

PathWave Signal Generation (PWSG) for 5G NR

Key features

- Generate 3GPP Rel 15, Rel 16 and Rel 17 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 17 test model presets for FR1 and FR2
- Support 3GPP Rel 17 UL FRC configurations and Rel 15 DL FRC configurations
- Support 3GPP Rel 15 PRACH configuration for conformance test
- Support multiple BWP and mixed numerology in a single carrier
- Support multi-user channel generation with PUSCH and PDSCH
- 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 3GPP Rel 16 Features (NR-U, eMIMO, eDSS, NR Positioning)
- Support 3GPP Rel 17 TB processing over multi-slots (TBoMS) PUSCH
- Support SCPI programming
- Real-Time HARQ/TA with M9484C for gNB receiver performance tests

Simplify Custom Signal Creation

Keysight Technologies, Inc. PathWave Signal Generation (PWSG) for 5G NR 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, two types of applications are available:

- **PathWave signal generation desktop** is running on PC like Signal Studio, which can create and download generated waveforms into Keysight signal generators.
- **PathWave signal generation embedded** is running as firmware inside Keysight signal generators like M9384B/M9383B and M9484C VXG with touch-optimized UI.

Two types of licenses are available:

- N7631APPC:
 - PathWave signal generation desktop uses it as a PC-based license for waveform creation and download to a supported signal generator
 - PathWave signal generation embedded uses it for touch-optimized GUI application
- N7631EMBC:
 - An instrument-embedded license for waveform creation, downloading, and playback

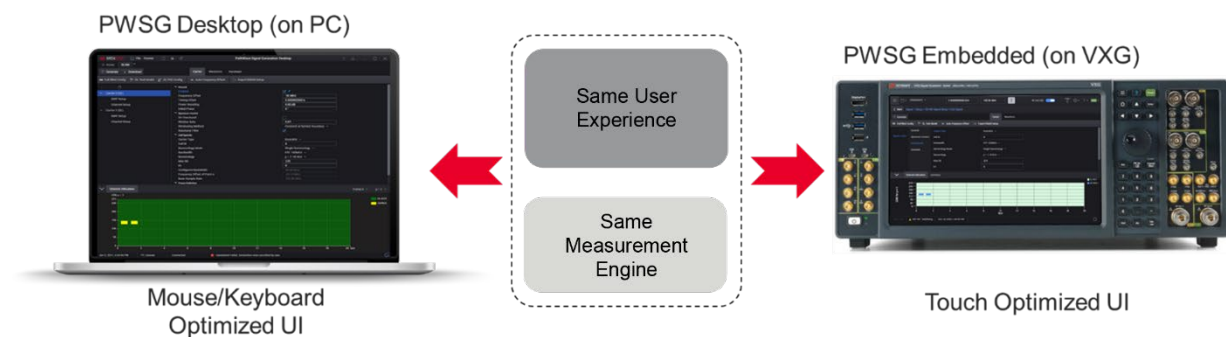


Figure 1. PathWave signal generation desktop vs. embedded

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	PathWave signal generation embedded
Live connectivity <ul style="list-style-type: none">• X-Series signal generator (9 kHz to 6 GHz and up to 7.205 GHz with FRQ option): N5182B MXG, N5172B EXG, N5166B CXG• M941xA VXT PXI vector transceiver: M9410A/M9411A (380 MHz to 6 GHz), M9415A (380 MHz to 12 GHz)• M9384B/M9484C VXG signal generator (1MHz to 54 GHz) SISO or 2-ch MIMO	<ul style="list-style-type: none">• M9384B VXG microwave signal generator (1 MHz to 44 GHz)• M9484C VXG microwave signal generator (1 MHz to 54 GHz or up to 110 GHz with V3080A)
Waveform playback <ul style="list-style-type: none">• M9421A PXIe VXT (60 MHz to 6 GHz)• M9381A PXIe VSG (1 MHz to 6 GHz)• M9383A PXIe microwave signal generator (1 MHz to 44 GHz)• M9336A PXIe I/Q AWG• P9336A USB I/Q AWG• M8190A/M8195A AXIe AWG• M8190A AXIe AWG + E8267D PSG	

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 for FDD and TDD
- 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 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

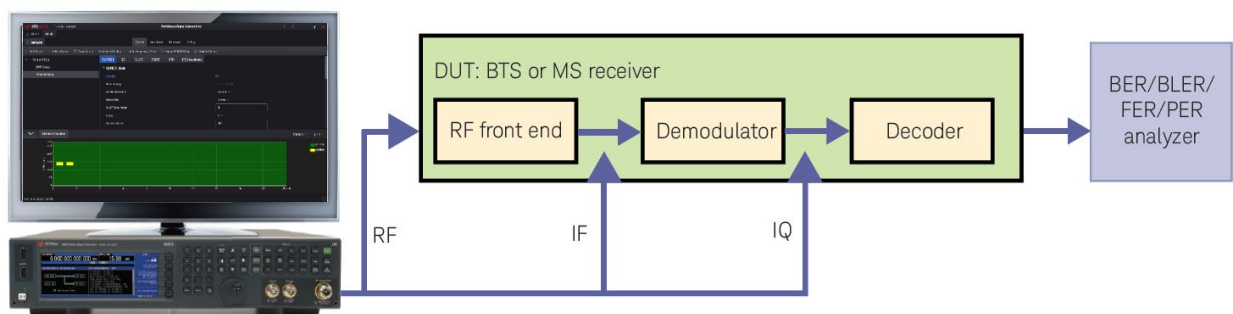


Figure 3. Generate receiver test signals for early testing of your receiver with Keysight X-Series signal generators and PathWave signal generation.

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).

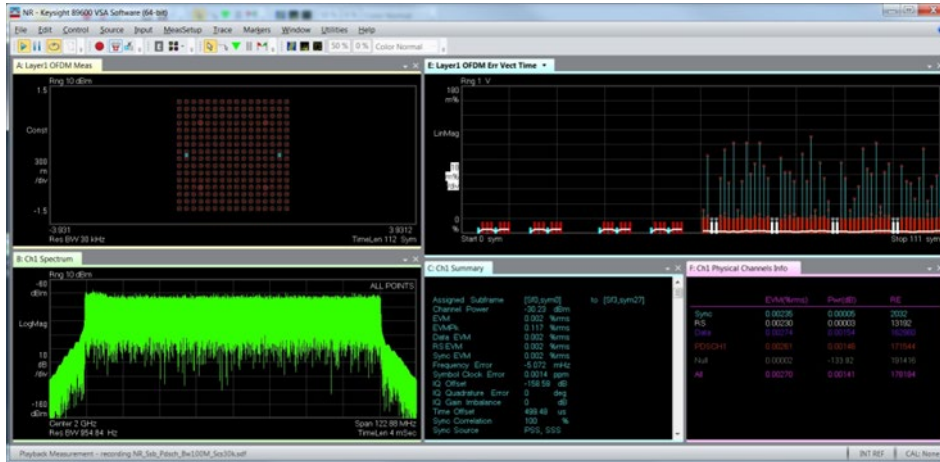


Figure 4. 5G NR single carrier measurement in VSA.

Performance test

PathWave signal generation for 5G NR 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 Licensing

PathWave signal generation desktop for 5G NR offers two types of license: a PC-based or embedded license N7631APPC, and a waveform playback license N7631EMBC. And they can make the PathWave signal generation software working either in a PC license mode or instrument license mode as the description below.

- N7631APPC is PC based license which enables PWSG desktop 5G NR application operating in PC license mode to generate and make a live connection to download signal waveforms into multiple signal generators, VXTs or AWGs without license requirement. N7631APPC is typically recommended for R&D teams. If the N7631APPC license is installed on an instrument, then it can work same as N7631EMBC license as instrument license mode.
- N7631EMBC is an embedded license installed on a signal generator, which enables you to generate, make a live connection to download and offline playback 5G NR waveforms with Keysight signal generators, VXTs or AWGs. N7631EMBC is recommended for design and verification or manufacturing teams.
- PC license mode: when N7631APPC license is installed in a stand-alone PC, then the PWSG desktop is working as the PC license mode. No license is required inside the instrument if generated waveform is downloaded but the downloaded waveform can't be saved or renamed.
- Instrument license mode: each instrument needs a valid license (N7631APPC or N7631EMBC) to playback waveforms. Waveforms can be saved in signal generators for offline playback.

PathWave signal generation - desktop	With N7631APPC license	With N7631EMBC license
Operation mode	PC license mode ¹	Instrument license mode ²
Live connection to SG/VXT	Yes	Yes
Programming API	Yes	Yes
Export VSA setx setup files	Yes	Yes
Waveform export	Yes ³	Yes ³
Offline playback	No/Yes ⁴	Yes ⁴
License type	Node-locked, transportable, USB portable, floating (single site, single region, worldwide)	Node-locked, transportable

1. Downloaded waveforms can't be renamed or stored in non-volatile memory. New download is required to play different waveforms.
2. Waveforms can be saved and renamed in signal generators for offline playback.
3. When the waveform is exported as waveform file (*.wfm), it requires waveform playback license in instrument (N7631APPC, N7631EMBC or 5/50 pack).
4. Offline waveform playback requires embedded waveform playback license (N7631APPC, N7631EMBC or 5/50 pack license) on signal generators, VXTs or AWGs

PWSG Embedded for 5G NR Licensing

PWSG Embedded for 5G NR is fully integrated application in VXG signal generator's firmware. PWSG Embedded shares same measurement technology as PWSG desktop while its GUI is optimized for touch-based operations. The feature can be enabled with N7631APPC license.

PWSG for 5G NR Feature Summary

PathWave signal generation for 5G NR 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): 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 4x4)	✓
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	✓
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 (Rel17)	✓
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	✓
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	✓

Features	Support
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	✓
Rel-17 TB Processing over Multi-Slots PUSCH	✓
Multiple SSB (Up to 4) in one carrier	✓
Real-Time HARQ/TA (1Tx) with M9484C	✓

Supported standards

Specification	Name	Version	Date
3GPP TS38.211	Physical channels and modulation	17.4.0	2022.12
3GPP TS38.212	Multiplexing and channel coding	17.4.0	2022.12
3GPP TS38.213	Physical layer procedures for control	17.4.0	2022.12
3GPP TS38.214	Physical layer procedures for data	17.4.0	2022.12
3GPP TS38.141-1	Base Station (BS) conformance testing Part 1: Conducted conformance testing	17.5.0	2022.03
3GPP TS38.141-2	Base Station (BS) conformance testing Part 2: Radiated conformance testing	17.5.0	2022.03

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 (typical)				
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 application 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 6, 12, 24 or 36 months

Try Before You Buy!

Download the PathWave signal generation and use it free for 30 days to make measurements with your analysis hardware or use our recorded demo signals by selecting File > Recall > Recall Demo > Pulse > on the software toolbar.

Request your free trial license today:

www.keysight.com/find/signalstudio_trial

PathWave signal generation for 5G NR license

PWSG desktop PC application license or PWSG embedded license (N7631APPC)

Software license type	Software license	KeysightCare subscription
Node-locked perpetual	R-Y5B-001-A	R-Y6B-001-y ²
Node-locked time-based	R-Y4B-001-z ¹	Included
Transportable perpetual	R-Y5B-004-D	R-Y6B-004-y ²
Transportable time-based	R-Y4B-004-z ¹	Included
Floating perpetual (single site)	R-Y5B-002-B	R-Y6B-002-y ²
Floating time-based (single site)	R-Y4B-002-z ¹	Included
Floating perpetual (regional)	R-Y5B-006-F	R-Y6B-006-y ²
Floating time-based (regional)	R-Y4B-006-z ¹	Included
Floating perpetual (worldwide)	R-Y5B-010-J	R-Y6B-010-y ²
Floating time-based (worldwide)	R-Y4B-010-z ¹	Included
USB portable perpetual	R-Y5B-005-E	R-Y6B-005-y ²
USB portable time-based	R-Y4B-005-z ¹	Included

Waveform playback license (N7632EMBC)

Software License Type	Software License	KeysightCare Subscription
Node-locked perpetual	R-Y5B-001-A	R-Y6B-001-y ²
Node-locked time-based	R-Y4B-001-z ¹	Included
Transportable perpetual	R-Y5B-004-D	R-Y6B-004-y ²
Transportable time-based	R-Y4B-004-z ¹	Included

One-month KeysightCare support and subscription

Support subscription	Description
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-506	1-month extension for floating (regional) perpetual license
R-Y6B-510	1-month extension for floating (worldwide) perpetual license
R-Y6B-505	1-month extension for USB portable perpetual license

- 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.
- Support subscription for all perpetual licenses can be extended with monthly extensions.
- M9383B/M9384B and M9484C VXG microwave signal generator uses the N7631APPC license

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

- 5G NR waveform creation and playback: www.keysight.com/find/N7631APPC
- 5G NR waveform creation and offline playback: www.keysight.com/find/N7631EMBC

Comprehensive online documentation: www.keysight.com/find/signalstudio_support

PathWave signal creation desktop software: www.keysight.com/find/PWSG_software

PathWave signal generation embedded firmware: www.keysight.com/find/VXG

5G test solutions, application notes and video: www.keysight.com/find/5G

Literatures

PathWave Signal Generation, Brochure, [5989-6448EN](#)

For more information on Keysight Technologies' products, applications, or services, please visit: www.keysight.com



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