N/E9055EM0E
Power Amplifier Test Application

Key Features

- Characterize PA (Power Amplifier) with Pre-distortion applied in RF and millimeter wave, with simple and integrated multi-touch user interface

- Provide smart link for automated signal generator closed loop control with power servo to auto-adjust PA output power

- Extracts DPD model and apply Pre-distortion to linearize PA output with supported DPD model as Look-up table (LUT), Volterra Series, Memory Polynomial, Iterative Learning Control (ILC)

- Support user-defined DPD models with MATLAB scripts

- Show both Pre-DPD and Post-DPD measurement results in one screen, for ease of comparison. Easily switch between Pre-DPD and Post-DPD results

- Support PA measurements with AM / AM, AM / PM, ACP, Delta EVM, Demod EVM (5G NR FDD or TDD, LTE-FDD 802.11ac/ax/be), Power vs Demod EVM

- Supports multi-carrier measurements to show EVM results in single screen

- Support waveform processing with crest factor reduction using clipping and filtering or peak cancellation methods

- Use embedded DPD (Look-Up-Table or Memory Polynomial) function of the M9384B or M9484C VXG, so it can avoid downloading Pre-distorted waveform for each DPD iteration, which can improve measurement speed

- Support frequency up to 50 GHz with 2 GHz bandwidth with N9042B UXA and M9384B or M9484C VXG

- Support the burst shape & mask formation to reconstruct the reference waveform and its mask signals for users to evaluate the impact of power support of PA on EVM readouts

- Support M9484B VXG with 2-channel, or PXI VXT and AWG for PA Envelope Tracking (ET) measurement

KEYSIGHT

Power Amplifier Measurement Application

Modern mobile communications, such as 5G NR and WLAN place new demands on linearity, bandwidth and power consumption in wireless components, mobile terminals, or base stations. One of the most non-linear components is the PA (Power Amplifier). The design of the power amplifier must allow it to:

- Increase spectral efficiency
- Reduce distortion and non-linearity

N9055EM0E Power Amplifier measurement application is an integrated PA testing system mainly targeting 5G NR, WLAN, or other wideband PA test scenarios. N9055EM0E is running inside Keysight X-series Signal Analyzers which can connect Keysight Signal Generators for signal generation to make both Pre-DPD and Post-DPD PA measurements as the typical measurements shown in the right table.

Digital Pre-Distortion Technology

Power amplifiers with high PAPR (Peak to Average Power Ratio) signals can create non-linearity problems. When a high-power signal is applied to the PA input, the PA can't linearly amplify the signal, possibly resulting gain saturation and distortion, and ultimately leading to signal quality degradation, such as worse ACP and EVM. DPD technology can be used to compensate for the non-linear behavior of the PA. DPD applies "inverse" distortion to the PA input signal to cancel the distortion generated by the PA. There are several types of DPD methods, including memoryless and memory, which convey the memory effect on a PA. N9055EM0E supports the following methods:

- Look-up table
- Volterra series
- Memory polynomial
- Iterative Learning Control (ILC)
- User-defined DPD model with MATLAB scripts

Typical Measurements

Distortion measurement

- AM / AM
- AM-PM

Spectrum measurement

- Channel power
- ACP

Modulation quality

- Delta EVM
- Dynamic EVM (PA Enable Mask)
- Demod EVM (5G or WLAN)
- Power vs. Demod EVM

Apply Your Signals in Real World Testing

To use N9055EM0E Power Amplifier measurement application, you must have some properly configured instruments, as described here.

Signal generator recommended	Signal analyzer recommended
PXI VXT M9410A/M9411A/M9415A/M9416A[3]	PXI VXT M9410A/M9411A/M9415A/M9416A[3]
PXI VXT M941xA + M9471A (extend to 26.5 GHz)[5]	X-Series Signal Analyzer – UXA N9042B
VXG M9384B, M9484C[4]	X-Series Signal Analyzer – UXA N9041B[2]
X-Series Signal Generator – MXG N5182B[1]	X-Series Signal Analyzer – UXA N9040B[1]
Next Generation Signal Generator MXG N5186A[5]	X-Series Signal Analyzer – PXA N9030B[1], N9032B[2]
PXI VXT M9410A/M9411A	X-Series Signal Analyzer – PXA N9021B[2]
PXI VXT M9415A/M9416A	Wireless test set E6680A/E
Wireless test set E6680A/E	
PXI AWG M3202A (ET)	
M9384B/M9484C (ET)	

1. Those instruments will be supported with the XA2021 release (March 2021).
2. This Instrument will be supported with the XA2022 release (July 2021).
3. This instrument will be supported with XA2022 Update 1.0 release (November 2021).
4. This instrument will be supported with XA2022 Update 2.0 release (April 2022).
5. This instrument will be supported with XA2024 minor release (Oct 2023).

Power Amplifier Connection

To use N9055EM0E Power Amplifier measurement application, a connection diagram is shown below. SA (Signal Analyzer) and SG (Signal Generator) are connected through LAN connection.

- Connect SA and SG Trigger and 10 MHz Reference together (usually from SG to SA)
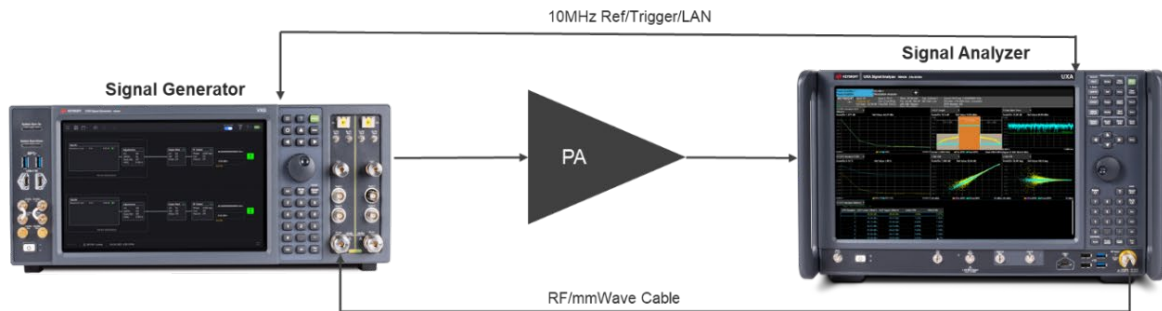- Connect PA (DUT) between SA and SG RF or mmWave port.

Figure 1. N9055EM0E Power Amplifier Test connection diagram using M9484C VXG and N9042B UXA
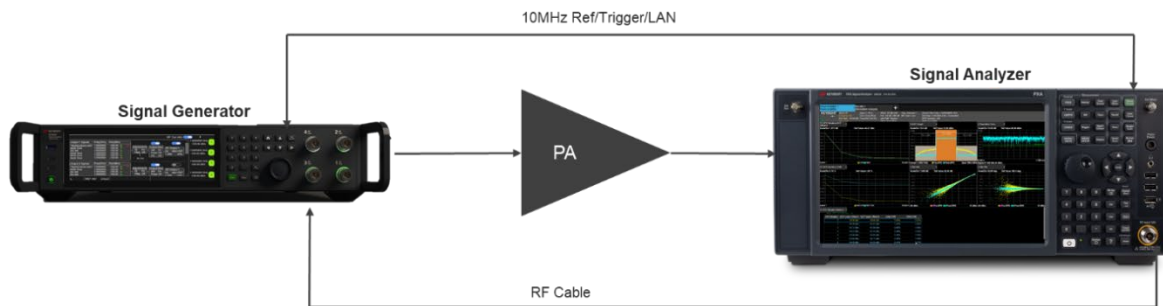

Figure 2. N9055EM0E Power Amplifier Test connection diagram using N5186A MXG and N9032B PXA

Connect to Remote 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, associated with a Name as optional for logging. 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.
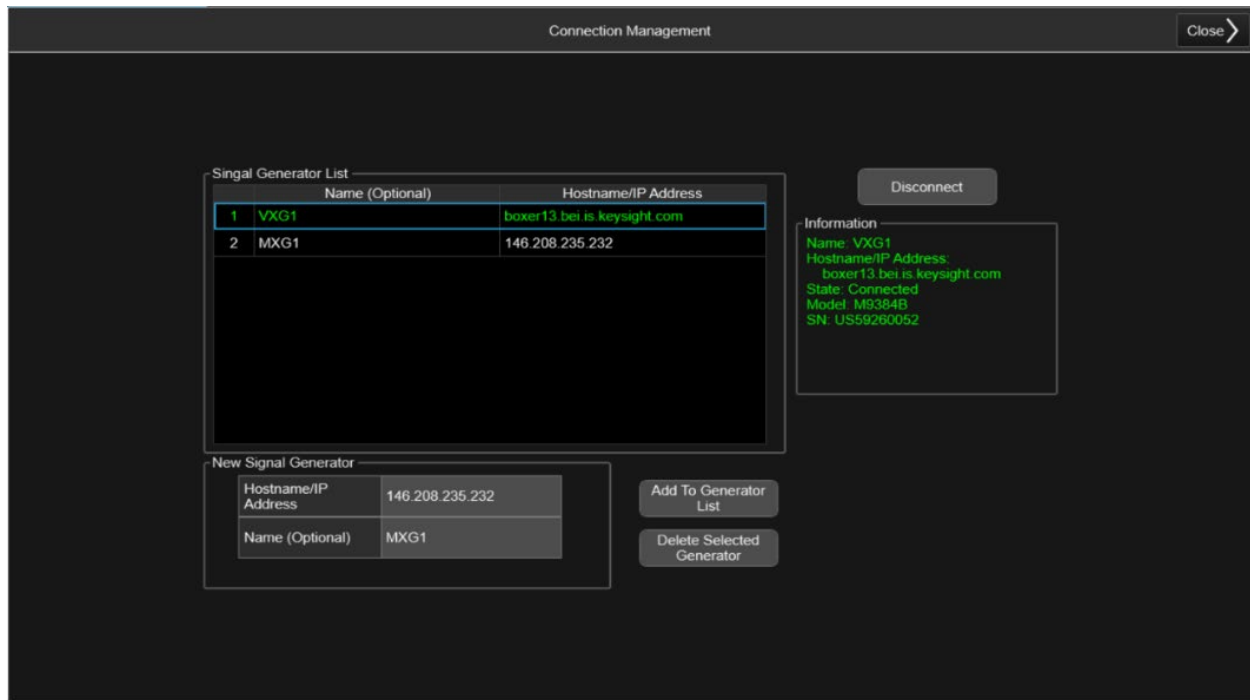

Figure 3. Signal Generation Management in the N9055EM0E Power Amplifier Test

Pre-DPD Measurements

Pre-DPD measurements are done by measuring reference signal played in SG. You can see the pre-DPD measurement results as shown in yellow color in all trace windows of PA Test.

You can restart the measurement to see new result or use "Continuous" mode to check Pre-DPD results continuously.

Figure 4. Pre-DPD Measurements

PA Test reference waveform is downloaded from SA to SG via LAN connection. The waveform name is configured as "RefWaveform" when it completes downloading to SG.

This is a screenshot for VXG, after reference waveform is downloaded from SA to VXG. You can see the "RefWaveform" file is shown with the status as playing.
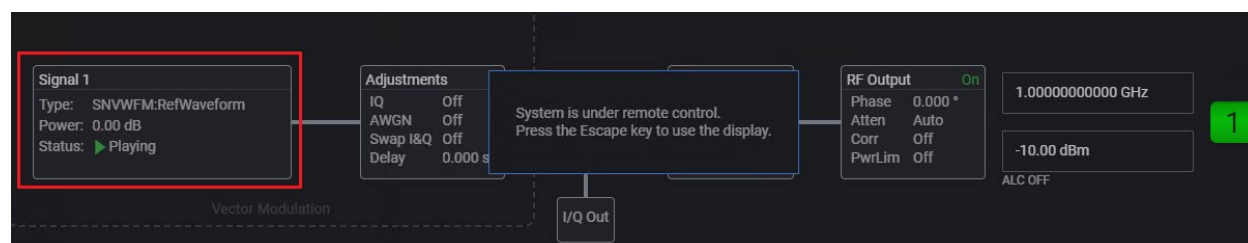

Figure 5. VXG screen display after reference waveform is downloaded from SA to SG

Digital Pre-distortion and Post-DPD Measurements

As you may know, PA is required to have higher linearity to amplify high PAPR signals. However, due to the limitations of cost, power consumption, and physical space, it is not easy to find higher linearity components that meet all of a particular system's requirements especially for wideband system like 5G, WLAN or Satellite Communication. DPD, one of the most cost-effective linearization techniques, adds an expanding non-linearity in the baseband that complements the compressing characteristic of the RF power amplifier (Figure 5). Ideally, the cascade of the pre-distorter and the power amplifier becomes linear and the original input is amplified by a constant gain. With the pre-distorter, the power amplifier can be utilized up to its saturation point while still maintaining good linearity, thereby significantly increasing its efficiency (Figure 6).
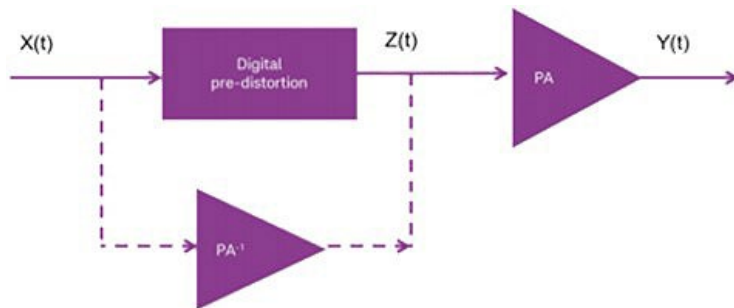

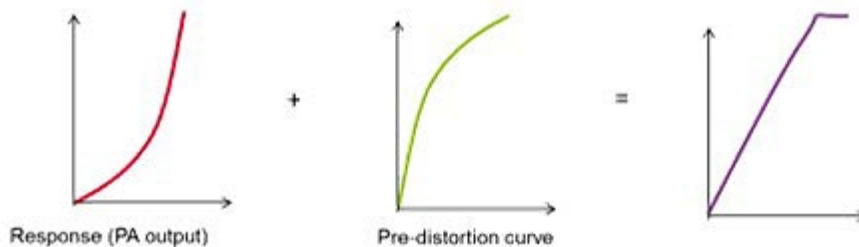**Figure 6.** DPD for a PA cascade

Figure 7. PA response with DPD

As shown in Figure 7, the DPD can be seen as an "inverse" of the PA. The DPD algorithm needs to model the PA behavior accurately and efficiently for successful DPD deployment.

Two DPD modes are supported with N9055EM0E:

- **Extract and Apply**: When DPD Mode is set to "Extract and Apply" (default), Power Amplifier measurements are done by measuring the post-distorted waveform played in SG. Once DPD process is completed, the pre-distorted waveform is generated inside SA, and then downloaded into SG again.
  - Four PA model types are supported: Memory polynomial, Volterra series, Iterative Learning Control (ILC), and LUT (Look-Up Table)
  - Users can specify the number of iterations
  - For memory polynomial and Volterra series memory model types, users can specify the memory order and non-linear order
  - The DPD model can be exported for further verification
  - Customer's proprietary DPD algorithm written in MATLAB (coming later)

- **Apply Only**: The waveform is directly pre-distorted according to the specified DPD mode
  - If the PA Model Type is LUT (Look-up Table), the waveform is pre-distorted with the user input DPD model file of PA input versus PA output in terms of amplitude and phase;
  - If the PA Model Type is Memory Polynomial or Volterra Series, the waveform is pre-distorted with the Memory Polynomial or Volterra Series Coefficient File.
  - Waveform is directly pre-distorted with the user input LUT or coefficient file, loaded using Recall function of Signal Analyzer.

The required measurement bandwidth for acquiring signals will be determined by the bandwidth to be optimized. For example, to cover the channel adjacent to a 400 MHz 5G NR signal or 320 MHz 802.11be signal, 1200 MHz or 960 MHz bandwidth must be available for capture. The X-Series signal analyzers UXA N9042B together with M9484C VXG can support a maximum bandwidth up to 2 GHz, which can provide bandwidth for analyzing DPD-applied waveforms with 400 MHz 5G NR FR2 signals or 320 MHz WLAN 802.11be signals.

Toggle between Pre-DPD and Post-DPD measurements

You can toggle measurement results between Pre-DPD (measuring Reference Waveform) or Post-DPD (measuring DPD Waveform), by turning DPD state.

In addition to explicitly setting DPD state to off, if a parameter is changed that needs to re-calculate DPD LUT or coefficients, the DPD State will be changed to off.
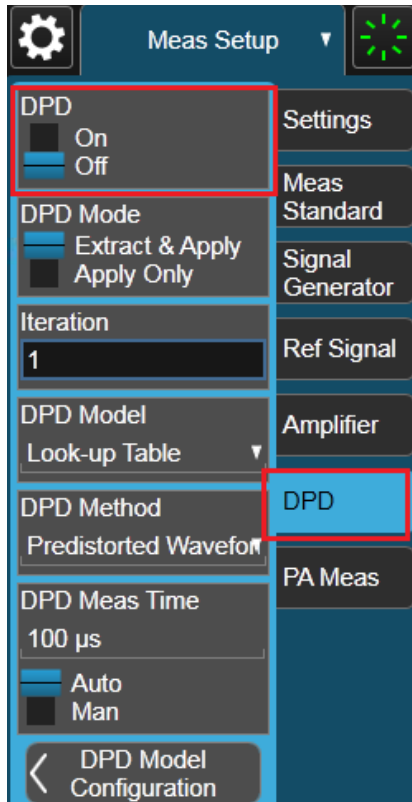

Figure 8. Toggle the DPD On / Off to switch between Pre-DPD and Post-DPD measurements

Enable Demod EVM in Power Amplifier Measurement Application

N9055EM0E Power Amplifier measurement application doesn't provide complicated EVM configuration. All the demodulation EVM parameters are synchronized from the measurement mode such as N9085EM0E for 5G NR and N9077EM1E/N9077EM2E for WLAN. So please make sure you have the 5G NR or WLAN license installed and the signal can be correctly demodulated in 5G NR or WLAN measurement application. You can either switch measurement Mode from Power Amplifier to 5G NR or open a new window for 5G NR mode as the example of Figure 8. When the EVM State is turned on in the Power Amplifier, demodulation EVM parameters will be synchronized from 5G NR mode automatically.
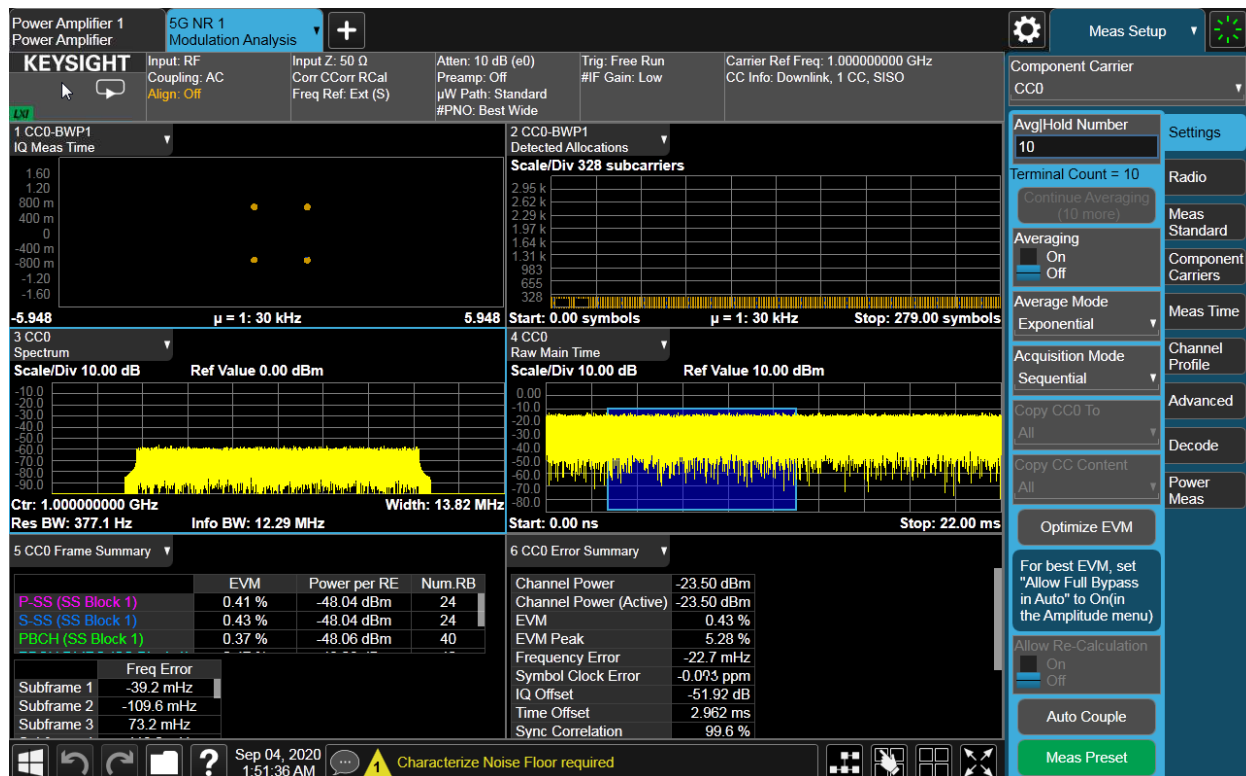

Figure 9. Switch from PA Test mode to 5G NR mode to check the correct demodulation settings

Enable "Optimize EVM"

You can turn on "Optimize EVM" in EVM configuration dialog, to get the optimized EVM result, Optimize EVM is designed as an "On/Off" state because there are multiple sub-measurements in one PA measurement loop such as ACP or EVM. As ACP and EVM use different hardware configurations, especially Mechanical Attenuator, then you'll hear a click noise when Mechanical Attenuator is adjusted. You can use "Single Mode" to avoid the continuous adjusting of the attenuator.

It is recommended to turn on "Optimize EVM" only in EVM vs. Power measurement, when Meas Type = Power Sweep; or use single mode when Meas Type = Single Power.

EVM vs. Power Measurement

The default measurement type is "Single Power" which means it will only make EVM measurement at the specified power. If you want to make the Power vs. EVM measurement, you can toggle the Meas Type from Single Power to Power Sweep, and then specify the Start Power, Stop Power, and Power Step. Min Power with DPD can also be specified, so only the power above the specified level will apply the DPD. You can toggle Extract DPD Once as On for only one time of DPD model extraction or it can extra the DPD model for each power level.
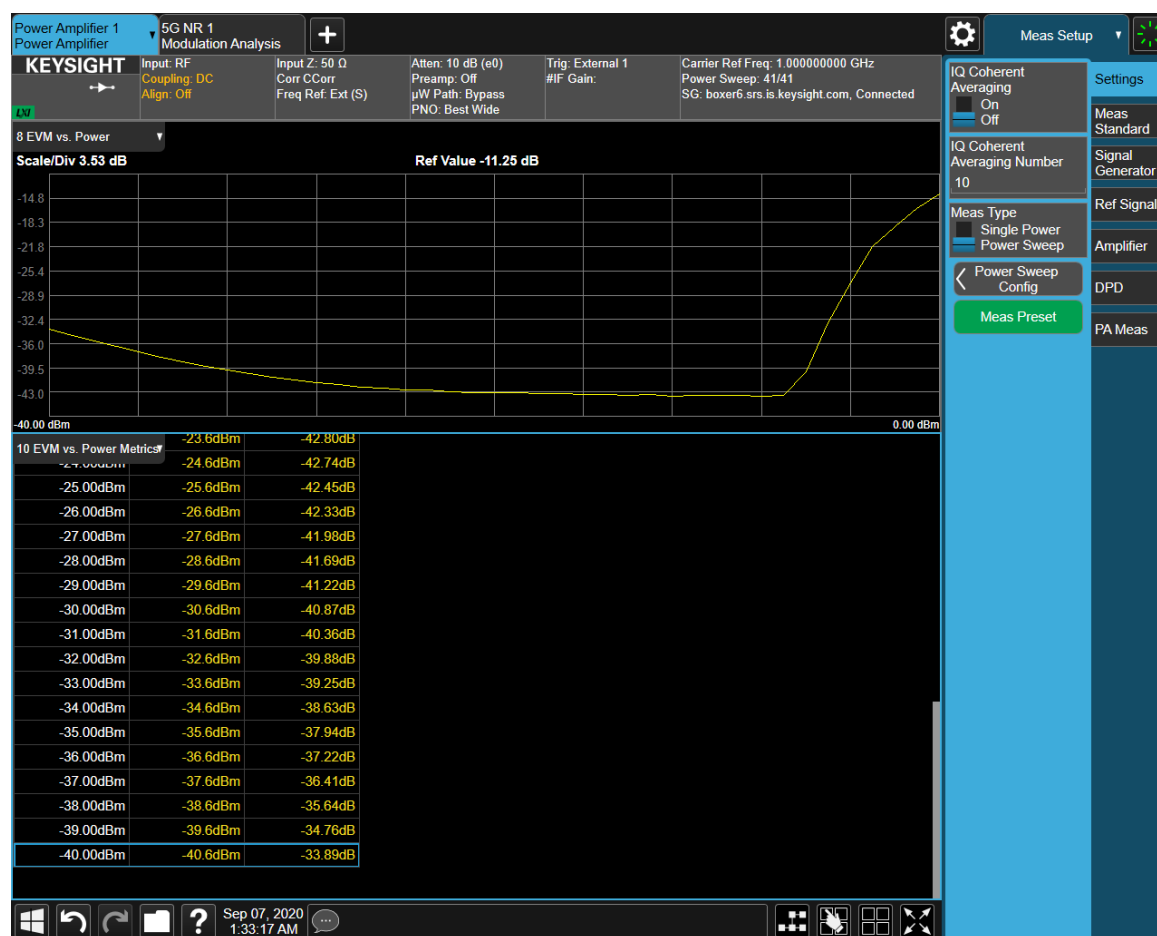

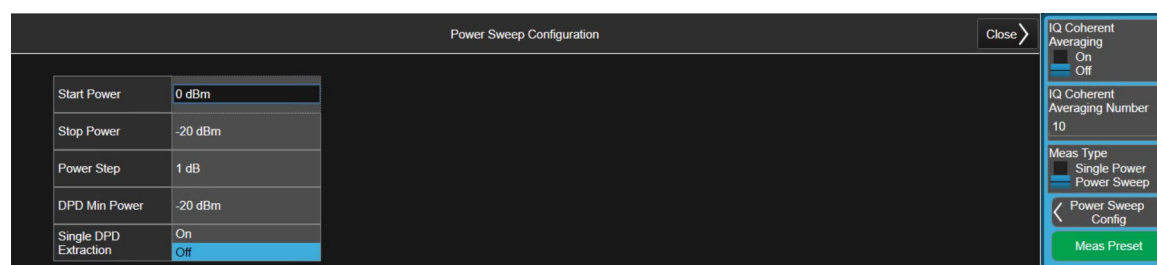**Figure 10.** Power vs. EVM result for 5G NR signal with DPD

Figure 11. Switch Meas Type from Single Power to Power Sweep and show the Power Sweep parameter settings

Apply DPD Directly to M9384B/M9484C VXG

M9384B or M9484C VXG supports DPD LUT (Look-Up Table) and Memory Polynomial models with FW version A.06.xx or later. Then N9055EM0E Power Amplifier measurement application doesn't need to download the Pre-distorted waveform into M9384B or M9484C VXG. N9055EM0E Power Amplifier measurement application just sends the DPD LUT or Memory Polynomial coefficients directly to M9384B or M9484C VXG, via SCPI command. This can significantly improve the overall PA test speed. You can see the flag "D" is shown on M9384B or M9484C VXG GUI. This means the DPD model is now enabled in M9384B VXG. When the connected SG is connected and detected with this feature, it will automatically switch the DPD Method from "Pre-distorted Waveform" to "Generator".
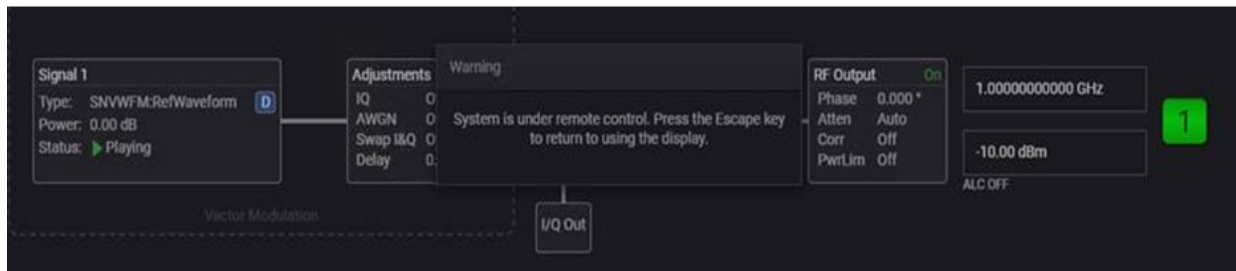

Figure 12. VXG front-panel display with DPD LUT enabled

Burst Formation & Mask for PA Enabled Signal

To improve the efficiency, the power amplifier (PA) can work in an energy saving mode. In this mode, an On-Off signal is used to turn the PA on or off. The PA is on when this signal is on, and it is off when this signal is off. This signal can be called PA enabled signal, which is a burst mask over the PA input signal. Now N9055EM0E can enable or disable the reconstruction of the reference waveform and its mask signals for users to evaluate the impact of the power supply On / Off of the PA on the EVM readouts.

When Burst Shape & Mask is enabled, zeros will be added before (@T1 as Lead Interval) and after (@T3 as Lag Interval and @T4 as Idle Interval) the resampled reference waveform as well as its Marker 1 signal. And a PA Enable Mask (the blue waveform in the diagram below) is constructed during the procedure so that a cyclic burst, of which the period is T1 + T2 + T3 + T4 and the duty cycle is (T1 + T2 + T3) / the period * 100%, is yielded and fed to the switch of the power supply of the PA under test.
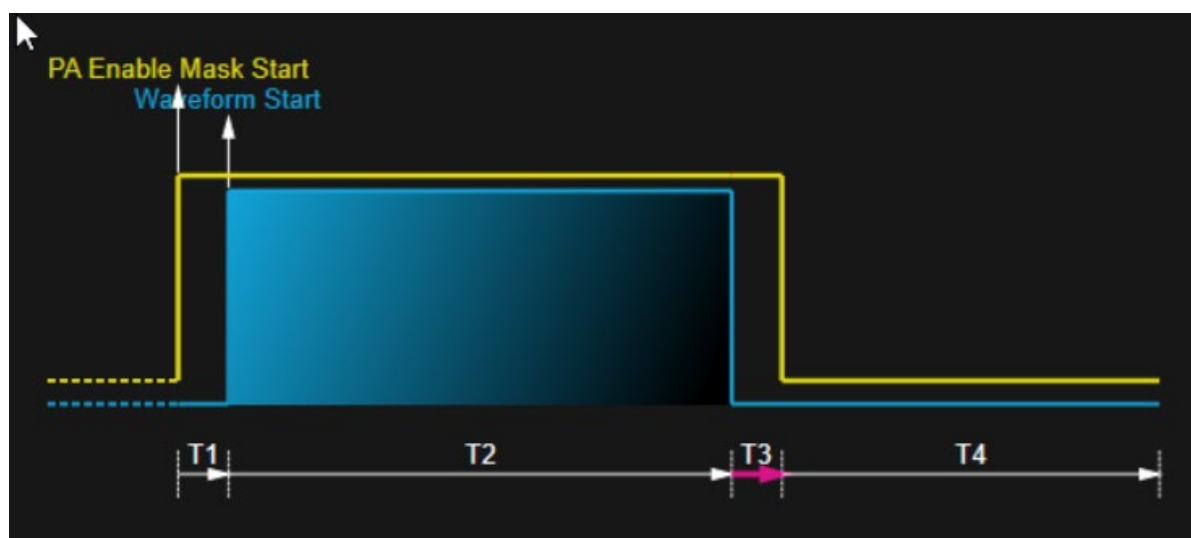

Figure 13. Burst Formation Mask for the PA Enabled Signal

Envelope Tracking Testing

Envelope tracking is an adaptive power control scheme for RF power amplifiers in which the RF PA power supply is dynamically adjusted to match the envelope of the transmit signal and delivers higher voltages only when needed, improving battery consumption and heat dissipation in the PA.

Envelope tracking provides two key system benefits:

- Maximum RF PA efficiency for longer battery life and usage time
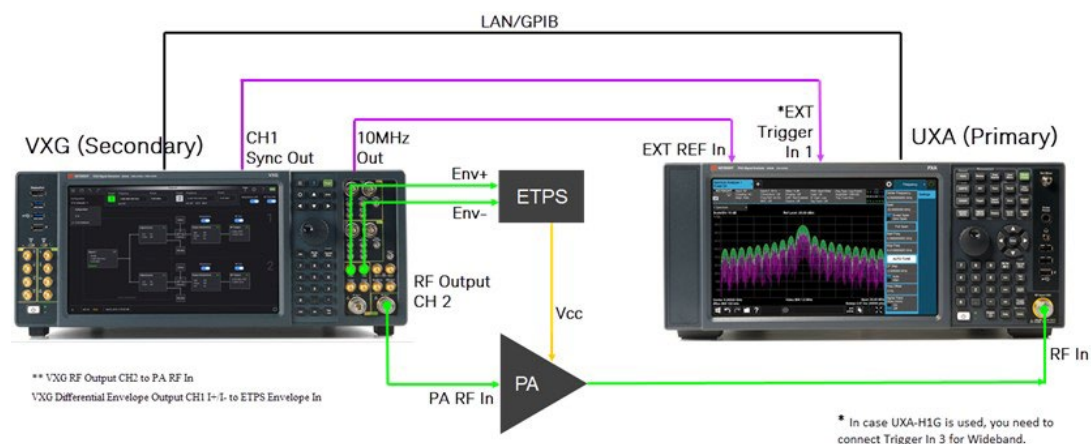- Maximum RF PA heat reduction

Figure 14. The instrument connection of Power Amplifier measurement with Envelope Tracking

Oversampling

The envelope is generated from the IQ sample's absolute magnitude, typically with 3x to 6x oversampling applied in order to create a wider bandwidth waveform. The basic sample rate of a 20 MHz LTE signal is 30.72 MHz and the envelope's sample rate will be 92.16 MHz for 3x oversampling and 184.32 MHz for 6x oversampling.

Shaping table

Raw envelope data generated from the IQ signal will go through the shaping table before being applied to the ET power supply (ETPS). Typically, the shaping table has a so-called "de-troughing" function to avoid having the envelope voltage drop down to 0 V. Shaping tables are usually based on maximum efficiency operation.

Timing alignment

ETPS dynamically adjusts the power supply voltage to the PA. As defined in the MIPI™ Alliance's eTrak standard, most ETPS have differential inputs and therefore, the envelope waveform generator must have differential output. ETPS output is applied to the PA's supply line. This voltage has to be applied to the PA with precise timing relative to the input RF signal. Typically, the timing alignment between RF and envelope has to be less than 1 ns. Rough timing adjustments between RF and envelope can be achieved with an oscilloscope before connecting to the ETPA and ETPS. However, due to internal delays in the ETPS and the RF PA, the final tuning has to be done with the ETPA output using parameters such as EVM or ACLR. Precise timing adjustments, down to a fraction of a nanosecond, may be required to optimize ET system performance.

Feature Summary

Feature	Parameter setting
General settings	IQ Coherent Averaging: On / Off
	Meas Type: Single Sweep or Power Sweep
	Power Sweep Config: Start Power, Stop Power, Power Step, DPD Min Power, Single DPD Extraction On / Off
Signal generator	Frequency
	RF Output: On / Off
	RF Off After Meas Preset: On / Off
	DC Calibration: On / Off
	ALC: On / Off
	Run-time Scaling: 70% (default)
	VXG: Channel 1 or Channel 2
	Apply settings to Signal Generator
	Connection Management
Measurement standard	Radio Standard Presets
	• 5G NR (BTS 10 MHz to 400 MHz and MS 5 to 400 MHz)
	• WLAN: 802.11a (20MHz), 802.11n (20/40MHz),802.11ac/ax 20/40/80/160 MHz
	• 802.11be 20/40/80/160/320 MHz[3]
	• Preset from WLAN Mod Accuracy
	5G NR settings
	• FR1 or FR2
	• SCS: 15/30/60/120 kHz
	• Preset from 5G NR EVM
Reference signals	Signal Studio or user-defined
	• Signal Studio waveforms
	• User defined types:
	∘ CSV/TEXT files[1]
	∘ Big Endian 16 bits
	∘ VSA Files (*.sdf)
	∘ MATLAB files
	Waveform Sample Rate
	Waveform Processing (Predefined Resampling Ratio with 1 as default)
	Crest Factor Reduction: Peak Cancellation, Clipping and Filtering
	Burst Formation & Mask (On/Off, Lead Interval/T1, Lag Interval/T3, Idle Interval/T4, Waveform Interval/T2)[2]
	Export to Signal Generator
	Support for recalling Complex Correction (*.s2p) files

1. This feature requires the M9384B VXG with FW version A.06 or above.
2. This feature requires the N9055EM0E with license version above 2021.1101.
3. NC-EVM (Noise Corrected) technology is supported with PXI VXT3 M9415A for WLAN 802.11be 320MHz.

Feature	Parameter setting
Amplifier settings	Max Input Power
	Loss In
	Gain
	Power Control Mode: PA Input or PA Output
	Input Power
Digital Pre-Distortion (DPD)	DPD Mode: On / Off
	DPD Mode
	• Extract and apply
	• Apply Only
	DPD Iteration: 1 to 100
	Meas DPD Iteration: On / Off
	DPD Model
	• Look-up table • Memory polynomial • Volterra series • Iterative Learning Control (ILC) also known as Direct DPD • Generalized Memory Polynomial (GMP) DPD • User-defined DPD model in MATLAB scripts
	DPD Mode: Generator or Pre-distorted Waveform
	• Generator supports the LUT and Memory Polynomial[1] DPD models
	DPD Meas Time: Auto or Manual
	LUT: Normalized or Absolute, LUT Size, AM / AM and AM / PM Polynomial order
	Memory Polynomial: LES using QR or SVD, Memory Order, Non-linear Order and Odd Orders Only On / Off
	Volterra Series: LES using QR or SVD, Memory Order, Non-linear Order Cross Term Order, and Odd Orders Only On / Off
	DPD Measure Time: Auto / Manual
PA measurement	AM / AM: polynomial order
	AM / PM: polynomial order
	ACP: RWB, Measurement Type, Power Ref Type, Carrier settings, Offset settings
	Radio Format: 5G NR, LTE-FDD or WLAN
	EVM: On / Off
	Report EVM in dB: On / Off
	EVM Meas Time
	Optimize EVM: On / Off
	Preset from 5G NR EVM, LTE-FDD or WLAN EVM
	Phase Noise Optimization: Auto or Best Close-in Noise, Balance Noise and Spurs, Best Spurs, Best Wide-Offset Noise, Fast Tuning
	Trigger Compensation: On / Off
	IF Gain: Auto or Low Gain / High Gain / Other
	Spectrum: Invert or Normal

1. This feature requires the M9384B VXG with FW version A.06 or above.

Feature	Parameter setting
Envelope tracking[1]	Envelope Tracking: On / Off
	Envelop Tracking Source: Non-Predistorted waveform, Predistorted waveform
	Envelope OSR: 1~32
	Conversion Input Type: Normalized I/Q Amplitude, Abs RF Output Voltage, Override Absolute RF
	Edit Shaping Table:
	Envelope SG & ETPS Configuration: Envelope Signal Generator Settings, ETPS settings
	Envelope delay (seconds)
	Envelope waveform saving[2]
Measurement (Common)	AM-AM trace (Pre-DPD and Post-DPD) (switches for On / Off)
	AM-PM trace (Pre-DPD and Post-DPD) (switches for On / Off)
	Number Results with Pre-DPD and Post-DPD (Delta EVM, Input Power, Output Power, Gain, Crest Factor In, Crest Factor Out)
	EVM Error Summary with Pre-DPD and Post-DPD (Channel Power, Channel Power / Active, EVM, Peak EVM, Frequency Error, Symbol Clock Error, I/Q Offset, Sync Correlation, Sync Source, Magnitude Error, Phase Error, I/Q Gain Imbalance, I/Q Quad Error, I/Q Time Skew, Cell ID)
Measurement (ACP)	ACP graph with Pre-DPD and Post-DPD with marker
	ACP Metrics with Pre-DPD and Post-DPD
	Total Carrier Power, Total PSD Offset frequency, Integration BW, Filter, ACP value (dBc and dBm)
Measurement (EVM Metrics)	EVM Metrics • Frequency Offset • Channel Power (Pre-DPD and Post-DPD) • Composite EVM (Pre-DPD and Post-DPD) • Peak EVM (Pre-DPD and Post-DPD) • Frequency Error (Pre-DPD and Post-DPD) • Sync Error (Pre-DPD and Post-DPD) • I/Q Offset (Pre-DPD and Post-DPD)
Measurement (EVM vs. Power)	EVM vs. Power trace with marker
	EVM vs. Power Metrics (Total Power, Carrier Power, EVM)
Measurement (DPD Iteration)	DPD Iteration EVM trace
	DPD Iteration ACP trace
	DPD Iteration Metrics (DPD iteration, ACP Lower Offset, ACP Upper Offset, Delta EVM, RMS EVM)

1. This feature requires the N9055EM0E with license version above 2021.1101.
2. This feature requires the N9055EM0E with license version above 2023.0801.

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

Try before you buy!

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

Power amplifier measurement application (N9055EM0E or E9055EM0E)

Power amplifier measurement application, Multi-touch (N9055EM0E)

Software license type	Software license	KeysightCare subscription
Node-locked perpetual	R-Y5C-001-A	R-Y6C-001-y[2]
Node-locked time-based	R-Y4C-001-z[1]	Included
Transportable perpetual	R-Y5C-004-D	R-Y6C-004-y[2]
Transportable time-based	R-Y4C-004-z[1]	Included
Floating perpetual (single site)	R-Y5C-002-B	R-Y6C-002-y[2]
Floating time-based (single site)	R-Y4C-002-z[1]	Included
Floating perpetual (worldwide)	R-Y5C-010-J	R-Y6C-010-y[2]
Floating time-based (worldwide)	R-Y4C-010-z[1]	Included
USB portable perpetual	R-Y5C-005-E	R-Y6C-005-y[2]
USB portable time-based	R-Y4C-005-z[1]	Included

One-month KeysightCare Support and Subscription

Software license type	
R-Y6B-501	1-month extension for node-locked perpetual license
R-Y6B-504	1-month extension for transportable perpetual license
R-Y6B-502	1-month extension for floating (single site) perpetual license
R-Y6B-510	1-month extension for floating (worldwide) perpetual license
R-Y6B-505	1-month extension for USB portable perpetual license

1. z means different time-based license duration. F for 6 months, L for 12 months, X for 24 months, and Y for 36 months. All time-based licenses have included the support subscription same as the time-base duration.
y means different support subscription duration. L for 12 months (as default), X for 24 months, Y for 36 months, and Z for 60-months. Support subscription must be purchased for all perpetual licenses with 12-months as the default. All software upgrades and KeysightCare support are provided for software licenses with valid support subscription.
2. Support subscription for all perpetual licenses can be extended with monthly extensions.

Hardware and Software Configuration

Model	Description	Additional information
Software		
N9055EM0E	Power Amplifier Measurement Application	Required
N9085EM0E	5G NR Measurement Application	5G NR EVM
N9080EM0E	LTE/LTE-A FDD Measurement Application	LTE FDD EVM
N9077EM0E	WLAN 802.11a/b/g/j/p/n/af/ah Meas Application	802.a/n EVM
N9077EM1E	WLAN 802.11ac/ax Measurement Application	802.11ac/ax EVM
N9077EM2E	WLAN 802.11be Measurement Application	802.11be EVM
N7631EMBC	Signal Studio for 5G NR, Waveform playback	5G NR waveforms
N7617EMBC	Signal Studio for WLAN, Waveform playback	WLAN waveforms

Hardware and Software Configuration

Model	Description	Additional information
N9041B/N9040B UXA and N9030B PXA signal analyzers		
526/532/544/550	Frequency range, up to 26.5, 32, 44 or 50 GHz	One required
B1X/B2X/B5X/H1G	Analysis bandwidth, 160[1], 255, 512 MHz or 1 GHz[2]	One required
P26/P32/P44/P50	Preamplifier, 26.5, 44, 50 GHz or 50 GHz basic	Optional
N9032B PXA and N9042B UXA extended signal analyzer		
508/513/526	Frequency range, up to 8.4, 13.6 or 26.5 GHz	One required
R10/R15/R20	Analysis bandwidth, 1, 1.5, or 2 GHz	One required
P08/P13/26	Preamplifier, 8.4, 13.6, or 26.5 GHz	Optional
526/544/550	Frequency range, up to 26.5, 44 or 50 GHz	One required
R10/R15/R20/R40	Analysis bandwidth, 1, 1.5, 2, or 4 or GHz	One required
P26/P44/P50/P5L	Preamplifier, 26.5, 44, 50 GHz or 50 GHz basic	Optional
M9484C VXG microwave signal generator		
M9484B-001	One channel, Option 002/003/004 adding channel 2/3/4	One required
506/508/514/520/532/544/554	Frequency range, 9 kHz to 6, 8.5, 14, 20, 31.8, 44, 54 GHz	One required
B1X/B2X/B5X/R10/R1E/R25	RF bandwidth, 160 MHz, 250 MHz, 500 MHz, 1 GHz, or 2.5 GHz	One required
500/600	High performance reference, enhanced high performance reference	One required
ST5/ST6	Low phase noise, enhanced low phase noise	One required
1EA/1EB/1EC/1EE	High output power from 9kHz GHz to 8.5, 20, 44/54, 43.5 GHz	Optional
M05/M10/M20/M40	Baseband generator memory upgrade to 512, 1024, 2048, 4096 MSa	Optional
N5186A MXG signal generator		
N5186A-001	One channel, Option 002/003/004 adding channel 2/3/4	One required
503/506/508	Frequency range, 9kHz to 3, 6, 8.5 GHz	One required
B2X/B5X/B9X	RF bandwidth, 250 MHz, 500 MHz, 960 MHz	One required
M05/M10/M20	Baseband generator memory upgrade to 512, 1024, 2048 MSa	Optional
1EA	High output power	Optional
EP3/EP4	Low phase noise, enhanced low phase noise	Optional
PXI VXT vector transceiver		
F06/F08/F12	Frequency range to 6 GHz, 8 GHz, 12 GHz	One required
B3X/B6X/B12	Bandwidth 300 MHz, 600 MHz, 1.2 GHz (M9410A/11A)	One required
B4X/B8X/B12	Bandwidth 400 MHz, 800 MHz, 1.2 GHz (M9415A/16A)	One required

1. B1X option for 160 MHz analysis bandwidth is only qualified with N9030B PXA.
2. N9041B UXA only qualifies with H1G option for 1GHz analysis bandwidth.

Additional Information

Websites

- X-Series measurement applications: www.keysight.com/find/X-Series_apps
- Download X-Series measurement application: www.keysight.com/find/X-Series_apps_software
- Learn about compatible instruments: www.keysight.com/find/X-Series_apps_platform
- 30-day trial license for X-Series measurement application: www.keysight.com/find/X-Series_apps_trial
- X-Series Signal Analyzers: www.keysight.com/find/X-Series_SA
- M9484C VXG Microwave Signal Generator: www.keysight.com/find/VXG
- N7614C Signal Studio for Power Amplifier: www.keysight.com/find/N7614C
- N9055EM0E Power Amplifier measurement application: www.keysight.com/find/N9055EM0E

Literatures

- X-Series Measurement Application, Brochure, 5989-8019EN
- 5G NR Measurement Application Technical Overview, 5992-2916EN
- WLAN Measurement Application, Technical Overview, 5992-2840EN
- Signal Studio for 5G NR, Technical Overview, 5992-2762EN
- Signal Studio for WLAN, Technical Overview, 5992-2742EN
- N7614C Signal Studio for Power Amplifier, Technical Overview, 5992-2741EN

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