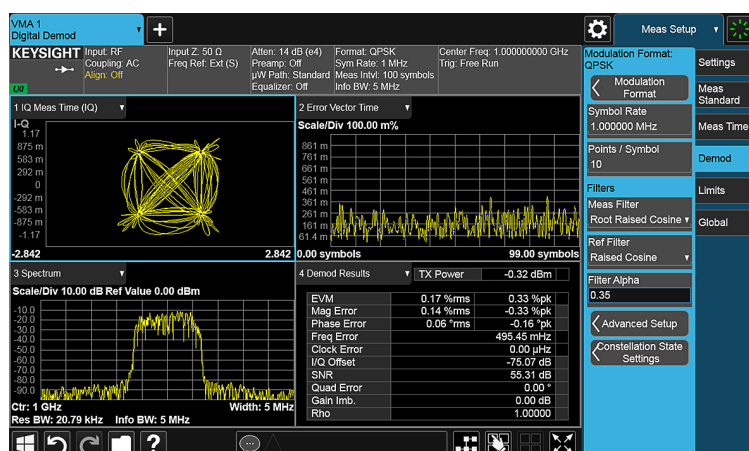# VMA Vector Modulation Analysis
X-Series Measurement Application, Multi-Touch UI

N9054EM0E for VMA Digital Demodulation
N9054EM1E for VMA Custom OFDM

– Perform standard-based and flexible digital demodulation analysis
– Perform custom OFDM demodulation analysis with user's configuration or recalling the 89600 VSA setup file or Signal Studio generated xSA setup file Multiple result traces and modulation quality results
– Spectrum measurements (monitor spectrum, channel power, OBW, CCDF, ACP, SEM and spurious)
– Multi-touch interface and SCPI remote interface
– Built-in, context-sensitive help
– Flexible licensing provides the option of using perpetual or time based licenses with one or multiple signal analyzers

KEYSIGHT
TECHNOLOGIES

VMA Vector Modulation Analysis Measurement Application

The VMA vector modulation analysis measurement application transforms the X-Series signal analyzers with multi-touch into vector signal analyzers by providing a wide range of measurements, digital types, and filters to perform comprehensive signal analysis, helping you thoroughly test your designs, ensure product quality, and optimize without compromise.

Flexible digital modulation analysis

The flexible digital modulation analysis adds the capability to visualize system perfor-mance rapidly and intuitively. Teamed with an Keysight X-Series signal analyzer, you can increase the speed of your measurement tasks with the flexibility this option offers:

- Support time domain measurement as I/Q waveform, spectrum measurement as monitor spectrum and modulation quality measurement as digital demod
- Customize modulation analysis formats including: 2-16 FSK, BPSk, QPSK, 8PSK, 16-1024QAM, DVB 16-256 QAM, MSK, ASK, APSK, VSB, Custom IQ etc.
- A complete set of measurement traces and modulation quality results, including raw main time, I/Q measurement time, I/Q measurement spectrum, EVM vs. symbol time, EVM spectrum, constellation, channel frequency response, EQ impulse response, EVM average/peak, magnitude error, phase error, frequency error, clock error, I/Q offset, SNR, quadrature error, gain imbalance, Rho and demod bits
- Convenient measurement preset to cover popular formats, including NADC, EDGE, PDC, PHS, DVB (16/32/64/256QAM), DVB-S2/S2X, TETRA, APCO-25, DMR, dPMR, WiSUN FSK and O-QPSK, DECT, VDL Mode 2, MIL-STD CPM and SOQPSK-TG

Flexible custom OFDM modulation analysis

- Support to configure user defined OFDM signal settings inside the measurement
- Support to recall 89600 VSA output *.setx setting files
- Support to recall Signal Studio Custom Modulation and Pre-5G (5GTF) output xSA *.xml setting files
- Convenient measurement preset including 5GTF, LTE (5 MHz), WLAN (802.11a), DOCSIS3.1 (Downstream and Upstream), DRM (ModeA/B 9K), DAB (Mode I), CDR (Tx Mode1)

Testing when no commercial test standard is available

The flexible digital modulation analysis option will help you design tests for proprietary and custom signals. It covers the demands of testing for single carrier, single modulation signals with a deep set of flexible modulation analysis tools that you can tweak to meet your needs. In addition, these flexible tools are SCPI programmable.

X-Series measurement applications

X-Series measurement applications increase the capability and functionality of Keysight Technologies, Inc. signal analyzers to speed time to insight. They provide essential measurements for specific tasks in general-purpose, cellular communications, wireless connectivity applications, covering established standards or modulation types. Applications are supported on both benchtop and modular, with the only difference being the level of performance achieved by the hardware you select.

Top Features

Visualize custom QPSK modulation analysis

Figure 1 shows QPSK modulation analysis with 1 MSa/s symbol rate, raised cosine filter alpha as 0.5. Modulation quality results are shown in quad view layout:
- Upper left: IQ constellation
- Lower left: spectrum
- Upper right: error vector magnitude versus time (symbol) trace
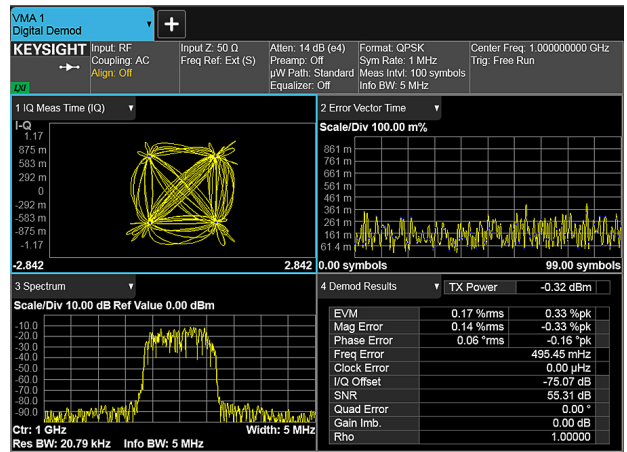- Lower right: demod results table

Figure 1.

I/Q waveform RF envelope analysis

Figure 2 shows the I/Q waveform RF envelope measurement. Meas time, sample rate etc. parameters are settable and the measurement results like Mean power, Pk-To-Mean ratio, Max power and Min power are shown at the bottom of the screen.
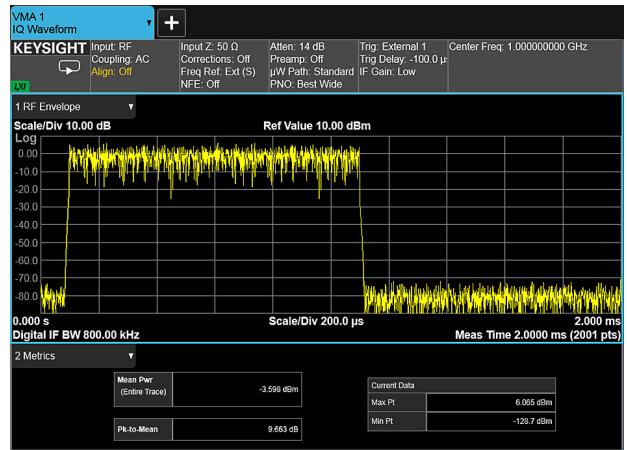

Figure 2.

Monitor spectrum

Figure 3 shows the spectrum measurement with monitor spectrum, which uses signal analyzer sweep mode with marker function band power turning on. Other spectrum measurements are also available like channel power, OBW, CCDF, ACP, SEM and spurious measurements.
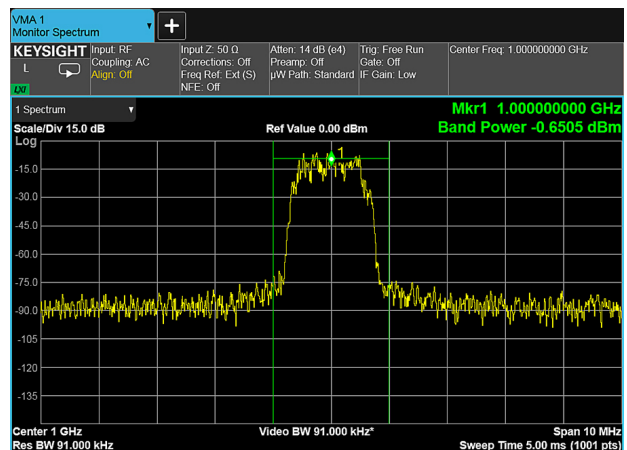

Figure 3.

APCO-25 modulation analysis

Figure 4 shows the modulation quality measurement for APCO-25 standard which is one of the more than 20 preset standards included in N9054EM0E. It shows a 2X2 layout with trace results:
- Constellation (upper left),
- Raw main time (upper right)
- Spectrum (lower left)
- Demod results (lower right)

Other trace results available can be chosen from the pop-up menu in each trace window.
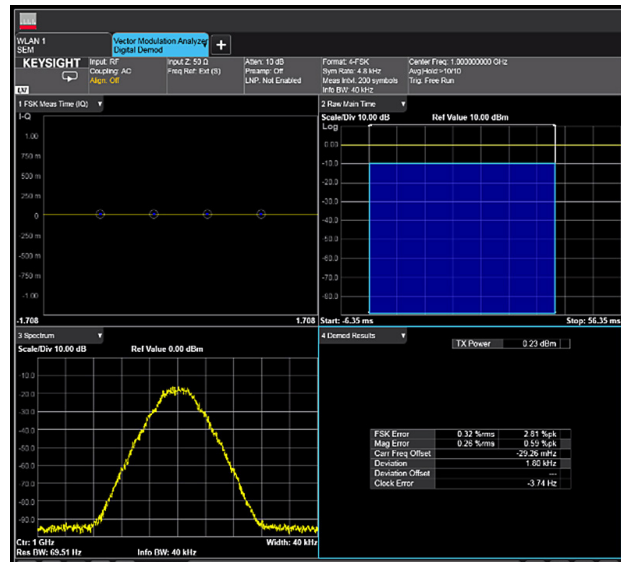

Figure 4.

Adjacent Channel Power (ACP)

Figure 5 shows the ACP measurement for a digital modulated signal.
- ACP measurement metrics (upper window)
- ACP measurement graph (lower window with Total carrier power, Lower and Upper ACP results vs. Reference carrier in both dBm and dBc formats)

Limit test is supported with Pass/Fail tag shown on the left top of the column.
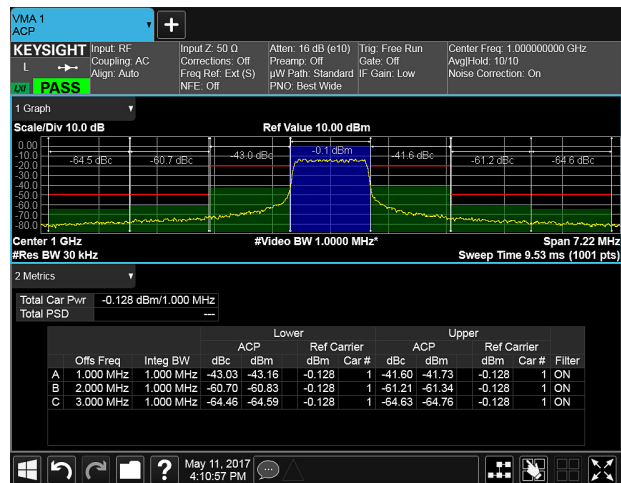
Figure 5.

Custom OFDM Modulation Analysis

Figure 6 shows the Custom OFDM modulation analysis based on the 89600 setting file (setx) recalled and exported from the N7630C Signal Studio for Pre-5G (5GTF). Note the following:
- Constellation view (upper left)
- I/Q Raw time (upper right)
- Spectrum view (lower left)
- Error summary with EVM, Data EVM, Freq Error, Symbol clock error, I/Q Offset, I/Q Quad Error, I/Q Gain Imbalance etc (lower right)
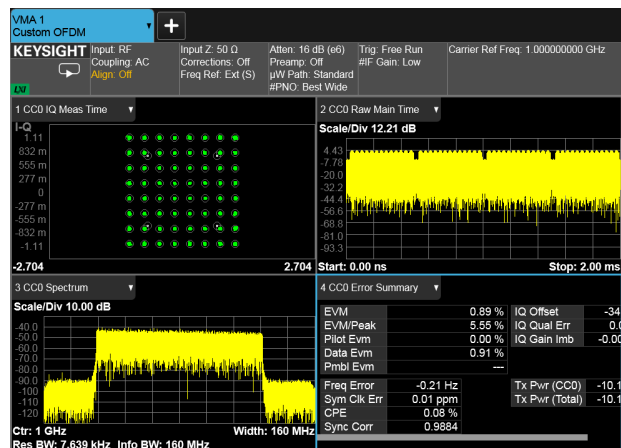
Figure 6.

ASK Modulation Analysis with Eye Diagram

Figure 7 shows the 2-ASK modulation analysis which is used in ETC standard.
  – Eye Diagram (upper left)
  – Demod metrics including the ASK error (RMS/Peak), Tx Power, Carrier Frequency Offset, Mod Depth and Est. Carrier Amplitude (upper right)
  – Spectrum (Lower left)
  – Eye diagram metrics for I and Q eye diagram (Lower right)

Figure 7.

Demod Bits & BER

Figure 8 is the Demod Bits and BER results shown for QPSK modulation with the PN-15 as payload. This measurement needs you turn on the BER under Meas Setup setting. To sync the measured bits with reference data, you may need to turn on the sync search and specify the sync pattern
  – BER results with Error Bits and Total Bits (you can specify the Total Bit Number under Meas Setup setting)
  – Demod Bits Data with measured bits are shown at odd rows and reference bits are shown at even rows

Figure 8.

Top Features

VMA Digital Demodulation Measurement Application

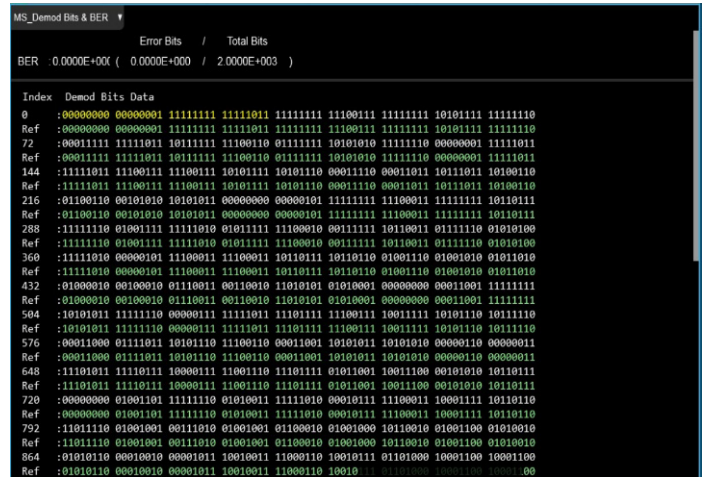| Standard Presets	
Cellular	NADC, EDGE, PDC, PHS (PHP)
Wireless networking	Wi-SUN (FSK), Wi-SUN (O-QPSK)
Digital video	ATSC 8/16VSB, DVB (16, 32, 64, 128, 256QAM), DVB-S2/S2X (16/32/64/128/256 APSK) [1, 3]
Radio	APCO-25 (C4FM/CQPSK, HCPM, HDQPSK), TETRA, DMR, dPMR
Other	DECT, VDL Mode 2, MIL-STD CPM (188-181C), SOQPSK-TG
Modulation Formats	
FSK	2, 4, 8, 16 level
	MSK (Type1 with specified differential decoder anchor state, Type2)
PSK	BPSK, D-BPSK, QPSK, OQPSK, DQPSK, D8PSK, π/4DQPSK, 8PSK, 3π/8 8PSK (EDGE), π/8 D8PSK, SOQPSK
QAM (absolute encoding)	16, 32, 64, 128, 256, 512, 1024, DVB-QAM (16, 32, 64, 128, 256)
APSK	16, 32
VSB	8, 16
ASK	2-ASK
Custom IQ	User defined constellation (support phase rotation, shift, differential and offset[4])
Filter types	Raised cosine, square-root raised cosine, Gaussian, EDGE, 1REC, 3RC, 4RC, APCO-25 P2 RC, SOQPSK-TG, low pass, rectangular, half-sine, user-defined, none
Alpha/BT	Continuously adjustable alpha from 0.05 to 1, and BT from 0.05 to 100
Symbol rate	Rate = Frequency span / (1+α); maximum symbol rate limited only by the measurement span
Equalizer	Equalizer On/Off, filter length, convergence, hold On/Off, recall equalizer coefficients from csv file [1]
FFT window	Flattop, gaussian, hanning, uniform
Optimization	Phase noise optimization (Best close-in noise, Best-wide offset Phase noise, Fast tuning), Gain imbalance/quad skew, Coupling on/off, Clock adjust, I/Q normalize on/off, Low SNR enhancement on/off, multi-carrier filter on/off, EVM normalization reference as constellation RMS or Max, I/Q Offset compensation on/off, I/Q rotation
Constellation state setting	User-friendly graph definition for constellation state
Limit test	Tx power, RMS EVM, frequency error, clock error settings for limit, customized trace limit
Measurement symbols	Up to 500,000 symbols
Flexible frame structure	Primary and secondary segments as separate settings (for DVB-S2/S2X measurements) [1]
Advanced analysis setup	Burst search Sync search (with user-selected synchronization word) Adjustable search length and offset timing
Measurements/displays	Monitor spectrum RF envelope I/Q waveform Spectrum measurements (channel power, occupied BW, ACP, SEM, CCDF and spurious) Raw main time Search time I/Q meas time (Real, Imag, Wrap Phase, Unwrap phase, IQ, Const, Eye I, Eye Q, Group Delay) I/Q ref time I/Q meas spectrum I/Q ref spectrum Error vector time Error vector spectrum Mag error Phase error Demod results (EVM %[4] or dB, SNR, freq error, clock error, SNR, quad error, gain imbalance, RHo) Demod bits & BER [2] Channel frequency response EQ impulse response Burst info (custom OFDM only) Eye digram metrics [2]

VMA Custom OFDM Measurement Application

Standard Presets	
Cellular	5GTF (PUSCH with QPSK, 16QAM or 64QAM); 3GPP LTE FDD (5 MHz, downlink)
Wireless networking	WLAN (802.11a)
Digital video	DOCSIS 3.1 (Downstream and Upstream), DRM (Model A/B 9K) [3]
Radio	DAB (Mode I); CDR (Tx Mode 1, Spectrum Mode 2 and Mode 10)
Other	None
Demodulation Settings	
Format	FFT length, Symbol sample frequency, Guard lower subcarrier, Guard upper subcarrier, Half subcarrier On/Off, DFT spread On/off, Transmitter window Beta setting
Resource	Preamble, Pilot (Known and Unknow), Data, Unspecified
Equalizer & Tracking	Equalizer Use, Data, DC Pilot and Preamble (On/Off) Tracking with data subcarrier, amplitude, phase and timing (On/Off)
Filter	None, or Filter type as Arbitrary, Windowed Sinc, and Remez
Advanced	Synchronization settings, compensate symbol clock error (On/Off), EVM normalized reference (On/Off), Extended Lock range (On/Off)

Measurements/displays	Monitor spectrum
	 RF envelope
	 I/Q waveform
	 Spectrum measurement (channel power, occupied BW, ACP, SEM, CCDF, and spurious)
	 Modulation analysis
	   – Raw main time
	   – Search time
	   – I/Q meas time
	   – I/Q ref time
	   – Error vector time
	   – Error vector spectrum
	   – Common pilot error
	   – Error summary (EVM rmd/peak, Pilot EVM, Data EVM, Preamble EVM, frequency error, symbol clock, CPE, Sync correlation)
	   – Burst info for Preamble, Pilot, Data, All and Null (EVM, Power, Modulation format and RU)
	   – Channel frequency response
	   – EQ impulse response

Other features (for both N9054EM0E and N9054EM1E)	IQ data recording (Raw data txt, Signal Studio CSV, or 89600 VSA sdf files) [1] IQ data recalling (Raw data txt, Signal Studio CSV, 89600 VSA sdf files) [1] Optimize EVM (get better EVM results by improving SNR and avoiding ADC overload) [3]

Notes:

1. Those features requires the firmware above A.22.0x and your N9054EM0E or N9054EM1E license version date must be above 2018.1018.
2. This feature requires the firmware above A.25.0x and your N9054EM0E license version date must be above 2019.1101
3. This feature requires the firmware above A.26.0x and your N9054EM0E or N9054EM1E license version date above 2020.0220.
4. This feature requires the firmware above A.28.0x and your N9054EM0E license version date above 2020.1001.

Key Specifications

Definitions

– All of the values shown below are nominal. These values indicate expected performance, or describe product performance that is useful in the application of the product, but is not covered by the product warranty.

Note: Data subject to change.

This section contains specifications for the N9054EM0E Vector Modulation Analysis Measurement Application, which support PSK formats: BPSK, QPSK, Offset QPSK, Shaped OQPSK, DQPSK, π/4 DQPSK, 8-PSK, π/8 D8PSK, D8PSK; QAM formats: 16/32/64/128/256/512/1024-QAM; FSK formats: 2/4/8/16-FSK; MSK formats: MSK Type 1, MSK Type 2; ASK formats: 2-ASK; APSK formats: 16/32 APSK; VSB formats: 8/16-VSB; others: CPM (FM), EDGE.

Accuracy, nominal		UXA	PXA	MXA	EXA	CXA
Condition		Modulation formats include BPSK, QPSK, DQPSK, π/4 DQPSK, 8-PSK, π/8 D8PSK, D8PSK, 16/32/64/128/256/512/1024-QAM; Center Frequency = 1 GHz; Transmit filter is RRC with **α** = 0.35; Result length set to at least 150 symbols, or 3 × Number of ideal constellation states; Average number = 10.				
Residual errors	Symbol rate[1]					
Residual EVM	1 MSa/s	0.50%	0.50%	0.70%	0.70%	0.70%
	10 MSa/s	0.50%	0.50%	0.70%	0.70%	0.70%
	25 MSa/s	0.50%	0.50%	1.10%	1.10%	N/A
	100 MSa/s	0.50%	0.50%	1.30%	N/A	N/A
Condition		Modulation formats include MSK Type 1 and MSK Type 2; Center Frequency = 1 GHz; Transmit filter is Gaussian with BT = 0.3; Result length set to 150 symbols; Average number = 10.				
Residual errors	Symbol rate[1]					
Residual EVM	10 MSa/s	0.50%	0.50%	0.90%	0.90%	1.00%
	80 MSa/s	1.40%	1.40%	1.80%	N/A	N/A
Condition		Modulation formats include 8-VSB and 16-VSB; Transmit filter is RRC with **α** = 0.115; Center Frequency < 3.6 GHz; Result length = 800; Average number = 10.				
Residual errors	Symbol rate[1]					
	10.762 MHz	1.50% (SNR 36 dB)	1.50% (SNR 36 dB)	1.50% (SNR 36 dB)	1.50% (SNR 36 dB)	1.50% (SNR 36 dB)

1. Supportable symbol rate is dependent on the analyzer hardware bandwidth option.

For a complete list of specifications refer to the appropriate specifications guide.

UXA: http://www.keysight.com/find/uxa_specifications
PXA: http://www.keysight.com/find/pxa_specifications
MXA: http://www.keysight.com/find/mxa_specifications
EXA: http://www.keysight.com/find/exa_specifications
CXA: http://www.keysight.com/find/cxa_specifications

Ordering Information

Flexible licensing and configuration

- **Perpetual:** License can be used in perpetuity.
- **Time-based:** License is time limited to a defined period, such as 12-months.
- **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.
- **USB portable:** Allows you to move the license from one instrument/computer to another by end-user only with certified USB dongle, purchased separately.
- **Software support subscription:** Allows the license holder access to Keysight technical support and all software upgrades

VMA digital demodulation measurement application (N9054EM0E)

Software License Type	Support Contract	Support Subscription
Node-locked perpetual	R-Y5C-001-A	R-Y6C-001-z^2
Node-locked time-based	R-Y4C-001-z^1	Included
Transportable perpetual	R-Y5C-004-D	R-Y6C-004- z^2
Transportable time-based	R-Y4C-004-z^1	Included
Floating perpetual (single site)	R-Y5C-002-B	R-Y6C-002-z^2
Floating time-based (single site)	R-Y4C-002-z^1	Included
USB portable perpetual	R-Y5C-005-E	R-Y6C-005- z^2
USB portable time-based	R-Y4C-005-z^1	Included

VMA custom OFDM measurement application (N9054EM1E)

Software License Type	Support Contract	Support Subscription
Node-locked perpetual	R-Y5C-001-A	R-Y6C-001-z^2
Node-locked time-based	R-Y4C-001-z^1	Included
Transportable perpetual	R-Y5C-004-D	R-Y6C-004- z^2
Transportable time-based	R-Y4C-004-z^1	Included
Floating perpetual (single site)	R-Y5C-002-B	R-Y6C-002-z^2
Floating time-based (single site)	R-Y4C-002-z^1	Included
USB portable perpetual	R-Y5C-005-E	R-Y6C-005- z^2
USB portable time-based	R-Y4C-005-z^1	Included

One month software support subscription extensions [3]

Model	Description
R-Y6C-501	1-month of support subscription for node-locked perpetual license
R-Y6C-502	1-month of support subscription for floating perpetual license (single site)
R-Y6C-504	1-month of support subscription for transportable perpetual license
R-Y6C-505	1-month of support subscription for USB portable perpetual license

Hardware Configurations

To learn more about compatible platforms and required configurations, please visit: www.keysight.com/find/X-Series_apps_platform

Software Models & Options

To learn more about X-Series measurement application licensing, model numbers and options, please visit: www.keysight.com/find/X-Series_apps_model

1. z means different time-based license duration. F for six 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.
2. z 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.
3. Support subscription for all perpetual licenses can be extended with monthly extensions.

Hardware Configuration

For vector modulation analysis measurements, Keysight recommends a minimum level of X-Series multi-touch instrument hardware functionality at each instrument performance point.Supported instruments include:

Benchtop:
- UXA N9041B [1]
- UXA N9040B
- PXA N9030B
- MXA N9021B
- MXA N9020B
- EXA N9010B
- CXA N9000B

PXIe:
- VSA up to 6 GHz   M9391A
- VSA up to 50 GHz M9393A
- VXT   M9410A/M9411A
- VXT   M9421A
- VXT   M9415A
- CXA-m M9290A

1. Currently this measurement application has been qualified for N9041B Input Port 1 and Port 2.

Capability	Instrument Option	Benefit
Analysis bandwidth	10 MHz minimum or wider	**Required:** based on bandwidth of signal under test
Electronic attenuator	-EA3	**Recommended:** Fast and reliable attenuation changes ideal for manufacturing without the wear associated with mechanical attenuators up to 3.6 GHz in 1 dB steps
Pre-amplifier	3.6 GHz (-P03) or higher up to instrument maximum RF frequency as available	**Recommended:** For maximizing the measurement sensitivity
Microwave preselector bypass option	-MPB	**Required:** For measurements > 3.6 GHz
External Mixer	-EXM	**Recommended:** For mmWave measurement up to 110 GHz

Additional Information

Product webpages:
www.keysight.com/find/N9054E
www.keysight.com/find/N9054EM1E

X-Series measurement applications:
www.keysight.com/find/X-Series_Apps

X-Series signal analyzers:
www.keysight.com/find/X-Series

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at:
www.keysight.com/find/contactus

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