, CAN and FlexRay with dedicated software options
	sources	any channel 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 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

Waveform math

Function		any logical combination of D0 to D15

Search and mark functions

The search function will be available in a future software release.

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 scope acquisition, the state (stays low, stays high or toggles) of the channels D0 to D15 is displayed in the signal icon

R&S®RTO-B4

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

R&S®RTO-B10

Additional 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 removable hard disk		
Disk type		hard disk
Disk size		≥ 160 Gbyte (nom.)
Firmware		installed upon delivery

R&S®RTO-K1

I^2C decoding		
Protocol configuration	bit rate	up to 3.4 Mbps (auto-detected)
	auto threshold setup	assisted threshold configuration for I^2C triggering and decoding
	device list	associate frame address with symbolic ID
Trigger (included in standard equipment)	source (clock and data)	any input channel or logical channel
	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
	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

SPI decoding		
Protocol configuration	type	2-wire, 3-wire and 4-wire SPI
	bit rate	up to 50 Mbps (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 (included in standard equipment)	source (MOSI, MISO, SS, CLK)	any input channel or logical channel
	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
	color coding	frame, word, error
	data format	hex, decimal, octal, binary, ASCII

R&S®RTO-K2

UART decoding		
Protocol configuration	bit rate	300 bps to 20 Mbps
	signal polarity	idle low, idle high
	number of bits	5 bit to 8 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 (included in standard equipment)	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 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
	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, 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
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

LIN 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, wakeup 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

R&S®RTO-K4

FlexRay 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, wakeup, 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

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		max. 10 Msample with one or two input signals, max. 6 Msample with three or four input signals; recording length independent of sampling rate	
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®RTO1002 and R&S®RTO1004	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®RTO1012 and R&S®RTO1014	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®RTO1022 and R&S®RTO1024	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®RTO1044	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

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)		
Digital Oscilloscope		
600 MHz, 10 Gsample/s 20/40 Msample, 2 channels	R&S®RTO1002	1316.1000.02
600 MHz, 10 Gsample/s 20/80 Msample, 4 channels	R&S®RTO1004	1316.1000.04
1 GHz, 10 Gsample/s 20/40 Msample, 2 channels	R&S®RTO1012	1316.1000.12
1 GHz, 10 Gsample/s 20/80 Msample, 4 channels	R&S®RTO1014	1316.1000.14
2 GHz, 10 Gsample/s 20/40 Msample, 2 channels	R&S®RTO1022	1316.1000.22
2 GHz, 10 Gsample/s 20/80 Msample, 4 channels	R&S®RTO1024	1316.1000.24
4 GHz, 20 Gsample/s 20/80 Msample, 4 channels	R&S®RTO1044	1316.1000.44
Hardware options (plug-in)		
MSO, 400 MHz for R&S®RTO with order no. 1316.1000.xx	R&S®RTO-B1	1304.9901.03
MSO, 400 MHz for R&S®RTO with order no. 1304.6002.xx	R&S®RTO-B1	1304.9901.02
OCXO 10 MHz	R&S®RTO-B4	1304.8305.02
GPIB Interface, for R&S®RTO with order no. 1316.1000.xx	R&S®RTO-B10	1304.8311.03
GPIB Interface, for R&S®RTO with order no. 1304.6002.xx	R&S®RTO-B10	1304.8311.02
Replacement Hard Disk, incl. firmware	R&S®RTO-B19	1304.8328.02
Sample memory upgrade		
Memory Upgrade, 50 Msample per channel	R&S®RTO-B101	1304.8428.02
Memory Upgrade, 100 Msample per channel	R&S®RTO-B102	1304.8434.02
Software options		
I^2C/SPI Decoding	R&S®RTO-K1	1304.8511.02
UART/RS-232 Decoding	R&S®RTO-K2	1304.8528.02
CAN/LIN Triggering and Decoding	R&S®RTO-K3	1304.8534.02
FlexRay Triggering and Decoding	R&S®RTO-K4	1304.8540.02
I/Q Software Interface	R&S®RTO-K11	1317.2975.02
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
1.0 GHz, active, 1 MΩ, 0.8 pF, R&S®ProbeMeter, micro button	R&S®RT-ZS10	1410.4080.02
1.0 GHz, active, 1 MΩ, 0.8 pF	R&S®RT-ZS10E	1418.7007.02
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
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
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
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/-ZS10E/-ZS20/-ZS30	R&S®RT-ZA2	1416.0405.02
Pin Set for R&S®RT-S10/-ZS10E/-ZS20/-ZS30	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/-ZD30	R&S®RT-ZA7	1417.0609.02
SMA Adapter	R&S®RT-ZA10	1416.0457.02
Probe Power Supply	R&S®RT-ZA13	1409.7789.02
Accessories		
Front Cover	R&S®RTO-Z1	1304.9101.02
Soft Case for R&S®RTO oscilloscopes and accessories	R&S®RTO-Z3	1304.9118.02
Rackmount Kit	R&S®ZZA-RTO	1304.8286.02

Service options		
Extended Warranty, one year	R&S®WE1RTO	Please contact your local Rohde & Schwarz sales office.
Extended Warranty, two years	R&S®WE2RTO	
Extended Warranty, three years	R&S®WE3RTO	
Extended Warranty, four years	R&S®WE4RTO	
Extended Warranty with Calibration Coverage, one year	R&S®CW1RTO	
Extended Warranty with Calibration Coverage, two years	R&S®CW2RTO	
Extended Warranty with Calibration Coverage, three years	R&S®CW3RTO	
Extended Warranty with Calibration Coverage, four years	R&S®CW4RTO	

Extended warranty with a term of one to four years (WE1 to WE4)
Repairs carried out during the contract term are free of charge [3]. Necessary calibration and adjustments carried out during repairs are also covered. Simply contact the forwarding agent we name; your product will be picked up free of charge and returned to you in top condition a couple of days later.

Extended warranty with calibration (CW1 to CW4)
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 [3] and calibration at the recommended intervals as well as any calibration carried out during repairs or option upgrades.

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

Service you can rely on

- Worldwide
- Local and personalized
- Customized and flexible
- Uncompromising quality
- Long-term dependability

About Rohde&Schwarz

Rohde&Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established more than 75 years ago, Rohde&Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

Environmental commitment

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

Certified Quality System
ISO 9001

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