DATA SHEET

N5531X
X-Series Measuring Receiver

KEYSIGHT TECHNOLOGIES

Conditions and Requirements

The Keysight N5531X X-Series measuring receiver offers 2 types of configurations: (1) Primary configuration- A "one-box" solution which is comprised of an N9030B PXA signal analyzer, multi-touch, with the N9091EM0E measuring receiver application, and a U5532C USB sensor module; and (2) Alternative configuration- A combination of an N9030B PXA with the N9091EM0E app, an N191xA EPM or P-Series power meter, and an N5532B sensor module. To achieve the optimal measurement results as specified, the best metrology practice must be applied and the required instrument conditions must be met.

PXA is the core instrument of the N5531X measuring receiver. The PXA instrument conditions stated in the PXA specification guide must be satisfied to meet the N5531X 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; The measurements need to be complete within a time period of 20 minutes after setting the Reference Level
- 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 PXA 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 PXA and the device under test (DUT) is required to achieve the best performance and meet the specifications for all test frequencies
- The following table summarizes PXA option and X-Series application selections under N5531X measuring receiver

Key features:

- Metrology-grade measurement accuracy
- Off-the-shelf, general-purpose instruments with specialized X-Series applications
- Best for signal source and step attenuator calibrations
- Abundant features with intuitive, easy-to-use multi-touch 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
- PM deviation
- Modulation rate
- Modulation distortion
- Modulation SINAD
- Audio frequency
- Audio AC level
- Audio distortion
- Audio SINAD
- Auto carrier triggering
- CCITT filters

Category	Option number	Description	Note
Required	N9030B-5xx	Any frequency options (e.g., 550)	
	N9030B-MPB	Microwave preselector bypass	Required for all frequency options except for 503
	N9030B-Pxx	Preamplifier, 100 kHz to the max frequency of PXA	
	N9030B-107	Audio input and digitizer	Required for audio analysis
	N9091EM0E	Measuring receiver application software	
Optional	N9030B-xxx	PXA options (e.g., N9030B-YAV)	Refer to N5531X configuration guide (5992-2675EN) and N9030B configuration guide (5992-1318EN) for more details
	N90xxEM0E	Most of X-Series applications (e.g., N9068EM0E)	
Conditionally supported	N9030B-B5X	Analysis bandwidth, 510 MHz	Only supported in the PXA without Option N9030B-107 (Audio input and digitizer) as it competes slot with Option N9030B-107
	N9030B-BBA	I/Q Baseband Inputs, Analog	Not compatible with Option N9030B-107 (Audio input and digitizer)

Key Specifications

1.0 Carrier frequency and bandwidth

Description	Specification	Supplemental information
Carrier frequency		
Maximum frequency		
Option 503	3.6 GHz	RF/μW frequency option
Option 508	8.4 GHz	RF/μW frequency option
Option 513	13.6 GHz	RF/μW frequency option
Option 526	26.5 GHz	RF/μW frequency option
Option 544	44 GHz	mmW frequency option
Option 550	50 GHz	mmW frequency option
Minimum frequency		
AC coupled[1]	10 MHz	In practice, limited by the need to keep modulation sidebands from folding, and by the interference from LO feedthrough. For absolute RF power and TRFL measurements, the minimum frequency is limited by the power sensor module.
DC coupled	2 Hz	
Maximum information bandwidth (info BW)[2]		
Standard	25 MHz	
Option B40	40 MHz	
Option B85	85 MHz	
Option B1X	160 MHz	
Option B2X	255 MHz[3]	
Option B5X	510 MHz[3]	Not compatible with Option 107 (Audio input and digitizer)

1. AC Coupled is only applicable to frequency Options 503, 508, 513, and 526.
2. The maximum Info BW indicates the maximum operational BW, which depends on the analysis BW option equipped with the analyzer. However, the demodulation specifications only apply to the “IF BW” indicated in the FM, AM, and PM sections.
3. Under “Measuring Receiver” Mode, limited to 160 MHz maximum.

1.1 Frequency modulation (FM)

Conditions required to meet specifications:

- Peak FM Deviation ≥10 Hz
- ß (modulation index) = (FM Deviation) / (FM rate). The maximum ß is 20,000; and it is 50 for rate >100 kHz, 20 for rate >200 kHz, and 5 for rate >500 kHz. The minimum ß is 0.001; and it is 1 for rate <50 Hz, 5 for rate <20 Hz.
- Info Bandwidth (IF BW) ≤40 MHz for center frequency (f_c) up to 50 GHz
- SINAD BW: (IF BW)/2
- Single tone: sinusoid modulation
- Center frequency (f_c): ≥100 kHz

Description		Specification	Supplemental information
Input power range		-24 to +30 dBm	
FM rate range[1]	100 kHz ≤ f_c < 50 GHz	10 Hz to 1 MHz	
Peak FM deviations range[1]	100 kHz ≤ f_c ≤ 50 GHz	16 MHz maximum	
FM deviation accuracy[2]			
Frequency range			
100 kHz to 3.6 GHz		±(1.0x10^{-7} x $Dev^{0.75}$+0.002) x (Dev + rate)	
3.6 to 8.4 GHz		±(2.0x10^{-7} × $Dev^{0.75}$+0.002) x (Dev + rate)	rate ≥2 kHz, ß ≥0.01 rate ≤ 20 Hz, (Dev + rate) ≥100
8.4 to 13.6 GHz		±(1.5x10^{-7} × $Dev^{0.75}$+0.002) x (Dev + rate)	rate≥1 MHz, ß ≥0.005 rate≤ 50 Hz, (Dev + rate) ≥200
13.6 to 17.1 GHz		±(2.5x10^{-7} × $Dev^{0.75}$+0.002) x (Dev + rate)	rate≥500 kHz, ß ≥0.01 rate≤ 50 Hz, (Dev + rate) ≥150
17.1 to 26.5 GHz		±(4.0x10^{-7} × $Dev^{0.75}$+0.003) x (Dev + rate)	rate≥100 kHz, ß ≥0.02 rate≤ 100 Hz, (Dev + rate) ≥150
26.5 to 34.5 GHz		±(5.0x10^{-7} × $Dev^{0.75}$+0.003) x (Dev + rate)	rate≥100 kHz, ß ≥0.02 rate≤ 100 Hz, (Dev + rate) ≥150
34.5 to 50 GHz		±(1.5x10^{-6} × $Dev^{0.75}$+0.003) x (Dev + rate)	rate≥20 kHz, ß ≥0.05 rate≤ 100 Hz, (Dev + rate) ≥150
AM rejection (50 Hz to 3 kHz BW)[3]			
Frequency range		**Max peak deviation**	
100 kHz to 3.6 GHz		0.6 Hz	
3.6 to 8.4 GHz		1.0 Hz	
8.4 to 13.6 GHz		1.4 Hz	
13.6 to 17.1 GHz		1.7 Hz	
17.1 to 26.5 GHz		2.6 Hz	
26.5 to 34.5 GHz		3.3 Hz	
34.5 to 50 GHz		5.3 Hz	

1. 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.
2. 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. In the FM deviation accuracy specifications, the FM deviation (Dev) and the rate are both in Hz.
3. AM rejection (also known as "incidental FM" due to AM) describes the instrument's FM reading for an input that is strongly AMed (with no FM); this specification includes contributions from residual FM. AM signal (Rate = 1 kHz, Depth = 50%), HPF=50 Hz, LPF = 3 kHz, Channel BW = 15 kHz. Conditions that would constrain FM deviation or beta near zero, or constrain the rate of modulation, do not apply to Incidental FM.

Description		Specification	Supplemental information
Residual FM (50 Hz to 3 kHz BW)[4, 5]			
RF frequency			
100 kHz to 3.6 GHz		< 0.4 Hz (rms)	
3.6 to 8.4 GHz		< 0.6 Hz (rms)	
8.4 to 13.6 GHz		< 0.9 Hz (rms)	
13.6 to 17.1 GHz		< 1.1 Hz (rms)	
17.1 to 26.5 GHz		< 1.7 Hz (rms)	
26.5 to 34.5 GHz		< 2.2 Hz (rms)	
34.5 to 50 GHz		< 3.3 Hz (rms)	
Detectors			Available: +peak, –peak, ±peak/2, peak hold, rms

4. The Residual FM specification is a warranted traceable worst-case figure for the entire band. For most instruments, at most frequencies, the actual residual FM performance is usually much better (lower). When testing the Residual FM of a DUT, the reading indicated by N9091EM0E is the combined noise of the DUT and the measuring receiver. If the FM noise of the DUT and measuring receiver are uncorrelated (normally the case), then these two contributors can only add to each other in a RSS (Root-Sum-Squared) manner. Therefore, we can say with high confidence that the FM noise of the DUT is no greater than the Residual FM indicated by N9091EM0E.
5. Residual FM describes the instrument's FM reading for an input that has no FM and no AM; this specification includes contributions from FM deviation accuracy. HPF = 50 Hz, LPF = 3 kHz, Channel BW = 15 kHz. Conditions that would constrain FM deviation or beta near zero, or constrain the rate of modulation, do not apply to residual FM.

1.2 Amplitude modulation

Conditions required to meet specifications:

- Info BW (IF BW) ≤ 40 MHz for center frequency (f_c) up to 50 GHz
- IF BW: 5 times of AM rate
- SINAD BW: (IF BW)/2
- Single tone: sinusoid modulation
- Center frequency (f_c): ≥ 100 kHz

Description		Specification	Supplemental information
Input power range		-24 to +30 dBm	
AM rate range[1]	100 kHz ≤ f_c < 50 GHz	10 Hz to 1 MHz	
AM depth range		1 to 99%	Capable of measuring AM depth range of 0 to 100%.
AM depth accuracy[2]			
Frequency range	**Depths**		
100 kHz to 3.6 GHz	2% to 99%	±0.001 × reading ±0.00001 x $(\text{rate}/1\text{ Hz})^{0.5}$ x reading	rate ≤10 kHz rate >10 kHz
3.6 to 13.6 GHz	5% to 99%	±0.001 × reading ±0.00001 x $(\text{rate}/1\text{ Hz})^{0.5}$ x reading	rate ≤10 kHz rate >10 kHz
13.6 to 17.1 GHz	5% to 99%	±0.001 × reading ±0.00001 x $(2 \times \text{rate}/1\text{ Hz})^{0.5}$ x reading	rate ≤5 kHz rate >5 kHz
17.1 to 26.5 GHz	5% to 99%	±0.001 × reading ±(0.00001 x $(3 \times \text{rate}/1\text{ Hz})^{0.5}$-2.2 x 10^{-4}) x reading	rate ≤5 kHz rate >5 kHz
26.5 to 34.5 GHz	5% to 99%	±0.0012 × reading ±(0.000012 x $(3 \times \text{rate}/1\text{ Hz})^{0.5}$-2.7x 10^{-4}) x reading	rate ≤5 kHz rate >5 kHz
34.5 to 50 GHz	5% to 99%	±0.0025 × reading ±(1.2 x10^{-7} x rate/1 Hz +2.5 x 10^{-3}) x reading	rate ≤5 kHz rate >5 kHz

1. When the carrier frequency fc is less than 10 MHz, to avoid the 0 Hz frequency wrap-around, the fc and IF BW must be chosen to satisfy IF BW <2 x (fc-100 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.
2. Flatness is the relative variation in indicated AM depth versus rate for a constant carrier frequency and depth.

Description	Specification	Supplemental information
Flatness (AM depth ≥ 5 %)		
Frequency range		
100 kHz to 3.6 GHz	$\pm(4\times10^{-5}$ x (rate/1 Hz)$^{0.5})$ x reading	
3.6 to 8.4 GHz	$\pm(8\times10^{-5}$ x (rate/1 Hz)$^{0.5})$ x reading	
8.4 to 13.6 GHz	±0.01 x reading $\pm(2.5\times10^{-4}$ x (rate/1 Hz)$^{0.6})$ x reading	rate ≤500 Hz rate >500 Hz
13.6 to 17.1 GHz	±0.015 x reading $\pm(2\times10^{-4}$ x (rate/1 Hz)$^{0.64})$ x reading	rate ≤500 Hz rate >500 Hz
17.1 to 26.5 GHz	±0.035 x reading $\pm(1.5\times10^{-3}$ x (rate/1 Hz)$^{0.5})$ x reading	rate ≤500 Hz rate >500 Hz
26.5 to 34.5 GHz	±0.05 x reading $\pm(1.5\times10^{-3}$ x (rate/1 Hz)$^{0.5})$ x reading	rate ≤1 kHz rate >1 kHz
34.5 to 50 GHz	±0.12 x reading $\pm(4\times10^{-3}$ x (rate/1 Hz)$^{0.5})$ x reading	rate ≤1 kHz rate >1 kHz
FM rejection (50 Hz to 3 kHz BW)[3]		
Frequency range		
100 kHz to 3.6 GHz	0.05% (peak)	
3.6 to 17.1 GHz	0.1% (peak)	
17.1 to 34.5 GHz	0.11% (peak)	
34.5 to 50 GHz	0.16% (peak)	
FM rejection (rms)[4]		
100 kHz to 8.4 GHz	0.025%	With Option N9030B-EP0
Residual AM (50 Hz to 3 kHz BW)[5]		
Frequency range		
100 kHz to 3.6 GHz	0.005% (rms)	
3.6 to 17.1 GHz	0.01% (rms)	
17.1 to 34.5 GHz	0.02% (rms)	
34.5 to 50 GHz	0.05% (rms)	
Detectors		Available: +peak, –peak, ±peak/2, peak hold, rms
Residual AM (30 Hz to 23 kHz BW)[6]		
100 kHz to 34.5 GHz	0.01% (rms)	
34.5 to 50 GHz	0.02% (rms)	

3. FM rejection (also known as “incidental AM” due to FM/PM) describes the instrument’s AM reading for an input that is strongly FMed (with no AM); this specification includes contributions from residual AM. FM signal (Rate = 1 kHz, Deviation = 50 kHz), HPF= 50 Hz, LPF = 3 kHz, Channel BW = 420 kHz. Conditions that would constrain AM depth, or constrain the rate of modulation, do not apply to incidental AM.
4. This specification includes contributions from residual AM. FM signal (Rate = 1 kHz, Deviation = 50 kHz), HPF= 50 Hz, LPF = 3 kHz, Channel BW = 12 MHz. Conditions that would constrain AM depth, or constrain the rate of modulation, do not apply to incidental AM.
5. Residual AM describes instruments AM reading for an input that has no AM and no FM; this specification includes contribution from AM depth accuracy. 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 PXA 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.
6. This specification includes contribution from AM depth accuracy. HPF = 30 Hz, LPF = 23 kHz, channel BW = 46 kHz. Option FBP is required beyond 3.6 GHz (Band 0).

1.3 Phase modulation (PM)

Conditions required to meet specifications:

- Info BW (IF BW) ≤ 40 MHz for center frequency (f_c) up to 50 GHz
- HPF = 20 Hz always On (unless otherwise stated)
- SINAD BW: (IF BW)/2
- Single tone: sinusoid modulation
- Center frequency (f_c): ≥ 100 kHz

Description		Specification	Supplemental information
Input power range		-24 to +30 dBm	
PM rate range[1]	100 kHz ≤ f_c < 50 GHz	50 Hz to 1 MHz	
Peak phase deviation[2,3]	100 kHz ≤ f_c < 50 GHz	0.01 to 25,000 radians	

1. Below 500 Hz PM rate, set the HPF to “None” to meet the PM deviation accuracy specifications.
2. The fc and IF BW must be chosen to satisfy IF BW < 2x (fc-100 kHz).
3. The maximum peak deviation that the instrument is capable of measuring depends on the IF BW setting and the modulation rate of the signal-under-test. The relationship is described by the equation: Max peak deviation (in radians) = [IF BW/(2 x modulation rate in Hz)] - 1.

Description	Specification	Supplemental information
PM deviation accuracy[1]		
Frequency range		
With Option N9030B-EP1 (Standard phase noise)		
100 kHz to 3.6 GHz	±Max {0.001 x reading$^{0.25}$ + 0.001,1.0 x 10^5 x rate^{-4} x reading} ±8.0 x 10^{-6} x rate$^{0.5}$ x reading$^{0.25}$	Dev ≥ 0.01 and rate ≤ 100 kHz Dev ≥ 0.01 and rate > 100 kHz
3.6 to 13.6 GHz	±Max {0.002 x reading$^{0.25}$ + 0.001,1.0 x 10^5 x rate^{-4} x reading} ±1.0 x 10^{-5} x rate$^{0.5}$ x reading$^{0.25}$	Dev ≥ 0.01 and rate ≤ 100 kHz Dev ≥ 0.01 and rate > 100 kHz
13.6 to 17.1 GHz	±Max {0.002 x reading$^{0.25}$ + 0.001,1.0 x 10^5 x rate^{-4} x reading} ±1.0 x 10^{-5} x rate$^{0.5}$ x reading$^{0.25}$	Dev ≥ 0.02 and rate ≤ 100 kHz Dev ≥ 0.02 and rate > 100 kHz
17.1 to 26.5 GHz	±Max {0.0025 x reading$^{0.25}$ + 0.0025,1.0 x 10^5 x rate^{-4} x reading} ±1.0 x 10^{-5} x rate$^{0.5}$ x reading$^{0.25}$	Dev ≥ 0.02 and rate ≤ 100 kHz Dev ≥ 0.02 and rate > 100 kHz
26.5 to 34.5 GHz	±Max {0.0025 x reading$^{0.25}$ + 0.0025,1.0 x 10^5 x rate^{-4} x reading} ±1.0 x 10^{-5} x rate$^{0.5}$ x reading$^{0.25}$	Dev ≥ 0.05 and rate ≤ 100 kHz Dev ≥ 0.05 and rate > 100 kHz
34.5 to 50 GHz	±Max {0.006 x reading$^{0.25}$ + 0.004,1.0 x 10^5 x rate^{-4} x reading} ±1.5 x 10^{-5} x rate$^{0.5}$ x reading$^{0.25}$	Dev ≥ 0.05 and rate ≤ 100 kHz Dev ≥ 0.05 and rate > 100 kHz
With Option N9030B-EP0 (Enhanced phase noise)		
100 kHz to 3.6 GHz	±Max {0.001 x reading$^{0.25}$ + 0.001,1.0 x 10^5 x rate^{-4} x reading} ±6.0 x 10^{-6} x rate$^{0.5}$ x reading$^{0.25}$	rate ≤ 100 kHz rate > 100 kHz
3.6 to 13.6 GHz	±Max {0.002 x reading$^{0.25}$ + 0.001,1.0 x 10^5 x rate^{-4} x reading} ±1.0 x 10^{-5} x rate$^{0.5}$ x reading$^{0.25}$	rate ≤ 100 kHz rate > 100 kHz
13.6 to 17.1 GHz	±Max {0.002 x reading$^{0.25}$ + 0.001,1.0 x 10^5 x rate^{-4} x reading} ±1.0 x 10^{-5} x rate$^{0.5}$ x reading$^{0.25}$	Dev ≥ 0.02 and rate ≤ 100 kHz Dev ≥ 0.02 and rate > 100 kHz
17.1 to 26.5 GHz	±Max {0.0025 x reading$^{0.25}$ + 0.001,1.0 x 10^5 x rate^{-4} x reading} ±1.0 x 10^{-5} x rate$^{0.5}$ x reading$^{0.25}$	Dev ≥ 0.02 and rate ≤ 100 kHz Dev ≥ 0.02 and rate > 100 kHz
26.5 to 34.5 GHz	±Max {0.0025 x reading$^{0.25}$ + 0.001,1.0 x 10^5 x rate^{-4} x reading} ±1.0 x 10^{-5} x rate$^{0.5}$ x reading$^{0.25}$	Dev ≥ 0.05 and rate ≤ 100 kHz Dev ≥ 0.05 and rate > 100 kHz
34.5 to 50 GHz	±Max {0.006 x reading$^{0.25}$ + 0.001,1.0 x 10^5 x rate^{-4} x reading} ±1.5 x 10^{-5} x rate$^{0.5}$ x reading$^{0.25}$	Dev ≥ 0.05 and rate ≤ 100 kHz Dev ≥ 0.05 and rate > 100 kHz

1. The reading and Dev are PM deviation in radian, and rate is PM rate in Hz (starting from 100 Hz for the specifications to apply). The function of Max {x, y} means whichever is greater between x and y.

AM rejection (50 Hz to 3 kHz BW)[1]		
Frequency range		
With Option N9030B-EP1 (Standard phase noise)		
100 kHz to 3.6 GHz	2.4 mrad (peak)	
3.6 to 8.4 GHz	4.0 mrad (peak)	
8.4 to 13.6 GHz	6.4 mrad (peak)	
13.6 to 17.1 GHz	8.0 mrad (peak)	
17.1 to 26.5 GHz	12.4 mrad (peak)	
26.5 to 34.4 GHz	16.2 mrad (peak)	
34.4 to 50 GHz	23.4 mrad (peak)	
With Option N9030B-EP0 (Enhanced phase noise)		
100 kHz to 3.6 GHz	0.4 mrad (peak)	
3.6 to 8.4 GHz	1.0 mrad (peak)	
8.4 to 13.6 GHz	1.6 mrad (peak)	
13.6 to 17.1 GHz	2.0 mrad (peak)	
17.1 to 26.5 GHz	3.1 mrad (peak)	
26.5 to 34.4 GHz	4.0 mrad (peak)	
34.4 to 50 GHz	5.6 mrad (peak)	

1. AM rejection (also known as "incidental PM" due to AM) describes the instrument's PM reading for an input that is strongly AMed (with no PM); this specification includes contributions from residual PM. AM signal (Rate = 1 kHz, Depth = 50%), HPF=50 Hz, LPF = 3 kHz, Channel BW = 15 kHz. Conditions that would constrain PM deviation or beta near zero, or constrain the rate of modulation, do not apply to incidental PM.

Residual PM (50 Hz to 3 kHz BW)[1]		
Frequency range		
With Option N9030B-EP1 (Standard phase noise)		
100 kHz to 3.6 GHz	<1.4 mrad (rms)	
3.6 to 8.4 GHz	<2.5 mrad (rms)	
8.4 to 13.6 GHz	<3.9 mrad (rms)	
13.6 to 17.1 GHz	<4.9 mrad (rms)	
17.1 to 26.5 GHz	<7.5 mrad (rms)	
26.5 to 34.4 GHz	<9.8 mrad (rms)	
34.4 to 50 GHz	<14.1 mrad (rms)	
With Option N9030B-EP0 (Enhanced phase noise)		
100 kHz to 3.6 GHz	<0.3 mrad (rms)	
3.6 to 8.4 GHz	<0.7 mrad (rms)	
8.4 to 13.6 GHz	<1.1 mrad (rms)	
13.6 to 17.1 GHz	<1.3 mrad (rms)	
17.1 to 26.5 GHz	<2.0 mrad (rms)	
26.5 to 34.4 GHz	<2.6 mrad (rms)	
34.4 to 50 GHz	<3.7 mrad (rms)	
Detectors		Available: +peak, –peak, ±peak/2, peak hold, rms

1. The Residual PM specification is a warranted traceable worst-case figure for the entire band. For most instruments, at most frequencies, the actual residual PM performance is usually much better (lower). When testing the Residual PM of a DUT, the reading indicated by N9091EM0E is the combined noise of the DUT and the measuring receiver. If the phase noise of the DUT and measuring receiver are uncorrelated (normally the case), then these two contributors can only add to each other in a RSS (Root-Sum-Squared) manner. Therefore, we can say with high confidence that the phase noise of the DUT is no greater than the Residual PM indicated by N9091EM0E.

1.4 RF frequency counter

Description	Specification	Supplemental information
RF frequency range	Refer to Section 1.0	
Sensitivity[1] 100 kHz ≤ f_c < 3.6 GHz 3.6 GHz ≤ f_c ≤ 26.5 GHz 26.5 GHz ≤ f_c ≤ 50 GHz	 0.4 mV_{rms} (-55 dBm) 1.3 mV_{rms} (-45 dBm) 4.0 mV_{rms} (-35 dBm)	In Auto mode
Maximum resolution	0.001 Hz	
Accuracy[2]	±(readout frequency x rfa + 0.100 Hz)[3]	At defaulted measurement settings.
Accuracy (for fc < 100 MHz)[4]	±(readout freq. x rfa + 0.002 Hz)[3]	±(readout freq. x rfa + 0.001 Hz) @ 99 percentile, or ≈2.576σ
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[5]

Description	Specification	Supplemental information
Frequency range	20 Hz to 250 kHz	Starting from 5 Hz for “DC coupled”
Input impedance		100 kΩ (nominal)
Maximum safe input level AC coupled DC coupled	 7 V_{rms} or 20 VDC 7 V_{rms} or 0 VDC	

1.6 Audio frequency counter[5]

Description	Specification	Supplemental information
Frequency range AC coupled DC coupled	 20 Hz to 250 kHz	 5 Hz to 250 kHz (nominal)
Accuracy[6] f < 1 kHz f ≥ 1 kHz	 ±(0.02 Hz + f x rfa)[3] ±(3 counts of the first 6 significant digits + f x rfa)[3]	
Resolution	0.01 Hz (8 digits)	
Sensitivity	≤ 5 mV	

1. Instrument condition: RBW ≤ 1 kHz, “Auto” mode.
2. Verified at 1 GHz with RBW = 1 kHz, gate time = 0.1 s (autocoupled), SNR = 50 dB. rfa = Internal reference frequency accuracy.
3. rfa = Internal reference frequency accuracy. See the “Internal Time Base Reference” section in the PXA specification guide for the Internal Reference Frequency Accuracy (rfa).
4. For the special case of Fc < 100 MHz, RBW = 300 Hz, and gate time = 0.5 s, the second term is < 0.002 Hz (3-sigma). The 0.002 Hz term includes noisiness as well as mean errors that occur at some frequencies, and thus cannot necessarily be reduced with averaging.
5. All audio measurements require PXA Option 107. All audio specifications are for “AC Coupled” path and nominally apply to “DC Coupled” path (unless stated otherwise).
6. Follow this procedure to verify this specification: Set an input audio signal at 100 mV. Set the PXA as follows: (1) Auto Level, (2) Auto IF BW, (3) LP is greater than the audio frequency, (4) HPF = 300 Hz or less than the audio frequency, and (5) Average = 5 Repeat.

1.7 Audio AC level (RMS)[1]

Description	Specification	Supplemental information
Frequency range AC coupled DC coupled	 20 Hz to 250 kHz	 5 Hz to 250 kHz (nominal)
Measurement level range	100 mV_{rms} to 3 V_{rms}	
Accuracy	1% of reading	
Detector mode		RMS

1.8 Audio distortion[1]

Description		Specification	Supplemental information
Display range (20 Hz to 250 kHz)		0.01 to 100% (-80 to 0 dB) to 250 kHz	Display range starts from 5 Hz for "DC coupled"
Accuracy[2]	AC coupled	±1 dB of reading (20 Hz to 20 kHz) ±2 dB of reading (20 to 80 kHz[3])	±0.3 dB of reading (nominal, 20 Hz to 200 kHz)
	DC coupled		±0.7 dB of reading (nominal, 5 Hz to 20 Hz) ±0.3 dB of reading (nominal, 20 Hz to 200 kHz)
Residual noise and distortion		< 0.3% (-50.4 dB)	<0.063% (-64 dB) (nominal)
Total noise			-73.2 dB characteristic performance
Total distortion			-74.8 dB characteristic performance

1.9 Audio SINAD[1]

Description		Specification	Supplemental information
Display range (20 Hz to 250 kHz)		0.00 to 80 dB	Display range starts from 5 Hz for "DC coupled"
Display resolution		0.001 dB	
Accuracy	AC coupled	±1 dB of reading (20 Hz to 20 kHz) ±2 dB of reading (20 to 80 kHz[3])	±0.3 dB of reading (nominal, 20 Hz to 200 kHz)
	DC coupled		±0.7 dB of reading (nominal, 5 Hz to 20 Hz) ±0.3 dB of reading (nominal, 20 Hz to 200 kHz)
Residual noise and distortion		50.4 dB	64 dB (nominal)
Total noise			73.2 dB characteristic performance
Total distortion			74.8 dB characteristic performance

1. All audio measurements require PXA Option 107. All audio specifications are for "AC Coupled" path and nominally apply to "DC Coupled" path (unless stated otherwise).
2. Verified in dB; can be converted into linear term in % using formula of % = [1-10^(A dB÷20)] x 100%.
3. Verified up to 80 kHz due to the limitation of test equipment.

1.10 Audio filters[1]

Description	Specification	Supplemental information
Filter flatness		Cutoff frequency (nominal); filter type
20 Hz high-pass filter		-3 dB @ 20 Hz HPF, 2-pole Butterworth
50 Hz high-pass filter	< ±1% at rates > 175 Hz	-3 dB @ 50 Hz HPF; 2-pole Butterworth
300 Hz high-pass filter	< ±1% at rates > 950 Hz	-3 dB @ 300 Hz HPF; 2-pole Butterworth
400 Hz high-pass filter	< ±1% at rates > 550 Hz	-3 dB @ 400 Hz HPF; 10-pole Butterworth
3 kHz low-pass filter	< ±1% at rates < 1.5 kHz	-3 dB @ 3 kHz LPF; 5-pole Butterworth
15 kHz low-pass filter	< ±1% at rates < 9 kHz	-3 dB @ 15 kHz LPF; 5-pole Butterworth
30 kHz low-pass filter	< ±1% at rates < 13.5 kHz	-3 dB @ 30 kHz LPF; 3-pole Butterworth
80 kHz low-pass filter	< ±1% at rates < 38.5 kHz	-3 dB @ 80 kHz LPF; 3-pole Butterworth
> 300 kHz low-pass filter	< ±1% at rates < 285 kHz	-3 dB @ 300 kHz LPF; 3-pole Butterworth
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 < 3º	Applicable to 25 µs, 50 µs, and 75 µs filters.

1. All audio measurements require PXA Option 107. All audio specifications are for "AC Coupled" path and nominally apply to "DC Coupled" path (unless stated otherwise).
2. Verified in dB; can be converted into linear term in % using formula of % = [1-10^(A dB÷20)] x 100%.
3. Verified up to 80 kHz due to the limitation of test equipment.

1.11 RF power[1, 2]

The Keysight N5531X measuring receiver system with the U5532C USB sensor modules or the N5532B/A sensor modules performs RF power measurements from -10 dBm (100 µW) to +30 dBm (1 W). When the N5532B/A sensor modules are used, the Keysight EPM Series power meters (N1913A, N1914A) or P-Series power meter (N1911A, N1912A), or legacy power meter (E4416A, E4417A, E4418B, E4419B) is required.

Description		Specification				Supplemental information			
RF power accuracy (dB)									
Power meter range 1 (+20 to +30 dBm)						Typicals			
		Sensor module options				Sensor module options			
		504	518	526	550	504	518	526	550
	100 kHz ≤ f_c ≤ 10 MHz	±0.287	—	—	—	±0.146	—	—	—
	10 MHz < f_c ≤ 30 MHz	±0.287	±0.287	±0.287[2]	—	±0.146	±0.146	±0.146[2]	—
	30 MHz < f_c ≤ 2 GHz	±0.287	±0.287	±0.287	±0.265	±0.146	±0.146	±0.146	±0.135
	2 GHz < f_c ≤ 4.2 GHz	±0.302	±0.287	±0.302	±0.279	±0.154	±0.154	±0.154	±0.142
	4.2 GHz < f_c ≤ 18 GHz	—	±0.466	±0.468	±0.342	—	±0.240	±0.241	±0.175
	18 GHz < f_c ≤ 26.5 GHz	—	—	±0.386	±0.332	—	—	±0.198	±0.170
	26.5 GHz < f_c ≤ 50 GHz	—	—	—	±0.363	—	—	—	±0.186

1. The N5531X 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. Absolute and relative accuracy specifications do not include mismatch uncertainty.
2. For U5532C USB sensor modules only.

Description		Specification				Supplemental information			
Power meter range 2 (0 to +20 dBm)						Typicals			
		Sensor module options				Sensor module options			
		504	518	526	550	504	518	526	550
	100 kHz ≤ f_c ≤ 10 MHz	±0.222	—	—	—	±0.113	—	—	—
	10 MHz < f_c ≤ 30 MHz	±0.222	±0.222	±0.222[2]	—	±0.113	±0.113	±0.113[2]	—
	30 MHz < f_c ≤ 2 GHz	±0.222	±0.222	±0.222	±0.191	±0.113	±0.113	±0.113	±0.097
	2 GHz < f_c ≤ 4.2 GHz	±0.242	±0.242	±0.242	±0.211	±0.123	±0.123	±0.123	±0.107
	4.2 GHz < f_c ≤ 18 GHz	—	±0.432	±0.433	±0.291	—	±0.222	±0.232	±0.148
	18 GHz < f_c ≤ 26.5 GHz	—	—	±0.342	±0.279	—	—	±0.175	±0.142
	26.5 GHz < f_c ≤ 50 GHz	—	—	—	±0.316	—	—	—	±0.161
Power meter range 3 (-5 to 0 dBm)						Typicals			
		Sensor module options				Sensor module options			
		504	518	526	550	504	518	526	550
	100 kHz ≤ f_c ≤ 10 MHz	±0.220	—	—	—	±0.112	—	—	—
	10 MHz < f_c ≤ 30 MHz	±0.220	±0.219	±0.220[2]	—	±0.112	±0.111	±0.112[2]	—
	30 MHz < f_c ≤ 2 GHz	±0.220	±0.219	±0.220	±0.189	±0.112	±0.111	±0.112	±0.096
	2 GHz < f_c ≤ 4.2 GHz	±0.240	±0.240	±0.240	±0.209	±0.122	±0.122	±0.122	±0.106
	4.2 GHz < f_c ≤ 18 GHz	—	±0.430	±0.432	±0.289	—	±0.221	±0.222	±0.148
	18 GHz < f_c ≤ 26.5 GHz	—	—	±0.341	±0.277	—	—	±0.174	±0.141
	26.5 GHz < f_c ≤ 50 GHz	—	—	—	±0.315	—	—	—	±0.161
Power meter range 4 (-10 to -5 dBm)						Typicals			
		Sensor module options				Sensor module options			
		504	518	526	550	504	518	526	550
	100 kHz ≤ f_c ≤ 10 MHz	±0.229	—	—	—	±0.117	—	—	—
	10 MHz < f_c ≤ 30 MHz	±0.229	±0.229	±0.229[2]	—	±0.117	±0.117	±0.117[2]	—
	30 MHz < f_c ≤ 2 GHz	±0.229	±0.229	±0.229	±0.200	±0.117	±0.117	±0.117	±0.102
	2 GHz < f_c ≤ 4.2 GHz	±0.249	±0.249	±0.249	±0.219	±0.127	±0.127	±0.127	±0.111
	4.2 GHz < f_c ≤ 18 GHz	—	±0.435	±0.437	±0.296	—	±0.224	±0.225	±0.151
	18 GHz < f_c ≤ 26.5 GHz	—	—	±0.347	±0.285	—	—	±0.178	±0.145
	26.5 GHz < f_c ≤ 50 GHz	—	—	—	±0.321	—	—	—	±0.164
RF power resolution	Display resolution	0.001 dB							
Instrument accuracy	Logarithmic	±0.02 dB							
	Linear	±0.5%							

1. The N5531X 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. Absolute and relative accuracy specifications do not include mismatch uncertainty.
2. For U5532C USB sensor modules only.

Description		Specification	Supplemental information
Input SWR			
U5532C Option 504, or	100 kHz to 2 GHz	< 1.10:1 (ρ = 0.048)	
N5532B Option 504	2 GHz to 4.2 GHz	< 1.28:1 (ρ = 0.123)	
U5532C Option 518, or	10 MHz to 2 GHz	< 1.10:1 (ρ = 0.048)	
N5532B Option 518	2 GHz to 18 GHz	< 1.28:1 (ρ = 0.123)	
U5532C Option 526, or	10 MHz to 30 MHz	< 1.10:1 (ρ = 0.048)	For U5532C-526 only
N5532B Option 526	30 MHz to 2 GHz	< 1.10:1 (ρ = 0.048)	
	2 GHz to 18 GHz	< 1.28:1 (ρ = 0.123)	
	18 GHz to 26.5 GHz	< 1.40:1 (ρ = 0.167)	
U5532C Option 550, or	30 MHz to 2 GHz	< 1.10:1 (ρ = 0.048)	
N5532B Option 550	2 GHz to 18 GHz	< 1.28:1 (ρ = 0.123)	
	18 GHz to 26.5 GHz	< 1.40:1 (ρ = 0.167)	
	26.5 GHz to 33 GHz	< 1.55:1 (ρ = 0.216)	
	33 GHz to 40 GHz	< 1.70:1 (ρ = 0.259)	
	40 GHz to 50 GHz	< 1.75:1 (ρ = 0.272)	
Zero set and measurement noise[1]	N5532B	±680 nW	
	U5532C	±500 nW	
Zero drift of sensors	N5532B	< 100 nW	
(1 hour, at constant temperature after 24 hour warm-up)	U5532C	< 70 nW	
RF power ranges of N5531X with U5532C or N5532B sensor modules		-20 dBm (10 μW) to +30 dBm (1 W)	RF power accuracy specifications are provided from -10 dBm and above.
Response time (0 to 99% of reading)			150 ms x number of averages (nominal)
Displayed units		(0 to 99% of reading)	

1. 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.

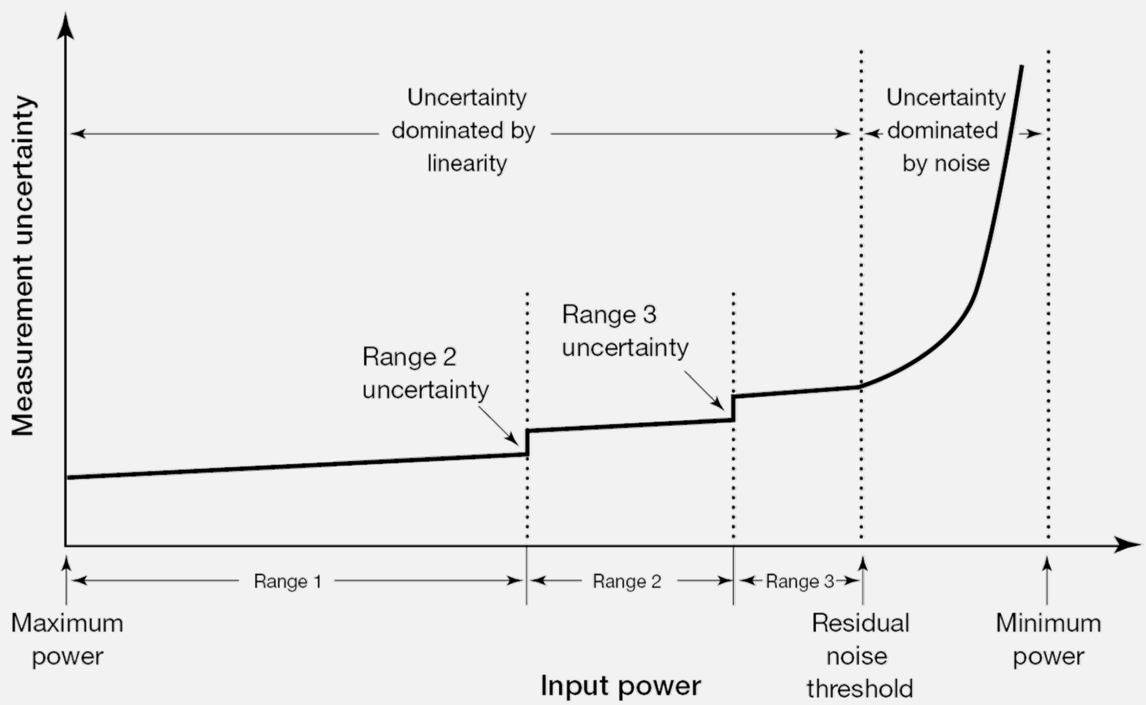

Figure 1. Measurement uncertainty vs. input power relationship

1.12 Tuned RF level [1, 2, 3]

Note: While the Tuned RF level specifications listed below are for IFBW settings of 75 Hz and 10 Hz, the IFBW in N5531X 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 = 3.6 GHz. For the Tuned RF Level with Tracking, the minimum power = 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	+30 dBm		For Opt N9030B-503
		+24 dBm		For Opt 9030B-508/513/526
		+20 dBm		For Opt N9030B-544/550
Minimum power (dBm)[4]				
Opt N9030B-503/508/513/526		**75 Hz IFBW[5]**	**10 Hz IFBW[6]**	
Frequency range		**Preamp On**	**Preamp On**	
100 to 200 kHz		-123.0	-137.8	Band 0
200 to 500 kHz		-126.0	-140.8	Band 0
500 kHz to 1 MHz		-130.0	-144.8	Band 0
1 to 10 MHz		-132.0	-146.8	Band 0
10 MHz to 2.1 GHz		-136.0	-150.8	Band 0
2.1 to 3.6 GHz		-134.0	-148.8	Band 0
3.5 to 8.4 GHz		-130.2	-145.0	Band 1
8.3 to 13.6 GHz		-129.2	-144.0	Band 2
13.5 to 16.9 GHz		-123.2	-138.0	Band 3
16.9 to 20 GHz		-121.2	-136.0	Band 4
20 to 26.5 GHz		-106.7	-121.5	Band 4
Minimum power (dBm)[4]				
Opt N9030B-544/550		**75 Hz IFBW[5]**	**10 Hz IFBW[6]**	
Frequency range		**Preamp On**	**Preamp On**	
100 to 200 kHz		-123.0	-137.8	Band 0
200 to 500 kHz		-126.0	-140.8	Band 0
500 kHz to 1 MHz		-128.0	-142.8	Band 0
1 to 10 MHz		-132.0	-146.8	Band 0

1. PXA Option N9030B-MPB is required to perform Tuned RF Level measurements above 3.6 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 30 kHz and 200 kHz IF bandwidth (IFBW), TRFL minimum power level will be degraded by a factor of 10log(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.
5. With 75 Hz IFBW setting selected, the measurement automatically switches the RBW to the 30 Hz setting for SNR values < 10 dB.
6. With 10 Hz IFBW setting selected, the measurement automatically switches the RBW to the 1 Hz setting for SNR values < 10 dB.

Description	Specification		Supplemental Information
Minimum power (dBm)[4]			
Opt N9030B-544/550	75 Hz IFBW[5]	10 Hz IFBW[6]	
Frequency range	Preamp On	Preamp On	
10 MHz to 2.1 GHz	-135.0	-149.8	Band 0
2.1 to 3.6 GHz	-134.0	-148.8	Band 0
3.5 to 8.4 GHz	-126.2	-141.0	Band 1
8.3 to 13.6 GHz	-126.2	-141.0	Band 2
13.5 to 17.1 GHz	-125.2	-140.0	Band 3
17 to 20 GHz	-124.2	-139.0	Band 4
20 to 26.5 GHz	-117.7	-132.5	Band 4
26.4 to 30 GHz	-113.7	-128.5	Band 5
30 to 34 GHz	-111.7	-126.5	Band 5
33.9 to 37 GHz	-109.7	-124.5	Band 6
37 to 40 GHz	-99.7	-114.5	Band 6
40 to 44 GHz	-97.7	-112.5	Band 6
44 to 46 GHz	-96.7	-111.5	Band 6
46 to 50 GHz	-95.7	-110.5	Band 6
Linearity	±(0.009 dB + 0.005 dB/10 dB step)[7]		
Relative measurement accuracy			
Residual noise threshold[8] to maximum power	±(0.015 dB + 0.005 dB/10 dB step)[7, 9, 10] (nominal)		
Minimum power to residual noise threshold	±(cumulative error[11] + 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[12]	±0.031 dB		
Range 3 uncertainty[13]	±0.031 dB		

1. PXA Option N9030B-MPB is required to perform Tuned RF Level measurements above 3.6 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 ºC.
3. Absolute and relative accuracy specifications do not include mismatch uncertainty.
4. With 30 kHz and 200 kHz IF bandwidth (IFBW), TRFL minimum power level will be degraded by a factor of 10log(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.
5. With 75 Hz IFBW setting selected, the measurement automatically switches the RBW to the 30 Hz setting for SNR values < 10 dB.
6. With 10 Hz IFBW setting selected, the measurement automatically switches the RBW to the 1 Hz setting for SNR values < 10 dB.
7. 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.
8. 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.
9. 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. Additionally, for the PXA with mmW frequency option, if the change of measured frequency crosses frequency bands, allow 10 minutes for thermal stability before taking the first measurement within the new band.
10. This includes the linearity accuracy.
11. 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.
12. 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 PXA display will indicate that the measuring receiver is in Range 2.
13. 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 PXA display will indicate that the measuring receiver is in Range 3.

Description	Specification	Supplemental information
Absolute measurement accuracy		
+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[1] + 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[2]	±0.031 dB	
Range 3 uncertainty[3]	±0.031 dB	

1. 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 jRange. 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 Uncertainty is ±0.222 dB, as indicated in the table on the next page. The Residual Noise Threshold Power is calculated by adding 30 dB to the Minimum Power specification in the table on the previous page. Assume the measurement frequency is 2 GHz. The Residual Noise Threshold Power is then -136 dBm + 30 dB = -106 dBm using the formula on this page. The cumulative error is then ±(0.222 dB + $\lceil 106/10 \rceil$ x 0.005 dB), or ±0.277 dB, where $\lceil x \rceil$ is a ceiling function that means the smallest integer not less than x, which is 11 in this example.
2. 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 PXA display will indicate that the Measuring Receiver is in Range 2.
3. 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 PXA display will indicate that the Measuring Receiver is in Range 3. In the example mentioned in footnote 1. above, since the measurements step through both Range 2 and Range 3, the range-to-range uncertainties need to be taken into account. Therefore, the total absolute power measurement uncertainty in this example can be calculated as ±(0.222 dB + $\lceil 106/10 \rceil$× 0.005 dB + 0.031 dB + 0.031 dB + 0.0012x(120-106)^2 dB) = ±0.574 dB.

Note

As the displayed average noise level (DANL) of a spectrum/signal 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/signal analyzers. The residuals specification for the PXA 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 PXA's RF input connector and switch to the PXA's spectrum analysis mode to verify the PXA residuals.

1.12 Tuned RF level (continued)

Description		Specification				Supplemental information			
Power meter uncertainty (dB)									
Power meter range 1 (+20 to +30 dBm)						**Typicals**			
		Sensor module options				Sensor module options			
		504	518	526	550	504	518	526	550
	100 kHz ≤ f_c ≤ 10 MHz	±0.287	—	—	—	±0.146	—	—	—
	10 MHz < f_c ≤ 30 MHz	±0.287	±0.287	±0.287[1]	—	±0.146	±0.146	±0.146[1]	—
	30 MHz < f_c ≤ 2 GHz	±0.287	±0.287	±0.287	±0.265	±0.146	±0.146	±0.146	±0.135
	2 GHz < f_c ≤ 4.2 GHz	±0.302	±0.302	±0.302	±0.279	±0.154	±0.154	±0.154	±0.142
	4.2 GHz < f_c ≤ 18 GHz	—	±0.466	±0.468	±0.342	—	±0.240	±0.241	±0.175
	18 GHz < f_c ≤ 26.5 GHz	—	—	±0.386	±0.332	—	—	±0.198	±0.170
	26.5 GHz < f_c ≤ 50 GHz	—	—	—	±0.363	—	—	—	±0.186
Power meter range 2 (0 to +20 dBm)						**Typicals**			
		Sensor module options				Sensor module options			
		504	518	526	550	504	518	526	550
	100 kHz ≤ f_c ≤ 10 MHz	±0.222	—	—	—	±0.113	—	—	—
	10 MHz < f_c ≤ 30 MHz	±0.222	±0.222	±0.222[1]	—	±0.113	±0.113	±0.113[1]	—
	30 MHz < f_c ≤ 2 GHz	±0.222	±0.222	±0.222	±0.191	±0.113	±0.113	±0.113	±0.097
	2 GHz < f_c ≤ 4.2 GHz	±0.242	±0.242	±0.242	±0.211	±0.123	±0.123	±0.123	±0.107
	4.2 GHz < f_c ≤ 18 GHz	—	±0.432	±0.433	±0.291	—	±0.222	±0.232	±0.148
	18 GHz < f_c ≤ 26.5 GHz	—	—	±0.342	±0.279	—	—	±0.175	±0.142
	26.5 GHz < f_c ≤ 50 GHz	—	—	—	±0.316	—	—	—	±0.161
Power meter range 3 (-5 to 0 dBm)						**Typicals**			
		Sensor module options				Sensor module options			
		504	518	526	550	504	518	526	550
	100 kHz ≤ f_c ≤ 10 MHz	±0.220	—	—	—	±0.112	—	—	—
	10 MHz < f_c ≤ 30 MHz	±0.220	±0.219	±0.220[1]	—	±0.112	±0.111	±0.112[1]	—
	30 MHz < f_c ≤ 2 GHz	±0.220	±0.219	±0.220	±0.189	±0.112	±0.111	±0.112	±0.096
	2 GHz < f_c ≤ 4.2 GHz	±0.240	±0.240	±0.240	±0.209	±0.122	±0.122	±0.122	±0.106
	4.2 GHz < f_c ≤ 18 GHz	—	±0.430	±0.432	±0.289	—	±0.221	±0.222	±0.148
	18 GHz < f_c ≤ 26.5 GHz	—	—	±0.341	±0.277	—	—	±0.174	±0.141
	26.5 GHz < f_c ≤ 50 GHz	—	—	—	±0.315	—	—	—	±0.161

1. For U5532C USB sensor modules only.

Description		Specification				Supplemental information			
Power meter range 4 (-10 to -5 dBm)						Typicals			
		Sensor module options				Sensor module options			
		504	518	526	550	504	518	526	550
	100 kHz ≤ f_c ≤ 10 MHz	±0.229	—	—	—	±0.117	—	—	—
	10 MHz < f_c ≤ 30 MHz	±0.229	±0.229	±0.229[1]	—	±0.117	±0.117	±0.117[1]	—
	30 MHz < f_c ≤ 2 GHz	±0.229	±0.229	±0.229	±0.200	±0.117	±0.117	±0.117	±0.102
	2 GHz < f_c ≤ 4.2 GHz	±0.249	±0.249	±0.249	±0.219	±0.127	±0.127	±0.127	±0.111
	4.2 GHz < f_c ≤ 18 GHz	—	±0.435	±0.437	±0.296	—	±0.224	±0.225	±0.151
	18 GHz < f_c ≤ 26.5 GHz	—	—	±0.347	±0.285	—	—	±0.178	±0.145
	26.5 GHz < f_c ≤ 50 GHz	—	—	—	±0.321	—	—	—	±0.164

1. For U5532C USB sensor modules only.

Description	Specification	Supplemental information
Operating frequency range		
Option N9030B-503/508/513/526/544/550	100 kHz to 3.6 GHz	
N9030B-508/513/526/544/550	3.6 to 8.4 GHz	Requires Option N9030B-MPB
N9030B-513/526/544/550	8.4 to 13.6 GHz	Requires Option N9030B-MPB
Option N9030B-526/544/550	13.6 to 26.5 GHz	Requires Option N9030B-MPB
Option N9030B-544/550	26.5 to 44 GHz	Requires Option N9030B-MPB
N9030B	44 to 50 GHz	Requires Option N9030B-MPB
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	

N5531X Ordering Information

For the N5531X with the primary configuration: order an N9030B PXA and a U5532C USB sensor module;

For the N5531X with the alternative configuration: order an N9030B PXA, a power meter, and an N5532B sensor module.

N9030B PXA signal analyzer, multi-touch

Select one of the following frequency options

- N9030B-503: 2 Hz to 3.6 GHz
- N9030B-508: 2 Hz to 8.4 GHz
- N9030B-513: 2 Hz to 13.6 GHz
- N9030B-526: 2 Hz to 26.5 GHz
- N9030B-544: 2 Hz to 44 GHz
- N9030B-550: 2 Hz to 50 GHz

Other PXA options

N9030B-MPB

Microwave preselector bypass (required for TRFL measurements above 3.6 GHz)

N9030B-P03/P08/P13/P26/P44/P50

Preamplifier (required for the best TRFL specifications up to the maximum frequency of the PXA frequency option covers)

The N5531X ordering system automatically selects a preamplifier option to cover up to the maximum frequency defined by the PXA frequency option

- N9030B-P03 Preamplifier, 3.6 GHz
- N9030B-P08 Preamplifier, 8.4 GHz
- N9030B-P13 Preamplifier. 13.6 GHz
- N9030B-P26 Preamplifier, 26.5 GHz
- N9030B-P44 Preamplifier, 44 GHz
- N9030B-P50 Preamplifier, 50 GHz

N9030B-107

Audio input and digitizer (required for audio analysis, only operational with N9091EM0E measuring receiver application or with N9092EM0E avionics measurement application)

N9030B-033

Measuring receiver connector accessory kit, 26.5 GHz (Optional) provides a set of metrology-grade coaxial connector adapters including quantity 2 of each: type-N (f) to 3.5 mm (f), APC-7 to APC-3.5 (f), 3.5 mm (f) to 3.5 mm (f), 3.5 mm (m) to 3.5 mm (f); and a 3.5 mm (m-f) RF cable assembly.

N9030B-034

Measuring receiver connector accessory kit, 50 GHz (Optional) provides a set of metrology-grade coaxial connector adapters including quantity 2 of each: type-N (f) to 2.4 mm (f), APC-7 to 2.4 mm (f), 2.4 mm (f) to 3.5 mm (f), 2.4 mm (f) to 2.4 mm (f), 2.4 mm (f) to 3.5 mm (m); and a 2.4 mm (m-f) 50 GHz cable assembly.

X-Series measurement applications

N9091EM0E

X-Series measuring receiver application (required for measuring receiver)

PXA option upgrades[1]

N9030BU-MPB

Microwave preselector bypass (required for TRFL measurements above 3.6 GHz, if the PXA (with any frequency option) has Opt LNP installed), or

N9030BU-HL1

Microwave preselector bypass (required for TRFL measurements above 3.6 GHz, if the PXA (with option 508/513/526) does not have Opt LNP installed), or

N9030BU-HL2

Microwave preselector bypass (required for TRFL measurements above 3.6 GHz, if the PXA (with option 544/550) does not have Opt LNP installed)

N9030BU-P03/P08/P13/P26/P44/P50

Preamplifier (required for the best TRFL specifications up to the maximum frequency of the PXA base instrument)

N9030BU-107

Audio input and digitizer (required for audio analysis, only operational with N9091EM0E, or with N9092EM0E)

U5532C USB sensor module (for the primary configuration)

Select frequency option

U5532C-504

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

U5532C-518

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

U5532C-526

10 MHz to 26.5 GHz USB sensor module, APC-3.5 (m) input connector

U5532C-550

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

Select from U5532C options (optional)

Power meter (for the alternative configuration)

Select one model

N1913A

EPM Series single channel power meter

N1914A

EPM Series dual channel power meter

N1911A

P-Series single channel power meter

N1912A

P-Series dual channel power meter

Select from power meter options (optional)

1. For the existing N9030B PXA only. Upgrades for certain PXA options may not be available for earlier instruments. For detailed information regarding availability and compatibility of options, please visit http://www.keysight.com/find/pxa_upgrades

N5532B sensor module (for the alternative configuration)

Select 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 N1911A/12A power meter (required when the N1911A/12A P-Series power meter is used), can also be ordered standalone

Select from N5532B options (optional)

Related Literature

Publication title	Publication type	Publication number
N5531X in general		
N5531X X-Series measuring receiver configuration guide	Configuration Guide	5992-2675EN
PXA in general		
PXA X-Series Signal Analyzer, Multi-touch N9030B	Configuration Guide	5992-1318EN
Power meter in general		
N1913A/N1914A EPM Power Meters	Data Sheet	5990-4019EN
N1911A/N1912A P-Series Power Meters	Data Sheet	5989-2471EN
Power measurement fundamentals		
Fundamentals of RF and Microwave Power Measurements (Part 1), Introduction to Power, History, Definition, International Standards, and Traceability	Application Note 1449-1	5988-9213EN
Fundamentals of RF and Microwave Power Measurements (Part 2), Power Sensors and Instrumentation	Application Note 1449-2	5988-9214EN
Fundamentals of RF and Microwave Power Measurements (Part 3), Power Measurement Uncertainty per International Guides	Application Note 1449-3	5988-9215EN
Fundamentals of RF and Microwave Power Measurements (Part 4), An Overview of Keysight Instrumentation for RF/Microwave Power Measurements	Application Note 1449-4	5988-9216EN
Tuned RF level measurement uncertainty analysis		
Metrology-Grade Measurement Challenges Easily measure RF power accuracy using the N5531X	Application Note	5992-3577EN

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