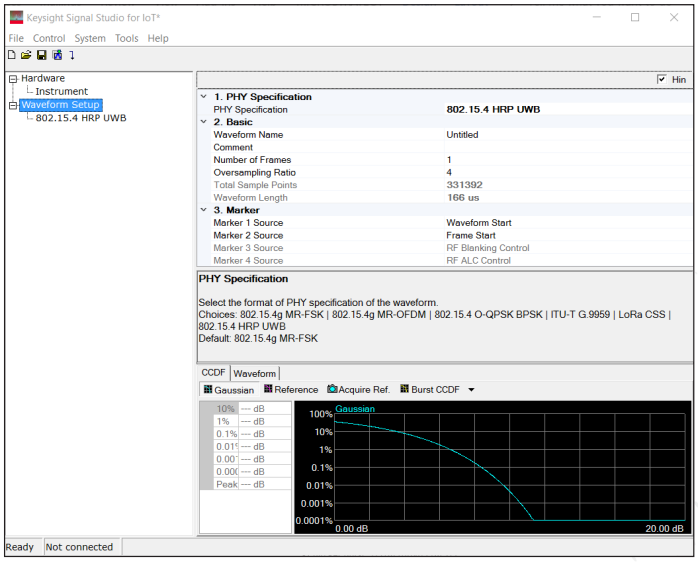
TECHNICAL OVERVIEW

N7610C Signal Studio for IoT

2021



- Create Keysight validated and performance-optimized reference signals compliant to IEEE 802.15.4 (for ZigBee), 802.15.4 (SUN FSK and SUN OFDM), LoRa CSS, ITU-T G.9959 (for Z-Wave), and 802.15.4/4z HRP UWB PHY standards
- Support ZigBee 2.4 GHz O-QPSK and BPSK modulation and spreading as defined in IEEE 802.15.4
- Support 802.15.4 mandatory profiles for SUN FSK and SUN OFDM PHY mode, respectively
- Support Z-Wave R1/R2/R3 data rate modes as defined in ITU-T G.9959
- Support LoRa CSS uplink signal creation with impairments
- Support IEEE 802.15.4 and 802.15.4z HRP UWB signal creation with impairments
- Provide signals with full-channel coding, flexible configuration of MAC headers and data types for receiver testing
- Accelerate the signal creation process with a user interface based on parameterized and graphical signal configuration and tree-style navigation

KEYSIGHT TECHNOLOGIES

Simplify IoT (Internet of Things) Signal Creation

Keysight Technologies, Inc. Signal Studio software is a flexible suite of signal-creation tools that will reduce the time you spend on signal simulation. For short range communications such as IoT and M2M, Signal Studio's performance-optimized reference signals - validated by Keysight - enhance the characterization and verification of your devices. Through its application-specific user-interface you'll create standards-based and custom test signals for component, transmitter, and receiver test.

Component and transmitter test

Signal Studio's basic capabilities use waveform playback mode to create and customize waveform files needed to test components and transmitters. Its user-friendly interface lets you configure signal parameters, calculate the resulting waveforms and download files for playback. The applications for these partially coded, statistically correct signals include:

- Parametric test of components, such as amplifiers and filter
- Performance characterization and verification of RF sub-systems

Receiver test

Signal Studio's advanced capabilities enable you to create fully channel-coded signals for receiver bit-error-rate (BER), block-error-rate (BLER), packet-error-rate (PER), or frame error rate (FER) analysis. Applications include:

- Performance verification and functional test of receivers, during RF/baseband integration and system verification
- Coding verification of baseband subsystems, including FPGAs, ASICs, and DSPs

More advanced capabilities operate in real-time mode, which is used to define the parameters of non-repeating and dynamically changing signals needed for receiver testing. A graphical user interface provides a direct instrument connection for parameter transfer and closed-loop or interactive control during signal generation.

Apply your signals in real-world testing

Once you have setup your signals in Signal Studio, you can download them to a variety of Keysight instruments and software platforms. Signal Studio software complements these platforms by providing a cost-effective way to tailor them to your test needs in design, development and production test.

- Vector signal generators
  - X-Series: MXG, EXG, and CXG
  - PSG
  - ESG[1]
  - First-generation MXG[1]
  - M9381A PXIe VSG
  - M9383A PXIe VXG (1 MHz to 44 GHz)
  - M9383B VXG-m Microwave Signal Generator (1 MHz to 44 GHz)
  - M9384B VXG Microwave Signal Generator (1 MHz to 44 GHz)
  - M9410A/M9411A/M9415A PXIe VXT
- Waveform playback supports
  - E6640A EXM wireless test
  - M9420A/M9421A
  - M8190A arbitrary waveform generator
  - M9336A PXIe AWG
  - P9336A USB AWG

1. N7610C 2019 update 1.0 or above doesn't support MXG-A N5182A and ESG E4438C.

Typical measurements

Test components the following capabilities:

- IMD/NPR
- ACLR
- CCDF
- EVM
- Modulation accuracy
- Code domain power
- Channel power
- Occupied bandwidth

Verify receivers with the following capabilities:

- Fully-coded 802.15.4 O-QPSK/BPSK
- 802.15.4 PHY SUN FSK and SUN OFDM
- ITU-T G.9959 Z-Wave FSK/GFSK
- LoRa CSS
- 802.15.4/4z HRP UWB
- Sensitivity
- Maximum input level
- Selectivity
- Blocking
- Intermodulation
- Power control

Component and Transmitter Test

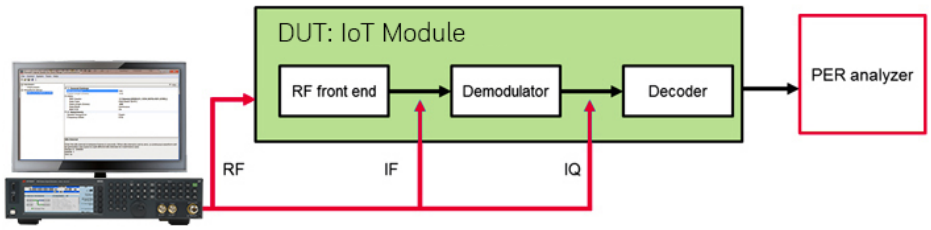


Figure 1. Generate fully channel-coded signals to evaluate IoT receiver PER with a Keysight MXG vector signal generator.

Most IoT (Internet of Things) technologies are implemented in small, low-cost IC forms or complete drop-in modules. Whether you're using single technology formats, such as ZigBee, or multi-format combination modules with WLAN, *Bluetooth*®, LoRa and ZigBee, Signal Studio software provides a flexible suite of signal-creation tools to reduce receiver testing time on chip-set design, validation and troubleshooting. Combined with Keysight signal generators, the N7610C provides performance-optimized reference signals to enhance the characterization and verification of Devices Under Test (DUTs). Through its application-specific user interface, engineers can create standards-based and custom test signals for component and receiver tests.

The N7610C provides advanced capabilities to address applications defined in IEEE 802.15.4 for ZigBee O-QPSK/BPSK, 802.15.4 for SUN FSK and SUN OFDM, LoRa CSS, ITU-T G.9959 for Z-Wave FSK/GFSK, and IEEE 802.15.4/4z HRP UWB. Use the baseband signal to perform demodulation and decoding verification on chips. To thoroughly test the demodulation capabilities of a module, a fully-coded test signal is necessary. This level of coding enables engineer to determine if each functional stage of a receiver is operating correctly and enables the use of the test signal to perform Packet Error Rate (PER) measurements.

The N7610C's graphical user interface provides a direct instrument connection for parameter transfer and closed-loop or interactive control during signal generation. After a signal is set up in Signal Studio, it can be downloaded into a variety of Keysight instruments. Signal Studio software complements these platforms by providing a cost-effective way to tailor them to the test needs in design, development and production test.

Top Features

Fully-coded IEEE 802.15.4 O-QPSK and BPSK signals for ZigBee PHY measurements

- Supports 2.4 GHz O-QPSK modulation and spreading
- Supports generation of PPDU with standard defined preamble, SFD and configurable PHY payload
- Supports generation of multi-packet signal with variable packet length and different payload
- Applies impairments to ideal signal, frequency offset and timing error

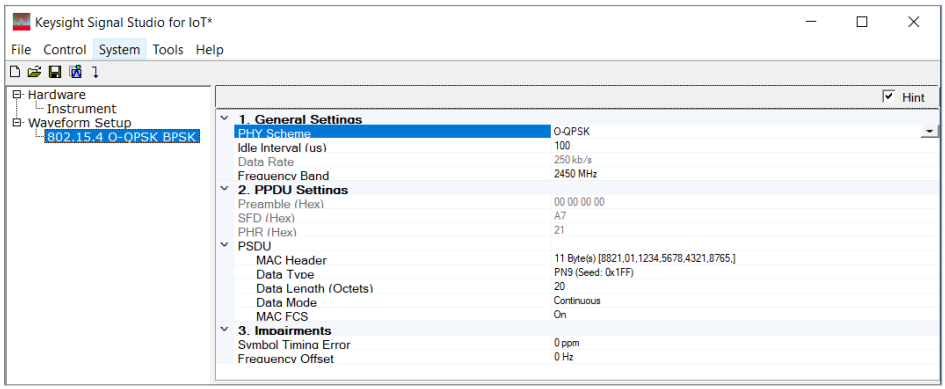


Figure 2. ZigBee O-QPSK configuration user interface

Easy to generate SUN FSK and SUN OFDM signals for 802.15.4 PHY measurements

- Supports multi-rate and multi-regional frequencies and multi-data rate combinations defined in IEEE 802.15.4 specifications
- Supports SUN FSK and SUN OFDM PHY formats
- Sets SHR and PHR in relevant tests separately
- Configures MAC header settings, MAC FCS, sequence control, data type, and data length
- Provides impairment tests with Symbol Timing Error, Frequency offset, and Frequency deviation

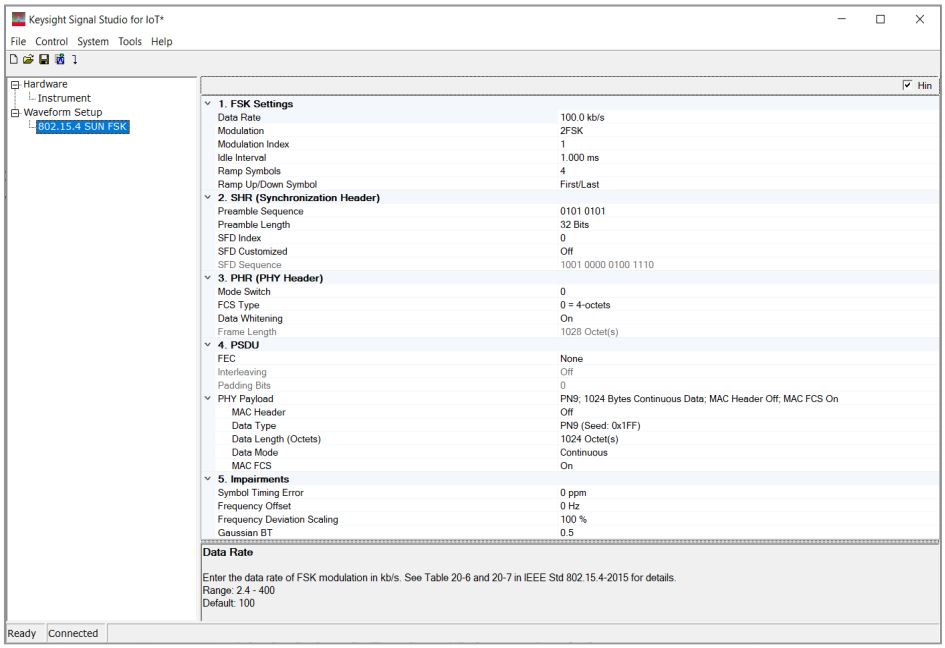


Figure 3. SUN FSK configuration user interface

Top Features (Continued)

Easy to generate LoRa CSS signals for receiver testing

- Support LoRa CSS signal creation (uplink)
- Support spreading factor, bandwidth, and idle time etc. general settings
- Support header settings with coding rate, and Payload CRC On/Off
- Support flexible payload settings
- Support adding impairments to the LoRa signal with symbol timing error, frequency offset and frequency drift

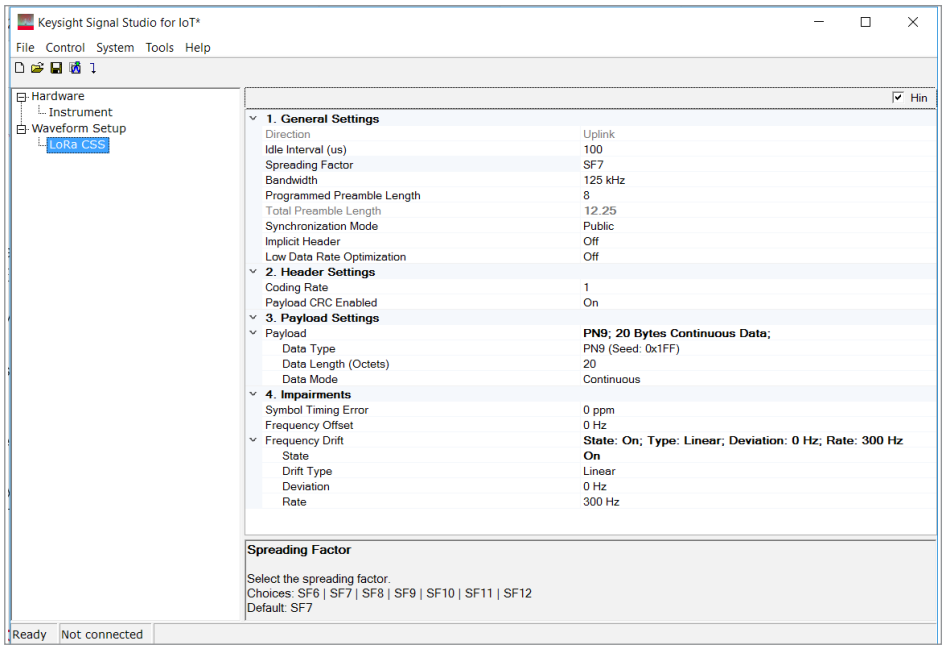
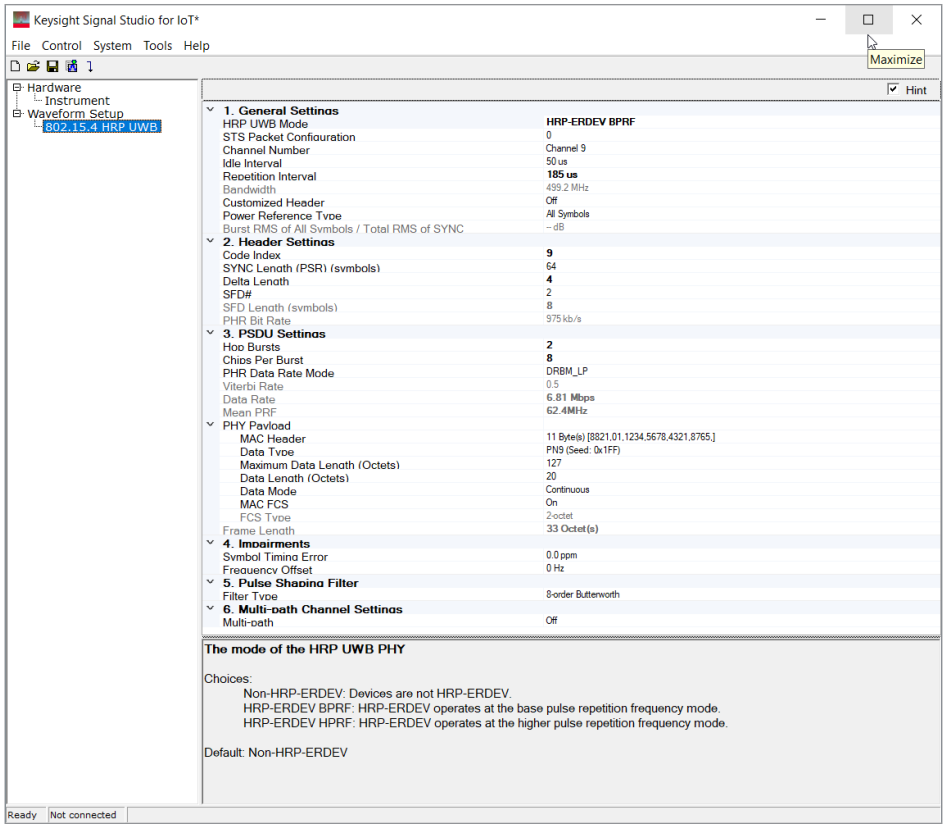


Figure 4. LoRa CSS configuraiton user interface

Easy to generate 802.15.4 and 802.15.4z HRP UWB signals for receiver testing

- Support IEEE 802.15.4 HRP UWB Non-HRP-ERDEV signal creation
- Support IEEE 802.15.4z HRP UWB HRP-ERDEV BPRF (base pulse repetition frequency mode) and HPRF (higher pulse repetition frequency mode) signal creation
- Support general settings with channel number and idle time
- Support customized header settings
- Support flexible PSDU settings
- Support adding impairments to HRP UWB signals with symbol timing error, and/or frequency offset
- Support impairment with static multi-path settings
- Support pulse shaping filter with 8-order Butterworth or user defined filter
- Support fixed STS sequence for ToF (Time Of Flight) testing



Measurement Details

Standard	Component and receiver testing
	Advanced waveform playback mode
IEEE 802.15.4 SUN FSK	– FSK setting – Date rate: 2.4 to 400 kb/s – Modulation: 2FSK, 4FSK – Modulation index: 0.33 to 2.0 – Idle interval: 0 to 200 ms – Ramp symbols: 1 to 10 – Synchronization header (SHR) – Preamble length for 2FSK: 32 to 8000 bits; for 4FSK: 64 to 16000 bits – SFD index: 0/1 – SFD sequence: values as defined in Table 131 and 132 in standards – PHY header (PHR) – Mode switch: 0/1 – When mode switch = 0, FCS type: 0/1, Data whitening: on/off, Frame length: 1026 or 1028 octets – When mode switch = 1, Mode switch parameter entry: 0 to 3 , New mode FEC: On/off, New mode, page, modulation scheme and mode, Checksum, Parity check – PSDU – FEC: None/RSC/NRNSC – Interleaving: On/off – PHY payload: -- MAC header: Can be configured -- Data length: 0 to 2047 octets -- MAC FCS: On/off – Impairments: symbol timing error, frequency offset, frequency deviation scaling, Gaussian BT.
IEEE 802.15.4 SUN OFDM	– OFDM settings – Option: 1/2/3/4 – Idle interval: 0 to 200 ms – Windowing length: 0 to 256 – PSDU – MCS, modulation and coding, scramble, OFDM interleaving: varied according to definitions in standard – PHY payload: -- MAC header: Can be configured -- Data length: 0 to 2047 octets -- MAC FCS: On/off – PHY header (PHR) information
IEEE 802.15.4 O-QPSK/BPSK (ZigBee)	– General setting – Idle interval: 0 to 200 ms – Support frequency band – O-QPSK: 780 MHz, 868 MHz, 915 MHz and 2450 MHz – Support data rate – O-QPSK: 100 kbps, 250 kbps – BPSK: 20 kbps, 40 kbps – PSDU – Mac header: Can be configured – Data length: 0 to 127 octets – MAC FCS: On/off – Impairments: symbol timing error, frequency offset

Measurement Details (Continued)

Standard	Component and receiver testing
	Advanced waveform playback mode

FSK/GFSK
LoRa CSS
	– General setting
	  – Uplink only
	  – Spread factor: SF6/7/8/9/10/11/12
	  – Bandwidth: 7.8125, 10.4167, 15.625, 20.8333, 31.25, 41.667, 62.5, 125, 250, 500 kHzPSDU
	– Programmed preamble length: 4~6512
	– Synchronization mode: Public or Private with user defined sync word
	– Impairment
	  – Symbol timing error: –300 to 300 ppm
	  – Frequency Offset: –200 kHz to 200 kHz
	  – Frequency drift: On/Off with linear or sine drift type
	– Payload setting
	  – PN9, PN15, Custom Bit Pattern or User file
	  – Payload CRC enabled On/Off

IEEE 802.15.4 and 802.15.4z
HRP UWB
	– General settings
	  – HRP UWB Mode: Non-HRP-UWB, HRP-ERDEV BRPF, HRP-ERDEV-HPRF
	  – STS Packet Configuration: 0, 1, 2, 3
	  – Channel number: 0~15
	  – Idle Interval (us) (0-200000)
	  – Time Scale Factor: 0~10 (1 as default)
	  – Repetition interval
	– Header settings
	  – Preamble Code Sequence (customized header for Non-HRP-UWB)
	  – SFD Sequence (customized header for Non-HRP-UWB)
	  – Code Index: 1~24 (Non-HRP-ERDEV), 9~24 (HRP-ERDEV BPRF), 1~32 (HRP-ERDEV HPRF)
	  – Sync Length (PSR) (symbols): 16/64/1024/4096 (Non-HRP-ERDEV), 16/24/32/48/64/96/128/256/1024/4096 (HRP-ERDEV BPRF), 16/24/32/48/64/96/128/256 (HRP-ERDEV HBPF)
	  – Delta length: 4/16/64 (Non-HRP-ERDEV and HRP-ERDEV HBPF), 4 (HRP-ERDEV BPRF)
	– PSDU settings
	  – Viterbi Rate: 0.5 or 1
	  – Hop Burst: 2/8/32
	  – Chip Per Burst: 1/2/8/16/64/128/512
	  – PHR Data Rate Mode: DRBM_LP and DRMB_HP (HRP-ERDEV BPRF), DRBM_LR and DRMB_HR (HRP-ERDEV HPRF)
	  – Data Rate: from 110 kbps to 27.23 Mbps
	– PHY Payload
	  – MAC header
	  – Data Type: PN9, PN15, Custom Bit Pattern or User file
	  – Data Length: 0~127 octets
	  – Data Mode: continuous or truncated
	  – MAC FCS: On/Off
	– STS settings
	  – STS type: AES-128 STS, Fixed STS
	  – Delta length for STS
	  – Active segment length: 64, 128 or 256
	  – Number of Active segments: 1, 2, 3, 4
	– Impairment
	  – Symbol Timing Error: -300 ~ +300 ppm
	  – Frequency Offset: -200 ~ +200 kHz
	– Pulse Shaping Filter: 8-order Butterworth or User Defined
	– Multi-path Channel settings: multi-path static settings with mulit-path index, multi-path delay and multi-path power

Key Specifications

The following performance characteristics apply to the N7610C Signal Studio for IoT application.

Definitions

Typical (typ): Represents characteristic performance, which 80% of the instruments manufactured will meet. This data is not warranted, does not include measurement uncertainty, and is valid only at room temperature (approximately 25 °C).

Characteristic performance: Non-warranted value based on testing during development phase of this product.

The EVM measurements were made with an N9030A PXA signal analyzer with Option B1X (160 MHz bandwidth), using the Keysight 89600 VSA software with Option 89601AYAC for 2FSK and Option 89601BHFC for OFDM modulation analysis.

The ACP measurement setting for 2FSK uses the definition in section 18.1.5.6 of the IEEE 802.15.4 standard. The ACP values for OFDM are measured on the first out-of-band channels (upper and lower), which are adjacent to the in-band channel. The bandwidth for both the in-band and out-of-band channels are set as the Channel Spacing values defined in Table 148 of the IEEE Standard 802.15.4, i.e., 1200 kHz, 800 kHz, 400 kHz and 200 kHz for Options 1, 2, 3 and 4 respectively.

IEEE 802.15.4g PHY standard	Parameters		Characteristic (typical)		N5172B EXG, N5182A/82B MXG signal generator
SUN FSK	Frequency: 920 MHz				Amplitude: ≤ 13 dBm
2FSK	Modulation index/Bit rate (bps)	0.5/100	FSK Error (RMS)		0.53%
			ACP (dB)	Offset Frequency M1	–64.2
				Offset Frequency M2	–65.6
			FSK Frequency Deviation Offset		7.19%
			FSK Zero Crossing Error		0.07%
		1/100	FSK Error (RMS)		0.56%
			ACP (dB)	Offset Frequency M1	–69.2
				Offset Frequency M2	–65.7
			FSK Frequency Deviation Offset		7.27%
			FSK Zero Crossing Error		0.04%

Key Specifications (Continued)

IEEE 802.15.4 PHY standard	Parameters		Characteristic (typical)	N5172B EXG, N5182A/82B MXG signal generator
SUN OFDM	Frequency: 920 MHz			Amplitude: ≤ 13 dBm
Option 1		MCS 1	EVM (RMS)	0.13%
			ACP (dB)	–46.1
		MCS 3	EVM (RMS)	0.14%
			ACP (dB)	–46.1
Option 2		MCS 1	EVM (RMS)	0.13%
			ACP (dB)	–61.9
		MCS 3	EVM (RMS)	0.13%
			ACP (dB)	–62.0
		MCS 5	EVM (RMS)	0.13%
			ACP (dB)	–60.8
Option 3		MCS 1	EVM (RMS)	0.14%
			ACP (dB)	–59.7
		MCS 3	EVM (RMS)	0.14%
			ACP (dB)	–59.5
		MCS 5	EVM (RMS)	0.16%
			ACP (dB)	–60.0
Option 4		MCS 3	EVM (RMS)	0.15%
			ACP (dB)	–39.7
		MCS 5	EVM (RMS)	0.15%
			ACP (dB)	–39.6
IEEE 802.15.4 PHY standard	**Parameters**		**Characteristic (typical)**	**N5172B EXG, N5182A/82B MXG signal generator**
O-QPSK	Frequency: 2450 MHz			Amplitude: 0 dBm
			Offset EVM	0.19%

Ordering Information

Software licensing and instrument configuration

Signal Studio offers flexible licensing options, including:

- **Node-locked license**: Allows you to create unlimited I/Q waveforms with a specific Signal Studio product and use them with a single, specific platform.
- **Transportable, perpetual license**: Allows you to create unlimited I/Q waveforms with a specific Signal Studio product and use them with a single platform (or PC in some cases) at a time. You may transfer the license from one product to another.Waveform license: Allows you to generate up to 545 user-configured I/Q waveforms with any Signal Studio product and use them with a single, specific platform.
- **Time-based license**: license is time limited to a period such as 12-month.

The table below lists fixed, perpetual licenses only; additional license types may be available. For detailed licensing information, please refer to the Licensing Options web page at www.keysight.com/find/SignalStudio_licensing

N7610C Signal Studio for IoT

Waveform playback licenses (N7610EMBC)

Software license type	Support contract	Description
Node-locked perpetual	R-Y5B-001-A	R-Y6B-001-Z[2]
Node-locked time-based	R-Y4B-001-Z[1]	Included
Transportable perpetual	R-Y5B-004-D	R-Y6B-004-Z[2]
Transportable time-based	R-Y4B-004-Z[1]	Included

One-month KeysightCare software support subscription extension[3]

Support subscription	Description
R-Y6B-501	1-month of support subscription for node-locked perpetual licenses
R-Y6B-504	1-month of support subscription for transportable perpetual licenses

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.
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.

Additional Information

Measurement, user and programming guides can be found on the product web page in the document library:

- www.keysight.com/find/n7610c

Signal Studio software

- www.keysight.com/find/SignalStudio

Keysight's IoT or M2M solutions pages

- www.keysight.com/find/IoT or www.keysight.com/find/m2m

Hardware configurations

To learn more about required hardware configurations, please visit:
www.keysight.com/find/SignalStudio_platforms

PC requirements

A laptop or desktop PC is required to run Signal Studio software as long as it meets or exceeds the minimum requirements: www.keysight.com/find/SignalStudio_pc

Signal studio models and options

To learn more about the Signal Studio models and options licensing information, please visit: www.keysight.com/find/SignalStudio_model

www.keysight.com/find/N7610C

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

KEYSIGHT TECHNOLOGIES