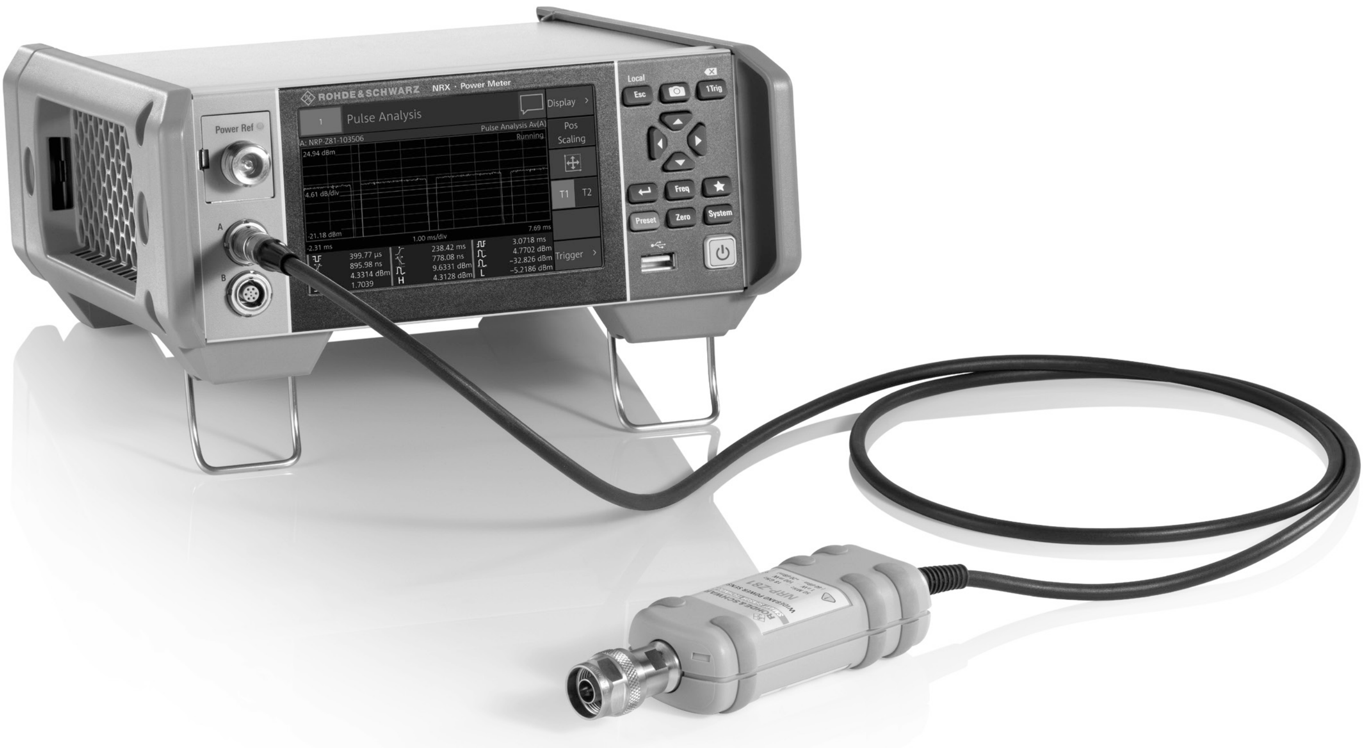
R&S®NRP-Zxx
Power Sensors
Specifications

3 year warranty



Data Sheet | Version 12.00

ROHDE&SCHWARZ

Version 12.00, April 2019

CONTENTS

Definitions

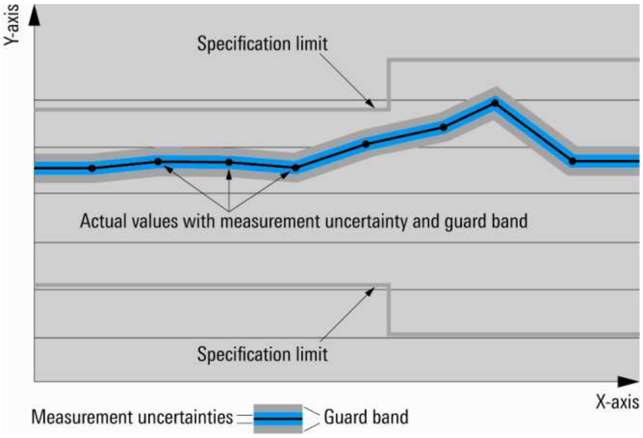
General

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.



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 indicated as follows: “parameter: value”.

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

In line with the 3GPP/3GPP2 standard, chip rates are specified in Mcps (million chips per second), whereas bit rates and symbol rates are specified in Mbps (million bits per second), kbps (thousand bits per second), Msps (million symbols per second) or ksps (thousand symbols per second), and sample rates are specified in Msample/s (million samples per second). Mcps, Mbps, Msps, kbps, ksps and Msample/s are not SI units.

Overview of the R&S®NRP-Zxx power sensors

Sensor type R&S®	Frequency range	Power range, max. average power / peak envelope power	Connector type
Two-path diode power sensors			
NRP-Z211	10 MHz to 8 GHz	1.0 nW to 100 mW (–60 dBm to +20 dBm) max. 400 mW (AVG) / 2 W (PK, 10 µs)	N
NRP-Z221	10 MHz to 18 GHz	1.0 nW to 100 mW (–60 dBm to +20 dBm) max. 400 mW (AVG) / 2 W (PK, 10 µs)	N
Wideband power sensors			
NRP-Z81	50 MHz to 18 GHz	1 nW to 100 mW (–60 dBm to +20 dBm) max. 200 mW (AVG) / 1 W (PK, 1 µs)	N
NRP-Z85	50 MHz to 40 GHz	1 nW to 100 mW (–60 dBm to +20 dBm) max. 200 mW (AVG) / 1 W (PK, 1 µs)	2.92 mm
NRP-Z86 model .40	50 MHz to 40 GHz	1 nW to 100 mW (–60 dBm to +20 dBm) max. 200 mW (AVG) / 1 W (PK, 1 µs)	2.40 mm
NRP-Z86 model .44	50 MHz to 44 GHz	1 nW to 100 mW (–60 dBm to +20 dBm) max. 200 mW (AVG) / 1 W (PK, 1 µs)	2.40 mm
Level control sensors			
NRP-Z28	10 MHz to 18 GHz	200 pW to 100 mW (–67 dBm to +20 dBm) max. 700 mW (AVG) / 4 W (PK, 10 µs)	N
NRP-Z98	9 kHz to 6 GHz	200 pW to 100 mW (–67 dBm to +20 dBm) max. 700 mW (AVG) / 4 W (PK, 10 µs)	N
Power sensor modules			
NRP-Z27	DC to 18 GHz	4 µW to 400 mW (–24 dBm to +26 dBm) max. 500 mW (AVG) / 30 W (PK, 1 µs)	N
NRP-Z37	DC to 26.5 GHz	4 µW to 400 mW (–24 dBm to +26 dBm) max. 500 mW (AVG) / 30 W (PK, 1 µs)	3.5 mm

Specifications in brief of the R&S®NRP-Zxx power sensors

Sensor type R&S®	Impedance matching (SWR)	Rise time Video BW	Zero offset (typ.)	Noise (typ.)	Uncertainty for power measurements at +20 °C to +25 °C	
					absolute	**relative**
Two-path diode power sensors						
NRP-Z211	10 MHz to 2.4 GHz: < 1.13 > 2.4 GHz to 8.0 GHz: < 1.20	< 10 µs > 40 kHz	290 pW	180 pW	*0.054 dB to 0.110 dB*	*0.022 dB to 0.112 dB*
NRP-Z221	10 MHz to 2.4 GHz: < 1.13 > 2.4 GHz to 8.0 GHz: < 1.20 > 8.0 GHz to 18.0 GHz: < 1.25				*0.054 dB to 0.143 dB*	*0.022 dB to 0.142 dB*
Wideband power sensors						
NRP-Z81	50 MHz to 2.4 GHz: < 1.16 > 2.4 GHz to 8.0 GHz: < 1.20 > 8.0 GHz to 18.0 GHz: < 1.25	< 13 ns > 30 MHz	220 pW	110 pW	*0.130 dB to 0.150 dB*	*0.039 dB to 0.148 dB*
NRP-Z85 NRP-Z86 model .40	50 MHz to 2.4 GHz: < 1.16 > 2.4 GHz to 8.0 GHz: < 1.20 > 8.0 GHz to 18.0 GHz: < 1.25 > 18.0 GHz to 26.5 GHz:< 1.30 > 26.5 GHz to 40.0 GHz:< 1.35				*0.130 dB to 0.170 dB*	*0.039 dB to 0.165 dB*
NRP-Z86 model .44	50 MHz to 2.4 GHz: < 1.16 > 2.4 GHz to 8.0 GHz: < 1.20 > 8.0 GHz to 18.0 GHz: < 1.25 > 18.0 GHz to 26.5 GHz:< 1.30 > 26.5 GHz to 40.0 GHz:< 1.35 > 40.0 GHz to 44.0 GHz:< 1.40				*0.130 dB to 0.190 dB*	*0.039 dB to 0.165 dB*
Level control sensors						
NRP-Z28	10 MHz to 2.4 GHz: < 1.11 > 2.4 GHz to 4.0 GHz: < 1.15 > 4.0 GHz to 8.0 GHz: < 1.22 > 8.0 GHz to 18 GHz: < 1.30	< 8 µs > 50 kHz	67 pW	42 pW	*0.047 dB to 0.130 dB*	*0.022 dB to 0.110 dB*
NRP-Z98	9 kHz to 2.4 GHz: < 1.11 > 2.4 GHz to 4.0 GHz: < 1.15 > 4.0 GHz to 6.0 GHz: < 1.22	–			*0.047 dB to 0.083 dB*	*0.022 dB to 0.066 dB*
Power sensor modules						
NRP-Z27	DC to 2.0 GHz: < 1.15 > 2.0 GHz to 4.2 GHz: < 1.18 > 4.2 GHz to 8.0 GHz: < 1.23 > 8.0 GHz to 12.4 GHz: < 1.25 > 12.4 GHz to 18.0 GHz:< 1.35	–	200 nW	120 nW	*0.070 dB to 0.112 dB*	*0.032 dB*
NRP-Z37	DC to 2.0 GHz: < 1.15 > 2.0 GHz to 4.2 GHz: < 1.18 > 4.2 GHz to 8.0 GHz: < 1.23 > 8.0 GHz to 12.4 GHz: < 1.25 > 12.4 GHz to 18.0 GHz:< 1.30 > 18.0 GHz to 26.5 GHz:< 1.45	–			*0.070 dB to 0.122 dB*	*0.032 dB*

Two-path power sensors in R&S®Smart Sensor Technology

R&S®NRP-Z211/-Z221 two-path diode universal power sensors

Specifications from 8 GHz to 18 GHz apply only to the R&S®NRP-Z221.

Frequency range	R&S®NRP-Z211	10 MHz to 8 GHz	
	R&S®NRP-Z221	10 MHz to 18 GHz	
Impedance matching (SWR)	10 MHz to 2.4 GHz	< 1.13 (**1.11**)	( ): +15 °C to +35 °C
	> 2.4 GHz to 8.0 GHz	< 1.20 (**1.18**)	
	> 8.0 GHz to 18.0 GHz	< 1.25 (**1.23**)	
Power measurement range	continuous average	1.0 nW to 100 mW (–60 dBm to +20 dBm)	
	burst average	1.0 µW to 100 mW (–30 dBm to +20 dBm)	
	timeslot/gate average	3.0 nW to 100 mW (–55 dBm to +20 dBm) [1]	
	trace	50 nW to 100 mW (–43 dBm to +20 dBm) [2]	
Max. power	average power	0.4 W (+26 dBm), continuous	
	peak envelope power	2.0 W (+33 dBm) for max. 10 µs	
Measurement subranges	path 1	–60 dBm to –5 dBm	
	path 2	–33 dBm to +20 dBm	
Transition regions	with automatic path selection [3]	(–10 ± 1) dBm to (–4 ± 1) dBm	
Dynamic response	video bandwidth	> 40 kHz (50 kHz)	( ): +15 °C to +35 °C
	single-shot bandwidth	> 40 kHz (50 kHz)	
	rise time 10 %/90 %	< 10 µs (8 µs)	
Acquisition	sample rate (continuous)	133.358 kHz (default) or 119.467 kHz [4]	
Triggering	internal		
	threshold level range	–33 dBm to +20 dBm	
	threshold level accuracy	identical to uncertainty for absolute power measurements	
	threshold level hysteresis	0 dB to 10 dB	
	dropout [5]	0 s to 10 s	
	external	see R&S®NRX base unit, R&S®NRP-Z3 USB adapter cable or R&S®NRP-Z5 USB sensor hub	
	slope (external, internal)	pos./neg.	
	delay	–5 ms to +100 s	
	hold-off	0 s to 10 s	
	resolution (delay, hold-off, dropout)	sample period (≈ 8 µs)	
	source	internal, external, immediate, bus, hold	
Zero offset	initial, without zeroing		( ): typical at 1 GHz +15 °C to +35 °C [ ]: 8 GHz to 18 GHz
	path 1	< 1.88 [2.0] (0.6) nW	
	path 2	< 0.94 [1.0] (0.3) µW	
	after external zeroing [6, 7]		
	path 1	< 370 [390] (290) pW	
	path 2	< 180 [190] (145) nW	
Zero drift [8]	path 1	< 140 [150] (0) pW	
	path 2	< 60 [65] (0) nW	
Measurement noise [9]	path 1	< 230 [240] (180) pW	
	path 2	< 110 [116] (90) nW	

Uncertainty for absolute power measurements [10] in dB

10 MHz to < 20 MHz		20 MHz to < 100 MHz		
0.168	0.176	0.155	0.158	0 °C to +50 °C
0.080	0.075	0.079	0.073	+15 °C to +35 °C
0.063	0.054	0.063	0.054	+20 °C to +25 °C

–60 –10 +20 –60 –10 +20

Power level in dBm Power level in dBm

100 MHz to 4 GHz		> 4 GHz to 8 GHz		
0.160	0.167	0.167	0.188	0 °C to +50 °C
0.086	0.090	0.098	0.122	+15 °C to +35 °C
0.071	0.075	0.085	0.110	+20 °C to +25 °C

–60 –10 +20 –60 –10 +20

Power level in dBm Power level in dBm

> 8 GHz to 12.4 GHz		> 12.4 GHz to 18 GHz		
0.173	0.201	0.189	0.217	0 °C to +50 °C
0.104	0.139	0.126	0.154	+15 °C to +35 °C
0.091	0.129	0.114	0.143	+20 °C to +25 °C

–60 –10 +20 –60 –10 +20

Power level in dBm Power level in dBm

Uncertainty for relative power measurements [11] in dB

	10 MHz to < 20 MHz			20 MHz to < 100 MHz		
+20	0.225	0.030	+20	0.210	0.030	0 °C to +50 °C
	0.086	0.026		0.085	0.026	+15 °C to +35 °C
–4	0.050	0.026	–4	0.050	0.026	+20 °C to +25 °C
–10	0.023	0.225	–10	0.023	0.210	0 °C to +50 °C
	0.022	0.086		0.022	0.085	+15 °C to +35 °C
–60	0.022	0.050	–60	0.022	0.050	+20 °C to +25 °C

–60 –10/–4 +20 –60 –10/–4 +20

Power level in dBm Power level in dBm

	100 MHz to 4 GHz			> 4 GHz to 8 GHz		
+20	0.218	0.057	+20	0.237	0.101	0 °C to +50 °C
	0.099	0.055		0.132	0.100	+15 °C to +35 °C
–4	0.071	0.055	–4	0.112	0.100	+20 °C to +25 °C
–10	0.023	0.218	–10	0.024	0.237	0 °C to +50 °C
	0.022	0.099		0.022	0.132	+15 °C to +35 °C
–60	0.022	0.071	–60	0.022	0.112	+20 °C to +25 °C

–60 –10/–4 +20 –60 –10/–4 +20

Power level in dBm Power level in dBm

	> 8 GHz to 12.4 GHz			> 12.4 GHz to 18 GHz		
+20	0.253	0.124	+20	0.263	0.124	0 °C to +50 °C
	0.155	0.123		0.162	0.123	+15 °C to +35 °C
–4	0.136	0.123	–4	0.142	0.123	+20 °C to +25 °C
–10	0.024	0.253	–10	0.024	0.263	0 °C to +50 °C
	0.022	0.155		0.022	0.162	+15 °C to +35 °C
–60	0.022	0.136	–60	0.022	0.142	+20 °C to +25 °C

–60 –10/–4 +20 –60 –10/–4 +20

Power level in dBm Power level in dBm

Additional characteristics of the R&S®NRP-Z211/-Z221 two-path diode power sensors

Sensor type	R&S®NRP-Z211/-Z221	two-path diode power sensor
Measurand		power of incident wave
		power of source (DUT) into 50 Ω [12]
RF connector	R&S®NRP-Z211/-Z221	N (male)
RF attenuation [13]	R&S®NRP-Z211/-Z221	not applicable
Measurement functions	stationary and recurring waveforms	continuous average
		burst average
		timeslot/gate average
		trace
	single events	trace
Continuous average function	measurand	mean power over recurring acquisition interval
	aperture	10 µs to 300 ms (20 ms default)
	window function	uniform or von Hann [14]
	duty cycle correction [15]	0.001 % to 99.999 %
	capacity of measurement buffer [16]	1 to 1024 results
Burst average function	measurand	mean power over burst portion of recurring signal (trigger settings required)
	detectable burst width	
	R&S®NRP-Z211/-Z221	25 µs to 50 ms
	minimum gap between bursts	10 µs
	dropout period [17] for burst end detection	0 to 3 ms
	exclusion periods [18]	
	start	0 to burst width
	end	0 s to 3 ms
	resolution (dropout and exclusion periods)	sample period (≈ 8 µs)
Timeslot/gate average function	measurand	mean power over individual timeslots/gates of recurring signal
	number of timeslots/gates	1 to 128 (consecutive)
	nominal length	10 µs to 0.1 s
	start of first timeslot/gate	at delayed trigger event
	exclusion periods [18]	
	start	0 to nominal length
	end	0 s to 3 ms
	resolution (nominal length and exclusion periods)	sample period (≈ 8 µs)
Trace function	measurand	mean power over pixel length
	acquisition	
	length (*Δ*)	100 µs to 300 ms
	start (referenced to delayed trigger)	–5 ms to +100 s
	result	
	pixels (*M*)	1 to 1024
	resolution (*Δ*/*M*)	
	non recurring or internally triggered	≥ 10 µs
	recurring and externally triggered	≥ 2.5 µs

Averaging filter	modes	auto off (fixed averaging number)
		auto on (continuously auto-adapted)
		auto once (automatically fixed once)
	auto off	
	supported measurement functions	all
	averaging number	2^N ; N = 0 to 16 (13 for trace function)
	auto on/once	
	supported measurement functions	continuous average, burst average, timeslot/gate average
	normal operating mode	averaging number adapted to resolution setting and power to be measured
	fixed noise operating mode	averaging number adapted to specified noise content
	result output	
	moving mode	continuous, independent of averaging number
	rate	can be limited to 0.1 s^{-1}
	repeat mode	only final result
Attenuation correction	function	corrects the measurement result by means of a fixed factor (dB offset)
	range	–200.000 dB to +200.000 dB
Embedding	function	incorporates a two-port device at the sensor input so that the measurement plane is shifted to the input of this device
	parameters	S_{11}, S_{21}, S_{12} and S_{22} of device
	frequencies	1 to 1000
Gamma correction	function	removes the influence of impedance mismatch from the measurement result so that the power of the source (DUT) into 50 Ω can be read
	parameters	magnitude and phase of reflection coefficient of source (DUT)
Frequency response correction	function	takes the frequency response of the sensor section and of the RF power attenuator into account (if applicable)
	parameter	center frequency of test signal
	residual uncertainty	see specification of calibration uncertainty and uncertainty for absolute and relative power measurements
Measurement times [19] 2^N: averaging number T: set number of timeslots w: nominal length of timeslot	continuous average	2 × (aperture + 145 µs) × 2^N + t_z
	buffered [16], without averaging	2 × (aperture + 166 µs) × buffer size + t_z
	timeslot/gate average	
	signal period – $T \times w$ > 100 µs	≤ 2 × signal period × (2^N + ½) + t_z
	all other cases	≤ 4 × signal period × (2^N + ¼) + t_z t_z : < 1.6 ms
Measurement speed without averaging aperture time = 10 µs	continuous average	
	single-triggered	550 s^{-1} (typ.)
	buffered [16]	3000 s^{-1} (typ.)
Zeroing (duration)	depends on setting of averaging filter	
	auto on	4 s
	auto off, integration time [20]	
	< 4 s	4 s
	4 s to 16 s	integration time
	> 16 s	16 s

Measurement error due to harmonics [21]	R&S®NRP-Z211/-Z221: all paths	*n* = 2	*n* = 3	*n*: multiple of carrier frequency
	–30 dBc	< 0.001 dB	< 0.003 dB	
	–20 dBc	< 0.002 dB	< 0.010 dB	
	–10 dBc	< 0.010 dB	< 0.040 dB	
Measurement error due to modulation [22]	general	depends on CCDF and RF bandwidth of test signal		
	WCDMA (3GPP test model 1-64)			
	worst case	–0.02 dB to +0.07 dB		
	typical	–0.01 dB to +0.03 dB		
Change of input reflection coefficient with respect to power [23]	R&S®NRP-Z211/-Z221			
	10 MHz to 2.4 GHz	< 0.02 (0.01)	( ): +15 °C to +35 °C	
	> 2.4 GHz	< 0.03 (0.02)		
Calibration uncertainty [24]	R&S®NRP-Z211/-Z221	path 1	path 2	
	10 MHz to < 100 MHz	*0.052 dB*	*0.053 dB*	
	100 MHz to 4.0 GHz	*0.061 dB*	*0.062 dB*	
	> 4.0 GHz to 8.0 GHz	*0.075 dB*	*0.076 dB*	
	> 8.0 GHz to 12.4 GHz	*0.080 dB*	*0.080 dB*	
	> 12.4 GHz to 18.0 GHz	*0.101 dB*	*0.102 dB*	
Interface to host	power supply	+5 V/0.2 A (USB high-power device)		
	remote control	as a USB device (function) in full-speed mode, compatible with USB 1.0/1.1/2.0 specifications		
	trigger input	differential (0 V/+3.3 V)		
	connector type	ODU Mini-Snap® L series, six-pole cylindrical straight plug		
	permissible total cable length	≤ 10 m (see also tables on page 28)		
Dimensions (W × H × L)	R&S®NRP-Z211/-Z221	48 mm × 31 mm × 170 mm (1.89 in × 1.22 in × 6.69 in)		
	length including connecting cable	approx. 1.6 m (62.99 in)		
Weight	R&S®NRP-Z211/-Z221	< 0.30 kg (0.66 lb)		

Wideband power sensors in R&S®Smart Sensor Technology

R&S®NRP-Z81/-Z85/-Z86 wideband power sensors

Specifications from DC to 18 GHz apply to the R&S®NRP-Z81.
Specifications from DC to 40 GHz apply to the R&S®NRP-Z85 and R&S®NRP-Z86 model .40.
Specifications from DC to 44 GHz apply to the R&S®NRP-Z86 model .44.

Frequency range	R&S®NRP-Z81	50 MHz to 18 GHz	
	R&S®NRP-Z85	50 MHz to 40 GHz	
	R&S®NRP-Z86 model .40	50 MHz to 40 GHz	
	R&S®NRP-Z86 model .44	50 MHz to 44 GHz	
Impedance matching (SWR)	50 MHz to 2.4 GHz	**< 1.16 (1.11)**	( ): +15 °C to +35 °C
	> 2.4 GHz to 8.0 GHz	**< 1.20 (1.18)**	
	> 8.0 GHz to 18.0 GHz	**< 1.25 (1.23)**	
	> 18.0 GHz to 26.5 GHz	**< 1.30 (1.28)**	
	> 26.5 GHz to 40.0 GHz	**< 1.35 (1.33)**	
	> 40.0 GHz to 44.0 GHz	**< 1.40 (1.38)**	
Power measurement range	continuous average	1 nW to 100 mW (–60 dBm to +20 dBm)	
	burst		
	full video bandwidth	20 µW to 100 mW (–17 dBm to +20 dBm)	
	300 kHz	4 µW to 100 mW (–24 dBm to +20 dBm)	
	trace, timeslot/gate	20 nW to 100 mW (–47 dBm to +20 dBm)	
	statistics	4 µW [25] to 100 mW (–24 dBm to +20 dBm)	
Max. power	average power	0.2 W (+23 dBm), continuous	
	peak envelope power	1.0 W (+30 dBm) for max. 1 µs	
Dynamic response	video bandwidth	≥ 30 MHz [26]	
	single-shot bandwidth	≥ 30 MHz [26]	
	video bandwidth setting	full (≥ 30 MHz), 5 MHz, 1.5 MHz, 300 kHz	
	rise time 10 %/90 %		
	full video bandwidth	**≤ 13 ns** [26] (f ≥ 500 MHz)	
		< 40 ns [26] (f < 500 MHz)	
	5 MHz	< 75 ns	
	1.5 MHz	< 250 ns	
	300 kHz	< 1.2 µs	
	detectable burst width	≥ 50 ns [26] (f ≥ 500 MHz, full video bandwidth)	
	overshoot	≤ 5 %	
Acquisition	sample rate [period]		
	full video bandwidth	$80 \times 10^6\ s^{-1}$ [12.5 ns]	
	5 MHz	$40 \times 10^6\ s^{-1}$ [25.0 ns]	
	1.5 MHz	$10 \times 10^6\ s^{-1}$ [100 ns]	
	300 kHz	$2.5 \times 10^6\ s^{-1}$ [400 ns]	
	capture length	50 ns to 1 s (depending on meas. function)	
	time base accuracy	±50 ppm	
	time base jitter	< 1 ns	
Triggering	internal		
	threshold level range	–30 dBm to +20 dBm (usable from –22 dBm with full video bandwidth)	
	threshold level accuracy	identical to uncertainty for absolute power measurements	
	threshold level hysteresis	0 dB to 10 dB	
	dropout [5]	0 s to 10 s	
	external	see R&S®NRX base unit, R&S®NRP-Z3 USB adapter cable or R&S®NRP-Z5 USB sensor hub	
	slope (external, internal)	pos./neg.	
	delay	–51.2 µs to +10 s	
	hold-off	0 s to 10 s	
	resolution (delay, hold-off, dropout)	sample period	
	source	internal, external, immediate, bus, hold	

Zero offset After external zeroing [27] ( ): typical at 1 GHz		R&S®NRP-Z81	R&S®NRP-Z85/-Z86
	continuous average		
	10 µs aperture time	< 400 (220) pW	< 460 (235) pW
	other durations	< 10.0 (2.0) nW	< 11.4 (2.2) nW
	burst/timeslot/gate average, trace (pixel mean)		
	with averaging	< 10.0 (2.0) nW	< 11.4 (2.2) nW
	without averaging	< 200 (100) nW	< 230 (110) nW
	statistics	< 200 (100) nW	< 230 (110) nW
Zero drift [8, 27]		R&S®NRP-Z81	R&S®NRP-Z85/-Z86
	continuous average		
	10 µs aperture time	< 200 pW	< 230 pW
	other durations	< 500 pW	< 570 pW
	burst/timeslot/gate average, trace (pixel mean)		
	with averaging	< 2.0 nW	< 2.3 nW
	without averaging	< 150 nW	< 170 nW
	statistics	< 150 nW	< 170 nW
Measurement noise [27, 28] ( ): typical at 1 GHz		R&S®NRP-Z81	R&S®NRP-Z85/-Z86
	continuous average [29]		
	10 µs aperture time	< 200 (110) pW	< 230 (120) pW
	other durations	< 5.0 (1.0) nW	< 5.7 (1.1) nW
	trace/statistics (noise per sample)		
	full video bandwidth	< **3.0** (2.0) µW	< **3.5** (2.2) µW
	5 MHz	< 1.5 (1.0) µW	< 1.7 (1.1) µW
	1.5 MHz	< 0.9 (0.6) µW	< 1.0 (0.7) µW
	300 kHz	< 0.6 (0.4) µW	< 0.7 (0.5) µW
	burst/timeslot/gate average trace (pixel mean)	Multiply the noise-per-sample specification for full video bandwidth with noise reduction factors from tables B and C. For gate (pixel) lengths ≥ 2 µs, a noise value of 5 nW or better can be achieved with adequate averaging.	
Uncertainty for absolute power measurements [30] 0 °C to +50 °C		R&S®NRP-Z81	R&S®NRP-Z85/-Z86
	50 MHz to < 100 MHz	*0.15 dB (3.5 %)*	*0.15 dB (3.5 %)*
	100 MHz to 8.0 GHz	*0.13 dB (3.0 %)*	*0.13 dB (3.0 %)*
	> 8.0 GHz to 18.0 GHz	*0.15 dB (3.5 %)*	*0.15 dB (3.5 %)*
	> 18.0 GHz to 26.5 GHz	–	*0.15 dB (3.5 %)*
	> 26.5 GHz to 40.0 GHz	–	*0.17 dB (4.0 %)*
	> 40.0 GHz to 44.0 GHz	–	*0.19 dB (4.5 %)*

Uncertainty for relative power measurements [31] in dB

1 GHz to 18 GHz

+20	0.179	0.116	0.064
	0.155	0.105	0.058
	0.148	0.102	0.056
+10	0.145	0.094	0.116
	0.114	0.079	0.105
–15	0.105	0.075	0.102
	0.064	0.145	0.179
	0.045	0.114	0.155
–60	0.039	0.105	0.148

–60 –15 +10 +20

Power level in dBm

50 MHz to < 1GHz
> 18 GHz to 44 GHz

+20	0.193	0.130	0.088	0 °C to +50 °C
	0.170	0.120	0.083	+15 °C to +35 °C
	0.165	0.117	0.083	+20 °C to +25 °C
+10	0.162	0.110	0.130	0 °C to +50 °C
	0.134	0.098	0.120	+15 °C to +35 °C
–15	0.126	0.095	0.117	+20 °C to +25 °C
	0.068	0.162	0.193	0 °C to +50 °C
	0.051	0.134	0.170	+15 °C to +35 °C
–60	0.046	0.126	0.165	+20 °C to +25 °C

–60 –15 +10 +20

Power level in dBm

Table A Multipliers for zero offset, zero drift and noise specifications

Use these multipliers to calculate zero offset, zero drift and noise when operating the sensor at power levels above –20 dBm, at frequencies below 500 MHz, or at temperatures other than +23 °C.

Power Temperature	≤ –20 dBm	–10 dBm	–5 dBm	0 dBm	5 dBm	10 dBm	15 dBm	20 dBm
0 °C	**0.8** [0.9]	**0.9** [1.0]	**1.4** [1.5]	**3.2** [3.5]	**7.5** [8.5]	**17** [18]	**35** [37]	**65** [70]
+15 °C	**0.9** [1.0]	**1.1** [1.2]	**1.6** [1.8]	**3.4** [3.6]	**7.5** [8.5]			
+23 °C	**1.0** [1.2]	**1.3** [1.5]	**1.8** [2.0]	**3.5** [3.8]	**7.6** [8.7]			
+35 °C	**1.4** [1.7]	**1.7** [2.1]	**2.3** [2.6]	**3.9** [4.3]	**7.8** [9.0]			
+50 °C	**2.5** [3.0]	**2.7** [3.3]	**3.3** [4.0]	**5.2** [5.4]	**8.7** [9.5]			

[ ] At frequencies < 500 MHz.

Table B Noise reduction factors for gating and smoothing

The noise reduction factors in this table describe how measurement noise is reduced if the mean value of adjacent samples is taken over a time interval. The time interval can be the length of a gate, timeslot, or pixel in trace mode. Without averaging or for single events, use the leftmost column. If averaging is activated, use the columns for the individual repetition rates and additionally apply multipliers from table C. The repetition rate is identical to the frequency of the measurement being carried out, i.e. the inverse of the trigger period.

Repetition rate Gate (pixel) length	0	$10\ s^{-1}$	$100\ s^{-1}$	$10^3\ s^{-1}$	$10^4\ s^{-1}$	$5 \times 10^4\ s^{-1}$	$10^5\ s^{-1}$
25 ns	**0.7**						
50 ns	**0.5**						
100 ns	**0.4**						
200 ns	**0.3**						
500 ns	**0.2**						
1 µs	**0.16**	**0.15**		**0.14**			
2 µs	**0.14**	**0.13**	**0.12**	**0.11**		**0.10**	
10 µs	**0.11**	**0.1**	**0.09**	**0.08**	**0.07**	**0.06**	
100 µs	**0.10**	**0.09**	**0.07**	**0.06**	**0.04**		
1 ms	**0.10**	**0.07**	**0.06**	**0.035**			
10 ms	**0.10**	**0.06**	**0.035**				

Table C Noise reduction factors for averaging

Averaging number	2	4	8	16	32	64	128	256	512	1k	2k	4k	8k
Reduction factor	**0.7**	**0.5**	**0.35**	**0.25**	**0.18**	**0.13**	**0.09**	**0.063**	**0.044**	**0.031**	**0.022**	**0.016**	**0.011**

Example: A power measurement on a radar pulse is carried out by means of the timeslot/gate function. The gate length is set to 1 µs, and the averaging number to 32. The pulse repetition rate is 100 Hz, and the measurement is performed at +15 °C ambient temperature. The pulse power is about –10 dBm.

From the specifications, a 2σ noise-per-sample value of 2 µW (typ.) can be derived for reference conditions. Applying a multiplier of 1.1 from table A for +15 °C ambient temperature and –10 dBm pulse power results in 2.2 µW sampling noise under measurement conditions. Gating reduces noise by a factor of 0.15 (table B), and averaging further reduces noise by a factor of 0.18 (table C). The residual 2σ noise of mean power within the gate can then be calculated as follows: 2.2 µW × 0.15 × 0.18 = 59 nW (0.06 % of measured value).

Additional characteristics of the R&S®NRP-Z81/-Z85/-Z86 wideband power sensors

Sensor type		wideband diode power sensor
Measurand		power of incident wave
		power of source (DUT) into 50 Ω [12]
RF connector	R&S®NRP-Z81	N (male)
	R&S®NRP-Z85	2.92 mm (male)
	R&S®NRP-Z86	2.40 mm (male)
Measurement functions	stationary and recurring waveforms	continuous average
		burst
		timeslot/gate
		trace, statistics
	single events	trace, statistics
Continuous average function	measurand	mean power over recurring acquisition interval
	aperture	1 µs to 1 s (10 µs default)
	window function	uniform or von Hann [14]
	duty cycle correction [15]	0.001 % to 99.999 %
	capacity of measurement buffer [16]	1 to 8192 results
Burst average function	measurand	mean power over burst portion of recurring signal (trigger settings required)
	detectable burst width	50 ns to 0.1 s
	minimum gap between bursts	40 ns
	dropout period [17] for burst end detection	0 s to 0.1 s
	exclusion periods [18]	
	start	0 to burst width
	end	0 s to 51.2 µs
	resolution (dropout and exclusion periods)	sample period
Timeslot/gate function	measurand	mean, maximum and minimum power over individual timeslots/gates of recurring signal
	number of timeslots/gates	1 to 16 (consecutive)
	nominal length	50 ns to 0.1 s
	start of first timeslot/gate	at delayed trigger event
	exclusion periods [18]	
	start	0 to nominal length
	fence	0 s to 0.1 s (anywhere within timeslot)
	end	0 s to 51.2 µs
	resolution (nominal length and exclusion periods)	12.5 ns
Trace function	measurand	mean, random, maximum and minimum power over pixel length
	acquisition	
	length (Δ)	50 ns to 1 s
	start (referenced to delayed trigger)	$-4096 \times \Delta/M$ to +10 s
	result	
	pixels (M)	3 to 8192
	resolution (Δ/M)	
	normal	≥ sample period
	equivalent time	≥ 100 ps
	automatic pulse measurements	pulse width, pulse period, pulse off time, pulse duty cycle, pulse rise time, pulse fall time, pulse start time, pulse stop time, pulse top power, pulse base power, pulse peak power, pulse average power, positive overshoot, negative overshoot

Statistics functions	measurand	CCDF or PDF over accumulated records
	acquisition	
	mode	recurring or triggered
	length (aperture)	10 µs to 0.3 s
	start (referenced to delayed trigger)	0 s to +10 s
	exclusion period (fence)	0 s to 0.3 s (anywhere within aperture)
	number of accumulated records	2^N; N = 0 to 16 (set by averaging number)
	result	
	number of histogram classes (C)	3 to 8192
	power span (S)	0.01 dB to 100 dB
	minimum class width (S/C)	0.006 dB
Averaging filter	modes	auto off (fixed averaging number)
		auto on (continuously auto-adapted)
		auto once (automatically fixed once)
	auto off	
	supported measurement functions	all
	averaging number	2^N ; N = 0 to 20 (16 for trace/statistics)
	auto on/once	
	supported measurement functions	continuous average, burst average, timeslot/gate average
	normal operating mode	averaging number adapted to resolution setting and power to be measured
	fixed noise operating mode	averaging number adapted to specified noise content
	result output	
	moving mode	continuous, independent of averaging number
	rate	can be limited to 0.1 s^{-1}
	repeat mode	only final result
Attenuation correction	function	corrects the measurement result by means of a fixed factor (dB offset)
	range	–200.000 dB to +200.000 dB
Embedding	function	incorporates a two-port device at the sensor input so that the measurement plane is shifted to the input of this device
	parameters	S_{11}, S_{21}, S_{12} and S_{22} of device
	number of devices	user-definable
	frequencies (sum of all devices)	≤ 32000
Gamma correction	function	removes the influence of impedance mismatch from the measurement result so that the power of the source (DUT) into 50 Ω can be read
	parameters	magnitude and phase of reflection coefficient of source (DUT)
Frequency response correction	function	takes the frequency response of the power sensor into account
	parameter	center frequency of test signal
	residual uncertainty	see specification of calibration uncertainty and uncertainty for absolute power measurements
Measurement time [19] 2^N: averaging number T: number of timeslots w: nominal length of timeslot	continuous average	
	single-triggered	2 × (aperture + 6.5 µs) × $2^N + t_z$
	buffered [16], without averaging	2 × (aperture + 50 µs) × buffer size + t_z t_z : < 1.6 ms
	timeslot/gate average	
	signal period – $T \times w > 6$ µs	≤ signal period × (2^N + 1) + t_t
	all other cases	≤ 2 × signal period × (2^N + ½) + t_t t_t : 3 ms (typ.)
Measurement speed without averaging aperture time = 1 µs	continuous average	
	single-triggered	960 s^{-1} (typ.)
	buffered [16]	9800 s^{-1} (typ.)

Zeroing (duration)	including all functions, entire frequency range	8 s		
	restricted to < 500 MHz, all functions	4 s		
	restricted to ≥ 500 MHz, all functions	4 s		
	restricted to trace and statistics function, entire frequency range	20 ms		
Measurement error due to harmonics [32] n: multiple of carrier frequency	$n = 3$	≤ 4 GHz	4 GHz to 12.4 GHz	> 12.4 GHz
	–60 dBc	< 0.004 dB	< 0.003 dB	< 0.003 dB
	–40 dBc	< 0.035 dB	< 0.030 dB	< 0.025 dB
	–20 dBc	< 0.350 dB	< 0.300 dB	< 0.250 dB
	$n = 2$	≤ 4 GHz	4 GHz to 8 GHz	> 8 GHz
	–60 dBc	< 0.001 dB	< 0.002 dB	< 0.003 dB
	–40 dBc	< 0.010 dB	< 0.017 dB	< 0.025 dB
	–20 dBc	< 0.100 dB	< 0.170 dB	< 0.250 dB
Change of input reflection coefficient with respect to power [33]	–10 dBm to –60 dBm	< 0.035 (0.010)	( ): $f \leq 4$ GHz +15 °C to +35 °C	
	–10 dBm to 0 dBm	< 0.035 (0.025)		
	–10 dBm to +10 dBm	< 0.075 (0.055)		
	–10 dBm to +20 dBm	< 0.090 (0.080)		
Calibration uncertainty [34]		R&S®NRP-Z81	R&S®NRP-Z85/-Z86	
	50 MHz to < 100 MHz	*0.065 dB (1.5 %)*	*0.069 dB (1.6 %)*	
	≥ 100 MHz to 2.4 GHz	*0.052 dB (1.2 %)*	*0.052 dB (1.2 %)*	
	> 2.4 GHz to 4.0 GHz	*0.052 dB (1.2 %)*	*0.056 dB (1.3 %)*	
	> 4.0 GHz to 8.0 GHz	*0.056 dB (1.3 %)*	*0.060 dB (1.4 %)*	
	> 8.0 GHz to 12.5 GHz	*0.073 dB (1.7 %)*	*0.073 dB (1.7 %)*	
	> 12.5 GHz to 18.0 GHz	*0.086 dB (2.0 %)*	*0.090 dB (2.1 %)*	
	> 18.0 GHz to 26.5 GHz	–	*0.086 dB (2.0 %)*	
	> 26.5 GHz to 40.0 GHz	–	*0.116 dB (2.7 %)*	
	> 40.0 GHz to 44.0 GHz	–	*0.149 dB (3.5 %)*	
Interface to host	power supply	+5 V/0.5 A (USB high-power device)		
	remote control	as a USB device (function) in full-speed mode, compatible with USB 1.0/1.1/2.0 specifications		
	trigger input	differential (0 V/+3.3 V)		
	connector type	ODU Mini-Snap® L series, six-pole cylindrical straight plug		
	permissible total cable length	≤ 5 m (see also tables on page 28)		
Dimensions	W × H × L	48 mm × 31 mm × 170 mm (1.89 in × 1.22 in × 6.69 in)		
	length including connecting cable	approx. 1.6 m (62.99 in)		
Weight		< 0.30 kg (0.66 lb)		

Level control sensors in R&S®Smart Sensor Technology

R&S®NRP-Z28 level control sensor

Frequency range		10 MHz to 18 GHz		
Impedance matching (SWR) and insertion loss		input SWR	output SWR[35]	insertion loss[36] ( ): typical
	10 MHz to 2.4 GHz	< **1.35**	< **1.11**	< **8.0** (7.0) dB
	> 2.4 GHz to 4.0 GHz	< **1.45**	< **1.15**	< **8.5** (7.5) dB
	> 4.0 GHz to 8.0 GHz	< **1.75**	< **1.22**	< **9.5** (8.5) dB
	> 8.0 GHz to 12.4 GHz	< **1.80**	< **1.30**	< **10.5** (9) dB
	> 12.4 GHz to 18.0 GHz	< **1.90**	< **1.30**	< **11.0** (10) dB
Power measurement range RF output	continuous average	200 pW to 100 mW (–67 dBm to +20 dBm)		
	burst average	200 nW to 100 mW (–37 dBm to +20 dBm)		
	timeslot/gate average	600 pW to 100 mW (–62 dBm to +20 dBm)[1]		
	trace	10 nW to 100 mW (–50 dBm to +20 dBm)[2]		
Max. power RF input	average power			
	10 MHz to 2.4 GHz	0.7 W (+28.5 dBm)		continuous
	> 2.4 GHz to 8.0 GHz	0.9 W (+29.5 dBm)		
	> 8.0 GHz to 12.4 GHz	1.1 W (+30.5 dBm)		
	> 12.4 GHz to 18.0 GHz	1.3 W (+31.0 dBm)		
	peak envelope power	7.5 dB above max. average power (for 10 µs)		
Measurement subranges	path 1	–67 dBm to –14 dBm		
	path 2	–46 dBm to +6 dBm		
	path 3	–26 dBm to +20 dBm		
Transition regions	with automatic path selection[3]	(–19 –1/+2) dBm to (–13 –1/+2) dBm (+1 –1/+2) dBm to (+7 –1/+2) dBm		
Dynamic response	video bandwidth	> 50 kHz (100 kHz)		( ): +15 °C to +35 °C
	single-shot bandwidth	> 50 kHz (100 kHz)		
	rise time 10 %/90 %	< 8 µs (4 µs)		
Acquisition	sample rate (continuous)	133.358 kHz (default) or 119.467 kHz[4]		
Triggering	internal			
	threshold level range	–40 dBm to +20 dBm		
	threshold level accuracy	identical to uncertainty for absolute power measurements		
	threshold level hysteresis	0 dB to 10 dB		
	dropout[5]	0 s to 10 s		
	external	see R&S®NRX base unit, R&S®NRP-Z3 USB adapter cable or R&S®NRP-Z5 USB sensor hub		
	slope (external, internal)	pos./neg.		
	delay	–5 ms to +100 s		
	hold-off	0 s to 10 s		
	resolution (delay, hold-off, dropout)	sample period		
	source	internal, external, immediate, bus, hold		
Zero offset	initial, without zeroing			( ): typical at 1 GHz +15 °C to +35 °C [ ]: 8 GHz to 18 GHz
	path 1	< 505 [600] (100) pW		
	path 2	< 52 [60] (10) nW		
	path 3	< 5.2 [6] (1) µW		
	after external zeroing[6, 7]			
	path 1	< 114 [132] (67) pW		
	path 2	< 11 [13] (6) nW		
	path 3	< 1.1 [1.3] (0.6) µW		
Zero drift[8]	path 1	< 39 [44] (0) pW		
	path 2	< 3.3 [3.8] (0) nW		
	path 3	< 0.33 [0.38] (0) µW		
Measurement noise[9]	path 1	< 72 [83] (42) pW		
	path 2	< 7 [8] (4) nW		
	path 3	< 0.7 [0.8] (0.4) µW		

Uncertainty for absolute power measurements [10] in dB

10 MHz to < 20 MHz

0.174	*0.175*	*0.175*
0.075	*0.070*	*0.071*
0.056	*0.047*	*0.048*

–67 –19 +1 +20

Power level in dBm

20 MHz to < 100 MHz

0.147	*0.160*	*0.160*	0 °C to +50 °C
0.073	*0.069*	*0.069*	+15 °C to +35 °C
0.056	*0.047*	*0.048*	+20 °C to +25 °C

–67 –19 +1 +20

Power level in dBm

100 MHz to 4 GHz

0.159	*0.170*	*0.172*
0.084	*0.080*	*0.084*
0.066	*0.058*	*0.064*

–67 –19 +1 +20

Power level in dBm

> 4 GHz to 8 GHz

0.176	*0.185*	*0.189*	0 °C to +50 °C
0.101	*0.095*	*0.102*	+15 °C to +35 °C
0.083	*0.073*	*0.083*	+20 °C to +25 °C

–67 –19 +1 +20

Power level in dBm

> 8 GHz to 12.4 GHz

0.191	*0.198*	*0.205*
0.114	*0.104*	*0.117*
0.095	*0.080*	*0.097*

–67 –19 +1 +20

Power level in dBm

> 12.4 GHz to 18 GHz

0.218	*0.224*	*0.237*	0 °C to +50 °C
0.142	*0.130*	*0.151*	+15 °C to +35 °C
0.124	*0.105*	*0.130*	+20 °C to +25 °C

–67 –19 +1 +20

Power level in dBm

Uncertainty for relative power measurements [11] in dB

10 MHz to < 20 MHz

+20	*0.226*	*0.229*	*0.027*
	0.084	*0.080*	*0.022*
+7	*0.046*	*0.044*	*0.022*
+1	*0.226*	*0.027*	*0.229*
	0.083	*0.022*	*0.080*
–13	*0.045*	*0.022*	*0.044*
–19	*0.023*	*0.226*	*0.226*
	0.022	*0.083*	*0.084*
–67	*0.022*	*0.045*	*0.046*

–67 –19/–13 ±0/+8 +20

Power level in dBm

20 MHz to < 100 MHz

+20	*0.206*	*0.215*	*0.027*	0 °C to +50 °C
	0.082	*0.078*	*0.022*	+15 °C to +35 °C
+7	*0.046*	***0.044***	*0.022*	+20 °C to +25 °C
+1	*0.205*	*0.027*	*0.215*	0 °C to +50 °C
	0.081	*0.022*	*0.078*	+15 °C to +35 °C
–13	***0.044***	***0.022***	***0.044***	+20 °C to +25 °C
–19	*0.023*	*0.205*	*0.206*	0 °C to +50 °C
	0.022	*0.081*	*0.082*	+15 °C to +35 °C
–67	*0.022*	***0.044***	*0.046*	+20 °C to +25 °C

–67 –19/–13 ±0/+8 +20

Power level in dBm

100 MHz to 4 GHz

+20	*0.209*	*0.218*	*0.038*
	0.088	*0.085*	*0.032*
+7	*0.055*	*0.047*	*0.031*
+1	*0.206*	*0.028*	*0.218*
	0.083	*0.022*	*0.085*
–13	*0.048*	*0.022*	*0.047*
–19	*0.023*	*0.206*	*0.209*
	0.022	*0.083*	*0.088*
–67	*0.022*	*0.048*	*0.055*

–67 –19/–13 +1/+7 +20

Power level in dBm

> 4 GHz to 8 GHz

+20	*0.215*	*0.223*	*0.049*	0 °C to +50 °C
	0.097	*0.093*	*0.044*	+15 °C to +35 °C
+7	*0.066*	*0.059*	*0.043*	+20 °C to +25 °C
+1	*0.210*	*0.030*	*0.223*	0 °C to +50 °C
	0.088	*0.022*	*0.093*	+15 °C to +35 °C
–13	*0.054*	*0.022*	*0.059*	+20 °C to +25 °C
–19	*0.024*	*0.210*	*0.215*	0 °C to +50 °C
	0.022	*0.088*	*0.097*	+15 °C to +35 °C
–67	*0.022*	*0.054*	*0.066*	+20 °C to +25 °C

–67 –19/–13 +1/+7 +20

Power level in dBm

> 8 GHz to 12.4 GHz

+20	*0.224*	*0.231*	*0.064*
	0.111	*0.106*	*0.061*
+7	*0.084*	*0.077*	*0.060*
+1	*0.216*	*0.034*	*0.231*
	0.096	*0.027*	*0.106*
–13	*0.063*	*0.025*	*0.077*
–19	*0.024*	*0.216*	*0.224*
	0.022	*0.096*	*0.111*
–67	*0.022*	*0.063*	*0.084*

–67 –19/–13 +1/+7 +20

Power level in dBm

> 12.4 GHz to 18 GHz

+20	*0.244*	*0.245*	*0.086*	0 °C to +50 °C
	0.135	*0.128*	*0.084*	+15 °C to +35 °C
+7	*0.110*	*0.102*	*0.083*	+20 °C to +25 °C
+1	*0.230*	*0.040*	*0.245*	0 °C to +50 °C
	0.112	*0.034*	*0.128*	+15 °C to +35 °C
–13	*0.079*	*0.033*	*0.102*	+20 °C to +25 °C
–19	*0.024*	*0.230*	*0.244*	0 °C to +50 °C
	0.022	*0.112*	*0.135*	+15 °C to +35 °C
–67	*0.022*	*0.079*	*0.110*	+20 °C to +25 °C

–67 –19/–13 +1/+7 +20

Power level in dBm

R&S®NRP-Z98 level control sensor

Frequency range		9 kHz to 6 GHz		
Impedance matching (SWR) and insertion loss		input SWR	output SWR [35]	insertion loss [36] ( ): typical
	9 kHz to 2.4 GHz	< **1.35**	< **1.11**	< **8.0** (7.0) dB
	> 2.4 GHz to 4.0 GHz	< **1.45**	< **1.15**	< **8.5** (7.5) dB
	> 4.0 GHz to 6.0 GHz	< **1.75**	< **1.22**	< **9.5** (8.5) dB
Power measurement range RF output	continuous average	200 pW to 100 mW (–67 dBm to +20 dBm)		
Max. power RF input	average power			
	9 kHz to 2.4 GHz	0.7 W (+28.5 dBm)		continuous
	> 2.4 GHz to 6.0 GHz	0.9 W (+29.5 dBm)		
	peak envelope power	7.5 dB above max. average power (for 10 µs)		
Measurement subranges	path 1	–67 dBm to –14 dBm		
	path 2	–46 dBm to +6 dBm		
	path 3	–26 dBm to +20 dBm		
Transition regions	with automatic path selection [3]	(–19 $_{-1/+2}$) dBm to (–13 $_{-1/+2}$) dBm (+1 $_{-1/+2}$) dBm to (+7 $_{-1/+2}$) dBm		
Dynamic response	rise time 10 %/90 %	< 5 ms		
Acquisition	sample rate (continuous)	133.358 kHz		
Zero offset	initial, without zeroing			( ): typical at 1 GHz +15 °C to +35 °C
	path 1	< 505 (100) pW		
	path 2	< 52 (10) nW		
	path 3	< 5.2 (1) µW		
	after external zeroing [6, 7]			
	path 1	< 114 (67) pW		
	path 2	< 11 (6) nW		
	path 3	< 1.1 (0.6) µW		
Zero drift [8]	path 1	< 39 (0) pW		
	path 2	< 3.3 (0) nW		
	path 3	< 0.33 (0) µW		
Measurement noise [9]	path 1	< 72 (42) pW		
	path 2	< 7 (4) nW		
	path 3	< 0.7 (0.4) µW		

Uncertainty for absolute power measurements [10] in dB

9 kHz to < 20 kHz			**20 kHz to < 100 MHz**			
0.174	*0.175*	*0.175*	*0.147*	*0.160*	*0.160*	0 °C to +50 °C
0.075	*0.070*	*0.071*	*0.073*	*0.069*	*0.069*	+15 °C to +35 °C
0.056	*0.047*	*0.048*	*0.056*	*0.047*	*0.048*	+20 °C to +25 °C

–67 –19 +1 +20 –67 –19 +1 +20

Power level in dBm Power level in dBm

100 MHz to 4 GHz			**> 4 GHz to 6 GHz**			
0.159	*0.170*	*0.172*	*0.176*	*0.185*	*0.189*	0 °C to +50 °C
0.084	*0.080*	*0.084*	*0.101*	*0.095*	*0.102*	+15 °C to +35 °C
0.066	*0.058*	*0.064*	*0.083*	*0.073*	*0.083*	+20 °C to +25 °C

–67 –19 +1 +20 –67 –19 +1 +20

Power level in dBm Power level in dBm

Uncertainty for relative power measurements [11] in dB

	9 kHz to < 20 kHz				**20 kHz to < 100 MHz**			
+20	*0.226*	*0.229*	*0.027*	+20	*0.206*	*0.215*	*0.027*	0 °C to +50 °C
	0.084	*0.080*	*0.022*		*0.082*	*0.078*	*0.022*	+15 °C to +35 °C
+7	*0.046*	*0.044*	*0.022*	+7	*0.046*	***0.044***	*0.022*	+20 °C to +25 °C
+1	*0.226*	*0.027*	*0.229*	+1	*0.205*	*0.027*	*0.215*	0 °C to +50 °C
	0.083	*0.022*	*0.080*		*0.081*	*0.022*	*0.078*	+15 °C to +35 °C
–13	*0.045*	*0.022*	*0.044*	–13	***0.044***	***0.022***	***0.044***	+20 °C to +25 °C
–19	*0.023*	*0.226*	*0.226*	–19	*0.023*	*0.205*	*0.206*	0 °C to +50 °C
	0.022	*0.083*	*0.084*		*0.022*	*0.081*	*0.082*	+15 °C to +35 °C
–67	*0.022*	*0.045*	*0.046*	–67	*0.022*	***0.044***	*0.046*	+20 °C to +25 °C

–67 –19/–13 +1/+7 +20 –67 –19/–13 +1/+7 +20

Power level in dBm Power level in dBm

	100 MHz to 4 GHz				**> 4 GHz to 6 GHz**			
+20	*0.209*	*0.218*	*0.038*	+20	*0.215*	*0.223*	*0.049*	0 °C to +50 °C
	0.088	*0.085*	*0.032*		*0.097*	*0.093*	*0.044*	+15 °C to +35 °C
+7	*0.055*	*0.047*	*0.031*	+7	*0.066*	*0.059*	*0.043*	+20 °C to +25 °C
+1	*0.206*	*0.028*	*0.218*	+1	*0.210*	*0.030*	*0.223*	0 °C to +50 °C
	0.083	*0.022*	*0.085*		*0.088*	*0.022*	*0.093*	+15 °C to +35 °C
–13	*0.048*	*0.022*	*0.047*	–13	*0.054*	*0.022*	*0.059*	+20 °C to +25 °C
–19	*0.023*	*0.206*	*0.209*	–19	*0.024*	*0.210*	*0.215*	0 °C to +50 °C
	0.022	*0.083*	*0.088*		*0.022*	*0.088*	*0.097*	+15 °C to +35 °C
–67	*0.022*	*0.048*	*0.055*	–67	*0.022*	*0.054*	*0.066*	+20 °C to +25 °C

–67 –19/–13 +1/+7 +20 –67 –19/–13 +1/+7 +20

Power level in dBm Power level in dBm

Additional characteristics of the R&S®NRP-Z28/-Z98 level control sensors

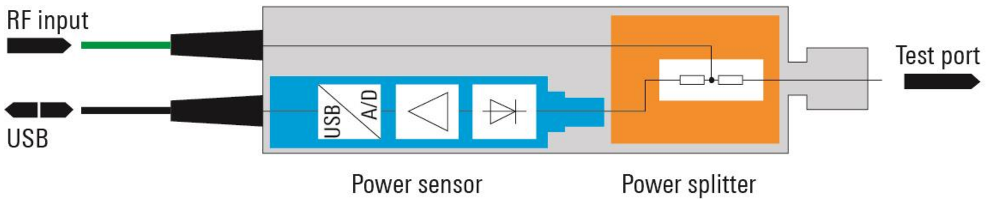
Shaded areas apply only to the R&S®NRP-Z28.

Sensor type		three-path diode power sensor combined with a resistive power splitter in a power leveling setup (see diagram at the end of this section)
Measurand		power available on a 50 Ω load
		power of wave emanating at RF output [12]
RF connectors		N (male)
Measurement functions	stationary and recurring waveforms	continuous average
		burst average
		timeslot/gate average
		trace
	single events	trace
Continuous average function	measurand	mean power over recurring acquisition interval
	aperture	
	R&S®NRP-Z28	10 µs to 300 ms (20 ms default)
	R&S®NRP-Z98	1 ms to 300 ms (20 ms default)
	window function	uniform or von Hann [14]
	duty cycle correction [15]	0.001 % to 99.999 %
	capacity of measurement buffer [16]	1 to 1024 results
Burst average function	measurand	mean power over burst portion of recurring signal (trigger settings required)
	detectable burst width	20 µs to 50 ms
	minimum gap between bursts	10 µs
	dropout period [17] for burst end detection	0 s to 3 ms
	exclusion periods [18]	
	start	0 to burst width
	end	0 s to 3 ms
	resolution (dropout and exclusion periods)	sample period (≈ 8 µs)
Timeslot/gate average function	measurand	mean power over individual timeslots/gates of recurring signal
	number of timeslots/gates	1 to 128 (consecutive)
	nominal length	10 µs to 0.1 s
	start of first timeslot/gate	at delayed trigger event
	exclusion periods [18]	
	start	0 to nominal length
	end	0 s to 3 ms
	resolution (nominal length and exclusion periods)	sample period (≈ 8 µs)
Trace function	measurand	mean power over pixel length
	acquisition	
	length (Δ)	100 µs to 300 ms
	start (referenced to delayed trigger)	–5 ms to +100 s
	result	
	pixels (M)	1 to 1024
	resolution (Δ/M)	
	non recurring or internally triggered	≥ 10 µs
	recurring and externally triggered	≥ 2.5 µs

Shaded areas apply only to the R&S®NRP-Z28.

Averaging filter	modes	auto off(fixed averaging number)		
		auto on(continuously auto-adapted)		
		auto once(automatically fixed once)		
	auto off			
	supported measurement functions	all		
	averaging number	2^N ; $N = 0$ to 16 (13 for trace function)		
	auto on/once			
	supported measurement functions	continuous average, burst average, timeslot/gate average		
	normal operating mode	averaging number adapted to resolution setting and power to be measured		
	fixed noise operating mode	averaging number adapted to specified noise content		
	result output			
	moving mode	continuous, independent of averaging number		
	rate	can be limited to 0.1 s^{-1}		
	repeat mode	only final result		
Attenuation correction	function	corrects the measurement result by means of a fixed factor (dB offset)		
	range	–200.000 dB to +200.000 dB		
Embedding	function	incorporates a two-port device at the RF output so that the measurement plane is shifted to the output of this device		
	parameters	S_{11}, S_{21}, S_{12} and S_{22} of device		
	frequencies	1 to 1000		
Gamma correction	function	removes the influence of impedance mismatch from the measurement result so that the power of the wave emanating at the RF output can be read		
	parameters	magnitude and phase of reflection coefficient of DUT		
Frequency response correction	function	takes the frequency response of the sensor section and of the power splitter into account		
	parameter	center frequency of test signal		
	residual uncertainty	see specification of calibration uncertainty and uncertainty for absolute and relative power measurements		
Measurement time [19] 2^N: averaging number T: set number of timeslots w: nominal length of timeslot	continuous average			
	R&S®NRP-Z28	$2 \times (\text{aperture} + 145\ \mu s) \times 2^N + t_z$ t_z : < 1.6 ms		
	R&S®NRP-Z98	$2 \times (\text{aperture} + 5\ \text{ms}) \times 2^N - 3.4\ \text{ms} + t_d$ t_d must be taken into account with activated auto delay (1 ms to 20 ms depending on temperature) [37]		
	buffered [16], without averaging	$2 \times (\text{aperture} + 250\ \mu s) \times \text{buffer size} + t_z$		
	timeslot/gate average			
	signal period – T × w > 100 µs	$\leq 2 \times \text{signal period} \times (2^N + ½) + t_z$		
	all other cases	$\leq 4 \times \text{signal period} \times (2^N + ¼) + t_z$		
Zeroing (duration)	depends on setting of averaging filter			
	auto on	4 s		
	auto off, integration time [20]			
	< 4 s	4 s		
	4 s to 16 s	integration time		
	> 16 s	16 s		
Measurement error due to harmonics [21]		$n = 2$	$n = 3$	
	–30 dBc	< 0.001 dB	< 0.003 dB	n: multiple of carrier frequency
	–20 dBc	< 0.002 dB	< 0.010 dB	
	–10 dBc	< 0.010 dB	< 0.040 dB	

Measurement error due to modulation [22]	general	depends on CCDF and RF bandwidth of test signal		
	WCDMA (3GPP test model 1-64)			
	worst case	–0.02 dB to +0.07 dB		
	typical	–0.01 dB to +0.03 dB		
Calibration uncertainty [24] (R&S®NRP-Z98 up to 6 GHz only)		path 1	path 2	path 3
	< 100 MHz	*0.056* dB	*0.047* dB	*0.048* dB
	100 MHz to 4.0 GHz	*0.066* dB	*0.057* dB	*0.058* dB
	> 4.0 GHz to 8.0 GHz	*0.083* dB	*0.072* dB	*0.072* dB
	> 8.0 GHz to 12.4 GHz	*0.095* dB	*0.077* dB	*0.077* dB
	> 12.4 GHz to 18.0 GHz	*0.124* dB	*0.100* dB	*0.101* dB
Interface to host	power supply	+5 V/0.2 A (USB high-power device)		
	remote control	as a USB device (function) in full-speed mode, compatible with USB 1.0/1.1/2.0 specifications		
	trigger input	differential (0 V/+3.3 V)		
	connector type	ODU Mini-Snap® L series, six-pole cylindrical straight plug		
	permissible total cable length	≤ 10 m (see also tables on page 28)		
Dimensions	W × H × L	48 mm × 50 mm × 250 mm (1.89 in × 1.97 in × 9.84 in)		
	length including connecting cable	approx. 1.75 m (68.89 in)		
Weight		< 0.7 kg (1.54 lb)		



Block diagram of the R&S®NRP-Z28/-Z98 level control sensors

Power sensor modules in R&S®Smart Sensor Technology

R&S®NRP-Z27/-Z37 power sensor modules

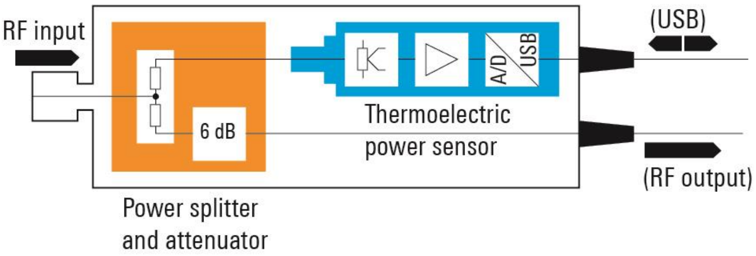
Specifications from 18 GHz to 26.5 GHz apply only to the R&S®NRP-Z37.

Frequency range	R&S®NRP-Z27	DC to 18 GHz		
	R&S®NRP-Z37	DC to 26.5 GHz		
Impedance matching (SWR)	RF input	R&S®NRP-Z27	R&S®NRP-Z37	
	DC to 2.0 GHz	**< 1.15**	**< 1.15**	
	> 2.0 GHz to 4.2 GHz	**< 1.18**	**< 1.18**	
	> 4.2 GHz to 8.0 GHz	**< 1.23**	**< 1.23**	
	> 8.0 GHz to 12.4 GHz	**< 1.25**	**< 1.25**	
	> 12.4 GHz to 18.0 GHz	**< 1.35**	**< 1.30**	
	> 18.0 GHz to 26.5 GHz	**–**	**< 1.45**	
	RF output	R&S®NRP-Z27	R&S®NRP-Z37	
	DC to 8.0 GHz	**< 1.6**	**< 1.6**	
	> 8.0 GHz to 26.5 GHz	**< 2.0**	**< 2.0**	
Power measurement range		4 µW to 400 mW (–24 dBm to +26 dBm), continuous, in a single range		
Max. power	average power	0.5 W (+27 dBm), continuous 1.0 W (+30 dBm) for max. 10 minutes		
	peak envelope power	30 W (45 dBm) for max. 1 µs		
Acquisition	sample rate	20.833 kHz (sigma-delta)		
Zero offset	after external zeroing [6, 7]	< 400 nW (typically 200 nW at 1 GHz)		
Zero drift [8]		< 160 nW		
Measurement noise [9]		< 240 nW (typically 120 nW at 1 GHz)		
Uncertainty for absolute power measurements [38]		+20 °C to +25 °C	+15 °C to +35 °C	0 °C to +50 °C
	with matched load on RF output (SWR < 1.05)			
	DC to < 100 MHz	*0.070 dB*	*0.077 dB*	*0.103 dB*
	100 MHz to 4.2 GHz	*0.075 dB*	*0.082 dB*	*0.106 dB*
	> 4.2 GHz to 8.0 GHz	*0.087 dB*	*0.094 dB*	*0.119 dB*
	> 8.0 GHz to 12.4 GHz	*0.093 dB*	*0.101 dB*	*0.130 dB*
	> 12.4 GHz to 18.0 GHz	*0.112 dB*	*0.121 dB*	*0.151 dB*
	> 18.0 GHz to 26.5 GHz	*0.122 dB*	*0.137 dB*	*0.190 dB*
	with R&S®FSMR26 connected to RF output			
	DC to < 100 MHz	*0.104 dB*	*0.109 dB*	*0.128 dB*
	100 MHz to 4.2 GHz	*0.116 dB*	*0.120 dB*	*0.138 dB*
	> 4.2 GHz to 8.0 GHz	*0.163 dB*	*0.166 dB*	*0.181 dB*
	> 8.0 GHz to 18.0 GHz	*0.183 dB*	*0.187 dB*	*0.207 dB*
	> 18.0 GHz to 26.5 GHz	*0.226 dB*	*0.235 dB*	*0.269 dB*
	with R&S®FSMR26 connected to RF output and activated load interference correction			
	DC to < 100 MHz	*0.067 dB*	*0.074 dB*	*0.101 dB*
	100 MHz to 4.2 GHz	*0.077 dB*	*0.083 dB*	*0.107 dB*
	> 4.2 GHz to 8.0 GHz	*0.092 dB*	*0.099 dB*	*0.123 dB*
	> 8.0 GHz to 12.4 GHz	*0.099 dB*	*0.107 dB*	*0.135 dB*
	> 12.4 GHz to 18.0 GHz	*0.122 dB*	*0.130 dB*	*0.159 dB*
	> 18.0 GHz to 26.5 GHz	*0.154 dB*	*0.167 dB*	*0.212 dB*
Uncertainty for relative power measurements [39]		*0.032 dB*		

Additional characteristics of the R&S®NRP-Z27/-Z37 power sensor modules

Sensor type		thermoelectric power sensor with signal pick-off at RF output (see diagram at the end of this section)	
Measurand		power of incident wave	
		power of source (DUT) into 50 Ω [12]	
RF connectors	input		
	R&S®NRP-Z27	N (male)	
	R&S®NRP-Z37	3.5 mm (male)	
	RF signal output	3.5 mm (male)	
Insertion loss Between RF input and RF output	DC to 2.0 GHz	< **14** (12.5) dB	( ): typical
	> 2.0 GHz to 4.2 GHz	< **15** (13.5) dB	
	> 4.2 GHz to 8.0 GHz	< **16** (14.0) dB	
	> 8.0 GHz to 12.4 GHz	< **17** (14.5) dB	
	> 12.4 GHz to 18.0 GHz	< **18** (15.5) dB	
	> 18.0 GHz to 26.5 GHz	< **19** (16.5) dB	
Measurement function	stationary and recurring waveforms	continuous average	
Continuous average function	measurand	mean power over recurring acquisition interval	
	aperture	1 ms to 100 ms (20 ms default)	
	window function	uniform or von Hann [14]	
	duty cycle correction [1515]	0.001 % to 99.999 %	
	capacity of measurement buffer [16]	1 to 1024 results	
Averaging filter	modes	auto off (fixed averaging number)	
		auto on (continuously auto-adapted)	
		auto once (automatically fixed once)	
	auto off		
	averaging number	2^N ; $N = 0$ to 16	
	auto on/once		
	normal operating mode	averaging number adapted to resolution setting and power to be measured	
	fixed noise operating mode	averaging number adapted to specified noise content	
	result output		
	moving mode	continuous, independent of averaging number	
	rate	can be limited to 0.1 s^{-1}	
	repeat mode	only final result	
Attenuation correction	function	corrects the measurement result by means of a fixed factor (dB offset)	
	range	–200.000 dB to +200.000 dB	
Gamma correction	function	removes the influence of impedance mismatch from the measurement result so that the power of the source (DUT) into 50 Ω can be read	
	parameters	magnitude and phase of reflection coefficient of source (DUT)	
Frequency response correction	function	takes the frequency response of the sensor section and of the power splitter into account	
	parameter	center frequency of test signal	
	residual uncertainty	see specification of calibration uncertainty and uncertainty for absolute power measurements	
Load interference correction	function	removing the influence of the load on the RF signal output from the power measurement result	
	parameters	magnitude and phase of reflection coefficient of load	
	residual uncertainty	see specification of load interference error	

Measurement time [19] 2^N: averaging number		2 × (aperture + 450 µs) × 2^N + 4 ms + t_d t_d (80 ms) must be taken into account when auto delay [37] is active	
Zeroing (duration)	depends on setting of averaging filter		
	auto on	4 s	
	auto off, integration time [20]		
	< 4 s	4 s	
	4 s to 16 s	integration time	
	> 16 s	16 s	
Calibration uncertainty [40]	DC to < 100 MHz	*0.063 dB*	
	100 MHz to 4.2 GHz	*0.070 dB*	
	> 4.2 GHz to 8.0 GHz	*0.082 dB*	
	> 8.0 GHz to 12.4 GHz	*0.088 dB*	
	> 12.4 GHz to 18.0 GHz	*0.109 dB*	
	> 18.0 GHz to 26.5 GHz	*0.118 dB*	
Temperature effect [41]	DC to 4.2 GHz	< 0.004 dB/K	
	> 4.2 GHz to 8.0 GHz	< 0.005 dB/K	
	> 8.0 GHz to 12.4 GHz	< 0.005 dB/K	
	> 12.4 GHz to 18.0 GHz	< 0.006 dB/K	
	> 18.0 GHz to 26.5 GHz	< 0.009 dB/K	
Linearity [42]	for power levels < 100 mW (20 dBm)	< 0.020 dB	
Power coefficient [43]		< (0.02 + 0.002 f/GHz) dB/W	
Load interference error [44] From RF signal output	DC to 2.0 GHz	**< 0.061** (0.003) dB	values in ( ) after load interference correction
	> 2.0 GHz to 12.4 GHz	**< 0.050** (0.012) dB	
	> 12.4 GHz to 18.0 GHz	**< 0.043** (0.016) dB	
	> 18.0 GHz to 26.5 GHz	**< 0.043** (0.022) dB	
Interface to host	power supply	+5 V/0.1 A (USB low-power device)	
	remote control	as a USB device (function) in full-speed mode, compatible with USB 1.0/1.1/2.0 specifications	
	trigger input	differential (0 V/+3.3 V)	
	connector type	ODU Mini-Snap® L series, six-pole cylindrical straight plug	
	permissible cable length	≤ 10 m (see also tables on page 28)	
Dimensions	W × H × L	48 mm × 50 mm × 250 mm (1.89 in × 1.97 in × 9.84 in)	
	length including connecting cable	approx. 1.75 m (68.89 in)	
Weight		< 0.7 kg (1.54 lb)	



Block diagram of the R&S®NRP-Z27/-Z37 power sensor modules

Accessories for sensors

R&S®NRP-Z2 extension cables

Application		for extending the connection between an R&S®NRP-Zxx power sensor and the R&S®NRX base unit, another Rohde & Schwarz measuring instrument, an R&S®NRP-Z3/-Z4 USB adapter cable or an R&S®NRP-Z5 USB sensor hub
Connectors	type	ODU Mini-Snap® L series, size 1, six-pole receptacle
	sensor side	
	models .03/.05/.10	with in-line receptacle
	model .15	with bulkhead receptacle for panel mounting < 5 mm wall thickness
	host side	straight plug
Length	model .03	1.5 m
	models .05/.15	3.5 m
	model .10	8.5 m
Permissible total length	including power sensor and R&S®NRX base unit or R&S®NRP-Z3/-Z4 USB adapter cable or R&S®NRP-Z5 USB sensor hub, if applicable	see tables below

Supported combinations with R&S®NRX base unit or other Rohde & Schwarz measuring instruments with ODU Mini-Snap® receptacle (e.g. R&S®FSMR, R&S®SMA200A, R&S®SMF100A)

R&S®NRP-Zxx power sensor		R&S®NRP-Z2 models				total length in m
		.03	.05/.15	.10		
●	+	●	–	–	=	3.0
●		–	●	–		5.0
●		–	–	●		10.0

(shaded combination only supported by R&S®NRX base unit; not permissible for R&S®NRP-Z81/-Z85/-Z86 power sensors)

Supported combinations with R&S®NRP-Z3/-Z4 USB adapter cables

R&S®NRP-Zxx power sensor		R&S®NRP-Z2 models			R&S®NRP-Z4 models			R&S®NRP-Z3/-Z4 model		total length in m
		.03	.05/.15		.06	.04	.11	.02		
●		–	–		●	–	–	–		1.6
●		–	–		–	●	–	–		2.0
●		–	–		–	–	●	–		2.5
●	+	–	–	+	–	–	–	●	=	3.5
●		●	–		–	–	–	●		5.0
●		–	●		●	–	–	–		5.1
●		–	●		–	●	–	–		5.5
●		–	●		–	–	●	–		6.0
●		–	●		–	–	–	●		7.0

(shaded combinations not permissible for R&S®NRP-Z81/-Z85/-Z86 power sensors)

Supported combinations with R&S®NRP-Z5 USB sensor hub (cable between sensor and hub)

R&S®NRP-Zxx power sensor		R&S®NRP-Z2 models			R&S®NRP-Z5 USB sensor hub		total length in m
	+	.03	.05/.15	+		=	
●		●	–		●		3.0
●		–	●		●		5.0

Supported combinations with R&S®NRP-Z5 USB sensor hub (cable between hub and host)

R&S®NRP-Z5 USB sensor hub		R&S®NRP-Z2 models		R&S®NRP-Z4 models				standard USB cable (max. length: 5 m)		total length in m
		.03	.05/.15	.06	.04	.11	.02			
●		●	–		–		–	–		3.0
●		–	●		–		–	–		5.0
●	+	–	–	●	–	–	–	–	=	0.1
●		–	–	–	●	–	–	–		0.5
●		–	–	–	–	●	–	–		1.0
●		–	–	–	–	–	●	–		2.0
●		–	–	–	–	–	–	●		5.0

R&S®NRP-Z3 active USB adapter cable

Application		for connecting an R&S®NRP-Zxx power sensor to a USB host (PC or Rohde & Schwarz measuring instrument with type A receptacle)
Trigger input	maximum voltage	±15 V
	logic level	
	low	< 0.8 V
	high	> 2.0 V
	input impedance	approx. 5 kΩ
Connectors	sensor	ODU Mini-Snap® L series, size 1, six-pole receptacle
	USB host	USB type A plug
Plug-in power supply	voltage/frequency	100 V to 240 V/50 Hz to 60 Hz
	tolerance	±10 % for voltage, ±3 Hz for frequency
	current consumption	25 mA (typ.) with sensor connected
	connection	via adapter to all common AC supplies (Europe, UK, USA, Australia)
Dimensions (W × H × L)	USB adapter	48 mm × 45 mm × 140 mm (1.89 in × 1.77 in × 5.51 in)
	length including connecting cable	approx. 2 m (78.74 in)
	plug-in power supply	52 mm × 73 mm × 110 mm (2.05 in × 2.87 in × 4.33 in)
	length of line to USB adapter	approx. 2 m (78.74 in)
Weight	USB adapter	< 0.2 kg (0.44 lb)
	plug-in power supply	< 0.3 kg (0.66 lb)

R&S®NRP-Z4 passive USB adapter cable

Application		for connecting an R&S®NRP-Zxx power sensor to a USB host (PC or Rohde & Schwarz measuring instrument with type A receptacle)
Connectors	sensor side	ODU Mini-Snap® L series, size 1, six-pole receptacle
	models .02/.04/.06	with in-line receptacle
	model .11	with bulkhead receptacle for panel mounting < 5 mm wall thickness
	host side	USB type A plug
Dimensions (length)	model .02	approx. 2 m (78.74 in)
	model .04	approx. 0.5 m (19.69 in)
	model .06	approx. 0.15 m (5.91 in)
	model .11	approx. 1 m (39.37 in)

R&S®NRP-Z5 USB sensor hub

Application		for connecting up to four R&S®NRP-Zxx power sensors to • a USB host (PC or Rohde & Schwarz measuring instrument with type A receptacle) • a Rohde & Schwarz measuring instrument (other than the R&S®NRX) with circular sensor connector (ODU Mini-Snap® L series, size 1, six-pole receptacle)
Trigger input	maximum voltage	±8 V
	logic level	
	low	< 0.8 V
	high	> 2.0 V
	input impedance	approx. 10 kΩ
	minimum pulse width	35 ns (without R&S®NRP-Z2 extension cable)
Trigger output	high-level output voltage	< 5.3 V (no load), > 2.0 V (50 Ω)
	low-level output voltage	< 0.4 V at 5 mA sink current
Power supply	voltage/power	12 V to 24 V (DC)/24 W
	source	AC adapter supplied with the equipment or equivalent DC voltage source no supply from extra-low voltage supply systems or via secondary cables > 30 m (98.43 ft)
Connectors	sensors A to D	ODU Mini-Snap® L series, size 1, six-pole receptacle
	USB host	USB type B receptacle (certified USB 2.0 high-speed cable supplied with the equipment)
	for Rohde & Schwarz instrument	ODU Mini-Snap® L series, size 1, six-pole plug
	trigger input, trigger output	BNC receptacle
	power supply	receptacle for DC barrel connector, ∅ 5.5 mm × ∅ 2.1 mm × 9.5 mm; inner conductor is positive pole
Dimensions (W × H × L)	sensor hub	140.6 mm × 36.6 mm × 138 mm (5.54 in × 1.44 in × 5.43 in)
Weight	excluding accessories	< 0.55 kg (1.21 lb)
AC adapter	input voltage/frequency	100 V to 240 V/50 Hz to 60 Hz
	tolerance	±10 % for voltage, ±3 Hz for frequency
	input connector	C14 receptacle, in line with IEC 60320
	output voltage/power	12 V (DC)/36 W
	length of secondary cable	approx. 0.72 m (28.35 in)
	dimensions (W × H × L)	120 mm × 52 mm × 31 mm (4.72 in × 2.05 in × 1.22 in)
	weight	< 0.3 kg (0.66 lb)

General data

Temperature loading [45]	operating and permissible temperature range (in [ ] if different)	in line with IEC 60068
	R&S®NRP-Z5 USB sensor hub, R&S®NRP-Z3/-Z4 USB adapter cables	0 °C to +50 °C
	R&S®NRP-Zxx power sensors, R&S®NRP-Z2 extension cables	0 °C to +50 °C [–10 °C to +55 °C]
	storage temperature range	
	R&S®NRP-Z5 USB sensor hub R&S®NRP-Zxx power sensors, R&S®NRP-Z2 extension cables and R&S®NRP-Z3/-Z4 USB adapter cables	–40 °C to +70 °C
Climatic resistance		in line with EN 60068
	damp heat	+25 °C/+40 °C cyclic at 95 % relative humidity, with restrictions: noncondensing
Mechanical resistance	vibration	
	sinusoidal	5 Hz to 55 Hz, max. 2 g 55 Hz to 150 Hz, 0.5 g constant, in line with EN 60068
	random	10 Hz to 500 Hz, 1.9 g (RMS), in line with EN 60068
	shock	40 g shock spectrum, in line with EN 60068
	air pressure	
	operation	795 hPa (2000 m) to 1060 hPa
	transport	566 hPa (4500 m) to 1060 hPa
Electromagnetic compatibility		in line with EN 61326, EN 55011
Safety		in line with EN 61010-1, IEC 61010-1, CAN/CSA-C22.2 No. 61010-1-04, UL STD. No. 61010-1
Calibration interval	for R&S®NRP-Z8x power sensors	1 year
	for all other R&S®NRP-Zxx power sensors	2 years

Appendix

Reading the uncertainty of diode power sensors for relative power measurements

The example shows a level step of approx. 14 dB (–4 dBm → +10 dBm) at 1.9 GHz and an ambient temperature of +28 °C for an R&S®NRP-Z21 power sensor.

Ordering information

Designation	Type	Order No.
Two-path diode power sensors		
1 nW to 100 mW, 10 MHz to 8 GHz	R&S®NRP-Z211	1417.0409.02
1 nW to 100 mW, 10 MHz to 18 GHz	R&S®NRP-Z221	1417.0309.02
Wideband power sensors		
1 nW to 100 mW, 50 MHz to 18 GHz	R&S®NRP-Z81	1137.9009.02
1 nW to 100 mW, 50 MHz to 40 GHz (2.92 mm)	R&S®NRP-Z85	1411.7501.02
1 nW to 100 mW, 50 MHz to 40 GHz (2.40 mm)	R&S®NRP-Z86	1417.0109.40
1 nW to 100 mW, 50 MHz to 44 GHz (2.40 mm)	R&S®NRP-Z86	1417.0109.44
Level control sensors		
200 pW to 100 mW, 9 kHz to 6 GHz	R&S®NRP-Z98	1170.8508.02
200 pW to 100 mW, 10 MHz to 18 GHz	R&S®NRP-Z28	1170.8008.02
Power sensor modules		
4 µW to 400 mW, DC to 18 GHz	R&S®NRP-Z27	1169.4102.02
4 µW to 400 mW, DC to 26.5 GHz	R&S®NRP-Z37	1169.3206.02
Recommended extras		
R&S®NRPV virtual power meter (PC application), activation for one R&S®NRP-Zxx power sensor	R&S®NRPZ-K1	1418.9800.03
Sensor extension cable to 3 m	R&S®NRP-Z2	1146.6750.03
Sensor extension cable to 5 m	R&S®NRP-Z2	1146.6750.05
Sensor extension cable to 10 m	R&S®NRP-Z2	1146.6750.10
Sensor extension cable to 5 m (with bulkhead receptacle for panel mounting)	R&S®NRP-Z2	1146.6750.15
USB adapter cable (active)	R&S®NRP-Z3	1146.7005.02
USB adapter cable (passive, length: 2.0 m)	R&S®NRP-Z4	1146.8001.02
USB adapter cable (passive, length: 0.5 m)	R&S®NRP-Z4	1146.8001.04
USB adapter cable (passive, length: 0.15 m)	R&S®NRP-Z4	1146.8001.06
USB adapter cable (passive, length: 1.0 m, with bulkhead receptacle for panel mounting)	R&S®NRP-Z4	1146.8001.11
USB sensor hub	R&S®NRP-Z5	1146.7740.02

Warranty		
R&S®NRX base unit, power sensors and R&S®NRP-Z5		3 years
All other items [46]		1 year
Options		
Extended warranty, one year	R&S®WE1	Please 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 [47]. Necessary calibration and adjustments carried out during repairs are also covered.

Extended warranty with calibration (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 [47] 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 [47] and accredited calibration at the recommended intervals as well as any accredited calibration carried out during repairs or option upgrades.

Endnotes

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[1] Specifications apply to timeslots/gates with a duration of 12.5 % referenced to the signal period (duty cycle 1:8). For other waveforms, the following equation applies: lower measurement limit = lower measurement limit for continuous average mode / √(duty cycle).

[2] With a resolution of 256 pixels.

[3] Specifications apply to the default transition setting of 0 dB. The transition regions can be shifted by as much as –20 dB using an adequate offset.

[4] To prevent aliasing in the case of signals with discrete modulation frequencies between 100 kHz and 1 MHz.

[5] Time span prior to triggering, where the trigger signal must be entirely below the threshold level in the case of a positive slope and vice versa in the case of a negative slope.

[6] Specifications expressed as an expanded uncertainty with a confidence level of 95 % (two standard deviations). For calculating zero offsets at higher confidence levels, use the properties of the normal distribution (e.g. 99.7 % confidence level for three standard deviations).

[7] Specifications apply to zeroing with a duration of 4 s. Zeroing for more than 4 s lowers uncertainty correspondingly (half values for 16 s).

[8] Within one hour after zeroing, permissible temperature change ±1 °C, following a two-hour warm-up of the power sensor.

[9] Two standard deviations at 10.24 s integration time in continuous average mode, with aperture time set to default value. The integration time is defined as the total time used for signal acquisition, i.e. the product of twice the aperture time and the averaging number. Multiplying the noise specifications by √(10.24 s/integration time) yields the noise contribution at other integration times. Using a von Hann window function increases noise by a factor of 1.22.

[10] Expanded uncertainty (k = 2) for absolute power measurements on CW signals with automatic path selection and the default transition setting of 0 dB. Specifications include calibration uncertainty, linearity and temperature effect. Zero offset, zero drift and measurement noise must additionally be taken into account when measuring low powers. As a rule of thumb, the contribution of zero offset can be neglected for power levels above –30 dBm for the R&S®NRP-Z211/-Z221. The contribution of measurement noise depends on power and integration time and can be neglected below 0.01 dB.

Example: The uncertainty of a power measurement at 3.2 nW (–55 dBm) and 1.9 GHz is to be determined for an R&S®NRP-Z11. The ambient temperature is +29 ºC and the averaging number is set to 32 in the continuous average mode with an aperture time of 20 ms.

Since path 1 is used for the measurement, the typical absolute uncertainty due to zero offset is 64 pW (typical) after external zeroing, which corresponds to a relative measurement uncertainty of

$$10 \times \lg \frac{3.2\,\text{nW} + 64\,\text{pW}}{3.2\,\text{nW}} = 0.086\,\text{dB}$$

Using the formula in endnote 9, the absolute noise contribution of path 1 is typically 40 pW × √(10.24 s/(32 × 2 × 0.02 s)) = 113 pW, which corresponds to a relative measurement uncertainty of

$$10 \times \lg \frac{3.2\,\text{nW} + 113\,\text{pW}}{3.2\,\text{nW}} = 0.151\,\text{dB}$$

Combined with the uncertainty of 0.081 dB for absolute power measurements under the given conditions, the total expanded uncertainty is

$$\sqrt{0.086^2 + 0.151^2 + 0.081^2}\,\text{dB} = 0.192\,\text{dB}.$$

The contribution of zero drift has been neglected in this case. It must be treated like zero offset if it is relevant for total uncertainty.

[11] Expanded uncertainty (k = 2) for relative power measurements on CW signals of the same frequency with automatic path selection and a default transition setting of 0 dB. For reading the measurement uncertainty diagrams of universal, average and level control sensors, see the Appendix.

Specifications include calibration uncertainty (only if different paths are affected), linearity and temperature effect. Zero offset, zero drift and measurement noise must additionally be taken into account when measuring low powers. As a rule of thumb, the contribution of zero offset can be neglected for power levels above –30 dBm for the R&S®NRP-Z211/-Z221. The contribution of measurement noise depends on power and integration time and can be neglected below 0.01 dB.

Example: The uncertainty of a power step from 1 mW (0 dBm) to 10 nW (–50 dBm) at 5.4 GHz is to be determined for an R&S®NRP-Z11. The ambient temperature is +20 ºC and the averaging number is set to 16 for both measurements in the continuous average mode with an aperture time of 20 ms. For the calculation of total uncertainty, the relative contribution of noise, zero offset and zero drift must be taken into account for both measurements . In this example, all contributions at 0 dBm and the effect of zero drift have been neglected.

Since path 1 is used for the –50 dBm measurement, the typical absolute uncertainty due to zero offset is 64 pW after external zeroing, which corresponds to a relative measurement uncertainty of

$$10 \times \lg \frac{10\,\text{nW} + 64\,\text{pW}}{10\,\text{nW}} = 0.028\,\text{dB}$$

Using the formula in endnote 9, the absolute noise contribution of path 1 is typically 40 pW × √(10.24 s/(16 × 2 × 0.02 s)) = 160 pW, which corresponds to a relative measurement uncertainty of

$$10 \times \lg \frac{10\,\text{nW} + 160\,\text{pW}}{10\,\text{nW}} = 0.069\,\text{dB}$$

Combined with the uncertainty of 0.054 dB for relative power measurements under the given conditions, the total expanded uncertainty is

$$\sqrt{0.028^2 + 0.069^2 + 0.054^2}\,\text{dB} = 0.092\,\text{dB}$$

[12] Gamma correction activated.

[13] Preceding sensor section (nominal value).

[14] Preferably used with determined modulation when the aperture time cannot be matched to the modulation period. Compared to a uniform window, measurement noise is about 22 % higher.

[15] For measuring the power of periodic bursts based on an average power measurement.

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[16] To increase measurement speed, the power sensor can be operated in buffered mode. In this mode, measurement results are stored in a buffer of user-definable size and then output as a block of data when the buffer is full. To enhance measurement speed even further, the sensor can be set to record the entire series of measurements when triggered by a single event. In this case, the power sensor automatically starts a new measurement as soon as it has completed the previous one.

[17] This parameter enables power measurements on modulated bursts. The parameter must be longer in duration than modulation-induced power drops within the burst.

[18] To exclude unwanted portions of the signal from the measurement result.

[19] Valid for Repeat mode, extending from the beginning to the end of all transfers via the USB interface of the power sensor. Measurement times under remote control of the R&S®NRX base unit via IEC/IEEE bus are approximately 2.5 ms longer, extending from the start of the measurement up to when the measurement result has been supplied to the output buffer of the R&S®NRX.

[20] Integration time is defined as the total time used for signal acquisition, i.e. taking into account the chosen aperture/acquisition time and the averaging number.

[21] Magnitude of measurement error referenced to an ideal thermal power sensor that measures the sum power of carrier and harmonics. For the R&S®NRP-Z211/-Z221, specifications apply to automatic path selection and power levels up to +16 dBm or, within a subrange, to 0.1 mW (–10 dBm) for path 1 and 40 mW (+16 dBm) for path 2. Above the mentioned power limit, specifications must be raised by a factor of 1.25 per 1 dB rise in power level. Within a subrange, measurement errors are proportional to the measured power in W.

[22] Measurement error referenced to a CW signal of equal power and frequency. For the R&S®NRP-Z211/-Z221, specifications apply to automatic path selection and power levels up to +16 dBm or, within a subrange, to 0.1 mW (–10 dBm) for path 1 and 39.8 mW (+16 dBm) for path 2 Above the mentioned power limit, specifications must be raised by a factor of 1.25 per 1 dB rise in power level. Within a subrange, measurement errors are proportional to the measured power in W.

[23] Applies to the R&S®NRP-Z211/-Z221, referenced to 0 dBm.

[24] Expanded uncertainty (k = 2) for absolute power measurements on CW signals at the calibration level within a temperature range from +20 °C to +25 °C and at the calibration frequencies (10 MHz, 15 MHz, 20 MHz, 30 MHz, 50 MHz, 100 MHz; in steps of 250 MHz from 250 MHz to the upper frequency limit). Specifications include zero offset and measurement noise (up to a 2σ value of 0.004 dB). The calibration level for the R&S®NRP-Z211/-Z221 is –10 dBm for paths 1 and 2.

[25] With full video bandwidth. Reduce the specified minimum levels according to the reduction of sampling noise at lower bandwidths.

[26] Specifications are valid from +15 °C to +50 °C ambient temperature. Below +15 °C, video bandwidth and single-shot bandwidth continuously decrease down to 20 MHz (typical) at 0 °C. Accordingly, the sensor rise time increases up to 50 ns for signals below 500 MHz and up to 20 ns for higher frequencies (typical at 0 °C).

[27] Specifications are valid at +23 °C ambient temperature for power levels ≤ –20 dBm and frequencies ≥ 500 MHz. For measurements at other temperatures levels and/or frequencies, use the multipliers from table A.

[28] Measured over a one-minute interval, at constant temperature, two standard deviations.

[29] 512k averages taken with the aperture time set to default (10 µs). The measurement noise with other averaging numbers can be calculated by applying the multipliers indicated below:

Averaging number	512k	128k	32k	8k	2k	512	128	32	8
Integration time	10.49 s	2.62 s	655.36 ms	163.84 ms	40.96 ms	10.24 ms	2.56 ms	0.64 ms	0.16 ms
Noise multiplier	**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**

Using a von Hann window function further increases noise by a factor of 1.22. Integration time is defined as the total time used for signal acquisition, i.e. the product of twice the aperture time and the averaging number.

The measurement noise is always minimal for the default aperture time. Increasing the aperture time above this value is only useful for suppressing modulation-induced fluctuations of the measurement result, e.g. by matching the aperture time to the modulation period.

[30] Expanded uncertainty (k = 2) for absolute power measurements on CW signals. Specifications include calibration uncertainty, linearity, influence of sensor-induced harmonics reflected on the DUT, and temperature effect. Zero offset, zero drift and measurement noise must additionally be taken into account when measuring low powers. As a rule of thumb, the contribution of zero offset and zero drift can be neglected for power levels above –35 dBm if external zeroing has been applied. The contribution of measurement noise can be neglected below 0.02 dB.

Example: The power to be measured is 40 nW (–44 dBm) at 12 GHz in the continuous average mode; ambient temperature +35 ºC; averaging number set to 32k with an aperture time of 10 µs (1 s integration time).

The typical absolute uncertainty due to zero offset is 220 pW at +23 °C. From table A, a multiplier of 1.4 can be taken to read a typical zero offset of 308 pW at +35 °C. The corresponding relative measurement uncertainty can be calculated as follows:

$$10 \times \lg \frac{40\text{nW} + 308\text{pW}}{40\text{nW}} = 0.033\text{dB}$$

Using the noise multiplier (4) from endnote 29 and the multiplier (1.4) from table A, the absolute noise contribution is typically 110 pW × 4 × 1.4 = 616 pW, which corresponds to a relative measurement uncertainty of

$$10 \times \lg \frac{40\text{nW} + 616\text{pW}}{40\text{nW}} = 0.066\text{dB}$$

Combined with the value of 0.18 dB specified for the uncertainty of absolute power measurements at 12 GHz, the total expanded uncertainty is

$$\sqrt{0.18^2 + 0.033^2 + 0.066^2\ \text{dB}} = 0.195\,\text{dB}$$

The contribution of zero drift has been neglected in this case. It must be treated like zero offset if it is relevant for total uncertainty.

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[31] Expanded uncertainty (k = 2) for relative power measurements on CW signals of the same frequency, carried out using a matched source. For reading the measurement uncertainty, see the Appendix. For small power ratios up to 5 dB, expanded uncertainty will typically not exceed 0.06 dB (0.08 dB) at +23°C (from 0°C to +50°C).

Specifications include linearity of the sensor, influence of sensor-induced harmonics that may be re-reflected at the source (DUT), and temperature effect. Zero offset, zero drift and measurement noise must additionally be taken into account when measuring low powers. As a rule of thumb, the contribution of zero offset and zero drift can be neglected for power levels above –35 dBm if external zeroing has been applied. The contribution of measurement noise can be neglected below a two-sigma value of 0.02 dB. A source (DUT) SWR of 3 has been assumed for signal frequency harmonics emanating from the sensor.

Example: The uncertainty of a power step from 1 mW (0 dBm) to 1 µW (–30 dBm) at 31 GHz is to be determined with an R&S®NRP-Z85. The ambient temperature is +21 ºC and the averaging number is set to 128 for both measurements. Measurements are carried out in the continuous average mode with a default aperture time of 10 µs.

For the calculation of total uncertainty, the relative contribution of zero offset and zero drift can be neglected in this case since both power levels are higher than –30 dBm. Noise must be taken into account for measurements at 1 µW. Using the noise multiplier (64) from endnote 29 and the multiplier (1.0) from table A, the absolute noise contribution is typically 110 pW × 64 × 1.0 = 7 nW, which corresponds to a relative measurement uncertainty of

$$10 \times \lg \frac{1\ \mu\text{W} + 0.007\,\text{nW}}{1\ \mu\text{W}} = 0.030\,\text{dB}$$

Combined with the uncertainty of 0.126 dB for relative power measurements with a matched source (see table), total expanded uncertainty is

$$\sqrt{0.03^2 + 0.126^2}\,\text{dB} = 0.130\,\text{dB}$$

Mismatch of the source (DUT) at the signal frequency can further impair linearity due to a change of the input reflection coefficient of the power sensor as a function of applied power (for specifications of reflection coefficient changes, see page 13). Limits of the induced linearity error can be approximated by

$$\pm 8.7\ \text{dB} \cdot r_{\text{DUT}} \cdot \Delta r_{\text{SEN}}$$

where r_{DUT} denotes the magnitude of the reflection coefficient of the source (DUT) and Δr_{SEN} denotes the change of the input reflection coefficient of the power sensor.

[32] Magnitude of measurement error referenced to an ideal thermal power sensor that measures the sum power of carrier and harmonics. For power levels below –10 dBm, the specifications for 2 × f_0 (3 × f_0) can be lowered by a factor of √10 (10) per 10 dB below –10 dBm. Example: At 12 GHz/–30 dBm, the influence of the second harmonic, suppressed by 20 dBc, will cause an error of max. 0.25 dB ÷ 10 = 0.025 dB. Standard uncertainties can be assumed to be half the values.

[33] Magnitude of the change vector in the complex plane.

[34] Expanded uncertainty (k = 2) for absolute power measurements on CW signals at the calibration level (–10 dBm) within a temperature range from +20 °C to +25 °C and at the calibration frequencies (50/55/60/68/80/100/200/300/400/499.99/500/600/720/850/1000/1500 MHz; R&S®NRP-Z81: in steps of 0.5 GHz from 2 GHz to the upper frequency limit; R&S®NRP-Z85/-Z86: in steps of 1 GHz from 2 GHz to 26 GHz and in steps of 0.5 GHz from 26.5 GHz to 44 GHz). Specifications include zero offset and measurement noise (up to a 2σ value of 0.01 dB).

[35] Equivalent source SWR.

[36] Between RF input and RF output (test port).

[37] With activated auto delay, the beginning of a measurement sequence is delayed so that settled readings are obtained even if the measurement command (remote trigger) coincides with a signal step up to ±10 dB.

[38] Expanded uncertainty (k = 2) for absolute power measurements up to 100 mW (+20 dBm) at the calibration frequencies (see endnote 40). Specifications include calibration uncertainty, linearity, temperature effect and interference from the wave reflected by the load on the RF output. Zero offset, zero drift and measurement noise must additionally be taken into account when measuring low powers. If the measured power exceeds 100 mW, the power coefficient of the integrated power splitter must be taken into account (see endnote 43). As a rule of thumb, the contribution of zero offset can be neglected for power levels above –7 dBm if external zeroing has been applied. The contribution of measurement noise can be neglected below 0.01 dB.

Example: The power to be measured with an R&S®NRP-Z37 is 50 µW (–13 dBm) at 19 GHz; ambient temperature +29 ºC; averaging number set to 64 in continuous average mode with an aperture time of 20 ms.

The maximum absolute uncertainty due to zero offset (after external zeroing) is 400 nW, which corresponds to a relative measurement uncertainty of

$$10 \times \lg \frac{50\,\mu\text{W} + 400\,\text{nW}}{50\,\mu\text{W}} = 0.035\,\text{dB}$$

Using the formula in endnote 9, the maximum absolute noise contribution is 240 nW × √(10.24 s/(64 × 2 × 0.02 s)) = 480 nW, which corresponds to a relative measurement uncertainty of

$$10 \times \lg \frac{50\,\mu\text{W} + 480\,\text{nW}}{50\,\mu\text{W}} = 0.042\,\text{dB}$$

Combined with the value of 0.137 dB specified for the uncertainty of absolute power measurements, the total expanded uncertainty is

$$\sqrt{0.035^2 + 0.042^2 + 0.137^2}\,\text{dB} = 0.148\,\text{dB}$$

[39] Expanded uncertainty (k = 2) for relative power measurements on CW signals of the same frequency. Specifications include linearity and temperature effect. Zero offset, zero drift and measurement noise must additionally be taken into account when measuring low powers. As a rule of thumb, the contribution of zero offset can be neglected for power levels above –7 dBm if external zeroing has been applied. The contribution of measurement noise can be neglected below 0.01 dB. See also the example in endnote 9 for taking into account zero offset and noise with relative measurements.

[40] Expanded uncertainty (k = 2) for absolute power measurements at the calibration level (0 dBm) within a temperature range from +20 °C to +25 °C and at the calibration frequencies. Specifications include zero offset and measurement noise (up to a 2σ value of 0.004 dB). The load on the RF signal output must be of a low-reflection type (SWR < 1.05) or load interference correction must be applied.

Calibration frequencies: 0.1/0.5/1/3/5/10/50/100 MHz; in steps of 100 MHz from 100 MHz to the upper frequency limit.

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[41] Error of an absolute power measurement with respect to temperature, taking into account the power sensor section, the power splitter and the RF cable (temperature-dependent interference from the load on the RF signal output due to phase change).

[42] Expanded uncertainty for relative power measurements on CW signals of the same frequency, referenced to the calibration level (0 dBm) and excluding zero offset, zero drift and measurement noise.

[43] Maximum change of insertion loss of the power splitter with respect to input power, leading to an equivalent measurement error of the power sensor module and a change of the power available at the RF signal output. The power coefficient should be taken into account if the input power exceeds 100 mW (+20 dBm).

[44] Measurement error due to interference of the wave reflected by a mismatched load on the RF signal output. Specifications are indicated for a 0.1 reflection coefficient of the load. Since the load interference error is proportional to the amplitude of the reflected wave, half (twice) the values will be encountered for a reflection coefficient of 0.05 (0.2). The error introduced by an R&S®FSMR26 at the RF signal output does not exceed ±0.06 dB from DC to 2 GHz, ±0.10 dB up to 18 GHz, and ±0.14 dB up to 26.5 GHz.

Values in ( ) represent residual error contribution after numeric load interference correction. This correction function requires the complex reflection coefficient of the load to be transferred to the power sensor module. The residual error contribution of an R&S®FSMR26 at the RF signal output does not exceed ±0.003 dB from DC to 2 GHz, ±0.04 dB up to 18 GHz, and ±0.07 dB up to 26.5 GHz.

[45] The operating temperature range defines the span of ambient temperature in which the instrument complies with specifications. In the permissible temperature range, the instrument is still functioning but compliance with specifications is not warranted.

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

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

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