Agilent N5531S Measuring Receiver

Data Sheet

Up to 50 GHz

Key measurements include:

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

- *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*

Conditions and Requirements

The Agilent 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[1] 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 kohm) 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

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, refer to the "Measuring receiver personality" chapter in the PSA specifications guide (E4440-90647).

1.1 Frequency modulation

Description				Specification	Supplemental information
Input power range[a]				–18 to +30 dBm	
Operating rate range					
		100 kHz ≤ f_c < 10 MHz		20 Hz to 10 kHz	
		10 MHz ≤ f_c < 50 GHz		50 Hz to 200 kHz	
Peak frequency deviations[a]					Peak Deviation = IFBW/2 -Modulation Rate.
		100 kHz ≤ f_c < 10 MHz		40 kHz maximum	$IFBW_{max}$ = 5 MHz in "Auto" mode;
		10 MHz ≤ f_c ≤ 50 GHz		400 kHz maximum	$IFBW_{max}$ = 10 MHz in "Manual" mode
FM deviation accuracy[b]					
Frequency range	**Modulation rate**	**Peak deviation**	**ß**[c]		
250 kHz to	20 Hz to	200 Hz to	> 0.2	±1.5% of reading	
10 MHz	10 kHz	40 kHz	> 1.2	±1% of reading	
10 MHz to	50 Hz to	250 Hz to	> 0.2	±1.5% of reading	
6.6 GHz	200 kHz	400 kHz	> 0.45	±1% of reading	
6.6 to	50 Hz to	250 Hz to	> 0.2	±2.5% of reading	
13.2 GHz	200 kHz	400 kHz	> 8	±1% of reading	
13.2 to	50 Hz to	250 Hz to	> 0.2	±3.8% of reading	
31.15 GHz	200 kHz	400 kHz	> 16	±1% of reading	
31.15 to	50 Hz to	250 Hz to	> 0.2	±8.5% of reading	
50 GHz	200 kHz	400 kHz	> 32	±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

a. The modulation rates and the peak deviations that the system is capable of measuring are governed by the instrument's IFBW (Information Bandwidth) setting. Their relationship is described by the equation: Peak deviation (in Hz) = IFBW/2 - modulation rate.

b. When the carrier frequency fc is less than 10 MHz, to avoid the 0 Hz frequency wrap-around, the fc and IFBW must be chosen to satisfy [fc-(IFBW)/2] > 100 kHz.

c. ß 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[a]				
		100 kHz ≤ f_c < 10 MHz	20 Hz to 10 kHz	
		10 MHz ≤ f_c < 50 GHz	50 Hz to 100 kHz	
Depth range			5 to 99%	Capable of measuring AM depth range of 0 to 99%.
AM depth accuracy[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	
Flatness[c]				
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	
FM rejection (50 Hz to 3 kHz BW)				
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)[d, e]	
Detectors				Available: +peak, -peak, ±peak/2, peak hold, rms

a. When the carrier frequency fc is less than 10 MHz, to avoid the 0 Hz frequency wrap-around, the fc and IFBW must be chosen to satisfy [fc-(IFBW)/2] > 100 kHz.

b. 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.

c. Flatness is the relative variation in indicated AM depth versus rate for a constant carrier frequency and depth.

e. Preamp must be on to meet this specification for frequency range of 26.5 to 50 GHz.

f. 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 kHz ≤ f_c < 50 GHz	200 Hz to 20 kHz	
Maximum peak phase deviation				
		f_c < 10 MHz	450 radians[a]	
		f_c ≥ 10 MHz	12,499 radians[b]	In "Auto" mode
			24,999 radians[b]	In "Manual" mode
ΦM accuracy				
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)	
Residual PM (50 Hz to 3 kHz BW)				
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

a. 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 kHz. The specification of 450 radians applies for f_c = 200 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.

b. When the carrier frequency (fc) 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:

Max peak deviation (in radians) = [IFBW/(2 x modulation rate in Hz)] - 1

The maximum IFBW used in "Auto" mode is 5 x 10^6 Hz, therefore, Max peak deviation (in radians) = (2.5 x 10^6/modulation rate in Hz) - 1. In "Manual" mode, the maximum IFBW can be set to 10^7 Hz, hence, Max peak deviation (in radians) = (5 x 10^6/modulation rate in Hz) - 1.

Key Specifications *(Continued)*

1.4 RF frequency counter

Description	Specification	Supplemental information
Range	100 kHz to 50 GHz	
Sensitivity[a]		In "Auto" mode
100 kHz ≤ f_c < 3.0 GHz	0.4 mV_{rms} (–55 dBm)	
3.0 GHz ≤ f_c ≤ 26.5 GHz	1.3 mV_{rms} (–45 dBm)	
26.5 GHz ≤ f_c ≤ 50 GHz	4.0 mV_{rms} (–35 dBm)	
Maximum resolution	0.001 Hz	
Accuracy	± (readout freq. x freq. ref. accy +0.100 Hz)	
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[b]

Description	Specification	Supplemental information
Frequency range	20 Hz to 250 kHz	
Input impedance		100 kΩ (nominal)
Maximum safe input level	7 V_{rms} or 20 VDC	

a. Instrument condition: RBW ≤ 1 kHz.

b. All audio measurements require PSA Option 107.

Key Specifications *(Continued)*

1.6 Audio frequency counter

Description	Specification	Supplemental information
Frequency range	20 Hz to 250 kHz	
Accuracy[a]		With HPF set to minimum setting of < 20 Hz
f < 1 kHz	±(0.02 Hz + f x Internal Reference Accuracy)[b]	
f ≥ 1 kHz	±3 counts of the first 6 significant digits ± f x (Internal Reference Accuracy)	
Resolution	0.01 Hz (8 digits)	
Sensitivity	≤ 5 mV	

1.7 Audio AC (RMS) level

Description	Specification	Supplemental information
Frequency range	20 Hz to 250 kHz	
Measurement level range	100 mV_{rms} to 3 V_{rms}	
Accuracy	1% of reading	
Detector mode		RMS

a. 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, (5) Average = 5 Repeat.

b. Refer to the "Internal Time Base Reference" section in the PSA specification guide for the "Internal Reference Accuracy".

Key Specifications *(Continued)*

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 charactristic performance
Total distortion		74.8 dB charactristic performance

Key Specifications *(Continued)*

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 [a]	< ±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 [a]	< ±1% at rates < 30 kHz	
80 kHz low-pass filter [a]	< ±1% at rates < 80,000 Hz	
> 100 kHz low-pass filter	< ± 1% at rates < 100 kHz	
CCITT weighting filter Deviation from the ideal CCITT filter response	CCITT recommendation P53 ±0.2 dB at 800 Hz; ±1.0 dB, 300 Hz to 3 kHz ±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 < 3º	Applicable to 25 µs, 50 µs, and 75 µs filters. With 3 kHz Low-Pass filter and IFBW Mode set to "minimal".

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

Key Specifications *(Continued)*

1.11 RF Power[a, b]

The Agilent N5531S measuring receiver system with the N5532B/A sensor modules performs RF power measurements from –10 dBm (100 µW) to +30 dBm (1 W). The N5531S must be used with Agilent 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)									
+20 to +30 dBm	Power meter range 1					Typicals			
		Sensor module Options				**Sensor module Options**			
	+20 to +30 dBm	504	518	526	550	504	518	526	550
	100 kHz ≤ f_c ≤ 10 MHz	±0.356	–	–	–	±0.182	–	–	–
	10 MHz < f_c ≤ 30 MHz	±0.356	±0.361	–	–	±0.182	±0.185	–	–
	30 MHz < f_c ≤ 2 GHz	±0.356	±0.361	±0.361	±0.361	±0.182	±0.185	±0.185	±0.185
	2 GHz < f_c ≤ 4.2 GHz	±0.356	±0.392	±0.422	±0.367	±0.182	±0.201	±0.217	±0.188
	4.2 GHz < f_c ≤ 18 GHz	–	±0.400	±0.422	±0.367	–	±0.205	±0.217	±0.188
	18 GHz < f_c ≤ 26.5 GHz	–	–	±0.480	±0.387	–	–	±0.247	±0.199
	26.5 GHz < f_c ≤ 50 GHz	–	–	–	±0.420	–	–	–	±0.216
0 to +20 dBm	Power meter range 2					Typicals			
		Sensor module Options				**Sensor module Options**			
	0 to +20 dBm	504	518	526	550	504	518	526	550
	100 kHz ≤ f_c ≤ 10 MHz	±0.190	–	–	–	±0.097	–	–	–
	10 MHz < f_c ≤ 30 MHz	±0.190	±0.200	–	–	±0.097	±0.101	–	–
	30 MHz < f_c ≤ 2 GHz	±0.190	±0.200	±0.200	±0.200	±0.097	±0.101	±0.101	±0.101
	2 GHz < f_c ≤ 4.2 GHz	±0.190	±0.255	±0.301	±0.212	±0.097	±0.130	±0.154	±0.108
	4.2 GHz < f_c ≤ 18 GHz	–	±0.267	±0.301	±0.212	–	±0.136	±0.154	±0.108
	18 GHz < f_c ≤ 26.5 GHz	–	–	±0.380	±0.247	–	–	±0.195	±0.126
	26.5 GHz < f_c ≤ 50 GHz	–	–	–	±0.297	–	–	–	±0.152
RF power resolution	Display resolution	0.001 dB							
Instrumentation accuracy	Logarithmic	±0.02 dB							
	Linear	±0.5 %							

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

b. The N5531S RF Power Accuracy is derived from the Agilent power meter accuracy. The parameters listed in this section are components used to calculate the RF Power Accuracy. Application Note 1449-3 (literature number 5988-9215EN) does an excellent job of explaining how the components are combined to derive an overall accuracy number. The resulting calculation yields ±0.190 to ±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 ±0.213 to ±0.387 dB (depending on the frequency range and power under test). Absolute and relative accuracy specifications do not include mismatch uncertainty.

Key Specifications *(Continued)*

1.11 RF Power *(Continued)*

Description		Specification	Supplemental information
Input SWR			
N5532B/A *Option 504*	100 kHz to 2 GHz 2 GHz to 4.2 GHz	< 1.10:1 (ρ = 0.048) < 1.28:1 (ρ = 0.123)	
N5532B/A *Option 518*	10 MHz to 2 GHz 2 GHz to 18 GHz	< 1.10:1 (ρ = 0.048) < 1.28:1 (ρ = 0.123)	
N5532B/A *Option 526*	30 MHz to 2 GHz 2 GHz to 18 GHz 18 GHz to 26.5 GHz	< 1.10:1 (ρ = 0.048) < 1.28:1 (ρ = 0.123) < 1.40:1 (ρ = 0.167)	
N5532B/A *Option 550*	30 MHz to 2 GHz 2 GHz to 18 GHz 18 GHz to 26.5 GHz 26.5 GHz to 33 GHz 33 GHz to 40 GHz 40 GHz to 50 GHz	< 1.10:1 (ρ = 0.048) < 1.28:1 (ρ = 0.123) < 1.40:1 (ρ = 0.167) < 1.55:1 (ρ = 0.216) < 1.70:1 (ρ = 0.259) < 1.75:1 (ρ = 0.272)	
Zero set and measurement noise[a]	N5532B/A ±680 nW		
Zero drift of sensors (1 hour, at constant temperature after 24 hour warm-up)	N5532B/A < ±100 nW		
RF power ranges of N5531S with N5532B/A sensor modules		–20 dBm (10 µW) 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	

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

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".

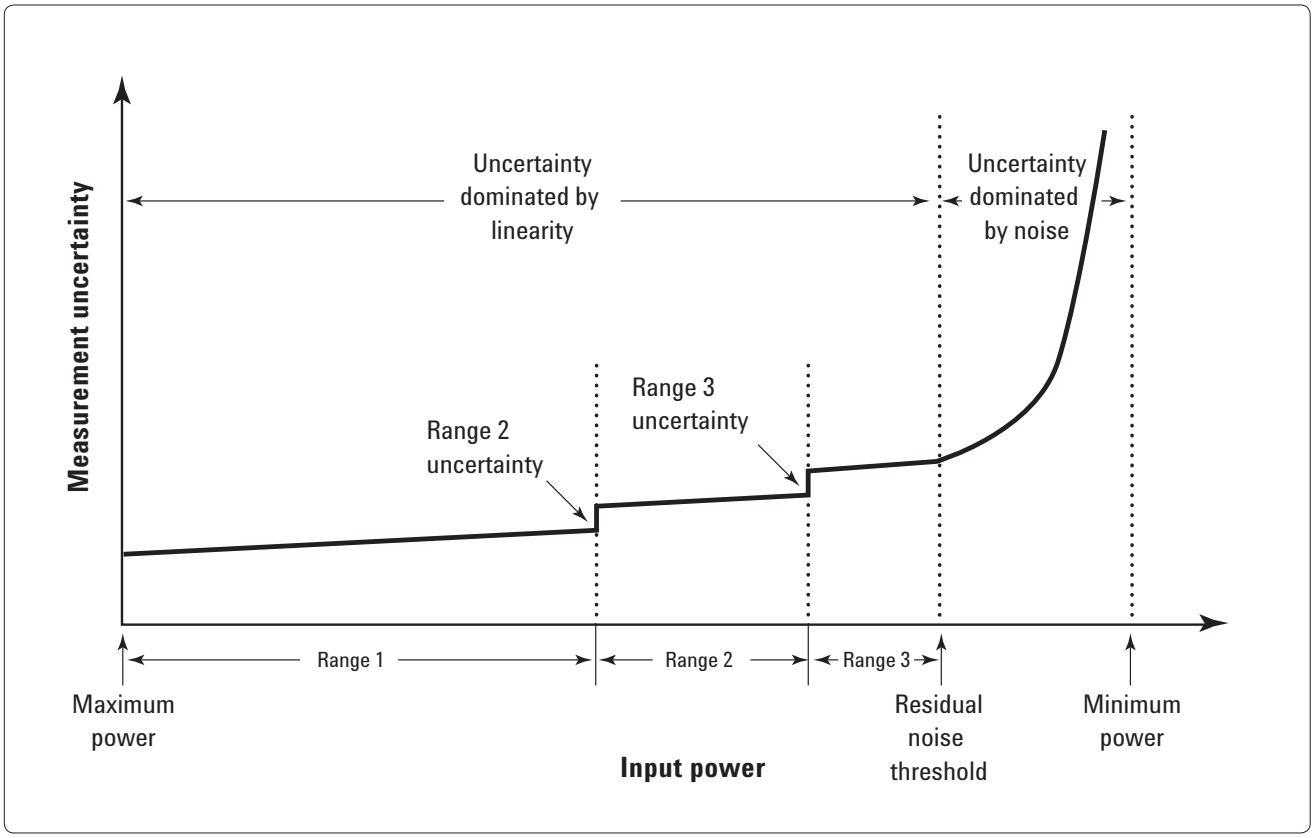

Figure 1. Measurement uncertainty vs. input power relationship

1.12 Tuned RF level[a, b, c]

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: ±(0.15 dB + 0.1 dB/MHz of span) to a max of ±0.40 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 [Integrated BW/(75 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				
Minimum power (dBm)[g] E4443A/45A/40A		**75 Hz IFBW**		**10 Hz IFBW[d, e]**		
	Frequency range	**Preamp uninstalled**	**Preamp installed[f]**	**Preamp uninstalled**	**Preamp installed[f]**	Also see Notes 1 and 2 on page 15
	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	
Minimum power (dBm)[g] E4447A/46A/48A		**75 Hz IFBW**		**10 Hz RBW[d, e]**		
	Frequency range	**Preamp uninstalled**	**Preamp installed[f]**	**Preamp uninstalled**	**Preamp installed[f]**	Also see Notes 1 and 2 on page 15
	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	

a. PSA *Option 123* is required to perform "Tuned RF Level" measurements above 3 GHz.

b. 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.

c. Absolute and relative accuracy specifications do not include mismatch uncertainty.

d. With 10 Hz IFBW setting selected, the measurement automatically switches the RBW to the 1 Hz setting for SNR values < 10 dB.

e. For instrument with 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.

f. 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 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 a same PSA instrument.

g. With 30 kHz and 200 kHz IF bandwidth (IFBW), TRFL minimum power level will be degraded by a factor of 10*log(IFBW/75 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.

1.12 Tuned RF level *(Continued)*

Description		Specification				Supplemental information
Minimum power (dBm) E4447A/46A/48A		**75 Hz IFBW**		**10 Hz IFBW**		
	Frequency range	**Preamp uninstalled**	**Preamp installed**	**Preamp uninstalled**	**Preamp installed**	Also see Notes 1 and 2 on page 14
	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		±(0.009 dB + 0.005 dB/10 dB step)[a]				
Relative measurement accuracy	Residual noise threshold[b] to maximum power	±(0.015 dB + 0.005 dB/10 dB step)[a, c, d] (nominal)				
	Minimum power to residual noise threshold	±(cumulative error[e] + 0.0012 x (input power - residual noise threshold power)^2)				
Residual noise threshold power (dBm)		Residual noise threshold power = minimum power +30 dB				
Range 2 uncertainty[f]		±0.031 dB				
Range 3 uncertainty[g]		±0.031 dB				

a. "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.

b. 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.

c. 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.

d. This includes the linearity accuracy.

e. 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 ±(0.015 dB + 0.005 dB/10 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 ±(0.015 + $\lceil 99/10 \rceil$ x 0.005 dB), or ±0.065 dB, where $\lceil x \rceil$ is a ceiling function that means the smallest integer is not less than x.

f. 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".

g. 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".

1.12 Tuned RF level (Continued)

Description		Specification	Supplemental information
Absolute measurement accuracy	**Preamp Off**		
	+20 dBm to maximum power	±(power meter range 1 uncertainty + 0.005 dB/10 dB step)	
	Residual noise threshold power to +20 dBm	±(power meter range 2 - 4 uncertainty + 0.005 dB/10 dB step)	
	Minimum power to residual noise threshold power	±(cumulative error[a] + 0.0012 x (input power – residual noise threshold power)^2)	
Absolute measurement accuracy	**Preamp On**		
	Residual noise threshold power to +16 dBm	±(power meter range 2 - 4 uncertainty + 0.005 dB/10 dB step)	
	Minimum power to residual noise threshold power	±(cumulative error[a] + 0.0012 x (input power – residual noise threshold power)^2)	
Residual Noise Threshold Power (dBm)	Residual Noise Threshold Power = Minimum Power + 30 dB		
Range 2 Uncertainty[b]	±0.031 dB		
Range 3 Uncertainty[c]	±0.031 dB		

a. 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: ±(Power Meter Range Uncertainty + 0.005 dB/10 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 ±0.190 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 dBm + 30 dB = –106 dBm using the formula on this page.

The cumulative error is then ±(0.190 dB + ⌈106/10⌉ X 0.005 dB), or ±0.245 dB, where ⌈x⌉ is a ceiling function that means the smallest integer not less than x, which is 11 in this example.

b. 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.

c. 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 1

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.

NOTE 2

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								
Power meter range 1 Uncertainty (dB)					Typicals			
+20 to +30 dBm	**Sensor Module Options**				**Sensor Module Options**			
	504	518	526	550	504	518	526	550
100 kHz ≤ f_c ≤ 10 MHz	±0.356	–	–	–	±0.182	–	–	–
10 MHz < f_c ≤ 30 MHz	±0.356	±0.361	–	–	±0.182	±0.185	–	–
30 MHz < f_c ≤ 2 GHz	±0.356	±0.361	±0.361	±0.361	±0.182	±0.185	±0.185	±0.185
2 GHz < f_c ≤ 4.2 GHz	±0.356	±0.392	±0.422	±0.367	±0.182	±0.201	±0.217	±0.188
4.2 GHz < f_c ≤ 18 GHz	–	±0.400	±0.422	±0.367	–	±0.205	±0.217	±0.188
18 GHz < f_c ≤ 26.5 GHz	–	–	±0.480	±0.387	–	–	±0.247	±0.199
26.5 GHz < f_c ≤ 50 GHz	–	–	–	±0.420	–	–	–	±0.216
Power meter range 2 [a] Uncertainty (dB)					Typicals			
0 to +20 dBm	**Sensor Module Options**				**Sensor Module Options**			
	504	518	526	550	504	518	526	550
100 kHz ≤ f_c ≤ 10 MHz	±0.190	–	–	–	±0.097	–	–	–
10 MHz < f_c ≤ 30 MHz	±0.190	±0.200	–	–	±0.097	±0.101	–	–
30 MHz < f_c ≤ 2 GHz	±0.190	±0.200	±0.200	±0.200	±0.097	±0.101	±0.101	±0.101
2 GHz < f_c ≤ 4.2 GHz	±0.190	±0.255	±0.301	±0.212	±0.097	±0.130	±0.154	±0.108
4.2 GHz < f_c ≤ 18 GHz	–	±0.267	±0.301	±0.212	–	±0.136	±0.154	±0.108
18 GHz < f_c ≤ 26.5 GHz	–	–	±0.380	±0.247	–	–	±0.195	±0.126
26.5 GHz < f_c ≤ 50 GHz	–	–	–	±0.297	–	–	–	±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			

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

N5531S Ordering Information

The Agilent 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/µW 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)

E444xA-107
Audio input 100 kΩ (required for audio analysis, only operational with Option 233)

AM/FM/PM triggering
Shipped standard with Option 233 (PSA firmware rev ≥ 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 ≥ 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[a] (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/µW 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 kΩ (required for audio analysis, only operational with Option 233)

a. 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.agilent.com/find/psa_upgrades

N5531S Ordering Information *(Continued)*

(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

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: ≥ A.11.21
- N1911A power meter: ≥ A.05.02
- N1912A power meter: ≥ A.05.02
- N1913A power meter: ≥ A.01.06
- N1914A power meter: ≥ A.01.06

Related Literature

Publication title	Publication type	Publication number
N5531S measuring receiver		
The Agilent N5531S Measuring Receiver	Technical Overview	5989-4795EN
Accurate Absolute and Relative Power Measurement Using the Agilent N5531S Measuring Receiver System	Application Note	5989-8161EN
PSA in general		
Selecting the Right Signal Analyzer for Your Needs	Selection Guide	5968-3413E
PSA Series	Brochure	5980-1283E
PSA Series	Data Sheet	5980-1284E
PSA Series	Configuration Guide	5989-2773EN
Self-Guided Demonstration for Spectrum Analysis	Product Note	5988-0735EN
Power meter in general		
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
EPM Series Power Meters	Technical Overview	5990-4159EN
Power measurement fundamentals		
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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