PathWave Signal Generation (PWSG) for 5G NR/5G-Advanced

Key features

- Generate 3GPP Rel 15, Rel 16, Rel 17 and Rel 18 standard-compliant 5G NR signals for testing base station and user equipment with channel coding and multi-antenna port support
- Fully support downlink channels for PBCH, PDSCH and PDCCH and uplink channels for PUSCH, PUCCH and PRACH
- Support downlink signals for PSS/SSS, CSI-RS, PBCH-DMRS, PDSCH-DMRS, PDSCH-PTRS, PDCCH-DMRS, RIM-RS and uplink signals for SRS, PUSCH-DMRS, PUCCH-DMRS, and PUCCH-PTRS
- Support 3GPP Rel 18 UL 8 Tx SU-MIMO, PUSCH 2 codewords, 24 antenna ports, and 3MHz DL test model
- Support 3GPP Rel 17 test model presets for FR1 and FR2
- Support 3GPP Rel 17 UL FRC configurations and Rel 15 DL FRC configurations
- Support 3GPP Rel 17 PUCCH test configuration
- Support 3GPP Rel 17 PRACH configuration for conformance test
- Support 3GPP Rel 17 TB processing over multi-slots (TBoMS) PUSCH
- Support 3GPP Rel 16 Features (NR-U, eMIMO, eDSS, NR Positioning)
- Support multiple BWP and mixed numerology in a single carrier
- Support multi-user channel generation with PUSCH and PDSCH
- Support MU-MIMO configuration
- Support downlink and uplink configuration with flexible sub-frame allocations
- Enable flexible signal configuration with both single-carrier and multi-carrier support
- Support DL-SCH user defined precoding
- Support 5G NR coexistence with LTE through dynamic spectrum sharing (DSS)
- Support SCPI programming
- Real-Time HARQ/TA with M9484C for gNB receiver performance tests

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Simplify Custom Signal Creation

Keysight PathWave Signal Generation (PWSG) for 5G NR/5G-Advanced application is a flexible signal creation tool that will reduce the time you spend on signal simulation. Quickly and easily generate 5G NR signals for component, transmitter, and receiver test.

For 5G NR/5G-Advanced application, two types are available:

- **PathWave Signal Generation Desktop for 5G NR/5G-Advanced** is running on PC like Signal Studio, which can create and download generated waveforms into various Keysight hardware platforms, such as signal generators, vector transceivers and arbitrary waveform generators.

- **PathWave Signal Generation Embedded for 5G NR/5G-Advanced** is running as firmware inside Keysight signal generators, such as M9384B, M9484C VXG and N5186A MXG with touch-optimized GUI.

PWSG Embedded shares same measurement technology as PWSG Desktop while its GUI is optimized for touch-based operations.
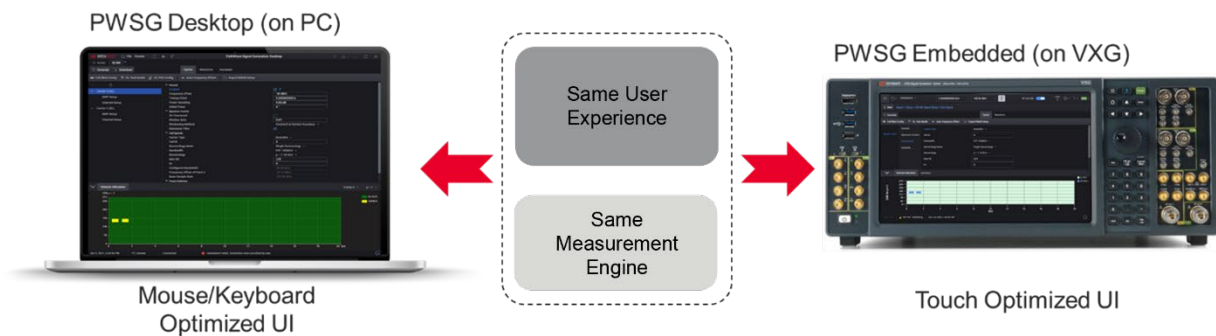

Figure 1. PathWave Signal Generation Desktop vs. Embedded

Apply Your Signals in Real-World Testing

Once you set up your signals in PathWave Signal Generation Desktop, you can download them to a variety of Keysight instruments. This offers flexibility in generating signals at various carrier frequencies with different bandwidths for multiple applications. PathWave Signal Generation Desktop software provides a cost-effective way to tailor your test equipment to your measurement needs in design and development.

PathWave Signal Generation Embedded is running inside the signal generator as embedded software which has the similar GUI and parameter settings as PathWave Signal Generation Desktop application. See feature summary page for details.

PathWave Signal Generation Desktop (license: N7631EMBC)	PathWave Signal Generation Embedded (license: N7631APPC or E7631APPC)
Live Connectivity • X-Series Signal Generator: N5182B MXG, N5172B EXG, and N5166B CXG • N5186A MXG Vector Signal Generator • M9410A/M9411A/M9415A/M9416A VXT PXI Vector Transceiver • M9484C VXG Vector Signal Generator • M9484C VXG Vector Signal Generator + VDI CCU • M9384B VXG Microwave Signal Generator • M8190A Arbitrary Waveform Generator • M8190A Arbitrary Waveform Generator DUC	**Embedded Application** • M9484C VXG Vector Signal Generator • M9384B VXG-m Microwave Signal Generator • N5186A MXG Vector Signal Generator
Waveform playback • X-Series Signal Generator: N5182B MXG, N5172B EXG, and N5166B CXG • N5186A MXG Vector Signal Generator • M9421A/M9410A/M9411A/M9415A/M9416A VXT PXI Vector Transceiver • M9381A/M9383A PXI VSG • M9336A PXIe I/Q AWG • P9336A USB I/Q AWG • M8190A/M8195A AXI AWG • M8190A AXI AWG + E8267D PSG • M9383B VXG-m Microwave Signal Generator • M9384B VXG Microwave Signal Generator • M9484C VXG Vector Signal Generator	**Waveform Playback** • M9484C VXG-C Vector Signal Generator • M9384B VXG-m Microwave Signal Generator • N5186A MXG Vector Signal Generator

Component and transmitter test

PathWave Signal Generation uses 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 on a vector signal generator or for analysis using the vector signal analysis software. The applications for these test signals include parametric test of components such as amplifiers and filters, and performance characterization and verification of RF sub-systems.

Once you set up your signals in PathWave Signal Generation Desktop, you can download them to a variety of Keysight instruments.

Figure 2. Typical component test configuration using PWSG Desktop with an X-Series signal generator and analyzer.

PathWave Signal Generation enables you to generate 5G NR signals to characterize the power and modulation performance of your components and transmitters. Easily manipulate a variety of signal parameters to simplify signal creation.

- Quickly configure and generate 5G NR test models
- Create spectrally correct signals for channel power, spectral mask, and spurious testing
- View CCDF, spectrum, time domain graphs to investigate the effects of power ramps, modulation formats, power changes, clipping, and other effects on device performance
- Adjust Peak-To-Average-Ratio (PAPR) with Crest Factor Reduction (CFR)
- Baseband filter and windowing for spectrum control to improve the out-of-band performance

Receiver test

PathWave Signal Generation for 5G NR/5G-Advanced application enables 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 for early test of receiver hardware.

- Performance verification and functional test of receivers, during RF/baseband integration and system verification
- Coding verification of baseband subsystems, including FPGAs, ASICs, and DSPs
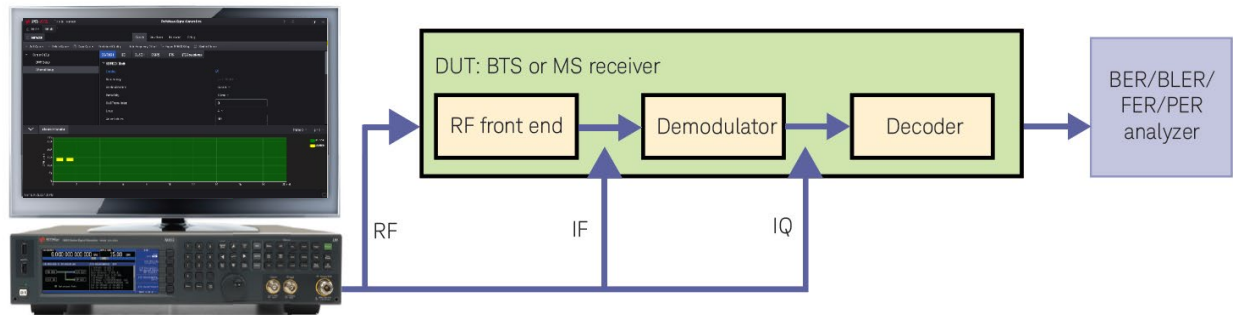
Figure 3. Generate receiver test signals for early testing of your receiver with Keysight X-Series signal generators and PathWave Signal Generation.

PathWave Signal Generation can be used to generate 5G NR signals for early testing of receiver system and component hardware. Using Keysight's PathWave Vector Signal Analysis (89600 VSA) software with a signal analyzers and/or oscilloscopes one can evaluate receiver performance at various stages of the receiver chain (RF, IF and IQ).
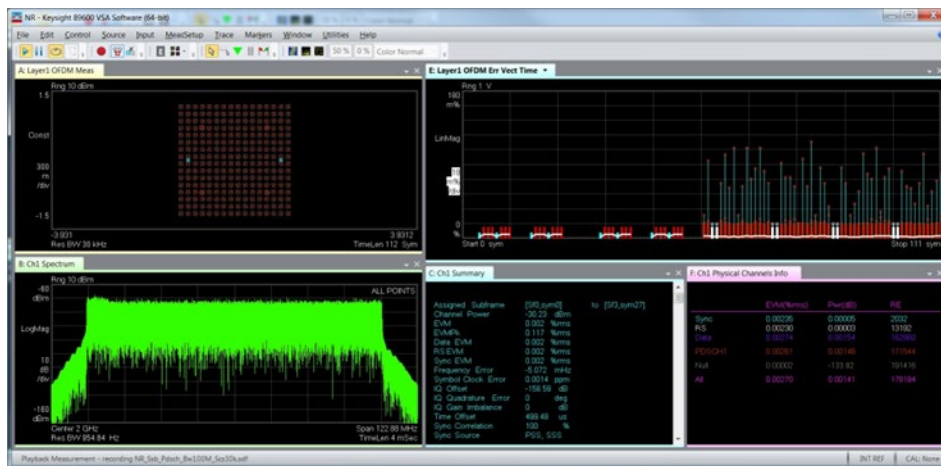

Figure 4. 5G NR single carrier measurement in VSA.

Performance test

PathWave Signal Generation for 5G NR/5G-Advanced application can be integrated to set up a test system for 5G NR performance tests. It has integrated 3GPP defined DL test models, DL/UL FRC presets, PUCCH test quick setups and PRACH test preambles configurations.

PWSG Desktop for 5G NR/5G-Advanced Licensing

PathWave Signal Generation Desktop for 5G NR/5G-Advanced works with N7631EMBC, the waveform playback license, to generate and make a live connection to download and playback 5G NR waveforms with Keysight signal generators, VXTs or AWGs.

PWSG Embedded for 5G NR/5G-Advanced Licensing

PWSG Embedded for 5G NR/5G-Advanced is fully integrated application in the signal generator's firmware and works with the licenses, N7631APPC for M9484C VXG, or, E7631APPC for N5186A MXG, to create and play 5G NR waveforms.

PWSG for 5G NR/5G-Advanced Feature Summary

PathWave Signal Generation for 5G NR/5G-Advanced allows you to create 5G NR standard-compliant signals for gNB or UE testing.

Features	Support
Subcarrier spacing 15 kHz, 30 kHz, 60 kHz, 120 kHz, 240 kHz, 480 kHz, 960 kHz	✓
FR1 Bandwidth (MHz): 3, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100	✓
FR2 Bandwidth (MHz): 50, 100, 200, 400, 800, 1600, 2000	✓
Downlink channels and signals: PDSCH, PDSCH-DMRS, PDSCH-PTRS, PDCCH, CSI-RS, RIM-RS	✓
Downlink SSBlock: PBCH, PSS, SSS, MIB auto generation for PBCH	✓
Downlink: SSBlock boosting per burst	✓
Uplink channels and signals: PUSCH, PUSCH-DMRS, PUSCH-PTRS, PUCCH (Format 0/1/2/3/4), PRACH, SRS	✓
Multi-user PUSCH and PDSCH	✓
LDPC channel coding for DL-SCH, UL-SCH	✓
Polar coding for BCH, DCI, and UCI	✓
Support transform pre-coding (DFT-S-OFDM) and Pi/2-BPSK for PUSCH	✓
MCS Table 5.1.3.1-1/2/3/4 for DL-SCH and 5.1.3.1-1/2/3 and 6.1.4.1-1/2 for UL-SCH	✓
HARQ retransmission and CBG transmission (Scenario based)	✓
Uplink and downlink configuration with flexible subframe allocations	✓
Multi-antenna transmission (up to 24 ports)	✓
Support for single carrier and multi-carriers	✓
Graphical display for frame resource allocation with "display detail" option	✓
Crest Factor Reduction (CFR) function with filter mask table editor and plot	✓
Export waveform files (encrypted waveform files)	✓
Live connection to signal generators and AWGs	✓
Offline waveform file playback	✓
Crest factor reduction	✓

Features	Support
Baseband filter and windowing for spectrum control to improve the out-of-band performance	✓
Mixed numerology in single carrier	✓
Multiple BWP in single carrier	✓
Multiple frame configuration	✓
Export 89600 VSA.SETX setup file	✓
DL FRC Config (Rel-15) and UL FRC Config (Rel-17)	✓
DL Test Model preset with FR1 TM1.1, 1.2, 2, 2a, 2b, 3.1, 3.1a, 3.1b, 3.2, 3.3 and FR2 TM1.1, 2, 2a, 3.1, 3.1a (Rel-17)	✓
User-defined TDD pattern for DL Test Model	✓
Predefined Configuration for FR1 and FR2 (downlink and uplink)	✓
PUCCH Quick Setup for TS38.141-1/2 clause 8 receiver performance tests	✓
Phase compensation for transmitted RF frequency in waveform generation	✓
RA Type 0/1/2 for PUSCH and RA Type 0/1 for PDSCH	✓
DCI auto generation with format 0_0, 0_1, 0_2, 1_0, 1_1, 1_2	✓
PRACH test preambles configuration (Rel-17)	✓
PRACH full-filled configuration (Rel-17)	✓
PUSCH frequency hopping (Off, Intra-slot or inter-slot frequency hopping)	✓
Multi-frame configuration with number of radio frames settings, SSB periodicity and new allocated slots format	✓
LTE Co-existence for DSS (Dynamic Spectrum Sharing)	✓
Arbitrary waveform based AWGN	✓
Payload data (PN9/15/23/31, Custom Pattern, User File)	✓
Rel-16 Features (NR-U, eMIMO, eDSS, NR Positioning)	✓
PDSCH and PUSCH rate match pattern	✓
User defined modulation type (such as 8/16/32 APSK)	✓
DL-SCH user defined precoding	✓
MSR DL Test Model (Added BC3 CS16/17 in TS37.141.2)	✓
8-layer, 2 codewords for PDSCH and PUSCH	✓
TB Processing over Multi-Slots PUSCH (Rel-17)	✓
Multiple SSB (Up to 4) in one carrier	✓
Real-Time HARQ/TA (1Tx) with M9484C	✓
Up to 8x8 MIMO for single user	✓

Supported standards

Specification	Name	Version	Date
3GPP TS38.211	Physical channels and modulation	18.3.0	2024.06
3GPP TS38.212	Multiplexing and channel coding	18.3.0	2024.06
3GPP TS38.213	Physical layer procedures for control	18.3.0	2024.06
3GPP TS38.214	Physical layer procedures for data	18.3.0	2024.06
3GPP TS38.141-1	Base Station (BS) conformance testing Part 1: Conducted conformance testing	18.6.0	2024.06
3GPP TS38.141-2	Base Station (BS) conformance testing Part 2: Radiated conformance testing	18.6.0	2024.06

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Performance characteristics

Definitions

Typical values are designated with the abbreviation "typ." These are performance beyond specification that 80% of the units exhibit with a 95% confidence. These values are not covered by the product warranty.

Measured (meas) is an attribute measured during the design phase for purposes of communicating expected performance, such as amplitude drift vs. time. This data is not warranted and is measured at room temperature (approximately 25 °C).

The following performance characteristics apply to the N5172B EXG and the N5182B MXG X-Series vector signal generators with enhanced dynamic range, Option UNV, except as noted.

Parameters

- Radio format: 1-carrier 5G NR downlink
- Frequencies measured at FR1: 2330 MHz, 3550 MHz, and 4990 MHz
- Power: At +6 dBm

Signal	Subcarrier spacing (kHz)	Carrier bandwidth (MHz)	Measurement	Specification
N5182B/N5172B (Typlical)				
5G NR Downlink FR1	15 kHz	50 MHz	ACPR – Adjacent	-60.2 dB
			ACPR – Alternate	-62.1 dB
			EVM (270 RB, 256QAM)	0.48%
	30 kHz	100 MHz	ACPR – Adjacent	-57.0 dB
			ACPR – Alternate	-59.6 dB
			EVM (270 RB, 256QAM)	0.49%
	60 KHz	100 MHz	ACPR – Adjacent	-57.6 dB
			ACPR – Alternate	-59.7 dB
			EVM (135 RB, 256QAM)	0.51%

Ordering Information

Software licensing and configuration

PWSG Desktop or Embedded offers flexible licensing options, including:

- 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, 24 or 36 months

- **PWSG Desktop 5G NR/5G-Advanced requires N7631EMBC waveform playback license**
- **PWSG Embedded 5G NR/5G-Advanced requires N7631APPC license for M9484C VXG, or E7631APPC license for N5186A MXG**

Software license type	Software license	KeysightCare subscription
Node-locked perpetual	SW1000-LIC-01	SW1000-SUP-01
Node-locked time-based	SW1000-SUB-01	Included
Transportable perpetual [1]	SW1000-LIC-01	SW1000-SUP-01
Transportable time-based [1]	SW1000-SUB-01	Included

1. Transportable license is supported on N5186A with firmware version A.16 and above.

One-month KeysightCare Support and Subscription

Software license	Software license type
SW1000-SUP-01	1-month extension for node-locked perpetual license
SW1000-SUP-01	1-month extension for transportable perpetual license

Try before you buy!

Download the PathWave Signal Generation and use it free for 30 days to make measurements with your analysis hardware: www.keysight.com/find/n7631embc

Request your free trial license today:

www.keysight.com/find/signalstudio_trial

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Hardware configurations

To learn more about compatible hardware and required configurations, please visit:

www.keysight.com/find/SignalStudio_platforms

PC requirements

A PC is required to run PWSG Desktop. www.keysight.com/find/SignalStudio_pc

Websites

www.keysight.com/find/PWSG

PathWave Signal Generation for 5G NR

- Embedded application: www.keysight.com/find/N7631APPC
- Desktop application: www.keysight.com/find/N7631EMBC

PathWave Signal Generation Desktop Software: www.keysight.com/find/PWSG_software

5G Test Solutions, Application Notes and Videos: www.keysight.com/find/5G

Literatures

PathWave Signal Generation, Brochure, 5989-6448EN

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