

R&S®NRP

Power Meter Family

Specifications



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Definitions

Product data applies under the following conditions:

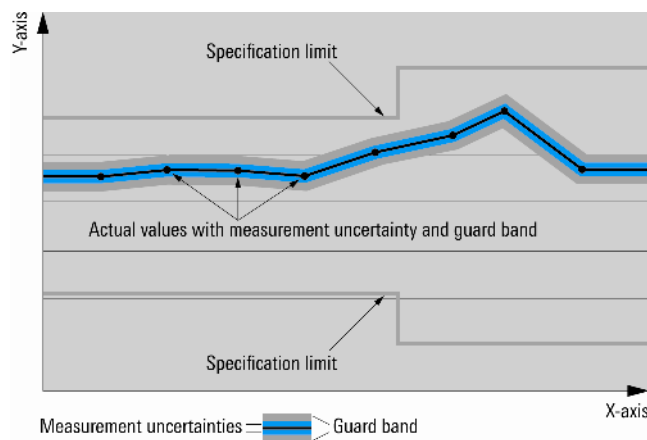
- Three hours storage at the expected operating temperature followed by 30 minutes warm-up, unless otherwise stated
- Specified environmental conditions met
- Recommended calibration interval adhered to
- All internal automatic adjustments performed, if applicable

Specifications with limits

Describe warranted product performance by means of a range of values for the specified parameter. These specifications are marked with limiting symbols such as $<$, $\leq$, $>$, $\geq$, $\pm$, or descriptions such as maximum and minimum.

Specifications in normal print refer to parameters where compliance is ensured by the design or derived from the measurement of related parameters.

Specifications in **bold** print are 100 % tested. Test limits have been narrowed by guard bands to take into account measurement uncertainties, drift and aging, if applicable.



Specifications without limits

Describe warranted product performance by means of a representative value for the specified parameter. Limits are omitted whenever they are not relevant for the specification (e.g. dimensional data).

Typical values (typ.)

Represent the population mean for the given parameter, derived from the design and/or production testing. Typical values are not warranted by Rohde & Schwarz.

Limits of uncertainty

Expanded uncertainties with a coverage factor of 2, calculated from the test assembly specifications and the modeled behavior of the sensor, including environmental conditions, aging, wear and tear, if applicable. The given values represent limits of uncertainty that are met by the Rohde & Schwarz instrument after calibration at a production or service site. Limits of uncertainty (in italics) are defined in EN 60359 and have been determined in line with the rules of the Guide to the Expression of Uncertainty in Measurement (GUM).

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
Universal power sensors			
NRP-Z11	10 MHz to 8 GHz	200 pW to 200 mW (–67 dBm to +23 dBm) max. 400 mW (AVG) / 1 W (PK, 10 µs)	N
NRP-Z21	10 MHz to 18 GHz	200 pW to 200 mW (–67 dBm to +23 dBm) max. 400 mW (AVG) / 1 W (PK, 10 µs)	N
NRP-Z31	10 MHz to 33 GHz	200 pW to 200 mW (–67 dBm to +23 dBm) max. 400 mW (AVG) / 1 W (PK, 10 µs)	3.50 mm
NRP-Z41	50 MHz to 40 GHz	200 pW to 100 mW (–67 dBm to +20 dBm) max. 200 mW (AVG) / 1 W (PK, 10 µs)	2.92 mm
NRP-Z61	50 MHz to 50 GHz	200 pW to 100 mW (–67 dBm to +20 dBm) max. 200 mW (AVG) / 1 W (PK, 10 µs)	2.40 mm
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
NRP-Z22	10 MHz to 18 GHz	2 nW to 2 W (–57 dBm to +33 dBm) max. 3 W (AVG) / 10 W (PK, 10 µs)	N
NRP-Z23	10 MHz to 18 GHz	20 nW to 15 W (–47 dBm to +42 dBm) max. 18 W (AVG) / 100 W (PK, 10 µs)	N
NRP-Z24	10 MHz to 18 GHz	60 nW to 30 W (–42 dBm to +45 dBm) max. 36 W (AVG) / 300 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
Thermal power sensors			
NRP-Z51 model .03	DC to 18 GHz	300 nW to 100 mW (–35 dBm to +20 dBm) max. 300 mW (AVG) / 20 W (PK, 1 µs)	N
NRP-Z52	DC to 33 GHz	300 nW to 100 mW (–35 dBm to +20 dBm) max. 300 mW (AVG) / 10 W (PK, 1 µs)	3.50 mm
NRP-Z55 model .03	DC to 40 GHz	300 nW to 100 mW (–35 dBm to +20 dBm) max. 300 mW (AVG) / 10 W (PK, 1 µs)	2.92 mm
NRP-Z55 model .04	DC to 44 GHz	300 nW to 100 mW (–35 dBm to +20 dBm) max. 300 mW (AVG) / 10 W (PK, 1 µs)	2.92 mm
NRP-Z56	DC to 50 GHz	300 nW to 100 mW (–35 dBm to +20 dBm) max. 300 mW (AVG) / 10 W (PK, 1 µs)	2.40 mm
NRP-Z57	DC to 67 GHz	300 nW to 100 mW (–35 dBm to +20 dBm) max. 300 mW (AVG) / 10 W (PK, 1 µs)	1.85 mm
NRP-Z58	DC to 110 GHz	300 nW to 100 mW (–35 dBm to +20 dBm) max. 300 mW (AVG) / 10 W (PK, 1 µs)	1.00 mm
Average power sensors			
NRP-Z91	9 kHz to 6 GHz	200 pW to 200 mW (–67 dBm to +23 dBm) max. 400 mW (AVG) / 1 W (PK, 10 µs)	N
NRP-Z92	9 kHz to 6 GHz	2 nW to 2 W (–57 dBm to +33 dBm) max. 3 W (AVG) / 10 W (PK, 10 µs)	N
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
Universal power sensors						
NRP-Z11	10 MHz to 2.4 GHz: < 1.13 > 2.4 GHz to 8.0 GHz: < 1.20	< 8 μs > 50 kHz	64 pW	40 pW	0.047 dB to 0.083 dB	0.022 dB to 0.066 dB
NRP-Z21	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				0.047 dB to 0.128 dB	0.022 dB to 0.110 dB
NRP-Z31	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 > 18.0 GHz to 26.5 GHz: < 1.30 > 26.5 GHz to 33.0 GHz: < 1.35				0.051 dB to 0.137 dB	0.022 dB to 0.118 dB
NRP-Z41	50 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 > 18.0 GHz to 26.5 GHz: < 1.30 > 26.5 GHz to 33.0 GHz: < 1.35 > 33.0 GHz to 40.0 GHz: < 1.37				0.074 dB to 0.150 dB	0.028 dB to 0.137 dB
NRP-Z61	50 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 > 18.0 GHz to 26.5 GHz: < 1.30 > 26.5 GHz to 33.0 GHz: < 1.35 > 33.0 GHz to 40.0 GHz: < 1.37 > 40.0 GHz to 50.0 GHz: < 1.40				0.074 dB to 0.191 dB	0.028 dB to 0.166 dB
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
NRP-Z22	10 MHz to 2.4 GHz: < 1.14 > 2.4 GHz to 8.0 GHz: < 1.20 > 8.0 GHz to 12.4 GHz: < 1.25 > 12.4 GHz to 18.0 GHz: < 1.30	< 8 μs > 50 kHz	0.7 nW	0.4 nW	0.079 dB to 0.178 dB	0.022 dB to 0.112 dB
NRP-Z23	10 MHz to 2.4 GHz: < 1.14 > 2.4 GHz to 8.0 GHz: < 1.25 > 8.0 GHz to 12.4 GHz: < 1.30 > 12.4 GHz to 18.0 GHz: < 1.41		7 nW	4 nW	0.078 dB to 0.199 dB	0.022 dB to 0.110 dB
NRP-Z24	10 MHz to 2.4 GHz: < 1.14 > 2.4 GHz to 8.0 GHz: < 1.25 > 8.0 GHz to 12.4 GHz: < 1.30 > 12.4 GHz to 18.0 GHz: < 1.41		20 nW	13 nW	0.078 dB to 0.222 dB	0.022 dB to 0.110 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	50 MHz to 2.4 GHz: < 1.16 > 2.4 GHz to 8.0 GHz: < 1.20				0.130 dB to 0.170 dB	0.039 dB to 0.165 dB
NRP-Z86 model .40	> 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					
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

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

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
Thermal power sensors						
NRP-Z51 model .03	DC to 100 MHz: < 1.03 > 100 MHz to 2.4 GHz: < 1.06 > 2.4 GHz to 12.4 GHz: < 1.13 > 12.4 GHz to 18.0 GHz:< 1.16	–	15 nW	15 nW	0.040 dB to 0.082 dB	0.010 dB
NRP-Z52	DC to 100 MHz: < 1.03 > 100 MHz to 2.4 GHz: < 1.06 > 2.4 GHz to 12.4 GHz: < 1.13 > 12.4 GHz to 18.0 GHz:< 1.16 > 18.0 GHz to 26.5 GHz:< 1.22 > 26.5 GHz to 33.0 GHz:< 1.28				0.040 dB to 0.101 dB	0.010 dB
NRP-Z55 model .03	DC to 100 MHz: < 1.03 > 100 MHz to 2.4 GHz: < 1.06 > 2.4 GHz to 12.4 GHz: < 1.13 > 12.4 GHz to 18.0 GHz:< 1.16 > 18.0 GHz to 26.5 GHz:< 1.22 > 26.5 GHz to 40.0 GHz:< 1.28				0.040 dB to 0.108 dB	0.010 dB
NRP-Z55 model .04	DC to 100 MHz: < 1.03 > 100 MHz to 2.4 GHz: < 1.06 > 2.4 GHz to 12.4 GHz: < 1.13 > 12.4 GHz to 18.0 GHz:< 1.16 > 18.0 GHz to 26.5 GHz:< 1.22 > 26.5 GHz to 40.0 GHz:< 1.28 > 40.0 GHz to 44.0 GHz:< 1.30				0.040 dB to 0.138 dB	0.010 dB
NRP-Z56	DC to 100 MHz: < 1.03 > 100 MHz to 2.4 GHz: < 1.06 > 2.4 GHz to 12.4 GHz: < 1.13 > 12.4 GHz to 18.0 GHz:< 1.16 > 18.0 GHz to 26.5 GHz:< 1.22 > 26.5 GHz to 40.0 GHz:< 1.28 > 40.0 GHz to 50.0 GHz:< 1.30				0.040 dB to 0.143 dB	0.010 dB
NRP-Z57	DC to 100 MHz: < 1.03 > 100 MHz to 2.4 GHz: < 1.06 > 2.4 GHz to 12.4 GHz: < 1.13 > 12.4 GHz to 18.0 GHz:< 1.16 > 18.0 GHz to 26.5 GHz:< 1.22 > 26.5 GHz to 40.0 GHz:< 1.28 > 40.0 GHz to 50.0 GHz:< 1.30 > 50.0 GHz to 67.0 GHz:< 1.35				0.040 dB to 0.248 dB	0.010 dB
NRP-Z58	DC to 100 MHz: < 1.05 > 100 MHz to 2.4 GHz: < 1.08 > 2.4 GHz to 12.4 GHz: < 1.18 > 12.4 GHz to 18.0 GHz:< 1.23 > 18.0 GHz to 26.5 GHz:< 1.28 > 26.5 GHz to 40.0 GHz:< 1.38 > 40.0 GHz to 50.0 GHz:< 1.46 > 50.0 GHz to 67.0 GHz:< 1.56 > 67.0 GHz to 80.0 GHz:< 1.60 > 80.0 GHz to 95.0 GHz:< 1.66 > 95.0 GHz to 110 GHz: < 1.70				0.040 dB to 0.318 dB	0.014 dB

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

Sensor type	Impedance matching (SWR)	Rise time	Video BW	Zero offset (typ.)	Noise (typ.)	Uncertainty for power measurements at +20 °C to +25 °C	
R&S®						absolute	relative
Average power sensors							
NRP-Z91	10 MHz to 2.4 GHz: < 1.13 > 2.4 GHz to 6.0 GHz: < 1.20	–		64 pW	40 pW	0.047 dB to 0.083 dB	0.022 dB to 0.066 dB
NRP-Z92	10 MHz to 2.4 GHz: < 1.14 > 2.4 GHz to 6.0 GHz: < 1.20			0.7 nW	0.4 nW	0.079 dB to 0.151 dB	0.022 dB to 0.087 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

Universal power sensors in R&S® Smart Sensor Technology

R&S® NRP-Z11/-Z21 universal power sensors

Specifications from 8 GHz to 18 GHz apply only to the R&S® NRP-Z21.

Frequency range	R&S® NRP-Z11	10 MHz to 8 GHz	
	R&S® NRP-Z21	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	200 pW to 200 mW (–67 dBm to +23 dBm)	
	burst average	200 nW to 200 mW (–37 dBm to +23 dBm)	
	timeslot/gate average	600 pW to 200 mW (–62 dBm to +23 dBm) ¹	
	trace	10 nW to 200 mW (–50 dBm to +23 dBm) ²	
Max. power	average power	0.4 W (+26 dBm), continuous	
	peak envelope power	1.0 W (+30 dBm) for max. 10 µs	
Measurement subranges	path 1	–67 dBm to –14 dBm	
	path 2	–47 dBm to +6 dBm	
	path 3	–27 dBm to +23 dBm	
Transition regions	with automatic path selection ³	(–19 ± 1) dBm to (–13 ± 1) dBm (+1 ± 1) dBm to (+7 ± 1) 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 +23 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® NRP2 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	< 470 [500] (100) pW	
	path 2	< 47 [50] (10) nW	
	path 3	< 4.7 [5] (1) µW	
	after external zeroing ^{6,7}		
	path 1	< 104 [110] (64) pW	
	path 2	< 10 [11] (6) nW	
	path 3	< 1.0 [1.1] (0.6) µW	
Zero drift ⁸	path 1	< 35 [37] (0) pW	
	path 2	< 3.0 [3.2] (0) nW	
	path 3	< 0.30 [0.32] (0) µW	
Measurement noise ⁹	path 1	< 65 [69] (40) pW	
	path 2	< 6.3 [6.6] (4.0) nW	
	path 3	< 0.63 [0.66] (0.4) µW	

R&S® NRP-Z11/-Z21 universal power sensors (continued)

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
+23		
Power level in dBm		

20 MHz to < 100 MHz

0.147	0.159	0.159
0.072	0.069	0.069
0.056	0.047	0.048
-67	-19	+1
+23		
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

100 MHz to 4 GHz

0.150	0.162	0.164
0.081	0.077	0.081
0.066	0.058	0.063
-67	-19	+1
+23		
Power level in dBm		

> 4 GHz to 8 GHz

0.160	0.170	0.174
0.096	0.089	0.097
0.083	0.072	0.082
-67	-19	+1
+23		
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

> 8 GHz to 12.4 GHz

0.168	0.176	0.184
0.106	0.096	0.110
0.094	0.079	0.096
-67	-19	+1
+23		
Power level in dBm		

> 12.4 GHz to 18 GHz

0.188	0.196	0.210
0.133	0.120	0.142
0.123	0.103	0.128
-67	-19	+1
+23		
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

R&S® NRP-Z11/-Z21 universal power sensors (continued)

Uncertainty for relative power measurements ¹¹ in dB

10 MHz to < 20 MHz			
+23	0.226 0.084	0.229 0.080	0.027 0.022
+7	0.046	0.044	0.022
+1	0.226 0.083	0.027 0.022	0.229 0.080
-13	0.045	0.022	0.044
-19	0.023 0.022	0.226 0.083	0.226 0.084
-67	0.022	0.045	0.046
-67	-19/-13	+1/+7	+23
Power level in dBm			

20 MHz to < 100 MHz			
+23	0.206 0.082	0.215 0.078	0.027 0.022
+7	0.046	0.044	0.022
+1	0.205 0.081	0.027 0.022	0.215 0.078
-13	0.044	0.022	0.044
-19	0.023 0.022	0.205 0.081	0.206 0.082
-67	0.022	0.044	0.046
-67	-19/-13	+1/+7	+23
Power level in dBm			

0 °C to +50 °C			
+15 °C to +35 °C			
+20 °C to +25 °C			
0 °C to +50 °C			
+15 °C to +35 °C			
+20 °C to +25 °C			
0 °C to +50 °C			
+15 °C to +35 °C			
+20 °C to +25 °C			
100 MHz to 4 GHz			
+23	0.209 0.088	0.218 0.085	0.038 0.032
+7	0.055	0.047	0.031
+1	0.206 0.083	0.028 0.022	0.218 0.085
-13	0.048	0.022	0.047
-19	0.023 0.022	0.206 0.083	0.209 0.088
-67	0.022	0.048	0.055
-67	-19/-13	+1/+7	+23
Power level in dBm			
> 4 GHz to 8 GHz			
+23	0.215 0.097	0.223 0.093	0.049 0.044
+7	0.066	0.059	0.043
+1	0.210 0.088	0.030 0.022	0.223 0.093
-13	0.054	0.022	0.059
-19	0.024 0.022	0.210 0.088	0.215 0.097
-67	0.022	0.054	0.066
-67	-19/-13	+1/+7	+23
Power level in dBm			
0 °C to +50 °C			
+15 °C to +35 °C			
+20 °C to +25 °C			
0 °C to +50 °C			
+15 °C to +35 °C			
+20 °C to +25 °C			
0 °C to +50 °C			
+15 °C to +35 °C			
+20 °C to +25 °C			
> 8 GHz to 12.4 GHz			
+23	0.224 0.111	0.231 0.106	0.064 0.061
+7	0.084	0.077	0.060
+1	0.216 0.096	0.034 0.027	0.231 0.106
-13	0.063	0.025	0.077
-19	0.024 0.022	0.216 0.096	0.224 0.111
-67	0.022	0.063	0.084
-67	-19/-13	+1/+7	+23
Power level in dBm			
> 12.4 GHz to 18 GHz			
+23	0.244 0.135	0.245 0.128	0.086 0.084
+7	0.110	0.102	0.083
+1	0.230 0.112	0.040 0.034	0.245 0.128
-13	0.079	0.033	0.102
-19	0.024 0.022	0.230 0.112	0.244 0.135
-67	0.022	0.079	0.110
-67	-19/-13	+1/+7	+23
Power level in dBm			
0 °C to +50 °C			
+15 °C to +35 °C			
+20 °C to +25 °C			
0 °C to +50 °C			
+15 °C to +35 °C			
+20 °C to +25 °C			
0 °C to +50 °C			
+15 °C to +35 °C			
+20 °C to +25 °C			

R&S® NRP-Z31 universal power sensor

Frequency range		10 MHz to 33 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)	
	> 18.0 GHz to 26.5 GHz	< 1.30 (1.28)	
	> 26.5 GHz to 33.0 GHz	< 1.35 (1.33)	
Power measurement range	continuous average	200 pW to 200 mW (–67 dBm to +23 dBm)	
	burst average	200 nW to 200 mW (–37 dBm to +23 dBm)	
	timeslot/gate average	600 pW to 200 mW (–62 dBm to +23 dBm) ¹	
	trace	10 nW to 200 mW (–50 dBm to +23 dBm) ²	
Max. power	average power	0.4 W (+26 dBm), continuous	
	peak envelope power	1.0 W (+30 dBm) for max. 10 µs	
Measurement subranges	path 1	–67 dBm to –14 dBm	
	path 2	–47 dBm to +6 dBm	
	path 3	–27 dBm to +23 dBm	
Transition regions	with automatic path selection ³	(–19 ± 1) dBm to (–13 ± 1) dBm (+1 ± 1) dBm to (+7 ± 1) 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 +23 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® NRP2 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 33 GHz
	path 1	< 470 [500] (100) pW	
	path 2	< 47 [50] (10) nW	
	path 3	< 2.4 [2.5] (0.5) µW	
	after external zeroing ^{6, 7}		
	path 1	< 104 [113] (64) pW	
	path 2	< 10 [11] (6) nW	
	path 3	< 0.5 [0.6] (0.3) µW	
Zero drift ⁸	path 1	< 35 [38] (0) pW	
	path 2	< 3.0 [3.3] (0) nW	
	path 3	< 0.15 [0.18] (0) µW	
Measurement noise ⁹	path 1	< 65 [71] (40) pW	
	path 2	< 6.3 [6.8] (4.0) nW	
	path 3	< 0.32 [0.37] (0.2) µW	

R&S® NRP-Z31 universal power sensor (continued)

Uncertainty for absolute power measurements ¹⁰ in dB

10 MHz to < 20 MHz

0.178	0.174	0.188
0.080	0.081	0.084
0.051	0.053	0.054
-67	-19	+1
		+23
Power level in dBm		

20 MHz to < 100 MHz

0.150	0.158	0.171
0.077	0.079	0.082
0.051	0.053	0.053
-67	-19	+1
		+23
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

100 MHz to 4 GHz

0.156	0.163	0.175
0.085	0.087	0.089
0.061	0.063	0.063
-67	-19	+1
		+23
Power level in dBm		

> 4 GHz to 8 GHz

0.163	0.169	0.179
0.088	0.090	0.091
0.063	0.065	0.065
-67	-19	+1
		+23
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

> 8 GHz to 12.4 GHz

0.175	0.178	0.186
0.095	0.097	0.098
0.070	0.072	0.072
-67	-19	+1
		+23
Power level in dBm		

> 12.4 GHz to 18 GHz

0.196	0.198	0.202
0.112	0.114	0.116
0.089	0.090	0.092
-67	-19	+1
		+23
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

> 18 GHz to 26.5 GHz

0.217	0.222	0.228
0.116	0.120	0.129
0.088	0.090	0.100
-67	-19	+1
		+23
Power level in dBm		

> 26.5 GHz to 33 GHz

0.247	0.257	0.273
0.142	0.149	0.167
0.116	0.119	0.137
-67	-19	+1
		+23
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

R&S® NRP-Z31 universal power sensor (continued)

Uncertainty for relative power measurements ¹¹ in dB

10 MHz to < 20 MHz				20 MHz to < 100 MHz			
+23	0.245	0.221	0.040	+23	0.217	0.219	0.026
	0.099	0.095	0.022		0.093	0.094	0.022
+7	0.044	0.044	0.022	+7	0.044	0.044	0.022
+1	0.227	0.029	0.221	+1	0.204	0.024	0.219
	0.093	0.022	0.095		0.090	0.022	0.094
-13	0.044	0.022	0.044	-13	0.044	0.022	0.044
-19	0.030	0.227	0.245	-19	0.022	0.204	0.217
	0.022	0.093	0.099		0.022	0.090	0.093
-67	0.022	0.044	0.044	-67	0.022	0.044	0.044
-67	-19/-13	+1/+7	+23	-67	-19/-13	+1/+7	+23
Power level in dBm				Power level in dBm			

R&S®NRP-Z41/-Z61 universal power sensors

Specifications from 50 MHz to 40 GHz apply to the R&S®NRP-Z41.

Specifications from 50 MHz to 50 GHz apply to the R&S®NRP-Z61.

Frequency range	R&S®NRP-Z41	50 MHz to 40 GHz	
	R&S®NRP-Z61	50 MHz to 50 GHz	
Impedance matching (SWR)	50 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)	
	> 18.0 GHz to 26.5 GHz	< 1.30 (1.28)	
	> 26.5 GHz to 33.0 GHz	< 1.35 (1.33)	
	> 33.0 GHz to 40.0 GHz	< 1.37 (1.35)	
	> 40.0 GHz to 50.0 GHz	< 1.40 (1.38)	
Power measurement range	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	average power	0.4 W (+23 dBm), continuous	
	peak envelope power	1.0 W (+30 dBm) for max. 10 µs	
Measurement subranges	path 1	–67 dBm to –14 dBm	
	path 2	–47 dBm to +6 dBm	
	path 3	–27 dBm to +20 dBm	
Transition regions	with automatic path selection ³	(–19 ± 1) dBm to (–13 ± 1) dBm (+1 ± 1) dBm to (+7 ± 1) 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®NRP2 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 50 GHz
	path 1	< 470 [500] (100) pW	
	path 2	< 47 [50] (10) nW	
	path 3	< 2.4 [2.5] (0.5) µW	
	after external zeroing ^{6,7}		
	path 1	< 104 [127] (64) pW	
	path 2	< 10 [13] (6) nW	
Zero drift⁸	path 3	< 0.5 [0.7] (0.3) µW	
	path 1	< 35 [38] (0) pW	
	path 2	< 3.0 [4.4] (0) nW	
Measurement noise⁹	path 3	< 0.15 [0.22] (0) µW	
	path 1	< 65 [80] (40) pW	
	path 2	< 6.3 [8.2] (4.0) nW	
	path 3	< 0.32 [0.45] (0.2) µW	

R&S® NRP-Z41/-Z61 universal power sensors (continued)

Uncertainty for absolute power measurements¹⁰ in dB

50 MHz to < 100 MHz

0.199	0.197	0.198
0.093	0.089	0.095
0.081	0.079	0.086
-67	-19	+1
+20		
Power level in dBm		

100 MHz to 8 GHz

0.145	0.143	0.145
0.090	0.087	0.091
0.078	0.074	0.079
-67	-19	+1
+20		
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

> 8 GHz to 12.4 GHz

0.158	0.156	0.159
0.100	0.097	0.102
0.089	0.085	0.090
-67	-19	+1
+20		
Power level in dBm		

> 12.4 GHz to 18 GHz

0.177	0.175	0.179
0.118	0.115	0.121
0.107	0.103	0.110
-67	-19	+1
+20		
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

> 18 GHz to 26.5 GHz

0.194	0.193	0.198
0.126	0.123	0.131
0.113	0.109	0.118
-67	-19	+1
+20		
Power level in dBm		

> 26.5 GHz to 33 GHz

0.216	0.215	0.221
0.144	0.142	0.152
0.131	0.128	0.139
-67	-19	+1
+20		
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

> 33 GHz to 40 GHz

0.232	0.232	0.240
0.152	0.150	0.164
0.138	0.135	0.150
-67	-19	+1
+20		
Power level in dBm		

> 40 GHz to 50 GHz

0.270	0.273	0.285
0.187	0.187	0.205
0.173	0.171	0.191
-67	-19	+1
+20		
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

R&S® NRP-Z41/-Z61 universal power sensors (continued)

Uncertainty for relative power measurements ¹¹ in dB

50 MHz to < 100 MHz				100 MHz to < 8 GHz				
+20	0.305	0.281	0.065	+20	0.191	0.192	0.050	0 °C to +50 °C
	0.128	0.116	0.042		0.104	0.105	0.047	+15 °C to +35 °C
+7	0.083	0.077	0.036	+7	0.082	0.083	0.046	+20 °C to +25 °C
+1	0.280	0.064	0.281	+1	0.189	0.042	0.192	0 °C to +50 °C
	0.114	0.038	0.116		0.099	0.039	0.105	+15 °C to +35 °C
-13	0.076	0.032	0.077	-13	0.076	0.038	0.083	+20 °C to +25 °C
-19	0.060	0.280	0.305	-19	0.032	0.189	0.191	0 °C to +50 °C
	0.035	0.114	0.128		0.029	0.099	0.104	+15 °C to +35 °C
-67	0.029	0.076	0.083	-67	0.028	0.076	0.082	+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				

R&S®NRP-Z211/-Z221 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®NRP2 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			
	path 1	< 1.88 [2.0] (0.6) nW	(): typical at 1 GHz +15 °C to +35 °C	
	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	[] : 8 GHz to 18 GHz	
	path 2	< 60 [65] (0) nW		
Measurement noise ⁹	path 1	< 230 [240] (180) pW		
	path 2	< 110 [116] (90) nW		

R&S®NRP-Z211/-Z221 universal power sensors (continued)

Uncertainty for absolute power measurements ¹⁰ in dB

10 MHz to < 20 MHz

0.168	0.176
0.080	0.075
0.063	0.054

Power level in dBm

20 MHz to < 100 MHz

0.155	0.158
0.079	0.073
0.063	0.054

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

100 MHz to 4 GHz

0.160	0.167
0.086	0.090
0.071	0.075

Power level in dBm

> 4 GHz to 8 GHz

0.167	0.188
0.098	0.122
0.085	0.110

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

> 8 GHz to 12.4 GHz

0.173	0.201
0.104	0.139
0.091	0.129

Power level in dBm

> 12.4 GHz to 18 GHz

0.189	0.217
0.126	0.154
0.114	0.143

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

Uncertainty for relative power measurements ¹¹ in dB

10 MHz to < 20 MHz

+20	0.225	0.030
-4	0.086	0.026
	0.050	0.026
-10	0.023	0.225
-60	0.022	0.086
	0.022	0.050

Power level in dBm

20 MHz to < 100 MHz

+20	0.210	0.030
-4	0.085	0.026
	0.050	0.026
-10	0.023	0.210
-60	0.022	0.085
	0.022	0.050

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

100 MHz to 4 GHz

+20	0.218	0.057
-4	0.099	0.055
	0.071	0.055
-10	0.023	0.218
-60	0.022	0.099
	0.022	0.071

Power level in dBm

> 4 GHz to 8 GHz

+20	0.237	0.101
-4	0.132	0.100
	0.112	0.100
-10	0.024	0.237
-60	0.022	0.132
	0.022	0.112

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

> 8 GHz to 12.4 GHz

+20	0.253	0.124
-4	0.155	0.123
	0.136	0.123
-10	0.024	0.253
-60	0.022	0.155
	0.022	0.136

Power level in dBm

> 12.4 GHz to 18 GHz

+20	0.263	0.124
-4	0.162	0.123
	0.142	0.123
-10	0.024	0.263
-60	0.022	0.162
	0.022	0.142

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

R&S® NRP-Z22 universal power sensor

Specifications apply when the power sensor is operated together with the RF power attenuator supplied. Please refer to the specifications of the R&S® NRP-Z21 when operating the power sensor section alone.

Frequency range		10 MHz to 18 GHz
Impedance matching (SWR)	10 MHz to 2.4 GHz	< 1.14
	> 2.4 GHz to 8.0 GHz	< 1.20
	> 8.0 GHz to 12.4 GHz	< 1.25
	> 12.4 GHz to 18.0 GHz	< 1.30
Power measurement range	continuous average	2 nW to 2 W (–57 dBm to +33 dBm)
	burst average	2 µW to 2 W (–27 dBm to +33 dBm)
	timeslot/gate average	6 nW to 2 W (–52 dBm to +33 dBm) ¹
	trace	100 nW to 2 W (–40 dBm to +33 dBm) ²
Max. power	average power	3 W (+35 dBm), continuous (see diagram)
	peak envelope power	10 W (+40 dBm) for max. 10 µs
Measurement subranges	path 1	–57 dBm to –4 dBm
	path 2	–37 dBm to +16 dBm
	path 3	–17 dBm to +33 dBm
Transition regions	with automatic path selection ³	(–9 ± 1.5) dBm to (–3 ± 1.5) dBm (+11 ± 1.5) dBm to (+17 ± 1.5) dBm
Dynamic response	video bandwidth	> 50 kHz (100 kHz)
	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	–30 dBm to +33 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® NRP2 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	
	path 1	< 5.9 (1.2) nW
	path 2	< 590 (120) nW
	path 3	< 59 (12) µW
	after external zeroing ^{6, 7}	
	path 1	< 1.3 (0.7) nW
	path 2	< 120 (60) nW
Zero drift ⁸	path 3	< 12 (6) µW
	path 1	< 0.4 (0) nW
	path 2	< 40 (0) nW
Measurement noise ⁹	path 3	< 4 (0) µW
	path 1	< 0.8 (0.4) nW
	path 2	< 80 (40) nW
	path 3	< 8 (4) µW

(): typical at 1 GHz
+15 °C to +35 °C

R&S® NRP-Z22 universal power sensor (continued)

Uncertainty for absolute power measurements¹⁰ in dB

10 MHz to < 100 MHz

0.180	0.237	–	–	
0.180	0.237	0.281	–	
0.180	0.237	0.281	0.316	
0.096	0.124	0.149	0.170	
0.079	0.088	0.104	0.119	
–57	+20	+30	+32	+33
Power level in dBm				

100 MHz to 4 GHz

0.186	0.242	–	–	0 °C to +50 °C
0.186	0.242	0.285	–	0 °C to +40 °C
0.186	0.242	0.285	0.320	0 °C to +35 °C
0.106	0.133	0.157	0.176	+15 °C to +35 °C
0.085	0.098	0.113	0.128	+20 °C to +25 °C
–57	+20	+30	+32	+33
Power level in dBm				

> 4 GHz to 12.4 GHz

0.203	0.255	–	–	
0.203	0.255	0.296	–	
0.203	0.255	0.296	0.330	
0.133	0.156	0.176	0.194	
0.116	0.125	0.137	0.151	
–57	+20	+30	+32	+33
Power level in dBm				

> 12.4 GHz to 18 GHz

0.223	0.271	–	–	0 °C to +50 °C
0.223	0.271	0.310	–	0 °C to +40 °C
0.223	0.271	0.310	0.343	0 °C to +35 °C
0.163	0.182	0.199	0.215	+15 °C to +35 °C
0.147	0.155	0.165	0.178	+20 °C to +25 °C
–57	+20	+30	+32	+33
Power level in dBm				

Uncertainty for relative power measurements^{11 12} in dB

10 MHz to < 100 MHz

+30	0.286	0.298	0.031	
	0.108	0.109	0.022	
+18	0.052	0.045	0.022	
+10	0.283	0.031	0.298	
	0.108	0.022	0.109	
–2	0.051	0.022	0.045	
–10	0.023	0.283	0.286	
	0.022	0.108	0.108	
–57	0.022	0.051	0.052	
–57	–10/–2	+10/+18	+30	
Power level in dBm				

100 MHz to 4 GHz

+30	0.272	0.289	0.041	0 °C to +50 °C
	0.112	0.113	0.032	+15 °C to +35 °C
+18	0.060	0.053	0.031	+20 °C to +25 °C
+10	0.268	0.032	0.289	0 °C to +50 °C
	0.108	0.022	0.113	+15 °C to +35 °C
–2	0.054	0.022	0.053	+20 °C to +25 °C
–10	0.024	0.268	0.272	0 °C to +50 °C
	0.022	0.108	0.112	+15 °C to +35 °C
–57	0.022	0.054	0.060	+20 °C to +25 °C
–57	–10/–2	+10/+18	+30	
Power level in dBm				

> 4 GHz to 12.4 GHz

+30	0.284	0.299	0.066	
	0.131	0.130	0.061	
+18	0.087	0.081	0.060	
+10	0.277	0.037	0.299	
	0.118	0.027	0.130	
–2	0.068	0.025	0.081	
–10	0.024	0.277	0.284	
	0.022	0.118	0.131	
–57	0.022	0.068	0.087	
–57	–10/–2	+10/+18	+30	
Power level in dBm				

> 12.4 GHz to 18 GHz

+30	0.300	0.310	0.088	0 °C to +50 °C
	0.152	0.148	0.084	+15 °C to +35 °C
+18	0.112	0.106	0.083	+20 °C to +25 °C
+10	0.288	0.043	0.310	0 °C to +50 °C
	0.131	0.035	0.148	+15 °C to +35 °C
–2	0.082	0.033	0.106	+20 °C to +25 °C
–10	0.024	0.288	0.300	0 °C to +50 °C
	0.022	0.131	0.152	+15 °C to +35 °C
–57	0.022	0.082	0.112	+20 °C to +25 °C
–57	–10/–2	+10/+18	+30	
Power level in dBm				

R&S® NRP-Z23 universal power sensor

Specifications apply when the power sensor is operated together with the RF power attenuator supplied. Please refer to the specifications of the R&S® NRP-Z21 when operating the power sensor section alone.

Frequency range		10 MHz to 18 GHz
Impedance matching (SWR)	10 MHz to 2.4 GHz	< 1.14
	> 2.4 GHz to 8.0 GHz	< 1.25
	> 8.0 GHz to 12.4 GHz	< 1.30
	> 12.4 GHz to 18.0 GHz	< 1.41
Power measurement range	continuous average	20 nW to 15 W (–47 dBm to +42 dBm)
	burst average	20 µW to 15 W (–17 dBm to +42 dBm)
	timeslot/gate average	60 nW to 15 W (–42 dBm to +42 dBm) ¹
	trace	1 µW to 15 W (–30 dBm to +42 dBm) ²
Max. power	average power	18 W (+42.5 dBm), continuous (see diagram)
	peak envelope power	100 W (+50 dBm) for max. 10 µs
Measurement subranges	path 1	–47 dBm to +6 dBm
	path 2	–27 dBm to +26 dBm
	path 3	–7 dBm to +42 dBm
Transition regions	with automatic path selection ³	(+1 ± 1.75) dBm to (+7 ± 1.75) dBm (+21 ± 1.75) dBm to (+27 ± 1.75) dBm
Dynamic response	video bandwidth	> 50 kHz (100 kHz)
	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	–19 dBm to +42 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® NRP2 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	
	path 1	< 60 (12) nW
	path 2	< 6 (1.2) µW
	path 3	< 600 (120) µW
	after external zeroing ^{6,7}	
	path 1	< 13 (7) nW
	path 2	< 1.3 (0.6) µW
	path 3	< 130 (60) µW
Zero drift ⁸	path 1	< 5 (0) nW
	path 2	< 0.4 (0) µW
	path 3	< 40 (0) µW
Measurement noise ⁹	path 1	< 8 (4) nW
	path 2	< 0.8 (0.4) µW
	path 3	< 80 (40) µW

(): typical at 1 GHz
+15 °C to +35 °C

R&S® NRP-Z23 universal power sensor (continued)

Uncertainty for absolute power measurements¹⁰ in dB

10 MHz to < 100 MHz

0.194	0.203	0.227	0.257
0.096	0.106	0.137	0.175
0.078	0.081	0.111	0.149
-47	+30	+36	+40

Power level in dBm

100 MHz to 4 GHz

0.187	0.197	0.222	0.253
0.105	0.115	0.144	0.181
0.087	0.094	0.120	0.156
-47	+30	+36	+40

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

> 4 GHz to 12.4 GHz

0.209	0.217	0.240	0.269
0.133	0.140	0.165	0.198
0.117	0.122	0.144	0.175
-47	+30	+36	+40

Power level in dBm

> 12.4 GHz to 18 GHz

0.238	0.245	0.266	0.292
0.166	0.172	0.193	0.221
0.151	0.155	0.172	0.199
-47	+30	+36	+40

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

Uncertainty for relative power measurements^{11 12} in dB

10 MHz to < 100 MHz

+42	0.226	0.229	0.027
	0.084	0.080	0.022
+28	0.046	0.044	0.022
+20	0.226	0.027	0.229
	0.083	0.022	0.080
+8	0.045	0.022	0.044
±0	0.023	0.226	0.226
	0.022	0.083	0.084
-47	0.022	0.045	0.046
-47	±0/+8	+20/+28	+42

Power level in dBm

100 MHz to 4 GHz

+42	0.209	0.218	0.038
	0.088	0.085	0.032
+28	0.055	0.047	0.031
+20	0.206	0.028	0.218
	0.083	0.022	0.085
+8	0.048	0.022	0.047
±0	0.023	0.206	0.209
	0.022	0.083	0.088
-47	0.022	0.048	0.055
-47	±0/+8	+20/+28	+42

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

> 4 GHz to 12.4 GHz

+42	0.224	0.231	0.064
	0.111	0.106	0.061
+28	0.084	0.077	0.060
+20	0.216	0.034	0.231
	0.096	0.027	0.106
+8	0.063	0.025	0.077
±0	0.024	0.216	0.224
	0.022	0.096	0.111
-47	0.022	0.063	0.084
-47	±0/+8	+20/+28	+42

Power level in dBm

> 12.4 GHz to 18 GHz

+42	0.244	0.245	0.086
	0.135	0.128	0.084
+28	0.110	0.102	0.083
+20	0.230	0.040	0.245
	0.112	0.034	0.128
+8	0.079	0.033	0.102
±0	0.024	0.230	0.244
	0.022	0.112	0.135
-47	0.022	0.079	0.110
-47	±0/+8	+20/+28	+42

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

R&S®NRP-Z24 universal power sensor

Specifications apply when the power sensor is operated together with the RF power attenuator supplied. Please refer to the specifications of the R&S®NRP-Z21 when operating the power sensor section alone.

Frequency range		10 MHz to 18 GHz
Impedance matching (SWR)	10 MHz to 2.4 GHz	< 1.14
	> 2.4 GHz to 8.0 GHz	< 1.25
	> 8.0 GHz to 12.4 GHz	< 1.30
	> 12.4 GHz to 18 GHz	< 1.41
Power measurement range	continuous average	60 nW to 30 W (–42 dBm to +45 dBm)
	burst average	60 µW to 30 W (–12 dBm to +45 dBm)
	timeslot/gate average	0.2 µW to 30 W (–37 dBm to +45 dBm) ¹
	trace	3 µW to 30 W (–25 dBm to +45 dBm) ²
Max. power	average power	36 W (+45.5 dBm), continuous (see diagram)
	peak envelope power	300 W (+55 dBm) for max. 10 µs
Measurement subranges	path 1	–42 dBm to +11 dBm
	path 2	–22 dBm to +31 dBm
	path 3	–2 dBm to +45 dBm
Transition regions	with automatic path selection ³	(+6 ± 2) dBm to (+12 ± 2) dBm (+26 ± 2) dBm to (+32 ± 2) dBm
Dynamic response	video bandwidth	> 50 kHz (100 kHz)
	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	–14 dBm to +45 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®NRP2 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	
	path 1	< 200 (40) nW
	path 2	< 20 (4) µW
	path 3	< 2 (0.4) mW
	after external zeroing ^{6, 7}	
	path 1	< 44 (20) nW
	path 2	< 4.2 (2) µW
	path 3	< 0.42 (0.2) mW
Zero drift ⁸	path 1	< 15 (0) nW
	path 2	< 1.3 (0) µW
	path 3	< 130 (0) µW
	path 3	< 0.26 (0.12) mW
Measurement noise ⁹	path 1	< 27 (13) nW
	path 2	< 2.6 (1.2) µW
	path 3	< 0.26 (0.12) mW
	path 3	< 0.26 (0.12) mW

(): typical at 1 GHz
+15 °C to +35 °C

R&S® NRP-Z24 universal power sensor (continued)

Uncertainty for absolute power measurements¹⁰ in dB

10 MHz to < 100 MHz

0.199	0.218	0.249	0.291
0.098	0.120	0.158	0.208
0.078	0.091	0.128	0.178
-42	+33	+40	+43
Power level in dBm			

100 MHz to 4 GHz

0.193	0.212	0.244	0.287	0 °C to +50 °C
0.108	0.128	0.164	0.213	+15 °C to +35 °C
0.088	0.102	0.136	0.184	+20 °C to +25 °C
-42	+33	+40	+43	
Power level in dBm				

> 4 GHz to 12.4 GHz

0.214	0.231	0.260	0.301
0.135	0.151	0.183	0.228
0.118	0.129	0.157	0.201
-42	+33	+40	+43
Power level in dBm			

> 12.4 GHz to 18 GHz

0.242	0.258	0.284	0.322	0 °C to +50 °C
0.167	0.181	0.208	0.248	+15 °C to +35 °C
0.151	0.160	0.183	0.222	+20 °C to +25 °C
-42	+33	+40	+43	
Power level in dBm				

Uncertainty for relative power measurements^{11 12} in dB

10 MHz to < 100 MHz

+45	0.226	0.229	0.027
	0.084	0.080	0.022
+33	0.046	0.044	0.022
+25	0.226	0.027	0.229
	0.083	0.022	0.080
+13	0.045	0.022	0.044
+5	0.023	0.226	0.226
	0.022	0.083	0.084
-42	0.022	0.045	0.046
-42	+5/+13	+25/+33	+45
Power level in dBm			

100 MHz to 4 GHz

+45	0.209	0.218	0.038	0 °C to +50 °C
	0.088	0.085	0.032	+15 °C to +35 °C
+33	0.055	0.047	0.031	+20 °C to +25 °C
+25	0.206	0.028	0.218	0 °C to +50 °C
	0.083	0.022	0.085	+15 °C to +35 °C
+13	0.048	0.022	0.047	+20 °C to +25 °C
+5	0.023	0.206	0.209	0 °C to +50 °C
	0.022	0.083	0.088	+15 °C to +35 °C
-42	0.022	0.048	0.055	+20 °C to +25 °C
-42	+5/+13	+25/+33	+45	
Power level in dBm				

> 4 GHz to 12.4 GHz

+45	0.224	0.231	0.064
	0.111	0.106	0.061
+33	0.084	0.077	0.060
+25	0.216	0.034	0.231
	0.096	0.027	0.106
+13	0.063	0.025	0.077
+5	0.024	0.216	0.224
	0.022	0.096	0.111
-42	0.022	0.063	0.084
-42	+5/+13	+25/+33	+45
Power level in dBm			

> 12.4 GHz to 18 GHz

+45	0.244	0.245	0.086	0 °C to +50 °C
	0.135	0.128	0.084	+15 °C to +35 °C
+33	0.110	0.102	0.083	+20 °C to +25 °C
+25	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
+5	0.024	0.230	0.244	0 °C to +50 °C
	0.022	0.112	0.135	+15 °C to +35 °C
-42	0.022	0.079	0.110	+20 °C to +25 °C
-42	+5/+13	+25/+33	+45	
Power level in dBm				

Additional characteristics of the R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z211/-Z221/-Z22/-Z23/-Z24 universal power sensors

Sensor type	R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61	three-path diode power sensor
	R&S®NRP-Z211/-Z221	two-path diode power sensor
	R&S®NRP-Z22/-Z23/-Z24	three-path diode power sensor with preceding RF power attenuator
Measurand		power of incident wave
		power of source (DUT) into 50 Ω ¹³
RF connector	R&S®NRP-Z11/-Z21/-Z211/-Z221/-Z22/-Z23/-Z24	N (male)
	R&S®NRP-Z31	3.50 mm (male)
	R&S®NRP-Z41	2.92 mm (male)
	R&S®NRP-Z61	2.40 mm (male)
RF attenuation ¹⁴	R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z211/-Z221	not applicable
	R&S®NRP-Z22	10 dB
	R&S®NRP-Z23	20 dB
	R&S®NRP-Z24	25 dB
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 μ s to 300 ms (20 ms default)
	window function	uniform or von Hann ¹⁵
	duty cycle correction ¹⁶	0.001 % to 99.999 %
	capacity of measurement buffer ¹⁷	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-Z11/-Z21/-Z31/-Z41/-Z61/-Z22/-Z23/-Z24	20 μ s to 50 ms
	R&S®NRP-Z211/-Z221	25 μ s to 50 ms
	minimum gap between bursts	10 μ s
	dropout period ¹⁸ for burst end detection	0 to 3 ms
	exclusion periods ¹⁹	
	start	0 to burst width
	end	0 s to 3 ms
	resolution (dropout and exclusion periods)	sample period ($\approx$ 8 μ s)
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 μ s to 0.1 s
	start of first timeslot/gate	at delayed trigger event
	exclusion periods ¹⁹	
	start	0 to nominal length
	end	0 s to 3 ms
	resolution (nominal length and exclusion periods)	sample period ($\approx$ 8 μ s)
Trace function	measurand	mean power over pixel length
	acquisition	
	length (Δ)	100 μ s 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	$\geq$ 10 μ s
	recurring and externally triggered	$\geq$ 2.5 μ s

Additional characteristics of the R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z211/-Z221/-Z22/-Z23/-Z24 universal power sensors (continued)

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 ²⁰	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 50Ω 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 ²¹ 2^N : averaging number T : set number of timeslots w : nominal length of timeslot	continuous average	$2 \times (\text{aperture} + 145 \mu\text{s}) \times 2^N + t_z$
	buffered ¹⁷ , without averaging	$2 \times (\text{aperture} + 166 \mu\text{s}) \times \text{buffer size} + t_z$
	timeslot/gate average	
	signal period – $T \times w > 100 \mu\text{s}$	$\leq 2 \times \text{signal period} \times (2^N + \frac{1}{2}) + t_z$
	all other cases	$\leq 4 \times \text{signal period} \times (2^N + \frac{1}{4}) + t_z$
		$t_z < 1.6 \text{ ms}$
Measurement speed without averaging aperture time = $10 \mu\text{s}$	continuous average	
	single-triggered	550 s^{-1} (typ.)
	buffered ¹⁷	3000 s^{-1} (typ.)
Zeroing (duration)	depends on setting of averaging filter	
	auto on	4 s
	auto off, integration time ²²	
	< 4 s	4 s
	4 s to 16 s	integration time
	> 16 s	16 s

Additional characteristics of the R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z211/-Z221/-Z22/-Z23/-Z24 universal power sensors (continued)

Measurement error due to harmonics ²³	R&S®NRP-Z11/-Z2x: all paths			n: multiple of carrier frequency
	R&S®NRP-Z211/-Z221: all paths			
	R&S®NRP-Z31: paths 1 and 2	n = 2	n = 3	
	R&S®NRP-Z41/-Z61: paths 1 and 2			
	–30 dBc	< 0.001 dB	< 0.003 dB	
	–20 dBc	< 0.002 dB	< 0.010 dB	
	–10 dBc	< 0.010 dB	< 0.040 dB	
	R&S®NRP-Z31/-Z41/-Z61: path 3	n = 2	n = 3	
–40 dBc	< 0.001 dB	< 0.010 dB		
–30 dBc	< 0.004 dB	< 0.040 dB		
–20 dBc	< 0.040 dB	< 0.100 dB		
Measurement error due to modulation ²⁴	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 ²⁵	R&S®NRP-Z11/-Z21/-Z31/-Z211/-Z221/-Z22/-Z23/-Z24			
	10 MHz to 2.4 GHz	< 0.02 (0.01)	(): +15 °C to +35 °C	
	> 2.4 GHz	< 0.03 (0.02)		
	R&S®NRP-Z41/-Z61			
	50 MHz to 8.0 GHz	< 0.04 (0.02)	(): levels ≤ 10 dBm	
	> 8.0 GHz to 18.0 GHz	< 0.06 (0.03)		
	> 18.0 GHz to 33.0 GHz	< 0.07 (0.04)		
	> 33.0 GHz to 50.0 GHz	< 0.09 (0.05)		
Calibration uncertainty ²⁶	R&S®NRP-Z11/-Z21	path 1	path 2	path 3
	10 MHz to < 100 MHz	0.056 dB	0.047 dB	0.048 dB
	100 MHz to 4.0 GHz	0.066 dB	0.057 dB	0.057 dB
	> 4.0 GHz to 8.0 GHz	0.083 dB	0.071 dB	0.072 dB
	> 8.0 GHz to 12.4 GHz	0.094 dB	0.076 dB	0.076 dB
	> 12.4 GHz to 18.0 GHz	0.123 dB	0.099 dB	0.099 dB
	R&S®NRP-Z31	path 1	path 2	path 3
	10 MHz to < 100 MHz	0.051 dB	0.053 dB	0.053 dB
	100 MHz to 4.0 GHz	0.061 dB	0.062 dB	0.062 dB
	> 4.0 GHz to 8.0 GHz	0.063 dB	0.063 dB	0.063 dB
	> 8.0 GHz to 12.4 GHz	0.070 dB	0.069 dB	0.069 dB
	> 12.4 GHz to 18.0 GHz	0.088 dB	0.087 dB	0.087 dB
	> 18.0 GHz to 26.5 GHz	0.088 dB	0.085 dB	0.087 dB
	> 26.5 GHz to 33.0 GHz	0.116 dB	0.113 dB	0.117 dB
	R&S®NRP-Z41/-Z61	path 1	path 2	path 3
	50 MHz to < 100 MHz	0.063 dB	0.055 dB	0.055 dB
	100 MHz to 8.0 GHz	0.075 dB	0.065 dB	0.065 dB
	> 8.0 GHz to 12.4 GHz	0.085 dB	0.075 dB	0.075 dB
	> 12.4 GHz to 18.0 GHz	0.103 dB	0.093 dB	0.093 dB
	> 18.0 GHz to 26.5 GHz	0.109 dB	0.096 dB	0.096 dB
	> 26.5 GHz to 33.0 GHz	0.127 dB	0.115 dB	0.115 dB
	> 33.0 GHz to 40.0 GHz	0.134 dB	0.120 dB	0.121 dB
	> 40.0 GHz to 50.0 GHz	0.168 dB	0.156 dB	0.158 dB
	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	
	R&S®NRP-Z22/-Z23/-Z24 ²⁷	path 1	path 2	path 3
	10 MHz to < 100 MHz	0.078 dB	0.072 dB	0.073 dB
	100 MHz to 4.0 GHz	0.084 dB	0.077 dB	0.077 dB
	> 4.0 GHz to 12.4 GHz	0.110 dB	0.095 dB	0.095 dB
	> 12.4 GHz to 18.0 GHz	0.139 dB	0.118 dB	0.118 dB

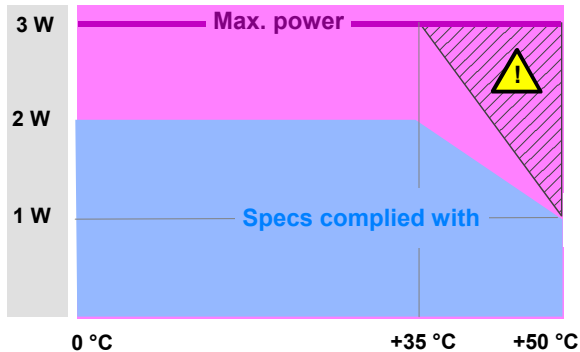
Additional characteristics of the R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z211/-Z221/-Z22/-Z23/-Z24 universal power sensors (continued)

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 57)
Dimensions (W × H × L)	R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z211/-Z221	48 mm × 31 mm × 170 mm (1.89 in × 1.22 in × 6.69 in)
	R&S®NRP-Z22	48 mm × 31 mm × 214 mm (1.89 in × 1.22 in × 8.42 in)
	R&S®NRP-Z23	60 mm × 54 mm × 285 mm (2.36 in × 2.13 in × 11.22 in)
	R&S®NRP-Z24	60 mm × 54 mm × 344 mm (2.36 in × 2.13 in × 13.54 in)
	length including connecting cable	
	model .02	approx. 1.6 m (62.99 in)
Weight	model .04 (R&S®NRP-Z11 only)	approx. 0.6 m (23.62 in)
	R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z211/-Z221	< 0.30 kg (0.66 lb)
	R&S®NRP-Z22	< 0.37 kg (0.82 lb)
	R&S®NRP-Z23	< 0.48 kg (1.06 lb)
	R&S®NRP-Z24	< 0.63 kg (1.39 lb)

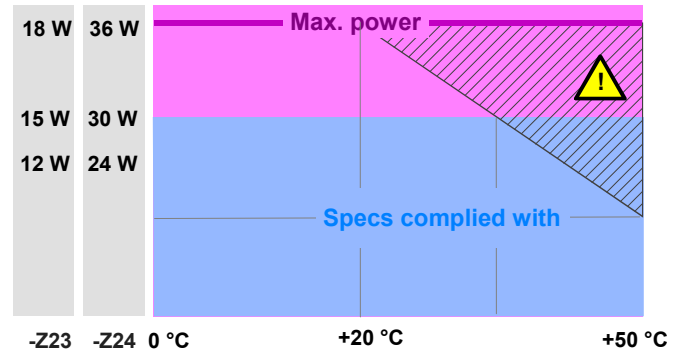
Power rating of the R&S®NRP-Z22/-Z23/-Z24

Hatched area: The maximum surface temperatures permitted by IEC 1010-1 are exceeded. Provide protection against inadvertent contacting or apply only a short-term load to the power sensor.

R&S®NRP-Z22



R&S®NRP-Z23/-Z24



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)	
Max. power	statistics	4 µW ²⁸ to 100 mW (–24 dBm to +20 dBm)	
	average power	0.2 W (+23 dBm), continuous	
Dynamic response	peak envelope power	1.0 W (+30 dBm) for max. 1 µs	
	video bandwidth	≥ 30 MHz ²⁹	
	single-shot bandwidth	≥ 30 MHz ²⁹	
	video bandwidth setting	full (≥ 30 MHz), 5 MHz, 1.5 MHz, 300 kHz	
	rise time 10 %/90 %		
	full video bandwidth	≤ 13 ns ²⁹ (f ≥ 500 MHz) < 40 ns ²⁹ (f < 500 MHz)	
	5 MHz	< 75 ns	
	1.5 MHz	< 250 ns	
	300 kHz	< 1.2 µs	
	detectable burst width	≥ 50 ns ²⁹ (f ≥ 500 MHz, full video bandwidth)	
	overshoot	≤ 5 %	
	Acquisition	sample rate [period]	
full video bandwidth		80 × 10 ⁶ s ^{–1} [12.5 ns]	
5 MHz		40 × 10 ⁶ s ^{–1} [25.0 ns]	
1.5 MHz		10 × 10 ⁶ s ^{–1} [100 ns]	
300 kHz		2.5 × 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 [®] NRP2 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		

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

Zero offset After external zeroing ³⁰ (): 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, 30}		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 ^{30, 31} (): typical at 1 GHz		R&S®NRP-Z81	R&S®NRP-Z85/-Z86
	continuous average ³²		
	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 ³³ 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 ³⁴ 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
	0.105	0.075	0.102
–15	0.064	0.145	0.179
	0.045	0.114	0.155
	0.039	0.105	0.148
–60	–60	–15	+10
	Power level in dBm		

50 MHz to < 1 GHz

+20	0.193	0.130	0.088
	0.170	0.120	0.083
	0.165	0.117	0.083
+10	0.162	0.110	0.130
	0.134	0.098	0.120
	0.126	0.095	0.117
–15	0.068	0.162	0.193
	0.051	0.134	0.170
	0.046	0.126	0.165
–60	–60	–15	+10
	Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C
0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C
0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

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

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	5×10 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 ¹³
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 μ s to 1 s (10 μ s default)
	window function	uniform or von Hann ¹⁵
	duty cycle correction ¹⁶	0.001 % to 99.999 %
	capacity of measurement buffer ¹⁷	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 ¹⁸ for burst end detection	0 s to 0.1 s
	exclusion periods ¹⁹	
	start	0 to burst width
	end	0 s to 51.2 μ s
	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 ¹⁹	
	start	0 to nominal length
	fence	0 s to 0.1 s (anywhere within timeslot)
	end	0 s to 51.2 μ s
	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	$\geq$ sample period
	equivalent time	$\geq$ 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

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

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
Attenuation correction	rate	can be limited to 0.1 s^{-1}
	repeat mode	only final result
Embedding	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 50Ω 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 ²¹ 2^N : averaging number T : number of timeslots w : nominal length of timeslot	continuous average	
	single-triggered	$2 \times (\text{aperture} + 6.5 \text{ µs}) \times 2^N + t_z$
	buffered ¹⁷ , without averaging	$2 \times (\text{aperture} + 50 \text{ µs}) \times \text{buffer size} + t_z$ $t_z < 1.6 \text{ ms}$
	timeslot/gate average	
	signal period – $T \times w > 6 \text{ µs}$	$\leq \text{signal period} \times (2^N + 1) + t_t$
	all other cases	$\leq 2 \times \text{signal period} \times (2^N + \frac{1}{2}) + t_t$ $t_t : 3 \text{ ms (typ.)}$
Measurement speed without averaging aperture time = 1 µs	continuous average	
	single-triggered	960 s^{-1} (typ.)
	buffered ¹⁷	9800 s^{-1} (typ.)

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

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 ³⁵ <i>n</i> : multiple of carrier frequency	<i>n</i> = 3	≤ 4 GHz	4 GHz to 12.4 GHz
	–60 dBc	< 0.004 dB	< 0.003 dB
	–40 dBc	< 0.035 dB	< 0.030 dB
	–20 dBc	< 0.350 dB	< 0.300 dB
	<i>n</i> = 2	≤ 4 GHz	4 GHz to 8 GHz
	–60 dBc	< 0.001 dB	< 0.002 dB
	–40 dBc	< 0.010 dB	< 0.017 dB
	–20 dBc	< 0.100 dB	< 0.170 dB
Change of input reflection coefficient with respect to power ³⁶	–10 dBm to –60 dBm	< 0.035 (0.010)	(): <i>f</i> ≤ 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 ³⁷		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 %)
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	
Dimensions	permissible total cable length	≤ 5 m (see also tables on page 57)	
	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)	

Thermal power sensors in R&S® Smart Sensor Technology

R&S® NRP-Z51/-Z52/-Z55/-Z56/-Z57 thermal power sensors

Specifications from DC to 18 GHz apply to the R&S® NRP-Z51 model .03.

Specifications from DC to 33 GHz apply to the R&S® NRP-Z52.

Specifications from DC to 40 GHz apply to the R&S® NRP-Z55 model .03.

Specifications from DC to 44 GHz apply to the R&S® NRP-Z55 model .04.

Specifications from DC to 50 GHz apply to the R&S® NRP-Z56.

Specifications from DC to 67 GHz apply to the R&S® NRP-Z57.

Frequency range	R&S® NRP-Z51 model .03	DC to 18 GHz		
	R&S® NRP-Z52	DC to 33 GHz		
	R&S® NRP-Z55 model .03	DC to 40 GHz		
	R&S® NRP-Z55 model .04	DC to 44 GHz		
	R&S® NRP-Z56	DC to 50 GHz		
	R&S® NRP-Z57	DC to 67 GHz		
Impedance matching (SWR)	DC to 100 MHz	< 1.03		
	> 100 MHz to 2.4 GHz	< 1.06		
	> 2.4 GHz to 12.4 GHz	< 1.13		
	> 12.4 GHz to 18.0 GHz	< 1.16		
	> 18.0 GHz to 26.5 GHz	< 1.22		
	> 26.5 GHz to 33.0 GHz	< 1.28		
	> 33.0 GHz to 40.0 GHz	< 1.28		
	> 40.0 GHz to 44.0 GHz	< 1.30		
	> 44.0 GHz to 50.0 GHz	< 1.30		
Power measurement range		300 nW to 100 mW (–35 dBm to +20 dBm), continuous, in a single range		
		0.3 W (+25 dBm), continuous		
Max. power	average power			
	peak envelope power			
	R&S® NRP-Z51	20 W (43 dBm) for max. 1 µs		
Acquisition	R&S® NRP-Z52/-Z55/-Z56/-Z57	10 W (40 dBm) for max. 1 µs		
	sample rate	20.833 kHz (sigma-delta)		
Zero offset	after external zeroing ⁶	< 25 nW (typically 15 nW at 1 GHz)		
Zero drift ⁸		< 8 nW		
Measurement noise ⁹		< 25 nW (typically 15 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
	DC to 100 MHz	0.040 dB	0.046 dB	0.067 dB
	> 100 MHz to 2.4 GHz	0.048 dB	0.053 dB	0.072 dB
	> 2.4 GHz to 8.0 GHz	0.054 dB	0.059 dB	0.079 dB
	> 8.0 GHz to 12.4 GHz	0.063 dB	0.068 dB	0.085 dB
	> 12.4 GHz to 18.0 GHz	0.082 dB	0.086 dB	0.100 dB
	> 18.0 GHz to 26.5 GHz	0.086 dB	0.086 dB	0.102 dB
	> 26.5 GHz to 33.0 GHz	0.101 dB	0.105 dB	0.121 dB
	> 33.0 GHz to 40.0 GHz	0.108 dB	0.112 dB	0.127 dB
	> 40.0 GHz to 44.0 GHz	0.138 dB	0.141 dB	0.155 dB
	> 44.0 GHz to 50.0 GHz	0.143 dB	0.146 dB	0.159 dB
	> 50.0 GHz to 59.0 GHz	0.206 dB	0.208 dB	0.220 dB
	> 59.0 GHz to 67.0 GHz	0.248 dB	0.250 dB	0.260 dB
Uncertainty for relative power measurements ³⁹		0.010 dB		

R&S® NRP-Z58 thermal power sensor

Frequency range		DC to 110 GHz		
Impedance matching (SWR)	DC to 100 MHz	< 1.05		
	> 100 MHz to 2.4 GHz	< 1.08		
	> 2.4 GHz to 12.4 GHz	< 1.18		
	> 12.4 GHz to 18.0 GHz	< 1.23		
	> 18.0 GHz to 26.5 GHz	< 1.28		
	> 26.5 GHz to 40.0 GHz	< 1.38		
	> 40.0 GHz to 50.0 GHz	< 1.46		
	> 50.0 GHz to 67.0 GHz	< 1.56		
	> 67.0 GHz to 80.0 GHz	< 1.60		
	> 80.0 GHz to 95.0 GHz	< 1.66		
	> 95.0 GHz to 110.0 GHz	< 1.70		
Power measurement range		300 nW to 100 mW (–35 dBm to +20 dBm), continuous, in a single range		
Max. power	average power	0.3 W (+25 dBm), continuous		
	peak envelope power	10 W (40 dBm) for max. 1 µs		
Acquisition	sample rate	20.833 kHz (sigma-delta)		
Zero offset	after external zeroing ⁶	< 34 nW (typically 15 nW at 1 GHz)		
Zero drift ⁸		< 11 nW		
Measurement noise ⁹		< 34 nW (typically 15 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
	DC to 100 MHz	0.041 dB	0.047 dB	0.068 dB
	> 100 MHz to 2.4 GHz	0.051 dB	0.057 dB	0.074 dB
	> 2.4 GHz to 12.4 GHz	0.074 dB	0.078 dB	0.093 dB
	> 12.4 GHz to 18.0 GHz	0.098 dB	0.101 dB	0.113 dB
	> 18.0 GHz to 26.5 GHz	0.099 dB	0.103 dB	0.115 dB
	> 26.5 GHz to 40.0 GHz	0.118 dB	0.122 dB	0.135 dB
	> 40.0 GHz to 50.0 GHz	0.166 dB	0.169 dB	0.182 dB
	> 50.0 GHz to 59.0 GHz	0.226 dB	0.229 dB	0.244 dB
	> 59.0 GHz to 67.0 GHz	0.265 dB	0.268 dB	0.280 dB
	> 67.0 GHz to 80.0 GHz	0.283 dB	0.286 dB	0.299 dB
	> 80.0 GHz to 95.0 GHz	0.298 dB	0.302 dB	0.317 dB
	> 95.0 GHz to 110.0 GHz	0.318 dB	0.321 dB	0.337 dB
Uncertainty for relative power measurements ³⁹	DC to 67.0 GHz	0.010 dB		
	> 67.0 GHz to 110.0 GHz	0.014 dB		

Additional characteristics of the R&S®NRP-Z51/-Z52/-Z55/-Z56/-Z57/-Z58 thermal power sensors

Sensor type		thermoelectric power sensor
Measurand		power of incident wave power of source (DUT) into 50 Ω ¹³
RF connector	R&S®NRP-Z51 model .03	N (male)
	R&S®NRP-Z52	3.50 mm (male)
	R&S®NRP-Z55 model .03	2.92 mm (male)
	R&S®NRP-Z55 model .04	2.92 mm (male)
	R&S®NRP-Z56	2.40 mm (male)
	R&S®NRP-Z57	1.85 mm (male)
	R&S®NRP-Z58	1.00 mm (male)
Measurement function	stationary and recurring waveforms	continuous average
Continuous average function	measurand	mean power over recurring acquisition interval
	aperture	0.5 ms to 300 ms (5 ms default)
	window function	uniform or von Hann ¹⁵
	duty cycle correction ¹⁶	0.001 % to 99.999 %
	capacity of measurement buffer ¹⁷	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
Attenuation correction	rate	can be limited to 0.1 s ⁻¹
	repeat mode	only final result
	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 power sensor 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 ²¹ 2^N : averaging number		$2 \times (\text{aperture} + 450 \mu\text{s}) \times 2^N + t_z + t_d$ $t_z < 4 \text{ ms}$ t_d must be taken into account when auto delay ⁴⁰ is active
	delay time t_d	
	R&S®NRP-Z51	80 ms
	R&S®NRP-Z52/-Z55/-Z56/-Z57/-Z58	40 ms
Measurement speed without averaging aperture time = 0.5 ms	continuous average	
	single-triggered	350 s ⁻¹ (typ.)
	buffered ¹⁷	520 s ⁻¹ (typ.)
Zeroing (duration)		10 s
Change of input reflection coefficient with respect to power	only for power levels > 15 dBm	< 0.005

Additional characteristics of the R&S®NRP-Z51/-Z52/-Z55/-Z56/-Z57/-Z58 thermal power sensors (continued)

Calibration uncertainty ⁴¹	R&S®NRP-Z51/-Z52/-Z55/-Z56/-Z57	
	DC to 100 MHz	0.040 dB
	> 100 MHz to 2.4 GHz	0.047 dB
	> 2.4 GHz to 8.0 GHz	0.054 dB
	> 8.0 GHz to 12.4 GHz	0.063 dB
	> 12.4 GHz to 18.0 GHz	0.082 dB
	> 18.0 GHz to 26.5 GHz	0.085 dB
	> 26.5 GHz to 33.0 GHz	0.101 dB
	> 33.0 GHz to 40.0 GHz	0.108 dB
	> 40.0 GHz to 44.0 GHz	0.138 dB
	> 44.0 GHz to 50.0 GHz	0.143 dB
	> 50.0 GHz to 59.0 GHz	0.190 dB
	> 59.0 GHz to 67.0 GHz	0.235 dB
	R&S®NRP-Z58	
	DC to 100 MHz	0.041 dB
	> 100 MHz to 2.4 GHz	0.051 dB
	> 2.4 GHz to 12.4 GHz	0.074 dB
	> 12.4 GHz to 18.0 GHz	0.098 dB
	> 18.0 GHz to 26.5 GHz	0.099 dB
	> 26.5 GHz to 40.0 GHz	0.118 dB
	> 40.0 GHz to 50.0 GHz	0.166 dB
	> 50.0 GHz to 59.0 GHz	0.211 dB
	> 59.0 GHz to 67.0 GHz	0.253 dB
	> 67.0 GHz to 80.0 GHz	0.256 dB
	> 80.0 GHz to 95.0 GHz	0.273 dB
	> 95.0 GHz to 110.0 GHz	0.294 dB
Temperature effect ⁴²	DC to 100 MHz	< 0.002 dB/K
	> 100 MHz to 50.0 GHz	< 0.004 dB/K
	> 50.0 GHz to 110.0 GHz	< 0.006 dB/K
Linearity ⁴³	DC to 67.0 GHz	0.007 dB
	> 67.0 GHz to 110.0 GHz	0.010 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 total cable length	≤ 10 m (see also tables on page 57)
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)

Average power sensors in R&S® Smart Sensor Technology

R&S® NRP-Z91 average power sensor

Frequency range		9 kHz to 6 GHz		
Impedance matching (SWR)	9 kHz to 2.4 GHz	< 1.13 (1.11)	(): +15 °C to +35 °C	
	> 2.4 GHz to 6.0 GHz	< 1.20 (1.18)		
Power measurement range		200 pW to 200 mW (–67 dBm to +23 dBm)		
Max. power	average power	0.4 W (+26 dBm), continuous		
	peak envelope power	1.0 W (+30 dBm) for max. 10 μs		
Measurement subranges	path 1	–67 dBm to –14 dBm		
	path 2	–47 dBm to +6 dBm		
	path 3	–27 dBm to +23 dBm		
Transition regions	with automatic path selection ³	(–19 ± 1) dBm to (–13 ± 1) dBm (+1 ± 1) dBm to (+7 ± 1) 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	< 470 (100) pW		
	path 2	< 47 (10) nW		
	path 3	< 4.7 (1) μW		
	after external zeroing ^{6, 7}			
	path 1	< 104 (64) pW		
	path 2	< 10.0 (6) nW		
	path 3	< 1.00 (0.6) μW		
Zero drift ⁸	path 1	< 35 (0) pW		
	path 2	< 3.0 (0) nW		
	path 3	< 0.3 (0) μW		
Measurement noise ⁹	path 1	< 65 (40) pW		
	path 2	< 6.3 (4) nW		
	path 3	< 0.63 (0.4) μW		

R&S® NRP-Z91 average power sensor (continued)

Uncertainty for absolute power measurements ¹⁰ in dB

9 kHz to < 20 kHz

0.174	0.175	0.175	
0.075	0.070	0.071	
0.056	0.047	0.048	
-67	-19	+1	+23

Power level in dBm

20 kHz to < 100 MHz

0.147	0.159	0.159	0 °C to +50 °C
0.072	0.069	0.069	+15 °C to +35 °C
0.056	0.047	0.048	+20 °C to +25 °C
-67	-19	+1	+23

Power level in dBm

100 MHz to 4 GHz

0.150	0.162	0.164	
0.081	0.077	0.081	
0.066	0.058	0.063	
-67	-19	+1	+23

Power level in dBm

> 4 GHz to 6 GHz

0.160	0.170	0.174	0 °C to +50 °C
0.096	0.089	0.097	+15 °C to +35 °C
0.083	0.072	0.082	+20 °C to +25 °C
-67	-19	+1	+23

Power level in dBm

Uncertainty for relative power measurements ¹¹ in dB

9 kHz to < 20 kHz

+23	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	+1/+7	+23

Power level in dBm

20 kHz to < 100 MHz

+23	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	+1/+7	+23	

Power level in dBm

100 MHz to 4 GHz

+23	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	+23

Power level in dBm

> 4 GHz to 6 GHz

+23	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	+23	

Power level in dBm

R&S® NRP-Z92 average power sensor

Specifications apply when the power sensor is operated together with the RF power attenuator supplied. Please refer to the specifications of the R&S® NRP-Z91 when operating the power sensor section alone.

Frequency range		9 kHz to 6 GHz
Impedance matching (SWR)	9 kHz to 2.4 GHz	< 1.14
	> 2.4 GHz to 6.0 GHz	< 1.20
Power measurement range	continuous average	2 nW to 2 W (–57 dBm to +33 dBm)
Max. power	average power	3 W (+35 dBm), continuous (see diagram)
	peak envelope power	10 W (+40 dBm) for max. 10 µs
Measurement subranges	path 1	–57 dBm to –4 dBm
	path 2	–37 dBm to +16 dBm
	path 3	–17 dBm to +33 dBm
Transition regions	with automatic path selection ³	(–9 ± 1.5) dBm to (–3 ± 1.5) dBm (+11 ± 1.5) dBm to (+17 ± 1.5) dBm
Dynamic response	rise time 10 %/90 %	< 5 ms
Acquisition	sample rate (continuous)	133.358 kHz
Zero offset	initial, without zeroing	
	path 1	< 5.9 (1.2) nW
	path 2	< 590 (120) nW
	path 3	< 59 (12) µW
	after external zeroing ^{6 7}	
	path 1	< 1.3 (0.7) nW
	path 2	< 120 (60) nW
	path 3	< 12 (6) µW
Zero drift ⁸	path 1	< 0.4 (0) nW
	path 2	< 40 (0) nW
	path 3	< 4 (0) µW
Measurement noise ⁹	path 1	< 0.8 (0.4) nW
	path 2	< 80 (40) nW
	path 3	< 8 (4) µW

(): typical at 1 GHz
+15 °C to +35 °C

R&S® NRP-Z92 average power sensor (continued)

Uncertainty for absolute power measurements ¹⁰ in dB

9 kHz to < 100 MHz

0.180	0.237	—	—	
0.180	0.237	0.281	—	
0.180	0.237	0.281	0.316	
0.096	0.124	0.149	0.170	
0.079	0.088	0.104	0.119	
-57	+20	+30	+32	+33

Power level in dBm

100 MHz to < 4 GHz

0.186	0.242	—	—	0 °C to +50 °C
0.186	0.242	0.285	—	0 °C to +40 °C
0.186	0.242	0.285	0.320	0 °C to +35 °C
0.106	0.133	0.157	0.176	+15 °C to +35 °C
0.085	0.098	0.113	0.128	+20 °C to +25 °C
-57	+20	+30	+32	+33

Power level in dBm

4 GHz to 6 GHz

0.203	0.255	—	—	0 °C to +50 °C
0.203	0.255	0.296	—	0 °C to +40 °C
0.203	0.255	0.296	0.330	0 °C to +35 °C
0.133	0.156	0.176	0.194	+15 °C to +35 °C
0.116	0.125	0.137	0.151	+20 °C to +25 °C
-57	+20	+30	+32	+33

Power level in dBm

Uncertainty for relative power measurements ^{11 12} in dB

9 kHz to < 100 MHz

+33	0.286	0.298	0.031
+18	0.108	0.109	0.022
+18	0.052	0.045	0.022
+10	0.283	0.031	0.298
+10	0.108	0.022	0.109
-2	0.051	0.022	0.045
-10	0.023	0.283	0.286
-10	0.022	0.108	0.108
-57	0.022	0.051	0.052
-57	-10/-2	+10/+18	+33

Power level in dBm

100 MHz to 4 GHz

+33	0.272	0.289	0.041	0 °C to +50 °C
+18	0.112	0.113	0.032	+15 °C to +35 °C
+18	0.060	0.053	0.031	+20 °C to +25 °C
+10	0.268	0.032	0.289	0 °C to +50 °C
+10	0.108	0.022	0.113	+15 °C to +35 °C
-2	0.054	0.022	0.053	+20 °C to +25 °C
-10	0.024	0.268	0.272	0 °C to +50 °C
-10	0.022	0.108	0.112	+15 °C to +35 °C
-57	0.022	0.054	0.060	+20 °C to +25 °C
-57	-10/-2	+10/+18	+33	

Power level in dBm

> 4 GHz to 6 GHz

+33	0.284	0.299	0.066	0 °C to +50 °C
+18	0.131	0.130	0.061	+15 °C to +35 °C
+18	0.087	0.081	0.060	+20 °C to +25 °C
+10	0.277	0.037	0.299	0 °C to +50 °C
+10	0.118	0.027	0.130	+15 °C to +35 °C
-2	0.068	0.025	0.081	+20 °C to +25 °C
-10	0.024	0.277	0.284	0 °C to +50 °C
-10	0.022	0.118	0.131	+15 °C to +35 °C
-57	0.022	0.068	0.087	+20 °C to +25 °C
-57	-10/-2	+10/+18	+33	

Power level in dBm

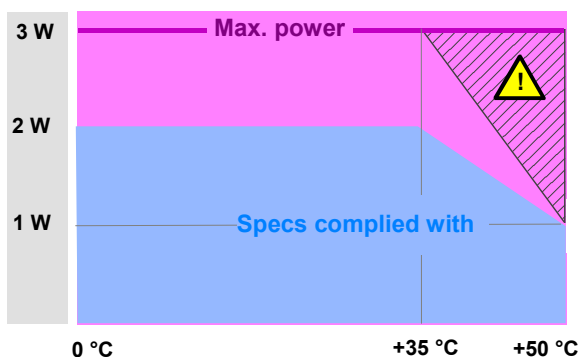
Additional characteristics of the R&S®NRP-Z91/-Z92 average power sensors

Sensor type		three-path diode power sensor; R&S®NRP-Z92 with preceding RF power attenuator
Measurand		power of incident wave
		power of source (DUT) into 50 Ω ¹³
RF connector		N (male)
RF attenuation ¹⁴	R&S®NRP-Z91	not applicable
	R&S®NRP-Z92	10 dB
Measurement function	stationary and recurring waveforms	continuous average
Continuous average function	measurand	mean power over recurring acquisition interval
	aperture	1 ms to 300 ms (20 ms default)
	window function	uniform or von Hann ¹⁵
	duty cycle correction ¹⁶	0.001 % to 99.999 %
	capacity of measurement buffer ¹⁷	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
Embedding ²⁰	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 time ²¹ 2^N : averaging number	continuous average	$2 \times (\text{aperture} + 5 \text{ ms}) \times 2^N - 3.4 \text{ ms} + t_d$ t_d must only be taken into account with activated auto delay (1 ms to 20 ms depending on temperature) ⁴⁰
Zeroing (duration)	depends on setting of averaging filter	
	auto on	4 s
	auto off, integration time ²²	
	< 4 s	4 s
	4 s to 16 s	integration time
	> 16 s	16 s

Additional characteristics of the R&S®NRP-Z91/-Z92 average power sensors (continued)

Measurement error due to harmonics ²³		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 ²⁴	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 ²⁵	9 kHz to 2.4 GHz	< 0.02 (0.01)		(:) : +15 °C to +35 °C		
	> 2.4 GHz	< 0.03 (0.02)				
Calibration uncertainty ²⁶	R&S®NRP-Z91	path 1	path 2	path 3		
	9 kHz to < 100 MHz	0.056 dB	0.047 dB	0.048 dB		
	100 MHz to 4.0 GHz	0.066 dB	0.057 dB	0.057 dB		
	> 4.0 GHz to 6.0 GHz	0.083 dB	0.071 dB	0.072 dB		
	R&S®NRP-Z92 ²⁷	path 1	path 2	path 3		
	9 kHz to < 100 MHz	0.078 dB	0.072 dB	0.073 dB		
	100 MHz to 4.0 GHz	0.084 dB	0.077 dB	0.077 dB		
	> 4.0 GHz to 6.0 GHz	0.110 dB	0.095 dB	0.095 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 57)				
Dimensions (W × H × L)	R&S®NRP-Z91	48 mm × 31 mm × 170 mm (1.89 in × 1.22 in × 6.69 in)				
	R&S®NRP-Z92	48 mm × 31 mm × 214 mm (1.89 in × 1.22 in × 8.42 in)				
	length including connecting cable					
	model .02	approx. 1.6 m (62.99 in)				
	model .04	approx. 0.6 m (23.62 in)				
Weight	R&S®NRP-Z91	< 0.30 kg (0.66 lb)				
	R&S®NRP-Z92	< 0.37 kg (0.82 lb)				

Power rating of the R&S®NRP-Z92



Hatched area: The maximum surface temperatures permitted by IEC 1010-1 are exceeded. Provide protection against inadvertent contacting or apply only a short-term load to the power sensor.

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 ⁴⁴	insertion loss ⁴⁵ (): 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®NRP2 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		

R&S® NRP-Z28 level control sensor (continued)

Uncertainty for absolute power measurements¹⁰ 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
0.073	0.069	0.069
0.056	0.047	0.048
-67	-19	+1
+20		
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

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
0.101	0.095	0.102
0.083	0.073	0.083
-67	-19	+1
+20		
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

> 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
0.142	0.130	0.151
0.124	0.105	0.130
-67	-19	+1
+20		
Power level in dBm		

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

R&S® NRP-Z28 level control sensor (continued)

Uncertainty for relative power measurements ¹¹ in dB

10 MHz to < 20 MHz			
+20	0.226 0.084	0.229 0.080	0.027 0.022
+7	0.046	0.044	0.022
+1	0.226 0.083	0.027 0.022	0.229 0.080
-13	0.045	0.022	0.044
-19	0.023 0.022	0.226 0.083	0.226 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 0.082	0.215 0.078	0.027 0.022
+7	0.046	0.044	0.022
+1	0.205 0.081	0.027 0.022	0.215 0.078
-13	0.044	0.022	0.044
-19	0.023 0.022	0.205 0.081	0.206 0.082
-67	0.022	0.044	0.046
-67	-19/-13	±0/+8	+20
Power level in dBm			
0 °C to +50 °C +15 °C to +35 °C +20 °C to +25 °C			

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

> 8 GHz to 12.4 GHz			
+20	0.224 0.111	0.231 0.106	0.064 0.061
+7	0.084	0.077	0.060
+1	0.216 0.096	0.034 0.027	0.231 0.106
-13	0.063	0.025	0.077
-19	0.024 0.022	0.216 0.096	0.224 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 0.135	0.245 0.128	0.086 0.084
+7	0.110	0.102	0.083
+1	0.230 0.112	0.040 0.034	0.245 0.128
-13	0.079	0.033	0.102
-19	0.024 0.022	0.230 0.112	0.244 0.135
-67	0.022	0.079	0.110
-67	-19/-13	+1/+7	+20
Power level in dBm			
0 °C to +50 °C +15 °C to +35 °C +20 °C to +25 °C			

R&S® NRP-Z98 level control sensor

Frequency range	9 kHz to 6 GHz		
Impedance matching (SWR) and insertion loss		input SWR output SWR ⁴⁴ insertion loss ⁴⁵ (): 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	
path 2		< 3.3 (0) nW	
path 3		< 0.33 (0) μW	
Measurement noise ⁹		path 1	
	path 2	< 7 (4) nW	
	path 3	< 0.7 (0.4) μW	

R&S® NRP-Z98 level control sensor (continued)

Uncertainty for absolute power measurements ¹⁰ in dB

9 kHz to < 20 kHz

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 kHz to < 100 MHz

0.147	0.160	0.160	
0.073	0.069	0.069	
0.056	0.047	0.048	
-67	-19	+1	+20

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

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 6 GHz

0.176	0.185	0.189	
0.101	0.095	0.102	
0.083	0.073	0.083	
-67	-19	+1	+20

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

Uncertainty for relative power measurements ¹¹ in dB

9 kHz to < 20 kHz

+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	+1/+7	+20

Power level in dBm

20 kHz to < 100 MHz

+20	0.206	0.215	0.027
	0.082	0.078	0.022
+7	0.046	0.044	0.022
+1	0.205	0.027	0.215
	0.081	0.022	0.078
-13	0.044	0.022	0.044
-19	0.023	0.205	0.206
	0.022	0.081	0.082
-67	0.022	0.044	0.046
-67	-19/-13	+1/+7	+20

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

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 6 GHz

+20	0.215	0.223	0.049
	0.097	0.093	0.044
+7	0.066	0.059	0.043
+1	0.210	0.030	0.223
	0.088	0.022	0.093
-13	0.054	0.022	0.059
-19	0.024	0.210	0.215
	0.022	0.088	0.097
-67	0.022	0.054	0.066
-67	-19/-13	+1/+7	+20

Power level in dBm

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

0 °C to +50 °C
+15 °C to +35 °C
+20 °C to +25 °C

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
RF connectors		power of wave emanating at RF output ¹³
Measurement functions	stationary and recurring waveforms	N (male)
		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 μ s to 300 ms (20 ms default)
	R&S®NRP-Z98	1 ms to 300 ms (20 ms default)
	window function	uniform or von Hann ¹⁵
	duty cycle correction ¹⁶	0.001 % to 99.999 %
	capacity of measurement buffer ¹⁷	1 to 1024 results
Burst average function	measurand	mean power over burst portion of recurring signal (trigger settings required)
	detectable burst width	20 μ s to 50 ms
	minimum gap between bursts	10 μ s
	dropout period ¹⁸ for burst end detection	0 s to 3 ms
	exclusion periods ¹⁹	
	start	0 to burst width
	end	0 s to 3 ms
	resolution (dropout and exclusion periods)	sample period ($\approx$ 8 μ s)
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 μ s to 0.1 s
	start of first timeslot/gate	at delayed trigger event
	exclusion periods ¹⁹	
	start	0 to nominal length
	end	0 s to 3 ms
	resolution (nominal length and exclusion periods)	sample period ($\approx$ 8 μ s)
Trace function	measurand	mean power over pixel length
	acquisition	
	length (Δ)	100 μ s 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	$\geq$ 10 μ s
	recurring and externally triggered	$\geq$ 2.5 μ s

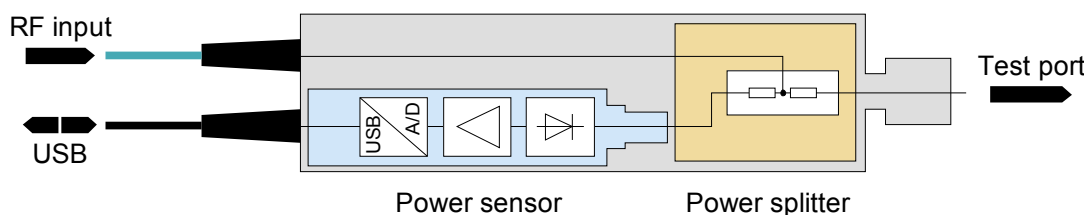
Additional characteristics of the R&S®NRP-Z28/-Z98 level control sensors (continued)

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 ²¹	continuous average			
	R&S®NRP-Z28	$2 \times (\text{aperture} + 145 \text{ } \mu\text{s}) \times 2^N + t_z$ $t_z : < 1.6 \text{ ms}$		
	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) ⁴⁰		
	buffered ¹⁷ , without averaging	$2 \times (\text{aperture} + 250 \text{ } \mu\text{s}) \times \text{buffer size} + t_z$		
	timeslot/gate average			
	signal period – $T \times w > 100 \text{ } \mu\text{s}$	$\leq 2 \times \text{signal period} \times (2^N + \frac{1}{2}) + t_z$		
	all other cases	$\leq 4 \times \text{signal period} \times (2^N + \frac{1}{4}) + t_z$		
Zeroing (duration)	depends on setting of averaging filter			
	auto on	4 s		
	auto off, integration time ²²			
	< 4 s	4 s		
	4 s to 16 s	integration time		
	> 16 s	16 s		
Measurement error due to harmonics ²³		$n = 2$	$n = 3$	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	

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

Measurement error due to modulation ²⁴	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		
Calibration uncertainty ²⁶ (R&S®NRP-Z98 up to 6 GHz only)	typical	−0.01 dB to +0.03 dB		
		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
Interface to host	> 12.4 GHz to 18.0 GHz	0.124 dB	0.100 dB	0.101 dB
	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		
Dimensions	permissible total cable length	≤ 10 m (see also tables on page 57)		
	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.

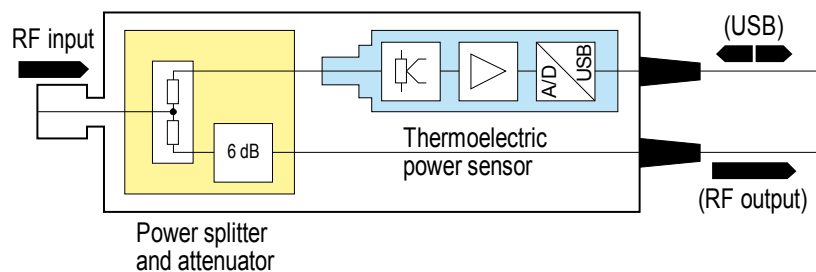
Frequency range	R&S®NRP-Z27	DC to 18 GHz		
	R&S®NRP-Z37	DC to 26.5 GHz		
Impedance matching (SWR)	RF input	R&S®NRP-Z27	R&S®NRP-Z37	
	DC to 2.0 GHz	< 1.15	< 1.15	
	> 2.0 GHz to 4.2 GHz	< 1.18	< 1.18	
	> 4.2 GHz to 8.0 GHz	< 1.23	< 1.23	
	> 8.0 GHz to 12.4 GHz	< 1.25	< 1.25	
	> 12.4 GHz to 18.0 GHz	< 1.35	< 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 ⁴⁶		+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 ⁴⁷		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 ¹³	
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 ¹⁵	
	duty cycle correction ¹⁶	0.001 % to 99.999 %	
	capacity of measurement buffer ¹⁷	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	

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

Measurement time ²¹ 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 ⁴⁰ is active	
Zeroing (duration)	depends on setting of averaging filter		
	auto on	4 s	
	auto off, integration time ²²		
	< 4 s	4 s	
	4 s to 16 s	integration time	
	> 16 s	16 s	
Calibration uncertainty ⁴⁸	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 ⁴⁹	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 ⁵⁰	for power levels < 100 mW (20 dBm)	< 0.020 dB	
Power coefficient ⁵¹		< (0.02 + 0.002 f/GHz) dB/W	
Load interference error ⁵² 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 57)	
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®NRP2 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	
	model .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
	model .05/.15	3.5 m
	model .10	8.5 m
Permissible total length	including power sensor and R&S®NRP2 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®NRP2 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	=	
•		•	–		3.0
•		–	•		5.0
•		–	•		10.0

(shaded combination only supported by R&S®NRP2 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
Connectors	input impedance	approx. 5 kΩ
	sensor	ODU Mini-Snap® L series, size 1, six-pole receptacle
Plug-in power supply	USB host	USB type A plug
	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
Dimensions (W × H × L)	connection	via adapter to all common AC supplies (Europe, UK, USA, Australia)
	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)
Weight	length of line to USB adapter	approx. 2 m (78.74 in)
	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® NRP2) 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
Trigger output	minimum pulse width	35 ns (without R&S® NRP-Z2 extension cable)
	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, Ø 5.5 mm × Ø 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)

R&S[®]NRP2 base unit

Application		multichannel power meter
Sensors		R&S [®] NRP-Zxx series
Measurement channels	R&S [®] NRP2	1
	R&S [®] NRP2 + R&S [®] NRP-B2	2
	R&S [®] NRP2 + R&S [®] NRP-B2 + R&S [®] NRP-B5	4
Measurement functionality	single-channel	see sensor specifications, plus: relative measurement referenced to result or user-selectable reference value, storage of minima and maxima (max, min, max – min), limit monitoring
	display	
	absolute	in W, dBm and dBμV
	relative	in dB, as change in percent (Δ %) or as quotient
	multichannel	simultaneous measurement in up to 4 channels; individual results, ratios, relative ratios ⁵³ or difference of results of 2 channels can be displayed
	display	
	ratio	in dB, as change in percent (Δ %), as quotient or as one of the following impedance matching parameters: SWR, return loss, reflection coefficient
	relative ratio ⁵³	in dB, as change in percent (Δ %) or as quotient
	difference	difference of powers in W, expressed in W or dBm
Display	type	color TFT graphics screen ⁵⁴ , ¼ VGA (320 × 240 pixel), full size, with adjustable backlighting
	result representation	
	numeric measurements	up to 4 results can simultaneously be displayed in separate windows (full size, ½ size or ¼ size, depending on number of results)
	format	digital, digital and analog
	resolution	
	digital values	selectable in 4 steps: 0.001 dB/0.01 %/4½ digits (W, quotient) 0.01 dB/0.1 %/3½ digits (W, quotient) 0.1 dB/1.0 %/2½ digits (W, quotient) 1 dB/1.0 %/2½ digits (W, quotient)
	analog display	depending on user-definable scale end values
	additional information	min, max, max – min, mean, stdev and number of recent measurements, frequency
	measurement of power versus time	one or two ⁵⁴ traces can be displayed in one full-size window: absolute power, difference in or ratio of the power of two channels
	additional information	marker, gate and timeslot measurements within view area
	power envelope statistics	CCDF, CDF and PDF versus absolute power in dBm or versus relative power referenced to the average power level
	additional information	marker measurements

R&S®NRP2 base unit (continued)

Manual operation		Windows-oriented menus with hotkeys for the most important functions
Remote control	systems	IEC 60625.1 (IEEE488.1) and IEC 60625.2 (IEEE488.2)
	command set	SCPI-1999.0
	IEC/IEEE bus	
	interface functions	SH1, AH1, L3, LE3, T5, TE5, SR1, PP1, PP2, RL1, DC1, E2, DT1, C0
	connector	24-pin Amphenol (female)
	USB TMC	
	connector	USB type B receptacle
Firmware download	Ethernet LAN 10/100BaseT	
	connector	RJ-45 modular socket
Inputs/outputs (front panel)		from the R&S®NRP toolkit via the USB type B receptacle using a Windows-compatible program
	A, B (R&S®NRP-B2 option)	sensor inputs for R&S®NRP-Zxx power sensors
	connector	ODU Mini-Snap® L series, size 1, six-pole receptacle
	POWER REF (R&S®NRP-B7 option)	1 mW/50 MHz, CW and pulsed (10 kHz) signal
Inputs/outputs (rear panel)	connector	N (female)
	OUT1/TRIG OUT	
	modes	TRIG OUT: Trigger Output ⁵⁴ OUT1: Analog Output, Pass/Fail, OFF
	Trigger Output	output for trigger signal from/to sensors
	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
	output impedance	50 Ω
	Analog Output	recorder output; user-definable linear relation to measurement result of display windows 1 to 4
	Pass/Fail	limit indicator with two user-selectable output voltages for identifying the pass and fail states in the case of limit monitoring
	OFF	0 V
	voltage range OUT1	0 V to +3.3 V
	setting accuracy	±1 % of voltage reading + (0/+8 mV)
	resolution	12 bit (monotone)
	output impedance OUT1	1 kΩ
	connector	BNC (female)
	TRIG IN/OUT 2	
	modes	Analog Output and Trigger Input
	Analog Output	recorder output; user-definable linear relation to measurement result of display windows 1 to 4
	electrical characteristics	see OUT1
	Trigger Input	input for trigger signal to sensors
	maximum voltage	–7 V/+10 V
	logic level	
	low	< 0.8 V
	high	> 2.0 V
	impedance	10 kΩ/100 pF
	connector	BNC (female)
	sensor input C (A); D (B) (R&S®NRP-B5/-B6 option)	sensor inputs for R&S®NRP-Zxx power sensors
	connector	ODU Mini-Snap® L series, size 1, six-pole receptacle
Power supply	voltage, frequency	220 V to 240 V, 50 Hz to 60 Hz 100 V to 120 V, 50 Hz to 60 Hz and 400 Hz
	tolerance	±10 % for voltage and frequency
	apparent power	< 80 VA (including current consumption of up to four R&S®NRP-Zxx power sensors)
Dimensions	W × H × D	274 mm × 112 mm × 267 mm (10.79 in × 4.41 in × 10.51 in)
Weight		< 2.5 kg (5.51 lb)

Options for the R&S®NRP2 base unit

R&S®NRP-B2 second sensor input

Second sensor input (B)	application	for R&S®NRP-Zxx power sensors (available as standard on front panel)
	connector	ODU Mini-Snap® L series, size 1, six-pole receptacle

R&S®NRP-B5 third and fourth sensor input

Third (C) and fourth (D) sensor input	application	for R&S®NRP-Zxx power sensors (only on rear panel)
	connector	ODU Mini-Snap® L series, size 1, six-pole receptacle

R&S®NRP-B6 rear panel sensor inputs

Rear panel assembly	application	for sensor inputs A and B (only possible if the R&S®NRP-B5 option is not installed)
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R&S®NRP-B7 sensor check source

Sensor check source	application	as a power reference for testing sensors
	frequency	50 MHz
	power	1.00 mW
	uncertainty	
	+20 °C to +25 °C	0.85 %
	0 °C to +50 °C	1.00 %
	pulse repetition frequency	10 kHz ± 30 ppm
	duty cycle	50 % ± 200 ppm
	on/off ratio	60 dB (typ.)
	rise/fall time	< 50 ns
	SWR	< 1.05
	RF connector	N (female)

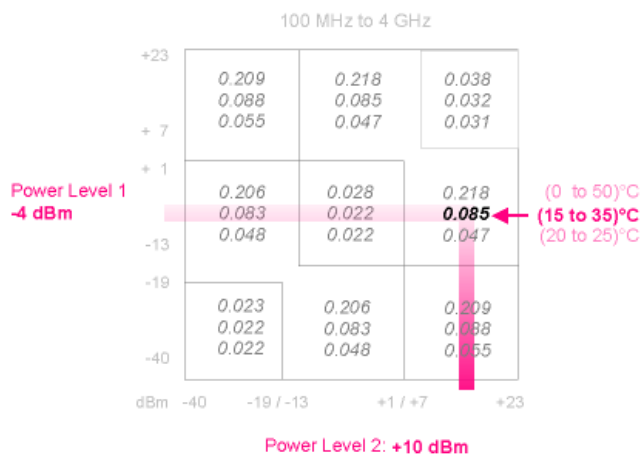
General data

Temperature loading ⁵⁵	operating and permissible temperature range (in [] if different)	in line with IEC 60068
	R&S®NRP2 base unit with options, 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 [–10 °C] to +50 °C [+55 °C]
	storage temperature range	
	R&S®NRP2 base unit with options, R&S®NRP-Z5 USB sensor hub	–40 °C to +70 °C
	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 and R&S®NRP-B7 sensor check source	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.
Base unit		
Power Meter	R&S®NRP2	1144.1374.02
Options		
Second Sensor Input (B)	R&S®NRP-B2	1146.8801.02
3rd and 4th Sensor Inputs (C, D) ⁵⁶	R&S®NRP-B5	1146.9608.02
Rear Panel Sensor Inputs A and B ⁵⁷	R&S®NRP-B6	1146.9908.02
Sensor Check Source	R&S®NRP-B7	1144.1000.02
Universal Power Sensors		
200 pW to 200 mW, 10 MHz to 8 GHz	R&S®NRP-Z11	1138.3004.02/04 ⁵⁸
200 pW to 200 mW, 10 MHz to 18 GHz	R&S®NRP-Z21	1137.6000.02
200 pW to 200 mW, 10 MHz to 33 GHz	R&S®NRP-Z31	1169.2400.02/04 ⁵⁸
200 pW to 100 mW, 50 MHz to 40 GHz	R&S®NRP-Z41	1171.8801.02
200 pW to 100 mW, 50 MHz to 50 GHz	R&S®NRP-Z61	1171.7505.02
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
2 nW to 2 W, 10 MHz to 18 GHz	R&S®NRP-Z22	1137.7506.02
20 nW to 15 W, 10 MHz to 18 GHz	R&S®NRP-Z23	1137.8002.02
60 nW to 30 W, 10 MHz to 18 GHz	R&S®NRP-Z24	1137.8502.02
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
Thermal Power Sensors		
300 nW to 100 mW, DC to 18 GHz	R&S®NRP-Z51	1138.0005.03
300 nW to 100 mW, DC to 33 GHz	R&S®NRP-Z52	1138.0505.02
300 nW to 100 mW, DC to 40 GHz	R&S®NRP-Z55	1138.2008.03
300 nW to 100 mW, DC to 44 GHz	R&S®NRP-Z55	1138.2008.04
300 nW to 100 mW, DC to 50 GHz	R&S®NRP-Z56	1171.8201.02
300 nW to 100 mW, DC to 67 GHz	R&S®NRP-Z57	1171.8401.02
300 nW to 100 mW, DC to 110 GHz	R&S®NRP-Z58	1173.7031.02
Average Power Sensors		
200 pW to 200 mW, 9 kHz to 6 GHz	R&S®NRP-Z91	1168.8004.02/04 ⁵⁸
2 nW to 2 W, 9 kHz to 6 GHz	R&S®NRP-Z92	1171.7005.02/42 ⁵⁹
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
19" Rack Adapter (for one R&S®NRP2 power meter and one empty casing)	R&S®ZZA-T26	1109.4387.00
19" Rack Adapter (for two R&S®NRP2 power meters)	R&S®ZZA-T27	1109.4393.00

Service 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, three years	R&S®WE3	
Extended Warranty, four years	R&S®WE4	
Extended Warranty with Calibration Coverage, one year	R&S®CW1	
Extended Warranty with Calibration Coverage, two years	R&S®CW2	
Extended Warranty with Calibration Coverage, three years	R&S®CW3	
Extended Warranty with Calibration Coverage, four years	R&S®CW4	

Extended warranty with a term of one to four years (WE1 to WE4)

Repairs carried out during the contract term are free of charge ⁶⁰. 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 ⁶⁰ and calibration at the recommended intervals as well as any calibration carried out during repairs or option upgrades.

Footnotes

- 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 / $\sqrt{\text{duty cycle}}$.
- 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 $\sqrt{(10.24 \text{ s}/\text{integration time})}$ 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 –35 dBm for the R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z91, –30 dBm for the R&S®NRP-Z211/-Z221, –25 dBm for the R&S®NRP-Z22/-Z92 and –15 dBm for the R&S®NRP-Z24. 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 °C 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 footnote 9, the absolute noise contribution of path 1 is typically $40 \text{ pW} \times \sqrt{(10.24 \text{ s}/(32 \times 2 \times 0.02 \text{ s}))} = 113 \text{ pW}$, 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 –35 dBm for the R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z91, –30 dBm for the R&S®NRP-Z211/-Z221, –25 dBm for the R&S®NRP-Z22/-Z92 and –15 dBm for the R&S®NRP-Z24. 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 °C 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 footnote 9, the absolute noise contribution of path 1 is typically $40 \text{ pW} \times \sqrt{(10.24 \text{ s}/(16 \times 2 \times 0.02 \text{ s}))} = 160 \text{ pW}$, 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 Specifications are based on the assumption that the measurements follow each other so fast (at intervals of no more than 10 s) that the temperature of the power attenuator does not change significantly. In the case of the R&S®NRP-Z22/-Z92, the average power must not exceed 1 W to be compliant with accuracy specifications for relative power measurements.
- ¹³ Gamma correction activated.
- ¹⁴ Preceding sensor section (nominal value).
- ¹⁵ 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.
- ¹⁶ For measuring the power of periodic bursts based on an average power measurement.
- ¹⁷ 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.
- ¹⁸ This parameter enables power measurements on modulated bursts. The parameter must be longer in duration than modulation-induced power drops within the burst.
- ¹⁹ To exclude unwanted portions of the signal from the measurement result.
- ²⁰ If embedding is used in conjunction with the R&S®NRP-Z22/-Z23/-Z24/-Z92, the data of the RF power attenuator preceding the sensor section is taken into account (automatically upon power-up of the sensor).
- ²¹ 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®NRP2 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®NRP2.
- ²² 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.
- ²³ 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-Z11/-Z21/-Z31/-Z41/-Z61/-Z91/-Z28/-Z98, specifications apply to automatic path selection and power levels up to +20 dBm or, within a subrange, to 12.6 µW (−19 dBm) for path 1, 1.26 mW (+1 dBm) for path 2 and 100 mW (+20 dBm) for path 3. 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. Use the nominal RF attenuation of the R&S®NRP-Z22/-Z23/-Z24/-Z92 to calculate the equivalent power at the input of the RF power attenuator. 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.
- ²⁴ Measurement error referenced to a CW signal of equal power and frequency. For the R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z91/-Z28/-Z98, specifications apply to automatic path selection and power levels up to +20 dBm or, within a subrange, to 12.6 µW (−19 dBm) for path 1, 1.26 mW (+1 dBm) for path 2 and 100 mW (+20 dBm) for path 3. 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. Use the nominal RF attenuation of the R&S®NRP-Z22/-Z23/-Z24/-Z92 to calculate the equivalent power at the input of the RF power attenuator. 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.
- ²⁵ Applies to the R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z211/-Z221/-Z91 and the sensor section of the R&S®NRP-Z22/-Z23/-Z24/-Z92, referenced to 0 dBm.
- ²⁶ 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 is −20 dBm for path 1 and 0 dBm for paths 2 and 3 with the R&S®NRP-Z11/-Z21/-Z31/-Z41/-Z61/-Z91/-Z28/-Z98 sensors and the sensor section of the R&S®NRP-Z22/-Z23/-Z24/-Z92 sensors. The calibration level for the R&S®NRP-Z211/-Z221 is −10 dBm for paths 1 and 2.
- ²⁷ Specifications include sensor section and RF power attenuator.
- ²⁸ With full video bandwidth. Reduce the specified minimum levels according to the reduction of sampling noise at lower bandwidths.
- ²⁹ 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).
- ³⁰ 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.
- ³¹ Measured over a one-minute interval, at constant temperature, two standard deviations.
- ³² 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.

- ³³ 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 $+35$ °C; averaging number set to $32k$ with an aperture time of 10 μ s (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 footnote 32 and the multiplier (1.4) from table A, the absolute noise contribution is typically 110 pW $\times 4 \times 1.4 = 616$ 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.

- ³⁴ 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 μ W (-30 dBm) at 31 GHz is to be determined with an R&S®NRP-Z85. The ambient temperature is $+21$ °C 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 μ s.

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 μ W. Using the noise multiplier (64) from footnote 32 and the multiplier (1.0) from table A, the absolute noise contribution is typically 110 pW $\times 64 \times 1.0 = 7$ 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 32). 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.

- ³⁵ 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 $2 \times f_0$ ($3 \times f_0$) can be lowered by a factor of $\sqrt{10}$ (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. $0.25 \text{ dB} \div 10 = 0.025 \text{ dB}$. Standard uncertainties can be assumed to be half the values.

- ³⁶ Magnitude of the change vector in the complex plane.

- ³⁷ 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).

- ³⁸ Expanded uncertainty ($k = 2$) for absolute power measurements. Specifications include calibration uncertainty, linearity and temperature effect. Zero offset and measurement noise must additionally be taken into account when measuring low powers, whereas zero drift is negligible over the entire measurement range. As a rule of thumb, the contribution of zero offset can be neglected for power levels above -20 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-Z56 is 5 μ W (-23 dBm) at 48 GHz; ambient temperature $+29$ °C; averaging number set to 64 in continuous average mode with an aperture time of 5 ms (default).

The absolute uncertainty due to zero offset (after external zeroing) is 25 nW, which corresponds to a relative measurement uncertainty of

$$10 \times \lg \frac{5 \mu\text{W} + 25 \text{ nW}}{5 \mu\text{W}} = 0.022 \text{ dB}$$

Using the formula in footnote 9, the absolute noise contribution is $25 \text{ nW} \times \sqrt{(10.24 \text{ s}/(64 \times 2 \times 0.005 \text{ s}))} = 100 \text{ nW}$, which corresponds to a relative measurement uncertainty of

$$10 \times \lg \frac{5 \mu\text{W} + 100 \text{ nW}}{5 \mu\text{W}} = 0.086 \text{ dB}$$

Combined with the value of 0.149 dB specified for the uncertainty of absolute power measurements at 48 GHz and +29 °C ambient temperature, the total expanded uncertainty is

$$\sqrt{0.149^2 + 0.022^2 + 0.086^2} = 0.173 \text{ dB}$$

- ³⁹ Expanded uncertainty (k = 2) for relative power measurements on CW signals of the same frequency. Specifications include linearity and temperature effect. Zero offset and measurement noise must additionally be taken into account when measuring low powers, whereas zero drift is negligible over the entire measurement range. As a rule of thumb, the contribution of zero offset can be neglected for power levels above –20 dBm if external zeroing has been applied. The contribution of measurement noise can be neglected below 0.01 dB. See also the example in footnote 11 for taking into account zero offset and noise with relative measurements.
- ⁴⁰ 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.
- ⁴¹ 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 (DC, 10 MHz, 50 MHz, 100 MHz, 300 MHz, 500 MHz, 750 MHz; in steps of 500 MHz from 1 GHz to the upper frequency limit). Specifications include zero offset and measurement noise (up to a 2σ value of 0.004 dB).
- ⁴² Error of an absolute power measurement with respect to temperature.
- ⁴³ Expanded uncertainty for relative power measurements referenced to the calibration level (0 dBm), excluding zero offset, zero drift and measurement noise.
- ⁴⁴ Equivalent source SWR.
- ⁴⁵ Between RF input and RF output (test port).
- ⁴⁶ Expanded uncertainty (k = 2) for absolute power measurements up to 100 mW (+20 dBm) at the calibration frequencies (see footnote 48). 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 footnote 51). 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 °C; 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 footnote 9, the maximum absolute noise contribution is $240 \text{ nW} \times \sqrt{(10.24 \text{ s}/(64 \times 2 \times 0.02 \text{ s}))} = 480 \text{ nW}$, 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

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

- ⁴⁷ 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 footnote 11 for taking into account zero offset and noise with relative measurements.
- ⁴⁸ 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.
- ⁴⁹ 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).
- ⁵⁰ 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.
- ⁵¹ 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).
- ⁵² 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.
- ⁵³ Quotient of a measured and a stored power ratio, e.g. for measuring gain compression of amplifiers.

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- ⁵⁴ Two-channel measurements in the trace mode of the R&S®NRP2 will be available in firmware version 07.03 to be released by the end of 2011.
- ⁵⁵ 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.
- ⁵⁶ R&S®NRP-B2 option required.
- ⁵⁷ Not in conjunction with the R&S®NRP-B5 option.
- ⁵⁸ Model .04 with reduced length of connecting cable (0.4 m).
- ⁵⁹ Order No. 1171.7005.42 includes an R&S®NRP-Z4 USB adapter cable (model .04, length: 0.5 m).
- ⁶⁰ Excluding defects caused by incorrect operation or handling and force majeure. Wear-and-tear parts are not included.

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