Channel Quality for Group Delay (N/E9056EM0E) Noise Power Ratio (N/E9056EM1E) Measurement Application

Key Features

- Characterize the performance of wideband RF components using multi-tones with spectrum, waveform, amplitude, phase, gain amplitude, gain phase, and group delay (absolute or relative) etc. measurements (N9056EM0E/E9056EM0E)
- Characterize the performance of wideband RF components using multi-tones and deep notches with Noise-Power-Ratio (NPR) measurements (N9056EM1E/E9056EM1E)
- User can flexibly define the number of tones and tone spacing for group delay measurement
- Support burst search for large group delay measurement
- Support U9361 RCAL receiver calibrator as “Use Current Measurement”
- Tones phase can be defined with phase type as zero phase, random phase or parabolic phase. You can also import a tone table as txt or csv format.
- Support Keysight X-Series Signal Generators (MXG, EXG) and VXG Microwave Signal Generator for multi-tones signal generation
- Support Keysight X-Series Signal Analyzers (UXA, PXA, or MXA) for channel quality/group delay measurement
- Use multi-touch user interface and SCPI remote interface
- Extend test assets with transportable, USB Portal or floating licenses between X-Series signal analyzers with multi-touch UI

KEYSIGHT

Group Delay and NPR

N9056EM0E Channel Quality/Group Delay and N9056EM1E Channel Quality/NPR measurement applications provide a solution to make repeatable channel response measurements such as group delay, Noise Power Ratio, and other characteristics of multi-channel signals targeting wideband components testing in 5G NR, WLAN etc. Group Delay/NPR are running inside Keysight X-series Signal Analyzers which can connect Keysight Signal Generators for multi-tone signal generation to make group delay measurements as the typical measurements shown below.

Typical measurements

- Group delay
- Noise Power Ratio (NPR)
- Spectrum
- Amplitude
- Phase
- Gain Amplitude
- Gain Phase

Instrument Connection

The instrument itself can introduce uncertainty in the measurement, including internal phase distortion and trigger delay. On the other hand, the initial phases for individual tones may be randomly generated to achieve better PAPR. To eliminate those uncertainties, a 2-step group delay measurement is recommended as the following diagram.

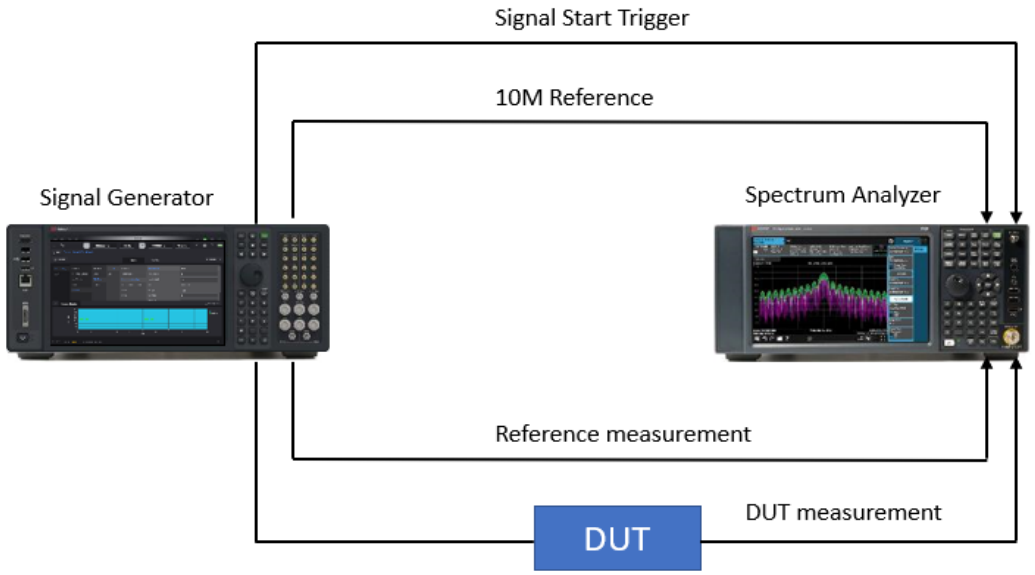


Figure 1. Group Delay or NPR Measurement Integrated System Connection Diagram

1. Connect signal generator to spectrum analyzer directly to perform a reference measurement to establish the reference data from the instruments, including phase distortion, trigger delay and initial tone phases.
2. Add DUT between signal generator and spectrum analyzer and perform the real measurement, the measured data will be then corrected with the reference data from step#1 to provide the group delay solely for DUT.

Apply Your Signals in Real World Testing

To use N9056EM0E Channel Quality/Group Delay measurement application, you must have some properly configured instruments, as described here.

Signal Generator	Signal Analyzer
VXG-B M9383B/M9484B (with N7621APPC) [1]	X-Series Signal Analyzer – UXA N9040B/N9042B
VXG-C M9484C (With N7621APPC) [1,2]	X-Series Signal Analyzer – PXA N9032B/N9030B
MXG N5186A (with E7621APPC) [1,2]	X-Series Signal Analyzer – MXA N9021B/N9020B
MXG N5182B (with N5180430B) [1]	PXI VXT M9421/10/11/15/16A
EXG N5172B (with N5180430B) [1]	
PXI VXT M9421/10/11/15/16A	

1. N7621APPC, E7621APPC and N5180430B are the required software license to generate the multi-tones inside SG.
2. For NPR measurement, it requires the M9484C or N5186A with the FW version above A.14.x.

What is Group Delay?

Group delay is a measure of the phase distortion with respect to frequency after passing through a device. From time domain perspective, it's also a measure of how long it takes for the signal to pass through a device. Here 'group' means a group of frequencies that is considered to have the constant delay after passing the device. Then, for a wider bandwidth, the delay values should be measured at many groups to form a complete group delay curve covering the whole bandwidth.

Mathematically, group delay is defined as:

$$\tau = -\frac{1}{2\pi}\frac{d\emptyset}{df}$$

Taking a look at the phase-to-frequency response, the linear phase is represented by the green line for the ideal case, and its slope represents the group delay for the overall frequency range. However, in a practical test with DUT, the phase response would be something like the red line, where deviations (called phase distortion) to the ideal slope could be observed. The phase distortion will result in a variable group delay for different frequency components in the signal, like a ripple.

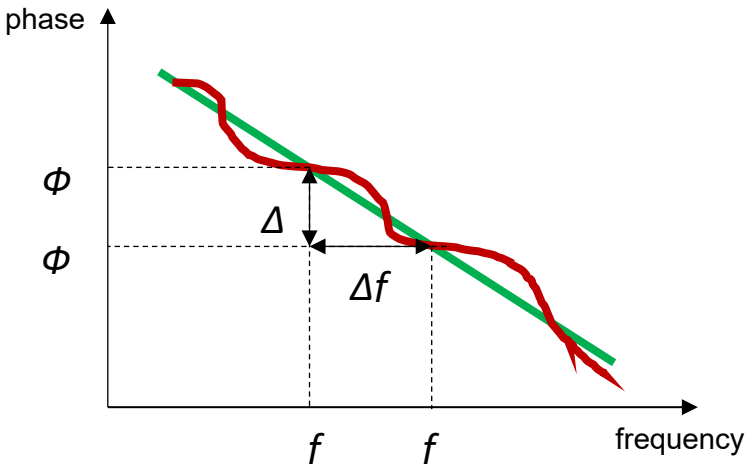
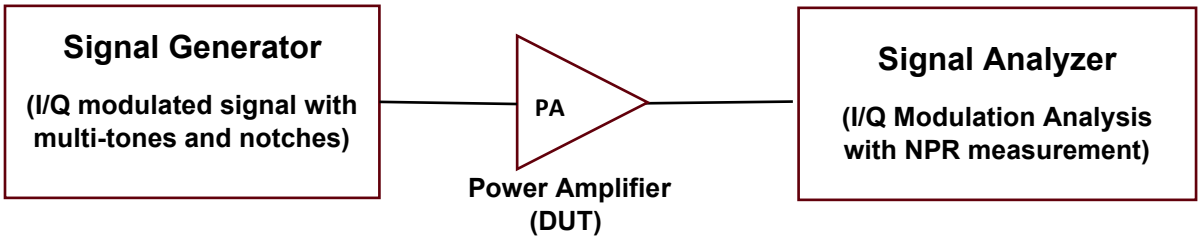


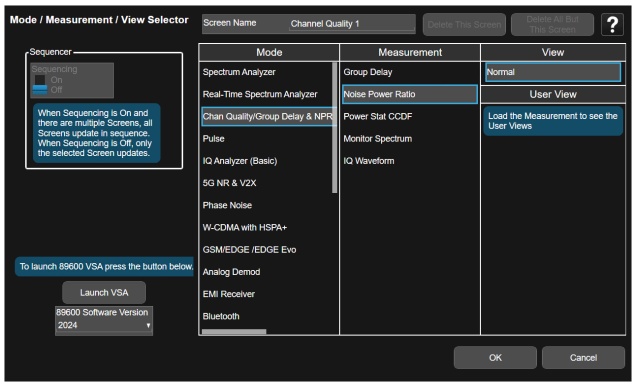
Figure 2. Group Delay Derived from phase vs. frequency

What is Noise Power Ratio (NPR)?

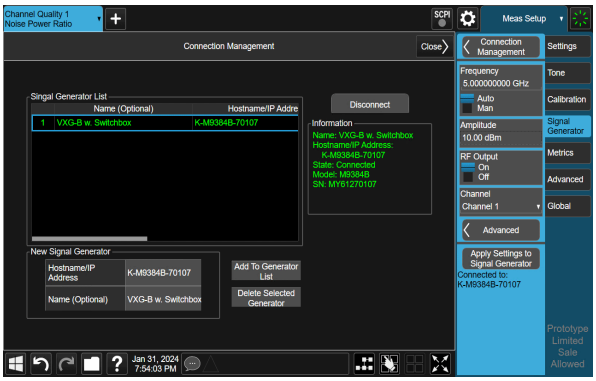
Noise-Power-Ratio (NPR) measurement is a useful tool to characterize the performance of wideband RF components like power amplifiers, filters, or mixers etc. for cellular, satellites communication, or other wideband systems. NPR measurement application typically uses the multi-tones with deep notches as the test signal simulating noise, multi-carrier CW tones or I/Q modulated signals. The intermodulation products generated in the non-linear RF components will fill up the notches that are placed within the channel bandwidth of interest.

Like the picture shown below, the signal generator will generate a test signal by defining multiple tones and notches using the multi-tone application software. Then spectrum analyzer is used to measure the noise power using Noise Power Ratio measurement application which shouldn't generate significant intermodulation distortion itself or masking the distortion generated by the RF component.

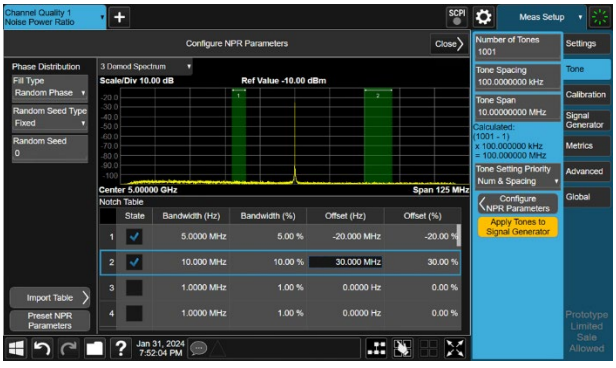




1) Select NPR measurement in Signal Analyzer



2) Connect Signal Generator



3) Configure Multi-tone and apply it to Signal Generator

4) Measure without the DUT and Do Calibrate; Connect DUT and make NPR measurement

Connect to Signal Generator via LAN Connection

If it is the first time to use a new generator, you'll need to input the IP address or Host name. Then you can add the configuration to the Signal Generator List, which will be stored even after instrument reboot. After connection is established between SA and SG, the SG Information is shown automatically in the information box and the button will be changed to **"Disconnect"**. You can add more Signal Generators in the list, only the **"Connected"** SG is highlighted in green color.

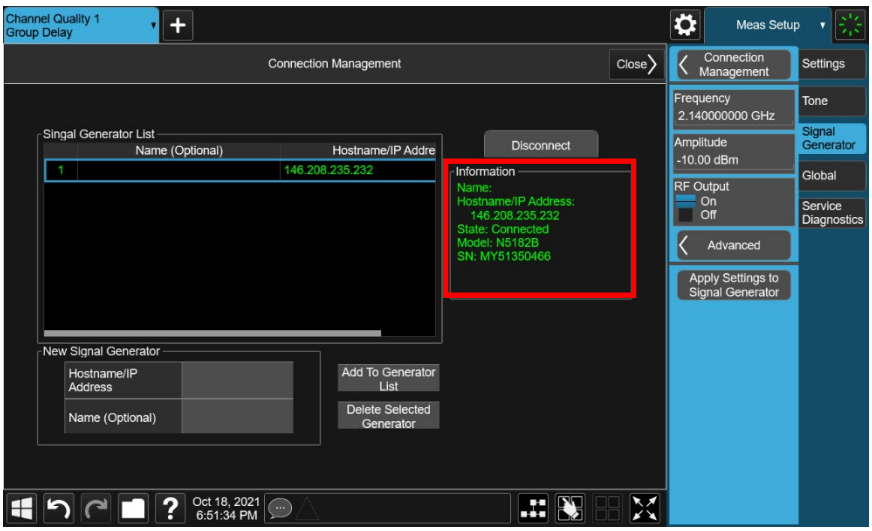


Figure 3. Signal Generator Connection Management

Multi-Tone Configuration

You can create a multi-tone table inside the N9056EM0E measure application. You can specify the number of tones, tone spacing and define the tone phase type as zero phase, random phase with random seed of phase, parabolic phase with initial phase. Or you can also import a previously generated tone table with the format as txt or csv. Then you can apply the tones to signal generators.

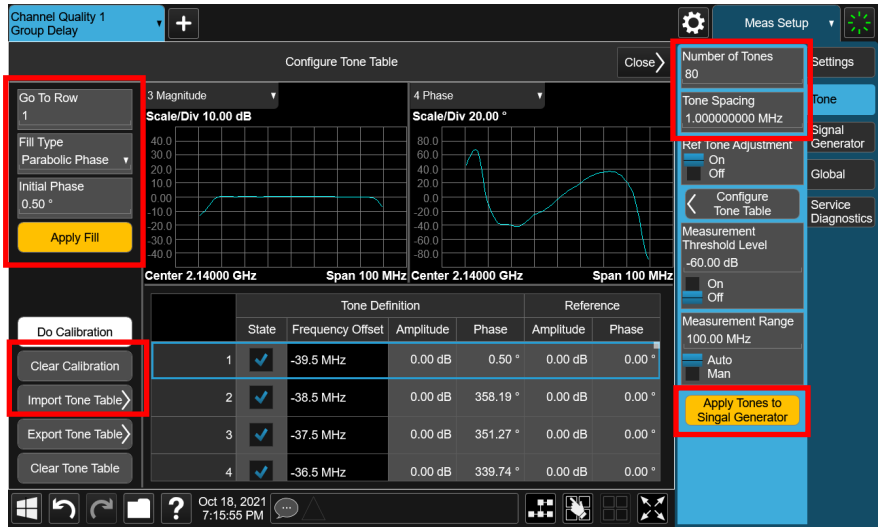


Figure 4. Multi-tone Configuration Table

Group Delay Measurement

For wideband DUT, group delay measurement needs to be done at many frequency groups, so multi-tone signal method would be a good choice for group delay measurement. Signal generator is able to generate the multi-tone signal with defined number of tones, tone spacing and configurable phase and playback it repeatedly. Then you are recommended to make the group delay measurement with two steps as below.

1. Firstly, you can connect the signal generator and signal analyzer with a cable. Then go to [Meas Setup] and [Configure Tone Table] menu as Figure 4 and then press **"Do Calibration"** button. It will do the group delay reference measurement and the calibration date will be applied with the real measurement if you turn on the **"Reference Tone Adjustment"** which is turned on by default.

2. Secondly you can connect the signal passes through the DUT, signal analyzer can measure the phase difference for the adjacent tones to determine the group delay. The measured data will be corrected with the calibration data from step#1 to provide the group delay solely for DUT.

When trigger is not available, it adds an unknown time gap between the measure time and signal start time, so the result cannot reflect the absolute group delay of the DUT. In this case, the measured result is called relative group delay, which has exactly the same delay curve pattern with the absolute one, but it may shift up/down along the Y-axis. Relative group delay makes sense in the tests that focus on the group delay variation across frequencies which will impact the distortion of the signal quality.

The following Figure 5 is measured with a wideband filter (2110-2170 MHz). Here we create 80 tones with tone spacing 1 MHz. Phase type defined as random and seed type as random are used. Then we apply the tones to the specified signal generator with frequency as 2140 MHz and amplitude as -10 dBm. You can see the group delay measurement results as the picture below. Yellow color is the current measurement trace. Blue color is the averaged trace. Pink color is the Reference trace.

Top left is the spectrum of the multi-tone signal passing through this filter. Top right is the phase trace; Middle left is the magnitude trace; Middle right is the group delay trace; Bottom left is the RF envelope trace; Bottom right is the metrics results including signal power, frequency error, clock error, and group delay results with sample, average and max hold detectors.

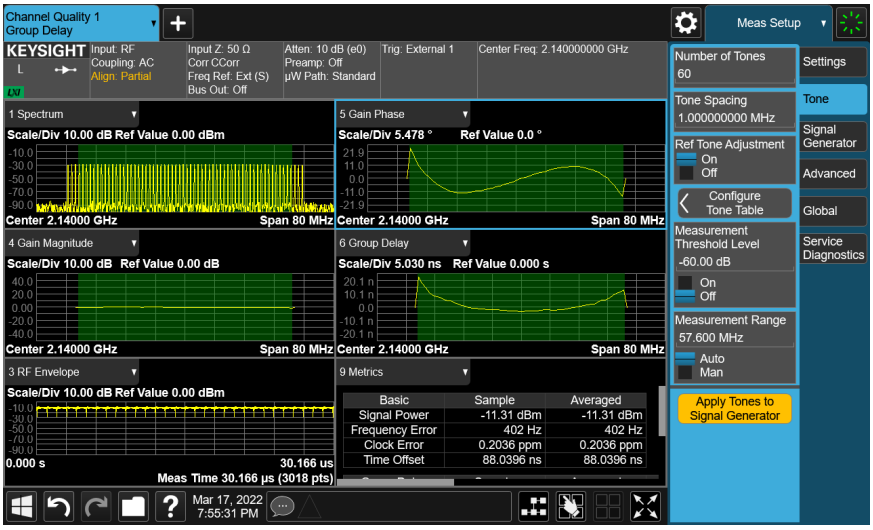


Figure 5. Group Delay measurement with a wideband filter as DUT

Noise Power Ratio (NPR) Measurement

Noise Power Ratio (NPR) measurement method and procedure is similar to the Group Delay measurement which can be summarized as four major steps. Firstly you can connect the SG and SA directly which can be configured inside the SA NPR meas application. Secondly you need configure the multi-tones with notches settings in SA and then apply it to signal generator. This will require the signal generator has a valid multi-tone generating license as N7621APPC for M9484C VXG-C or E7621APPC for N5186A MXG. Thirdly you can make the NPR measurement now without DUT and then do the calibrate which can improve the distortion and get better NPR results after calibration. Lastly you need connect the DUT and make the NPR measurement.

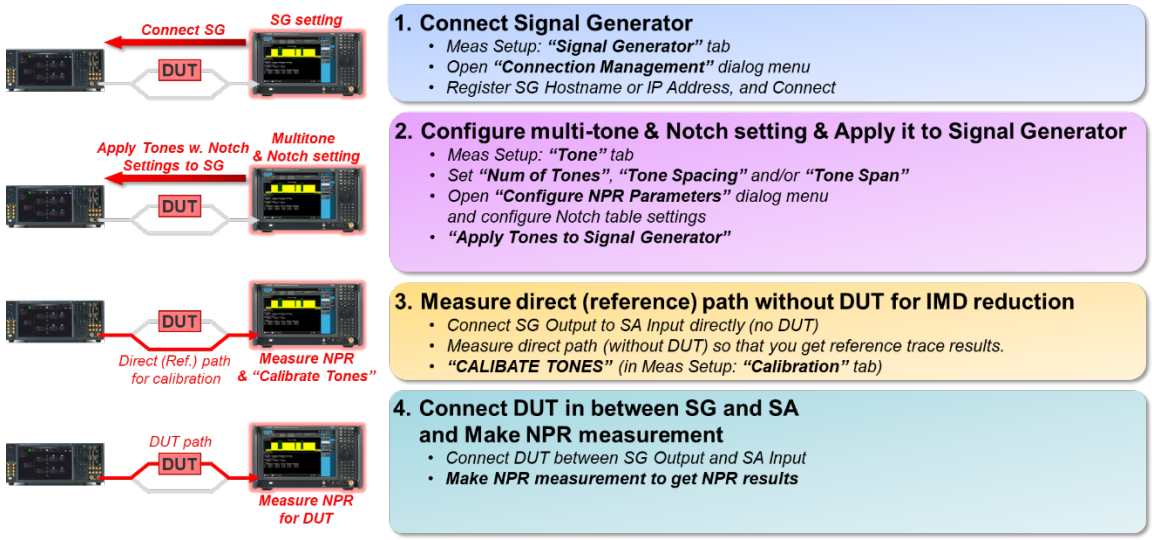


Figure 6. Noise Power Ratio (NPR) setup and measurement flow

The following Figure 7 is measured with a bandpass filter (4950-5050 MHz). Here we create 2 notches with notch 1 as offset -20MHz and Integration BW 5MHz and notch 2 as offset +30 MHz and Integration BW as 10MHz. We have already calibrated the whole system and get the reference NPR results around -66 dBc. Then we connect the DUT (bandpass filter) and make the NPR measurement with the result that NPR for Notch 1 is -57.26 dBc and for Notch is -59.12 dBc.

Figure 7. Noise Power Ratio (NPR) measurement with a bandpass filter as DUT

N9056EM0E/E9056EM0E Channel Quality for Group Delay Measurement Application Feature Summary

Feature	Parameter Setting
Group Delay Measurement	
General Settings	Average On/Off
	Average Mode: Exponential, Repeat
	Measurement Time (second)
	Measure Time: Auto (default)/Manual
	Burst Search (millisecond)
	Burst Search: On/Off (Default)
	Spur Avoidance: Enabled or Disabled (Default) (Applying for PXI VXT M9410A/11A/15A/16A as Zero-IF receiver)
Signal Generator	Frequency (Hz)
	Source: Internal or External (External is only shown with PXI VXT)
	Amplitude (dBm)
	RF Output: On (default)/Off
	DC Calibration: On (Default) /Off
	ALC: On (default) /Off
	Run-time Scaling: 70% (default)
	Apply Settings to Signal Generator
Advanced	DC Calibration: On (Default) or Off
	ALC: On (Default) or Off
	Run-time scaling: manual input (default as 70%)
	VXG Specific Parameters: Channel 1 (default) or Channel 2
Connection Management	Signal Generator List (table)
	Connect (showing the connected Signal Generation Information)
	IP Address and Hostname (Optional)
	Add To Signal Generator List
	Delete Selected Generator
Tone	Number of Tones (max. 20,000)
	Tone Spacing (min. 0.1 Hz, max. 1 GHz)
	Tone span (coupled with tone spacing and number of tones)
	Tone Setting Priority: Num & Spacing (default), Tone Span & Tone Spacing, Tone Span & Num of Tones
	Measurement Threshold Level: On/Off (default)
	• Measurement Threshold: -60 dB (default)
	Measurement Range
	• Auto (Default) /Manual
	Apply Tones to Signal Generator
	PAPR Estimation of generated waveform
Configure Tone Table	Fill Tone Phase Type: All States On, All States Off, Zero phase, Random phase, Parabolic phase
	Random Seed Type: Fixed (default)/Random (for random phase)
	Random Seed: 0 (default) or user input (for random phase with fixed random seed)
	Initial Phase: 0.5% (default) or user input (Parabolic Phase)
	Import Tone Table/Export Tone Table/ Clear Tone Table
Waveform	Signal Generator Location: Signal Generator or Local
	RMS Type (for local): Unspecified or Calculated
	Export Waveform (Save as Signal Studio waveform or CSV/TXT file)
Advanced	Frequency Offset Estimation: Normal or Extended
	DC Punctured: On of Off (Default)
	Phase Noise Optimization: Auto (Default) or Manual
	Phase Noise Optimization: Best Close-In (Offset<600 kHz), Balance Noise and Spurs (Offset <600 kHz), Best Wide-Offset (Offset>800 kHz), Fast Tuning
Calibration	Tone magnitude: On (default)/Off
	Tone phase: On (default)/Off
	Time Offset: On (default)/Off
	Reference time offset: 0.0 second (default)

Trace	Spectrum Trace: On/Off; Average Trace: On/Off; Reference Trace: On/Off
	Aperture: 4.0% (default) or user input
Measurements	Spectrum trace
	Phase/Magnitude trace
	Group Delay trace (relative or absolute)
	IQ Waveform
	RF Envelope
	Gain Magnitude
	Gain Phase
	Marker Table with marker position by tone index
	Metrics: Signal Power, Frequency Error, Clock Error, Time Offset,Group Delay as RMS, Pk+, PK-, (Pk-Pk)/2 (with Sample, Averaged, Max Hold detectors)

Power Stat CCDF Measurement	
General Settings	Counts (points)
	Meas Intervals (seconds)
	IF Gain: Low Gain, High Gain
Measurement	Average Power
	Power Probability Table (10%, 1.0%, 0.1%, 0.01%, 0.001%, 0.0001%)
	Peak: power and peak-average power ratio
	CCDF Trace (with Gaussian as Reference)
Monitor Spectrum Measurement	
General Settings	Average: On/Off; Average Number
	Average Mode: Exponential, Repeat
	Noise Floor Extension (if applicable)
	Span (Hz)
Measurement	Spectrum trace
	Gate trace
IQ Waveform Measurement	
General Settings	Average: On/Off; Average Number
	Average Mode: Exponential, Repeat
	Time Avg Number
	Meas Time (second)
	Sample Rate (Hz)
	Digital IF BW (Hz)
	Phase Noise Optimization: Best Close-In Phase Noise, Best Wide-Offset Phase Noise, Fast Tuning
	ADC Dither: Off (Best Noise), On (Best Log Accuracy)
	IF Gain: Auto-range (Follow Signals), Low gain (Best for Large Signals), High Gain (Best Noise Level), Other IF Gain (Explicit)
	IF Gain Offset
Measurement	RF Envelope
	IQ Waveform
	Metrics: Mean Power, Pk-to-Mean Ratio, Max Point, Min Point

N9056EM1E/E9056EM1E Channel Quality for Noise Power Ratio (NPR) Measurement Application Feature Summary

Feature	Parameter Setting
Group Delay Measurement	
General Settings	Average On/Off
	Average Mode: Exponential, Repeat
	Measurement Time (second)
	Measure Time: Auto (default)/Manual
Signal Generator	Frequency (Hz)
	Amplitude (dBm)
	RF Output: On (default)/Off
	DC Calibration: On (Default) /Off
	ALC: On (default) /Off
	Run-time Scaling: 70% (default)
	Apply Settings to Signal Generator
Connection Management	Signal Generator List (table)
	Connect (showing the connected Signal Generation Information)
	IP Address and Hostname (Optional)
	Add To Signal Generator List
	Delete Selected Generator
Tone	Number of Tones (max. 20,000)
	Tone Spacing (min. 0.1 Hz, max. 1 GHz)
	Tone span (coupled with tone spacing and number of tones)
	Tone Setting Priority: Num & Spacing (default), Tone Span & Tone Spacing, Tone Span & Num of Tones
	Apply Tones to Signal Generator
Configure NPR Parameters	Fill Type: Zero phase, Random phase, Parabolic phase
	Random Seed Type: Fixed (default)/Random (for random phase)
	Random Seed: 0 (default) or user input (for Random phase)
	Initial Phase: 0.5% (default) or user input (for Parabolic phase)
	Import Tone Table (Notch date with *.mtd files; Tone Data with *.txt files)
	Preset NPR Parameters
Calibration	IMD Suppression: On (default)/Off
	Active Tone Flatness: On (default)/Off
	Time Offset: On (default)/Off
	Ignore Center: On/Off (default)
	Number of Iterations: 10 (default) or user input
	Desired Suppression (Peak Power): 60 dBC or user input
	Calibrate Tones
Metrics	Power Reference: Active Power/Tone (default), Total Signal Power, Power/Tone, Peak Active Power, or Manual
	Manual Reference: 0 dBm (default) (for Manual Power Reference)
	Notch Guard Band: 0.0 Hz (default) or user input
Measurements	Spectrum trace
	RF Envelope
	Demod Spectrum
	Magnitude
	Metrics Power Summary: Signal Power, Worst NPR, NPR Ref Power, Frequency Error Active Tone Power Summary: Power (RMS), +Peak, -Peak Notch Metrics: Offset Frequency, Integration BW, NPR, Peak Power, Peak Frequency
	Marker Table: Mode (Normal/Delta/Off), Trace, X (Marker Frequency), Y (Marker Power), Band Function (Marker Noise/Band Power/Band Density/Off), Function Width, Function Value

Power Stat CCDF Measurement	
General Settings	Counts (points)
	Meas Intervals (seconds)
	IF Gain: Low Gain, High Gain
Measurement	Average Power
	Power Probability Table (10%, 1.0%, 0.1%, 0.01%, 0.001%, 0.0001%)
	Peak: power and peak-average power ratio
	CCDF Trace (with Gaussian as Reference)
Monitor Spectrum Measurement	
General Settings	Average: On/Off; Average Number
	Average Mode: Exponential, Repeat
	Noise Floor Extension (if applicable)
	Span (Hz)
Measurement	Spectrum trace
	Gate trace
IQ Waveform Measurement	
General Settings	Average: On/Off; Average Number
	Average Mode: Exponential, Repeat
	Time Avg Number
	Meas Time (second)
	Sample Rate (Hz)
	Digital IF BW (Hz)
	Phase Noise Optimization: Best Close-In Phase Noise, Best Wide-Offset Phase Noise, Fast Tuning
	ADC Dither: Off (Best Noise), On (Best Log Accuracy)
	IF Gain: Auto-range (Follow Signals), Low gain (Best for Large Signals), High Gain (Best Noise Level), Other IF Gain (Explicit)
	IF Gain Offset
Measurement	RF Envelope
	IQ Waveform
	Metrics: Mean Power, Pk-to-Mean Ratio, Max Point, Min Point

Ordering Information

Flexible software licensing and configuration

- **Node-locked**: Allows you to use the license on one specified instrument/computer.
- **Transportable**: Allows you to use the license on one instrument/computer at a time. This license may be transferred to another instrument/computer using Keysight's online tool.
- **Floating**: Allows you to access the license on networked instruments/computers from a server, one at a time. For concurrent access, multiple licenses may be purchased. Floating support single site, single region and worldwide three different types.
- **USB portable**: Allows you to move the license from one instrument/computer to another by end-user only with certified USB dongle, purchased separately.
- **Subscription (time-based)**: License is time limited to a defined period, such as 12-months

Channel Quality/Group Delay Measurement Application, Multi-touch (N9056EM0E/E9056EM0E)
Channel Quality/Noise Power Ratio (NPR) Measurement Application, Muli-touch (N9056EM1E/E9056EM1E)

Software License Type	Software License	KeysightCare Subscription
Node-locked perpetual	SW1000-LIC-01	SW1000-SUP-01[2]
Node-locked time-based	SW1000-SUB-01[1]	Included
Transportable perpetual	SW1000-LIC-01	SW1000-SUP-01[2]
Transportable time-based	SW1000-SUB-01[1]	Included
Floating perpetual (single site)	SW1000-LIC-01	SW1000-SUP-01[2]
Floating time-based (single site)	SW1000-SUB-01[1]	Included
Floating perpetual (worldwide)	SW1000-LIC-01	SW1000-SUP-01[2]
Floating time-based (worldwide)	SW1000-SUB-01[1]	Included
USB portable perpetual	SW1000-LIC-01	SW1000-SUP-01[2]
USB portable time-based	SW1000-SUB-01[1]	Included

Renewal Sales

Software License Type	Term or Duration	
SW1000-SUP-01	1-36 month	Node-Locked, Transportable, USB portable, Floating-single site, single region or worldwide with email delivery

1. Time-based license subscription can be chosen from the pre-defined 3/6/12/24/36 months or user specified duration between 3-36 months.
2. Support duration for node-locked perpetual license can be chosen from pre-defined 12/24/36/60 months or user specified duration between 12-60 months.
3. Node-locked support renewal duration can be chosen from 1-36 months.

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Evaluate a full-featured version of our X-Series measurement application with our FREE trial. Redeem one 30-day trial license of each measurement application online at www.keysight.com/find/X-Series_apps_trial

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- X-Series Signal Analyzers: www.keysight.com/find/X-Series
- M9484C VXG Vector Signal Generator www.keysight.com/find/VXG
- N5186A MXG Vector Signal Generator www.keysight.com/find/N5186A

Literatures

- X-Series Measurement Application, Brochure, 5989-8019EN