

# Keysight Technologies N5531S Measuring Receiver

Data Sheet



Unlocking Measurement Insights

## Conditions and Requirements

The Keysight N5531S measuring receiver system is comprised of a PSA spectrum analyzer with Option 233, a P-Series or EPM Series power meter, and an N5532B/A<sup>1</sup> sensor module for metrology and calibration applications. To achieve the optimal measurement results as specified, the best metrology practice must be applied and the required instrument conditions must be met.

PSA is the core component instrument of the N5531S measuring receiver. The PSA instrument conditions included in the PSA specification guide must be met to meet the N5531S specifications.

### Additional conditions required to meet specifications

- The system components are within their calibration cycle
- Tuned RF Level measurement is set to **High Accuracy Mode**
- Fast Mode is set to **Off** when performing modulation measurements
- For center frequency < 20 MHz, DC coupling is applied
- At least 2 hours of storage or operation at the operating temperature of 20 to 30 °C
- The PSA has been turned on at least 30 minutes with Auto Align On selected or if Auto Align Off is selected, Align All Now must be run:
  - Within the last 24 hours, and
  - Any time the ambient temperature changes more than 3 °C
  - After the analyzer has been at operating temperature at least 2 hours
- For analog modulation measurements, a direct connection between the PSA and the device under test (DUT) is required to achieve the best performance and meet the specifications for all test frequencies
- The following PSA options are required in addition to Option 233 as stated in the specifications:
  - Option 123 (pre-selector bypass) must be installed to meet TRFL specifications above 3 GHz
  - Option 107 (audio input 100 kΩ) is required with Option 233 (built-in measuring receiver personality) for the audio analysis
  - Option 1DS (pre-amplifier between 100 kHz and 3.05 GHz) or Option 110 (pre-amplifier between 10 MHz up to 50 GHz) is needed to achieve better sensitivity as indicated in the data sheet

### Key features:

- Metrology-grade measurement accuracy
- Off-the-shelf, general-purpose instruments with specialized PSA measurement personality
- Best for signal source and step attenuator calibrations
- Abundant features with easy-to-use user interfaces
- Sensor modules covering up to 50 GHz with single input connection

### Key measurements include:

- Frequency counter
- Absolute RF power
- Tuned RF level
- TRFL with tracking
- AM depth
- FM deviation
- oIM deviation
- Modulation rate
- Modulation distortion
- Modulation SINAD
- Audio frequency
- Audio AC level
- Audio distortion
- Audio SINAD
- Auto carrier triggering
- CCITT filters

1. As of April 1, 2010, the N5532A sensor module was discontinued and rolled to the N5532B. This document lists the N5532B/A as the N5532B and the N5532A share exactly the same specifications.

## Key Specifications

For detailed specifications, see the “Measuring receiver personality” chapter in the PSA specifications guide (E4440-90647).

### 1.1 Frequency modulation

Description		Specification	Supplemental information	
Input power range <sup>1</sup>		-18 to +30 dBm		
Operating rate range		$100 \text{ kHz} \leq f_c < 10 \text{ MHz}$	20 Hz to 10 kHz	
		$10 \text{ MHz} \leq f_c < 50 \text{ GHz}$	50 Hz to 200 kHz	
Peak frequency deviations <sup>1</sup>			Peak deviation = IFBW/2 - Modulation rate	
		$100 \text{ kHz} \leq f_c < 10 \text{ MHz}$	40 kHz maximum	
		$10 \text{ MHz} \leq f_c < 50 \text{ GHz}$	400 kHz maximum	
			IFBW <sub>max</sub> = 5 MHz in <b>Auto</b> mode;	
			IFBW <sub>max</sub> = 10 MHz in <b>Manual</b> mode	
FM deviation accuracy <sup>2</sup>				
Frequency range	Modulation rate	Peak deviation	$\beta^3$	
250 kHz to 10 MHz	20 Hz to 10 kHz	200 Hz to 40 kHz	> 0.2 > 1.2	±1.5 % of reading ±1 % of reading
10 MHz to 6.6 GHz	50 Hz to 200 kHz	250 Hz to 400 kHz	> 0.2 > 0.45	±1.5 % of reading ±1 % of reading
6.6 to 13.2 GHz	50 Hz to 200 kHz	250 Hz to 400 kHz	> 0.2 > 8	±2.5 % of reading ±1 % of reading
13.2 to 31.15 GHz	50 Hz to 200 kHz	250 Hz to 400 kHz	> 0.2 > 16	±3.8 % of reading ±1 % of reading
31.15 to 50 GHz	50 Hz to 200 kHz	250 Hz to 400 kHz	> 0.2 > 32	±8.5 % of reading ±1 % of reading
AM rejection (50 Hz to 3 kHz BW)				
Frequency range	Modulation rate	AM depths		
150 kHz to 3 GHz	400 Hz or 1 kHz	≤ 50 %	< 10 Hz peak deviation	
3 to 6.6 GHz	400 Hz or 1 kHz	≤ 50 %	< 10 Hz	
6.6 to 13.2 GHz	400 Hz or 1 kHz	≤ 50 %	< 20 Hz	
13.2 to 26.5 GHz	400 Hz or 1 kHz	≤ 50 %	< 40 Hz	
26.5 to 50 GHz	400 Hz or 1 kHz	≤ 50 %	< 75 Hz	
Residual FM (50 Hz to 3 kHz BW)				
RF frequency				
100 kHz to 6.6 GHz		< 1.5 Hz (rms)		
6.6 to 13.2 GHz		< 3 Hz (rms)		
13.2 to 31.15 GHz		< 6 Hz (rms)		
31.15 to 50 GHz		< 12 Hz (rms)		
Detectors			Available: +peak, -peak, ±peak/2, peak hold, rms	

1. The modulation rates and the peak deviations that the system is capable of measuring are governed by the instrument's IFBW

2. (Information Bandwidth) setting. Their relationship is described by the equation: Peak deviation (in Hz) = IFBW/2 - modulation rate.

3. When the carrier frequency  $f_c$  is less than 10 MHz, to avoid the 0 Hz frequency wrap-around, the  $f_c$  and IFBW must be chosen to satisfy  $[f_c - (IFBW)/2] > 100 \text{ kHz}$ .

4.  $\beta$  is the ratio of frequency deviation to modulation rate (deviation/rate).

## Key Specifications (continued)

### 1.2 Amplitude modulation

Description		Specification	Supplemental information
Input power range		-18 to +30 dBm	
Operating rate range <sup>1</sup>		$100 \text{ kHz} \leq f_c < 10 \text{ MHz}$	20 Hz to 10 kHz
		$10 \text{ MHz} \leq f_c < 50 \text{ GHz}$	50 Hz to 200 kHz
Depth range		5 to 99 %	Capable of measuring AM depth range of 0 to 99 %.
<b>AM depth accuracy<sup>2</sup></b>			
Frequency range	Modulation rate	Depths	
100 kHz to 10 MHz	50 Hz to 10 kHz	5 % to 99 %	±0.75 % of reading
10 MHz to 3 GHz	50 Hz to 100 kHz	20 % to 99 % 5 % to 20 %	±0.5 % of reading ±2.5 % of reading
3 to 26.5 GHz	50 Hz to 100 kHz	20 % to 99 % 5 % to 20 %	±1.5 % of reading ±4.5 % of reading
26.5 to 31.15 GHz	50 Hz to 100 kHz	20 % to 99 % 5 % to 20 %	±1.9 % of reading ±6.8 % of reading
31.15 to 50 GHz	50 Hz to 100 kHz	20 % to 99 % 5 % to 20 %	±6 % of reading ±26 % of reading
<b>Flatness<sup>3</sup></b>			
Frequency range	Modulation rate	Depths	
10 MHz to 3 GHz	90 Hz to 10 kHz	5 % to 99 %	±0.30 % of reading
3 to 26.5 GHz	90 Hz to 10 kHz	5 % to 99 %	±0.40 % of reading
26.5 to 50 GHz	90 Hz to 10 kHz	5 % to 99 %	±0.60 % of reading
<b>FM rejection (50 Hz to 3 kHz BW)</b>			
Frequency range	Modulation rate	Peak FM deviations	
250 kHz to 10 MHz	400 Hz or 1 kHz	< 5 kHz	< 0.14 % AM depth
10 MHz to 50.0 GHz	400 Hz or 1 kHz	< 50 kHz	< 0.36 % AM depth
Residual AM (50 Hz to 3 kHz BW)		< 0.01 % (rms) <sup>4,5</sup>	
Detectors			Available: +peak, -peak, ±peak/2, peak hold, rms

- When the carrier frequency  $f_c$  is less than 10 MHz, to avoid the 0 Hz frequency wrap-around, the  $f_c$  and IFBW must be chosen to satisfy  $[f_c - (\text{IFBW})/2] > 100 \text{ kHz}$ .
- For peak measurement only: AM accuracy may be affected by distortion generated by the measuring receiver. In the worst case this distortion can decrease accuracy by 0.1 % of reading for each 0.1 % of distortion.
- Flatness is the relative variation in indicated AM depth versus rate for a constant carrier frequency and depth.
- Preamp must be on to meet this specification for frequency range of 26.5 to 50 GHz.
- Follow this procedure to verify this specification: Input a clean CW signal (0 dBm) to the measuring receiver; Manually tune the frequency to the input signal; Set the PSA parameters as follows, (1) IF BW = 6 kHz, (2) Detector type = RMS, (3) High Pass Filter = 50 Hz, (4) Low Pass Filter = 3 kHz, (5) Set **RF Input Ranging** to **Man**, and decrease the input attenuation at 2 dB/step until **SigHi** message appears, and then back off 2 dB for the **SigHi** message to disappear.

## Key Specifications (continued)

### 1.3 Phase modulation

Description		Specification	Supplemental information
Input power range		-18 to +30 dBm	
Operating rate range	$100 \text{ kHz} \leq f_c < 10 \text{ GHz}$	200 Hz to 20 kHz	
Maximum peak phase deviation	$f_c < 10 \text{ MHz}$	450 radians <sup>1</sup>	
	$f_c \geq 10 \text{ MHz}$	12,499 radians <sup>2</sup>	In <b>Auto</b> mode
		24,999 radians <sup>2</sup>	In <b>Manual</b> mode
<b>Φ M accuracy</b>			
Frequency range	Deviations		
100 kHz to 6.6 GHz	> 0.7 rad	±1 % of reading	
	> 0.3 rad	±3 % of reading	
6.6 to 13.2 GHz	> 2.0 rad	±1 % of reading	
	> 0.6 rad	±3 % of reading	
13.2 to 26.5 GHz	> 4.0 rad	±1 % of reading	
	> 1.2 rad	±3 % of reading	
26.5 to 31.5 GHz	> 4.0 rad	±1 % of reading	
	> 1.3 rad	±3 % of reading	
31.5 to 50 GHz	> 8.0 rad	±1 % of reading	
	> 2.4 rad	±3 % of reading	
AM rejection (50 Hz to 3 kHz BW)	For 50 % AM at 1 kHz rate	< 0.03 rad (peak)	
<b>Residual PM (50 Hz to 3 kHz BW)</b>			
Frequency range			
100 kHz to 6.6 GHz			< 0.0017 rad (rms)
6.6 to 13.2 GHz			< 0.0033 rad (rms)
13.2 to 31.15 GHz			< 0.0066 rad (rms)
31.15 to 50 GHz			< 0.0130 rad (rms)
Detectors	Available: +peak, -peak, ±peak/2, peak hold, rms		

- When the carrier frequency  $f_c$  is less than 10 MHz, to avoid the 0 Hz frequency wrap-around, the  $f_c$  and IFBW must be chosen to satisfy  $[f_c - (\text{IFBW}/2)] > 100 \text{ kHz}$ . The specification of 450 radians applies for  $f_c = 200 \text{ kHz}$ , IFBW = 200 kHz, and a modulation rate of 200 Hz. The specification for maximum peak phase deviation will linearly improve as the allowed IFBW increase. As  $f_c$  increases, the IFBW can increase up to the maximum allowed IFBW in **Auto** or **Manual** modes.
- When the carrier frequency ( $f_c$ ) is equal to or greater than 10 MHz, the maximum peak deviation that the instrument is capable of measuring depends on the IFBW setting and the modulation rate of the signal-under-test. The relationship is described by the equation:  

$$\text{Max peak deviation (in radians)} = [\text{IFBW}/(2 \times \text{modulation rate in Hz})] - 1$$
- The maximum IFBW used in **Auto** mode is  $5 \times 10^6 \text{ Hz}$ , therefore, Max peak deviation (in radians) =  $(2.5 \times 10^6 / \text{modulation rate in Hz}) - 1$ . In **Manual** mode, the maximum IFBW can be set to 107 Hz, hence, Max peak deviation (in radians) =  $(5 \times 10^6 / \text{modulation rate in Hz}) - 1$ .

## Key Specifications (continued)

### 1.4 RF frequency counter

Description	Specification	Supplemental information
Range	100 kHz to 50 GHz	In Auto mode
Sensitivity <sup>1</sup>		
100 kHz $\leq f_c < 3.0$ GHz	0.4 mV <sub>rms</sub> (-55 dBm)	
3.0 GHz $\leq f_c \leq 26.5$ GHz	1.3 mV <sub>rms</sub> (-45 dBm)	
26.5 GHz $\leq f_c \leq 50$ GHz	4.0 mV <sub>rms</sub> (-35 dBm)	
Maximum resolution	0.001 Hz	
Accuracy		
Modes		Frequency and frequency error (manual tuning)
Sensitivity in manual tuning mode		Using manual ranging and changing RBW settings, sensitivity can be increased to approximately -100 dBm.

### 1.5 Audio input<sup>2</sup>

Description	Specification	Supplemental information
Frequency range	20 Hz to 250 kHz	
Input impedance		100 k $\Omega$ (nominal)
Maximum safe input level	7 V <sub>rms</sub> or 20 VDC	

### 1.6 Audio frequency counter

Description	Specification	Supplemental information
Frequency range	20 Hz to 250 kHz	
Accuracy <sup>3</sup>		With HPF set to minimum setting of < 20 Hz
$f < 1$ kHz	$\pm(0.02 \text{ Hz} + f \times \text{Internal Reference Accuracy})^4$	
$f \geq 1$ kHz	$\pm 3$ counts of the first 6 significant digits $\pm f \times (\text{Internal Reference Accuracy})$	
Resolution	0.01 Hz (8 digits)	
Sensitivity	$\leq 5$ mV	

### 1.7 Audio AC (RMS) level

Description	Specification	Supplemental information
Frequency range	20 Hz to 250 kHz	
Measurement level range	100 mV <sub>rms</sub> to 3 V <sub>rms</sub>	
Accuracy	1 % of reading	
Detector mode		RMS

- Instrument condition: RBW  $\leq 1$  kHz.
- All audio measurements require PSA Option 107.
- Follow this procedure to verify this specification: Set an input audio signal at 100 mV. Set the PSA as follows: (1) Auto Level, (2) Auto IF BW, (3) LP is greater than the audio frequency, (4) HP = 300 Hz or less than the audio frequency, and (5) Average = 5 Repeat.
- See the "Internal Time Base Reference" section in the PSA specification guide for the Internal Reference Accuracy.

## 1.8 Audio distortion

Description	Specification	Supplemental information
Display range (20 Hz to 250 kHz BW)	0.01 to 100 % (-80 to 0 dB)	
Accuracy (20 Hz to 250 kHz)	±1 dB of reading	
Residual noise and distortion	< 0.3 % (-50.4 dB)	
Total noise		-73.2 dB characteristic performance
Total distortion		-74.8 dB characteristic performance

## 1.9 Audio SINAD

Description	Specification	Supplemental information
Display range (20 Hz to 250 kHz BW)	0.00 to 80 dB	
Display resolution	0.01 dB	
Accuracy		
20 Hz to 20 kHz	±1 dB of reading	
20 kHz to 250 kHz	±2 dB of reading	
Residual noise and distortion	50.4 dB (< 0.3 %)	
Total noise		73.2 dB characteristic performance
Total distortion		74.8 dB characteristic performance

## 1.10 Audio filters

Description	Specification	Supplemental information
Filter flatness		
Non high-pass filter		< ± 1 % at rates > 20 Hz
50 Hz high-pass filter	< ±1 % at rates > 50 Hz	
300 Hz high-pass filter	< ±1 % at rates > 300 Hz	
400 Hz high-pass filter <sup>1</sup>	< ±1 % at rates > 400 Hz	
3 kHz low-pass filter	< ±1 % at rates < 3,030 Hz	
15 kHz low-pass filter	< ±1 % at rates < 15,030 Hz	
30 kHz low-pass filter <sup>1</sup>	< ±1 % at rates < 30 kHz	
80 kHz low-pass filter <sup>1</sup>	< ±1 % at rates < 80 kHz	
> 100 kHz low-pass filter	< ± 1 % at rates < 100 kHz	
CCITT weighting filter	CCITT recommendation P53	
Deviation from the ideal	±0.2 dB at 800 Hz; ±1.0 dB, 300 Hz to 3 kHz	
CCITT filter response	±2.0 dB, 50 to 300 Hz and 3 to 3.5 kHz; ±3.0 dB, 3.5 to 5 kHz	
De-emphasis filters	25 μs, 50 μs, 75 μs, and 750 μs	De-emphasis filters are single-pole, low-pass filters with nominal -3 dB frequencies of: 6,366 Hz for 25 μs, 3,183 Hz for 50 μs, 2,122 Hz for 75 μs, and 212 Hz for 750 μs.
Deviation from ideal de-emphasis filter	< 0.4 dB, or < 3°	Applicable to 25 μs, 50 μs, and 75 μs filters. With 3 kHz Low-Pass filter and IFBW Mode set to minimal.

1. PSA firmware revision ≥ A.11.08 or Option 23B

## 1.11 RF Power<sup>1,2</sup>

The Keysight N5531S measuring receiver system with the N5532B/A sensor modules performs RF power measurements from -10 dBm (100  $\mu$ W) to +30 dBm (1 W). The N5531S must be used with Keysight P-Series power meters (N1911A, N1912A), or EPM Series power meters (N1913A, N1914A). A LAN/GPIB gateway will be required if the EPM/EPM-P Series power meter is used.

Description	Specification	Supplemental information							
RF power accuracy (dB)									
	<b>Power meter range 1</b>					<b>Typicals</b>			
		Sensor module options				Sensor module options			
	+20 to +30 dBm	504	518	526	550	504	518	526	550
	100 kHz $< f_c \leq$ 10 MHz	$\pm 0.356$	–	–	–	$\pm 0.182$	–	–	–
	10 MHz $< f_c \leq$ 30 MHz	$\pm 0.356$	$\pm 0.361$	–	–	$\pm 0.182$	$\pm 0.185$	–	–
	30 MHz $< f_c \leq$ 2 GHz	$\pm 0.356$	$\pm 0.361$	$\pm 0.361$	$\pm 0.361$	$\pm 0.182$	$\pm 0.185$	$\pm 0.185$	$\pm 0.185$
	2 GHz $< f_c \leq$ 4.2 GHz	$\pm 0.356$	$\pm 0.392$	$\pm 0.422$	$\pm 0.387$	$\pm 0.182$	$\pm 0.201$	$\pm 0.217$	$\pm 0.188$
	4.2 GHz $< f_c \leq$ 18 GHz	–	$\pm 0.400$	$\pm 0.422$	$\pm 0.387$	–	$\pm 0.205$	$\pm 0.217$	$\pm 0.188$
	18 GHz $< f_c \leq$ 26.5 GHz	–	–	$\pm 0.480$	$\pm 0.387$	–	–	$\pm 0.217$	$\pm 0.199$
	26.5 GHz $< f_c \leq$ 50 GHz	–	–	–	$\pm 0.420$	–	–	–	$\pm 0.216$
	<b>Power meter range 2</b>					<b>Typicals</b>			
		Sensor module options				Sensor module options			
	0 to +20 dBm	504	518	526	550	504	518	526	550
	100 kHz $\leq f_c \leq$ 10 MHz	$\pm 0.190$	–	–	–	$\pm 0.097$	–	–	–
	10 MHz $< f_c \leq$ 30 MHz	$\pm 0.190$	$\pm 0.200$	–	–	$\pm 0.097$	$\pm 0.101$	–	–
	30 MHz $< f_c \leq$ 2 GHz	$\pm 0.190$	$\pm 0.200$	$\pm 0.200$	$\pm 0.200$	$\pm 0.097$	$\pm 0.101$	$\pm 0.101$	$\pm 0.101$
	2 GHz $< f_c \leq$ 4.2 GHz	$\pm 0.190$	$\pm 0.255$	$\pm 0.301$	$\pm 0.212$	$\pm 0.097$	$\pm 0.130$	$\pm 0.154$	$\pm 0.108$
	4.2 GHz $< f_c \leq$ 18 GHz	–	$\pm 0.267$	$\pm 0.301$	$\pm 0.212$	–	$\pm 0.136$	$\pm 0.154$	$\pm 0.108$
	18 GHz $< f_c \leq$ 26.5 GHz	–	–	$\pm 0.380$	$\pm 0.247$	–	–	$\pm 0.195$	$\pm 0.126$
	26.5 GHz $< f_c \leq$ 50 GHz	–	–	–	$\pm 0.297$	–	–	–	$\pm 0.152$
RF power resolution	Display resolution	0.001 dB							
Instrumentation accuracy	Logarithmic	$\pm 0.02$ dB							
	Linear	$\pm 0.5$ %							

1. For latest specification updates refer to N1911A/N1912A and N1913A/N1914A power meter User's Guides.

2. The N5531S RF Power Accuracy is derived from the power meter accuracy. The parameters listed in this section are components used to calculate the RF Power Accuracy. Fundamentals of RF and Microwave Power Measurements (5988-9215EN) does an excellent job of explaining how the components are combined to derive an overall accuracy number. The resulting calculation yields  $\pm 0.190$  to  $\pm 0.297$  dB when measuring a +10 dBm signal and ignoring DUT mismatch. Assuming 1.5:1 DUT SWR, the calculation would return a typical accuracy of  $\pm 0.213$  to  $\pm 0.387$  dB (depending on the frequency range and power under test). Absolute and relative accuracy specifications do not include mismatch uncertainty.



## 1.11 RF Power (continued)

Description	Specification	Supplemental information
Input SWR		
N5532B/A Option 504	100 kHz to 2 GHz	< 1.10:1 ( $\rho = 0.048$ )
	2 GHz to 4.2 GHz	< 1.28:1 ( $\rho = 0.123$ )
N5532B/A Option 518	10 MHz to 2 GHz	< 1.10:1 ( $\rho = 0.048$ )
	2 GHz to 18 GHz	< 1.28:1 ( $\rho = 0.123$ )
N5532B/A Option 526	30 MHz to 2 GHz	< 1.10:1 ( $\rho = 0.048$ )
	2 GHz to 18 GHz	< 1.28:1 ( $\rho = 0.123$ )
	18 GHz to 26.5 GHz	< 1.40:1 ( $\rho = 0.167$ )
N5532B/A Option 550	30 MHz to 2 GHz	< 1.10:1 ( $\rho = 0.048$ )
	2 GHz to 18 GHz	< 1.28:1 ( $\rho = 0.123$ )
	18 GHz to 26.5 GHz	< 1.40:1 ( $\rho = 0.167$ )
	26.5 GHz to 33 GHz	< 1.55:1 ( $\rho = 0.216$ )
	33 GHz to 40 GHz	< 1.70:1 ( $\rho = 0.259$ )
	40 GHz to 50 GHz	< 1.75:1 ( $\rho = 0.272$ )
Zero set and measurement noise <sup>1</sup>	N5532B/A $\pm 680$ nW	
Zero drift of sensors (1 hour, at constant temperature after 24 hour warm-up)	N5532B/A < $\pm 100$ nW	
RF power ranges of N5531S with N5532B/A sensor modules	-20 dBm (10 $\mu$ W) to +30 dBm (1 W)	One range for power sensors
Response time (0 to 99 % of reading)		150 ms x number of averages (nominal)
Displayed units	Watts, dBm, or Volts	

1. Since zero set and measurement noise cannot be separated, these two components are combined as one error term.

## Key Specifications (continued)

### TRFL Specification Nomenclature

The tuned RF level measurement uncertainty is represented primarily by two regions. For high signal-to-noise (S/N) measurements, the uncertainty is dominated by the linearity of the measuring receiver. For low S/N measurements, the measurement uncertainty is dominated by the noise of the measuring receiver being added to the measured signal. The input power at which the uncertainty switches from linearity dominated to noise dominated is labeled as Residual noise threshold. The minimum power level is defined as the noise floor of the measuring receiver system.

Additionally, there are 2 range-to-range change uncertainties known as Range 2 Uncertainty and Range 3 Uncertainty, respectively. Range 2 Uncertainty occurs when the measuring receiver switches from Range 1 to Range 2, and Range 3 uncertainty from Range 2 to Range 3. They are additive uncertainties applied to all measurements whose input powers across Range Switch Level.

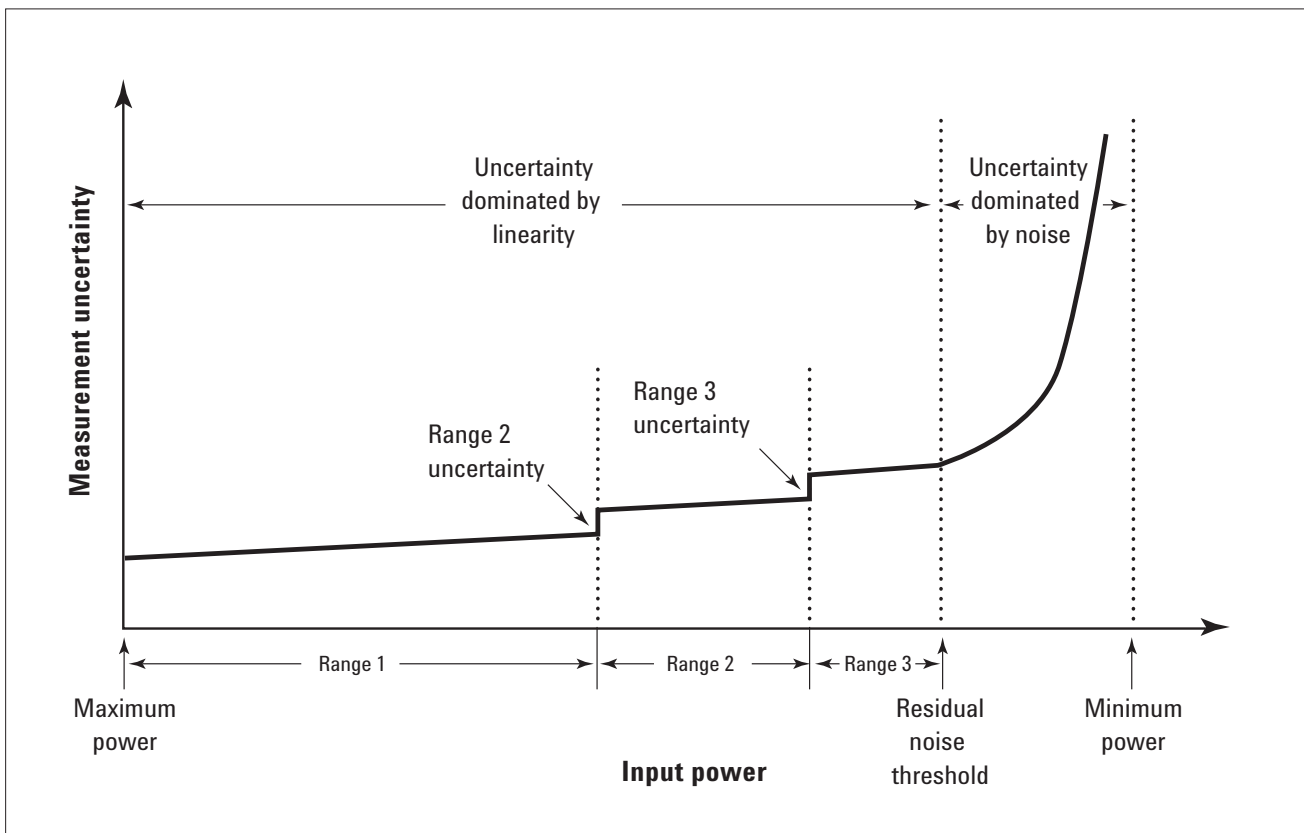


Figure 1. Measurement uncertainty vs. input power relationship

## Key Specifications (continued)

### 1.12 Tuned RF level<sup>1, 2, 3</sup>

Note: While the Tuned RF level specifications listed below are for IFBW settings of 75 Hz and 10 Hz, the IFBW in N5531S can also be set to 30 kHz or 200 kHz. The wider IFBW is capable of measuring sources with some degree of frequency instability by trading off measurement sensitivity.

For sources with frequency instability greater than 100 kHz, use the Tuned RF Level with Tracking measurement. When using the Tuned RF Level with Tracking, the following additional amplitude error must be applied due to FFT frequency response as the signal drifts within the tracking range:  $\pm(0.15 \text{ dB} + 0.1 \text{ dB/MHz of span})$  to a max of  $\pm 0.40 \text{ dB}$ , where span is equivalent to the tracking range setting in the measurement. The Tuned RF Level with Tracking measurement upper frequency limit = 3.05 GHz. For the Tuned RF Level with Tracking, the minimum power in the =  $10 * \log [\text{Integrated BW} / (75 \text{ Hz} * 1.06)]$ , relative to the specified 75 Hz minimum power level.

Description	Specification		Supplemental information			
Power range						
Maximum power	Preamp off	+30 dBm				
	Preamp on	+16 dBm				
<b>Minimum power (dBm)<sup>7</sup></b> <b>E4443A/45A/40A</b>	<b>Frequency range</b>	<b>75 Hz IFBW</b>		<b>10 Hz IFBW<sup>4, 5</sup></b>		Also see Notes 1 and 2 on page 15
		<b>Preamp uninstalled</b>	<b>Preamp installed<sup>6</sup></b>	<b>Preamp uninstalled</b>	<b>Preamp installed<sup>6</sup></b>	
	100 kHz to 2 MHz	-110	-124/-110	-129	-140/-129	
	2 to 10 MHz	-115	-131/-115	-134	-140/-134	
	10 MHz to 3.05 GHz	-117	-134/-133	-136	-140/-140	
	3.05 to 6.6 GHz	-117	-117/-127	-136	-136/-140	
	6.6 to 13.2 GHz	-108	-108/-116	-127	-127/-135	
	13.2 to 19.2 GHz	-100	-100/-110	-119	-119/-129	
19.2 to 26.5 GHz	-93	-93/-102	-112	-112/-121		
<b>Minimum power (dBm)<sup>7</sup></b> <b>E4447A/46A/48A</b>	<b>Frequency range</b>	<b>75 Hz IFBW</b>		<b>10 Hz IFBW<sup>4, 5</sup></b>		Also see Notes 1 and 2 on page 15
		<b>Preamp uninstalled</b>	<b>Preamp installed<sup>6</sup></b>	<b>Preamp uninstalled</b>	<b>Preamp installed<sup>6</sup></b>	
	100 kHz to 2 MHz	-110	-124/-110	-129	-140/-129	
	2 to 10 MHz	-115	-131/-115	-134	-140/-134	
	10 MHz to 3.05 GHz	-117	-134/-133	-136	-140/-140	
	3.05 to 6.6 GHz	-114	-114/-126	-133	-133/-140	
	6.6 to 13.2 GHz	-111	-111/-123	-130	-130/-140	
	13.2 to 19.2 GHz	-109	-109/-118	-128	-128/-137	

1. PSA Option 123 is required to perform Tuned RF Level measurements above 3 GHz.
2. These specifications are valid when the measuring receiver input is a CW tone and operating temperature is within the range of 20 to 30 °C.
3. Absolute and relative accuracy specifications do not include mismatch uncertainty.
4. With 10 Hz IFBW setting selected, the measurement automatically switches the RBW to the 1 Hz setting for SNR values < 10 dB.
5. For an instrument with a serial number prefix below US/MY4615, the minimum power level in 10 Hz IFBW setting is 10 dB higher than the values shown here. However, if the PSA contains Option 107, the values shown in the table still apply.
6. In the frequency range of 100 kHz to 3.05 GHz, the minimum power specifications with Preamp installed are presented in two values: A/B, where value A is for the PSA installed with Option 1DS, and value B is for the PSA installed with Option 110. Furthermore, in the frequency range of 100 kHz and 10 MHz, Option 110 is turned off for these measurements. Option 1DS only covers a frequency range of 100 kHz and 3.05 GHz, whereas Option 110 covers up to the maximum frequency of the PSA base instrument. Those two preamplifier options cannot coexist in the same PSA instrument.
7. With 30 kHz and 200 kHz IF bandwidth (IFBW), TRFL minimum power level will be degraded by a factor of  $10 \log(\text{IFBW}/75 \text{ Hz})$ , relative to the specified 75 Hz minimum power level. This will result in a degradation of 26 dB for the 30 kHz IFBW and 34 dB for the 200 kHz IFBW.

## Key Specifications (continued)

### 1.12 Tuned RF level (continued)

Description		Specification				Supplemental information
Minimum power (dBm) E4447A/46A/48A		75 Hz IFBW		10 Hz IFBW		Also see Notes 1 and 2 on page 14
	Frequency range	Preamp uninstalled	Preamp installed <sup>6</sup>	Preamp uninstalled	Preamp installed	
	19.2 to 26.5 GHz	-97	-97/-104	-116	-116/-123	
	26.5 to 31.15 GHz	-98	-98/-103	-117	-117/-122	
	31.15 to 41 GHz	-87	-87/-91	-106	-106/-110	
	41 to 45 GHz	-81	-81/-81	-100	-100/-100	
	45 to 50 GHz	-69	-69/-69	-88	-88/-88	
Linearity		$\pm(0.009 \text{ dB} + 0.005 \text{ dB}/10 \text{ dB step})^1$				
Relative measurement accuracy	Residual noise threshold <sup>2</sup> to maximum power	$\pm(0.015 \text{ dB} + 0.005 \text{ dB}/10 \text{ dB step})^{1,3,4}$ (nominal)				
	Minimum power to residual noise threshold	$\pm(\text{cumulative error}^e + 0.0012 \times (\text{input power} - \text{residual noise threshold power})^2)$				
Residual noise threshold power (dBm)		Residual noise threshold power = minimum power +30 dB				
Range 2 uncertainty <sup>6</sup>		$\pm 0.031 \text{ dB}$				
Range 3 uncertainty <sup>7</sup>		$\pm 0.031 \text{ dB}$				

- Step in this specification refers to the difference between relative measurements, such as might be experienced by stepping a stepped attenuator. Therefore, accuracy is computed by adding the uncertainty for each full or partial 10 dB step to the other uncertainty term. For example, if the two levels whose relative level is to be determined differ by 15 dB, consider that to be a difference of two 10-dB steps.
- The residual noise threshold power is the power level at which the signal-to-noise ratio (SNR) becomes the dominant contributor to the measurement uncertainty. See TRFL Specifications Nomenclature at the beginning of this section.
- Immediately following the system alignments, the measurement is made by manually setting frequency to that of the signal-under-test, Accuracy mode to High, and Measure Control to Single. For the E4446A/E4447A/E4448A, if the change of measured frequency crosses frequency bands (refer to previous page in the column of "Supplemental Information" for definitions of frequency bands for the E4446A/E4447A/E4448A), allow 10 minutes for thermal stability before taking the first measurement within the new band.
- This includes the linearity accuracy.
- In relative accuracy of TRFL measurements, the cumulative error is the error incurred when stepping from a higher power level to the Residual Noise Threshold Power level. The formula to calculate the cumulative error is  $\pm(0.015 \text{ dB} + 0.005 \text{ dB}/10 \text{ dB step})$ . For example, assume the higher level starting power is 0 dBm and the calculated Residual Noise Threshold Power is -99 dBm. The cumulative error would be  $\pm(0.015 + 99/10 \times 0.005 \text{ dB})$ , or  $\pm 0.065 \text{ dB}$ , where x is a ceiling function that means the smallest integer is not less than x.
- Add this specification when the measuring receiver enters the Range 2 state. Range 2 is entered when the Range 1 signal-to-noise ratio (SNR) falls between 50 and 28 dB. The SNR value is tuning band dependent. A prompt of Range 2 in the PSA display will indicate that the measuring receiver is in Range 2.
- Add this specification in addition to Range 2 Uncertainty when the measuring receiver software enters the Range 3 state. Range 3 is entered when the Range 2 SNR falls between 50 and 28 dB. The SNR value is tuning band dependent. A prompt of Range 3 in the PSA display will indicate that the measuring receiver is in Range 3.

## Key Specifications (continued)

### 1.12 Tuned RF level (continued)

Description	Specification	Supplemental information
Absolute measurement accuracy	Preamp Off	
	+20 dBm to maximum power	$\pm(\text{power meter range 1 uncertainty} + 0.005 \text{ dB}/10 \text{ dB step})$
	Residual noise threshold power to +20 dBm	$\pm(\text{power meter range 2} - 4 \text{ uncertainty} + 0.005 \text{ dB}/10 \text{ dB step})$
	Minimum power to residual noise threshold power	$\pm(\text{cumulative error} + 0.0012 \times (\text{input power} - \text{residual noise threshold power})^2)$
Absolute measurement accuracy	Preamp On	
	Residual noise threshold power to +16 dBm	$\pm(\text{power meter range 2} - 4 \text{ uncertainty} + 0.005 \text{ dB}/10 \text{ dB step})$
	Minimum power to residual noise threshold power	$\pm(\text{cumulative error}^1 + 0.0012 \times (\text{input power} - \text{residual noise threshold power})^2)$
Residual Noise Threshold Power (dBm)		Residual Noise Threshold Power = Minimum Power + 30 dB
Range 2 Uncertainty <sup>2</sup>	$\pm 0.031 \text{ dB}$	
Range 3 Uncertainty <sup>3</sup>	$\pm 0.031 \text{ dB}$	

- In absolute accuracy of TRFL measurements, the cumulative error is the error incurred when stepping from a higher power level to the Residual Noise Threshold power level. See Figure 1 for a graphic. In order to calculate the cumulative error, you must determine the Residual Noise Threshold power and determine the Power Meter Range. The formula to calculate the cumulative error is:  $\pm(\text{Power Meter Range Uncertainty} + 0.005 \text{ dB}/10 \text{ dB step})$ . For example: the power sensor is Option 504, starting power is 0 dBm and power will be stepped to -120 dBm. Therefore starting power falls in the Power Meter Range 2-4 and the uncertainty is  $\pm 0.190 \text{ dB}$ , as indicated in the table on the next page. The Residual Noise Threshold Power is -106 dBm at IFBW of 10 Hz. This is calculated per the Minimum Power specification in the table on the previous page. Assume no preamp is installed, and that the measurement frequency is 10 MHz to 3 GHz. The Residual Noise Threshold Power is  $-136 \text{ dBm} + 30 \text{ dB} = -106 \text{ dBm}$  using the formula on this page. The cumulative error is then  $\pm(0.190 \text{ dB} + 106/10 \times 0.005 \text{ dB})$ , or  $\pm 0.245 \text{ dB}$ , where x is a ceiling function that means the smallest integer not less than x, which is 11 in this example.
- Add this specification when the Measuring Receiver enters the Range 2 state. Range 2 is entered when the Range 1 signal-to-noise ratio (SNR) falls between 50 and 28 dB. The SNR value is tuning band dependent. A prompt of Range 2 in the PSA display will indicate that the Measuring Receiver is in Range 2.
- Add this specification in addition to Range 2 Uncertainty when the Measuring Receiver enters the Range 3 state. Range 3 is entered when the Range 2 SNR falls between 50 and 28 dB. The SNR value is tuning band dependent. A prompt of Range 3 in the PSA display will indicate that the Measuring Receiver is in Range 3.

#### NOTE

As the displayed average noise level (DANL) of a spectrum analyzer becomes very low, it can reveal residuals. These occur at discrete frequencies and arise from the various clocks and other components of the local oscillators. This is true for all modern spectrum analyzers. The residuals specification for the PSA Series is -100 dBm. Please take this information into consideration when you measure the TRFL level below -100 dBm. A user may apply a 50-ohm terminator to the PSA's RF input connector and switch to the PSA's spectrum analysis mode to verify the PSA residuals.

The sensor module (N5532B/A) may generate a residual of around -100 dBm or lower at frequency of 50 MHz and its harmonics. Please take this information into consideration when you use the N5532B/A to measure the TRFL level below -100 dBm at 50 MHz and its harmonics.

## Key Specifications (continued)

### 1.12 Tuned RF level (continued)

Description	Specification				Supplemental information			
Power Meter Range Uncertainty								
	<b>Power meter Uncertainty (dB)</b>				<b>Typicals</b>			
	Sensor module options				Sensor module options			
+20 to +30 dBm	504	518	526	550	504	518	526	550
100 kHz $\leq f_c \leq$ 10 MHz	$\pm 0.356$	—	—	—	$\pm 0.182$	—	—	—
10 MHz $< f_c \leq$ 30 MHz	$\pm 0.356$	$\pm 0.361$	—	—	$\pm 0.182$	$\pm 0.185$	—	—
30 MHz $< f_c \leq$ 2 GHz	$\pm 0.356$	$\pm 0.361$	$\pm 0.361$	$\pm 0.361$	$\pm 0.182$	$\pm 0.185$	$\pm 0.185$	$\pm 0.185$
2 GHz $< f_c \leq$ 4.2 GHz	$\pm 0.356$	$\pm 0.392$	$\pm 0.422$	$\pm 0.367$	$\pm 0.182$	$\pm 0.201$	$\pm 0.217$	$\pm 0.188$
4.2 GHz $< f_c \leq$ 18 GHz	—	$\pm 0.400$	$\pm 0.422$	$\pm 0.367$	—	$\pm 0.205$	$\pm 0.217$	$\pm 0.188$
18 GHz $< f_c \leq$ 26.5 GHz	—	—	$\pm 0.480$	$\pm 0.367$	—	—	$\pm 0.217$	$\pm 0.199$
26.5 GHz $< f_c \leq$ 50 GHz	—	—	—	$\pm 0.420$	—	—	—	$\pm 0.216$
	<b>Power meter range 2<sup>1</sup> Uncertainty (dB)</b>				<b>Typicals</b>			
	Sensor module Options				Sensor module Options			
0 to +20 dBm	504	518	526	550	504	518	526	550
100 kHz $\leq f_c \leq$ 10 MHz	$\pm 0.190$	—	—	—	$\pm 0.097$	—	—	—
10 MHz $< f_c \leq$ 30 MHz	$\pm 0.190$	$\pm 0.200$	—	—	$\pm 0.097$	$\pm 0.101$	—	—
30 MHz $< f_c \leq$ 2 GHz	$\pm 0.190$	$\pm 0.200$	$\pm 0.200$	$\pm 0.200$	$\pm 0.097$	$\pm 0.101$	$\pm 0.101$	$\pm 0.101$
2 GHz $< f_c \leq$ 4.2 GHz	$\pm 0.190$	$\pm 0.255$	$\pm 0.301$	$\pm 0.212$	$\pm 0.097$	$\pm 0.130$	$\pm 0.154$	$\pm 0.108$
4.2 GHz $< f_c \leq$ 18 GHz	—	$\pm 0.267$	$\pm 0.301$	$\pm 0.212$	—	$\pm 0.136$	$\pm 0.154$	$\pm 0.108$
18 GHz $< f_c \leq$ 26.5 GHz	—	—	$\pm 0.380$	$\pm 0.247$	—	—	$\pm 0.195$	$\pm 0.126$
26.5 GHz $< f_c \leq$ 50 GHz	—	—	—	$\pm 0.297$	—	—	—	$\pm 0.152$
Operating frequency range								
E4443A/45A/40A/47A/46A/48A	100 kHz to 3 GHz							
E4443A/45A/40A/47A/46A/48A	3 to 6.7 GHz				Requires Option 123			
E4445A/40A/47A/46A/48A	6.7 to 13.2 GHz				Requires Option 123			
E4440A/47A/46A/48A	13.2 to 26.5 GHz				Requires Option 123			
E4447A/46A/48A	26.5 to 42.98 GHz				Requires Option 123			
E4446A/48A	42.98 to 44 GHz				Requires Option 123			
E4448A	44 to 50 GHz				Requires Option 123			
Displayed units								
	Absolute				Watts, dBm, or Volts			
	Relative				Percent or dB			
Displayed resolution								
	6 digits in Watts or 5 digits in Volts mode							
	0.001 dB in dBm or dB (relative) mode							
Input SWR								
	See "RF Power" Section							

1. Refer to the PSA specification guide, E4440-90647, for more information.

## N5531S Ordering Information

The Keysight N5531S measuring receiver system is comprised of a PSA, a P-Series or EPM Series power meter, and an N5532B sensor module.

### PSA Series spectrum analyzer

(Select one model from the following models)

- E4443A  
3 Hz to 6.7 GHz
- E4445A  
3 Hz to 13.2 GHz
- E4440A  
3 Hz to 26.5 GHz
- E4447A  
3 Hz to 42.98 GHz
- E4446A  
3 Hz to 44 GHz
- E4448A  
3 Hz to 50 GHz

### PSA options (x = 0, 3, 5, 6, 7, 8)

#### **E444xA-233**

Built-in measuring receiver personality and PC software (required)

#### **E444xA-123**

Switchable preselector bypass (required for TRFL measurements above 3 GHz)

#### **E444xA-1DS**

RF internal preamplifier (required for the best TRFL specifications up to 3.05 GHz; does not co-exist with Option 110)

#### **E444xA-110**

RF/ $\mu$ W internal preamplifier (required for the best TRFL specifications up to the maximum frequency of the PS base instrument; does not co-exist with Option 1DS)

#### **E444xA-107**

Audio input 100 k $\Omega$  (required for audio analysis, only operational with Option 233)

#### **AM/FM/PM triggering**

Shipped standard with Option 233 (PSA firmware rev  $\geq$  A.11.08) or Option 23A

#### **CCITT filter (adds CCITT and 400-Hz HP, 30-kHz/80-kHz LP filters)**

Shipped standard with Option 233 (PSA firmware rev  $\geq$  A.11.08) or Option 23B

Select from PSA options for other measurements (Optional, Refer to PSA Configuration Guide for details of option compatibility and requirements)

## PSA option upgrades<sup>1</sup> (x = 0, 3, 5, 6, 7, 8)

### E444xAU-233

Built-in measuring receiver personality and PC software (required)

### E444xAU-123

Switchable preselector bypass (required for TRFL measurements above 3 GHz)

### E444xAU-1DS

RF internal preamplifier (required for the best TRFL specifications up to 3.05 GHz; does not co-exist with Option 110)

### E444xAU-110

RF/ $\mu$ W internal preamplifier (required for the best TRFL specifications up to the maximum frequency of the PSA base instrument; does not co-exist with Option 1DS)

### E444xAU-107

Audio input 100 k $\Omega$  (required for audio analysis, only operational with Option 233)

(Select one from the following models)

## P-Series power meter

### N1911A

P-Series single channel power meter

### N1912A

P-Series dual channel power meter

## EPM Series power meter

### N1913A

EPM Series single channel power meter

### N1914A

EPM Series dual channel power meter

1. Upgrades for certain PSA options may not be available for earlier instruments. For detailed information regarding availability and compatibility of options, please visit [http://www.keysight.com/find/psa\\_upgrades](http://www.keysight.com/find/psa_upgrades)



Select from power meter options (optional)

## N5532B sensor module

(Select one frequency option)

### N5532B-504

100 kHz to 4.2 GHz, type-N (m) input connector

### N5532B-518

10 MHz to 18 GHz, type-N (m) input connector

### N5532B-526

30 MHz to 26.5 GHz, APC-3.5 (m) input connector

### N5532B-550

30 MHz to 50 GHz, 2.4 mm (m) input connector

### N5532B-019

Adaptor to N191xA power meter (required when the N191xA power meter is used), can also be ordered standalone

Select from N5532B options (optional)

## Accessories

### N5531S-010

LAN connection kit (including one LAN hub and 3 regular LAN cables) (optional)

Note: For existing N5531S measuring receiver users who buy the N5532B sensor module to replace the N5532A: Using the N5532B in place of the N5532A requires the following firmware versions:

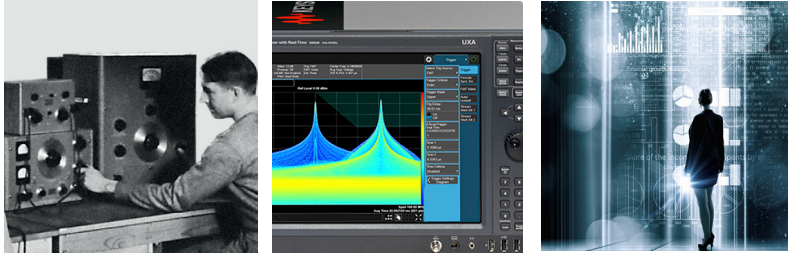
- E444xA PSA:  $\geq$  A.11.21
- N1911A power meter:  $\geq$  A.05.02
- N1912A power meter:  $\geq$  A.05.02
- N1913A power meter:  $\geq$  A.01.06
- N1914A power meter:  $\geq$  A.01.06

## Related Literature

Publication title	Publication type	Publication number
<b>N5531S measuring receiver</b>		
N5531S Measuring Receiver	Technical Overview	5989-4795EN
Accurate Absolute and Relative Power Measurement Using the Keysight N5531S Measuring Receiver System	Application Note	5989-8161EN
<b>PSA in general</b>		
Spectrum Analyzer and Signal Analyzer	Selection Guide	5968-3413E
<b>Power meter in general</b>		
P-Series Power Meters and Power Sensors	Data Sheet	5989-2471EN
P-Series Power Meters and Power Sensors	Technical Overview	5989-1049EN
EPM Series Power Meters	Data Sheet	5990-4019EN
<b>Power measurement fundamentals</b>		
Fundamentals of RF and Microwave Power Measurements, Introduction to Power, History, Definition, International Standards, and Traceability	Application Note 1449-1	5988-9213EN
Fundamentals of RF and Microwave Power Measurements, Power Sensors and Instrumentation	Application Note 1449-2	5988-9214EN
Fundamentals of RF and Microwave Power Measurements, Power Measurement Uncertainty per International Guides	Application Note 1449-3	5988-9215EN
Fundamentals of RF and Microwave Power Measurements, An Overview of Agilent Instrumentation for RF/Microwave Power Measurement	Application Note 1449-4	5988-9216EN

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