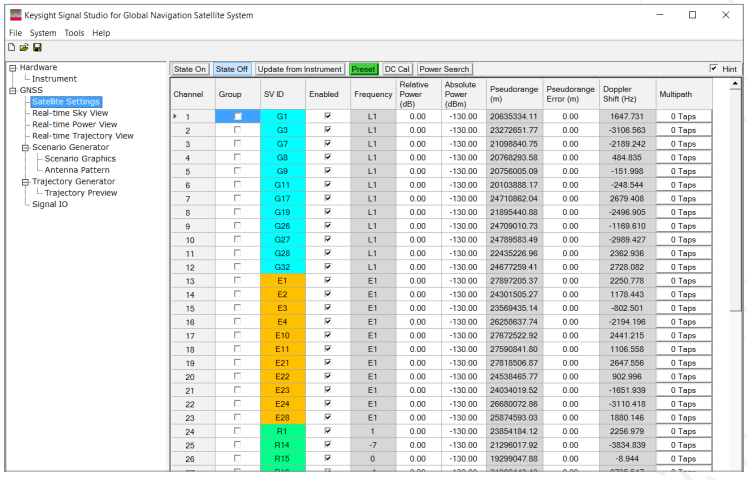
TECHNICAL OVERVIEW

N7609C

Signal Studio for Global Navigation Satellite Systems (GNSS) 2021

- Create Keysight validated real-time signals that simulate satellites from the U.S. Global Positioning System (GPS), Russian Global Navigation Satellite System (GLONASS), European Galileo system, or Chinese Beidou Navigation Satellite System (BDS, also known as Compass), Satellite Based Augmentation System (SBAS), or Quazi Zenith Satellite System (QZSS)
- GPS supports single band for L1 C/A, L5I, L5Q, or dual-band for L1 C/A plus L5I, and/or L5Q
- Simulate up to 15 line-of-sight satellites for each GNSS
- Up to 40 channels for line-of-sight and multipath signals for any combination of GPS, GLONASS, Beidou, SBAS or QZSS, and 16 additional channels for Galileo E1 line-of-sight and multipath signals
- Support static scenarios for stationary receivers or dynamic scenarios for moving receivers
- Control satellite visibility, power, multipath, and pseudorange error in real time
- Create waveform files that simulate single or multi-satellite for GPS, GLONASS, Galileo, Beidou (Compass), SBAS, or QZSS for manufacturing test
- Accelerate the signal creation process with a user interface based on parameterized and graphical signal configuration and tree-style navigation



KEYSIGHT TECHNOLOGIES

Simplify Global Navigation Satellite System (GNSS) Signal Creation

Signal Studio software is a flexible suite of signal-creation tools that will reduce the time you spend on signal simulation. For GNSS, including GPS, GLONASS, Galileo, Beidou and SBAS/QZSS, Signal Studio's performance-optimized 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 receiver test.

Component and transmitter test

Using live off-the-air satellite signals for GNSS receiver verification is unreliable because of the high variability and non-repeatability of these signals. N7609C Signal Studio's advanced capabilities enable you to create signals that simulate satellites in the GPS, GLONASS, Galileo, or Beidou constellations for testing GNSS receivers in an accurate and repeatable manner. The application simulates multiple signals from many different satellites, with different time delays, Doppler shifts, and power levels. The N7609C software also has the capability to create and transmit impairments such as multipath signals, loss of satellite visibility, and ionospheric and tropospheric atmospheric attenuation, and can also add calibrated AWGN. The ability to add these impairments allows the N7609C to provide a complete suite of signals for full verification of GNSS receivers. 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

The N7609C software's advanced capabilities operate in real-time mode, which is used to define the parameters of nonrepeating and dynamically changing signals needed for receiver testing. Its graphical interface provides a direct instrument connection for parameter transfer and interactive control during signal generation.

For receiver testing in production or simple receiver testing in R&D, the N7609C also offers a basic capability that uses waveform playback mode to generate signals. The waveform files simulate a single static satellite with fixed Doppler shift. These signals can be used to test receiver sensitivity, acquisition, and tracking. Single or multi-satellite satellite waveforms can be created for GPS, GLONASS, Galileo, Beidou (Compass), satellite-based augmentation systems (SBAS), or the Japanese Quazi-Zenith Satellite System (QZSS).

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. 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.

For real-time signal generation with advanced capability options:

- X-Series vector signal generators: N5182B MXG and N5172B EXG

For waveform playback using the basic capability option:

- Vector signal generators
  - X-series N5182B MXG and N5172B EXG
  - First-generation N5182A MXG [1]
  - ESG [1]
  - PSG
  - M9381A PXIe VSG
- E6640A EXM wireless test set

Typical receiver measurements

Time to First Fix (TTFF)

- Cold, warm, and hot start conditions

Receiver sensitivity

- Acquisition sensitivity
- Tracking sensitivity

Location accuracy

- Relative and absolute accuracy
- Moving receiver accuracy

1. N7609C 2019 update 1.0 or above doesn't support MXG-A N5182A and ESG E4438C.

Receiver Test

Receiver test using real-time signals

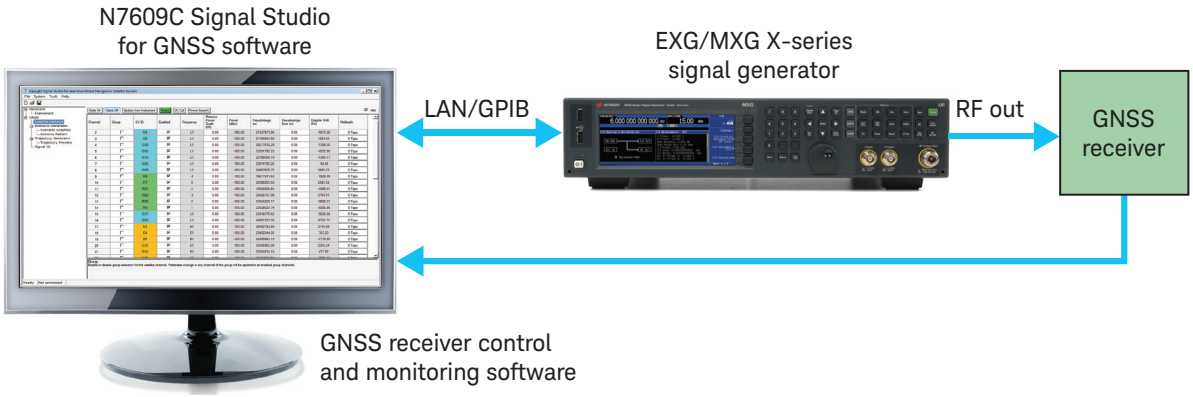


Figure 1. Generate real-time GNSS signals to test the time-to-first-fix (TTFF) or sensitivity of your receiver with Signal Studio's advanced capabilities with the configurations shown above.

Signal Studio enables you to easily create reliable and repeatable signals that simulate GPS, GLONASS, Galileo, and/or Beidou satellite signals or GPS dual-band L1 C/A plus L5I and/or L5Q satellite signals for receiver verification tests. The flexibility and features of this intuitive software make it ideal for an R&D environment.

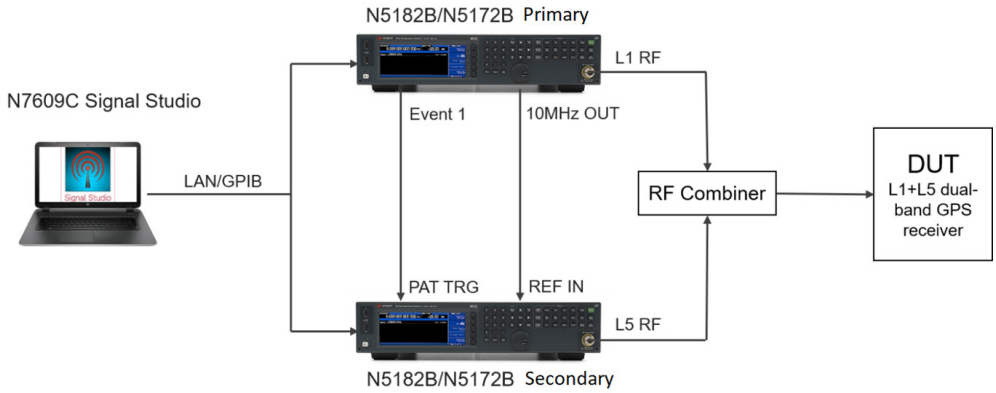
The software simulates up to 15 visible satellites per constellation, depending on the scenario and satellite visibility, and provides a total of 40 channels for satellite and multipath signals for GPS, GLONASS, Beidou and/or SBAS/QZSS. 16 additional channels are available for Galileo satellite and multipath signals. The real-time capability of the software enables you to change the satellite power and visibility while the signal is active, or add multipath or pseudorange errors. Use the static test mode to create simple static satellite signals with real-time adjustments for Doppler shift and delay, and individual power settings for each channel.

Real-time signals simulating orbiting GNSS satellites can be created in two different modes. The first mode uses a stored scenario file, containing the satellite information needed to simulate the signals visible to a receiver at a specific location and time, including the navigation messages. In this mode, signals up to 24 hours in duration can be simulated. A set of preconfigured scenario files is provided with the software. For longer simulations, a second mode uses the scenario generator settings to continuously create new scenario data. This mode requires a continuous data connection to the signal generator.

Dual-band GPS Receiver Testing

Modern GPS stellates Block IIF transmit navigation signals on L1 band (1.57542GHz) as well as L5 band (1.17645 GHz). Having 2 bands signal received will facilitate the receiver to reduce the pseudo-range error and therefore improve the location accuracy. To generate L1+L5 signals simultaneously, two N5172B/N5182B with option 503, 656 and 660 will be needed, as the frequency gap between L1 and L5 (400MHz) is larger than max 160MHz modulation BW of the signal generator. In addition, two signal generators must keep in synchronized playback, i.e. using master one to trigger the slave one, so that the signals from both instruments are in good synchronization.

- Primary MXG/EXG requires the N7609EMBC license as the GPS L1 C/A band signal generation
- Secondary MXG/EXG can use either N7609EMBC license or N7609EM1C license as the GPS secondary L5I, and/or L5Q band signal generation



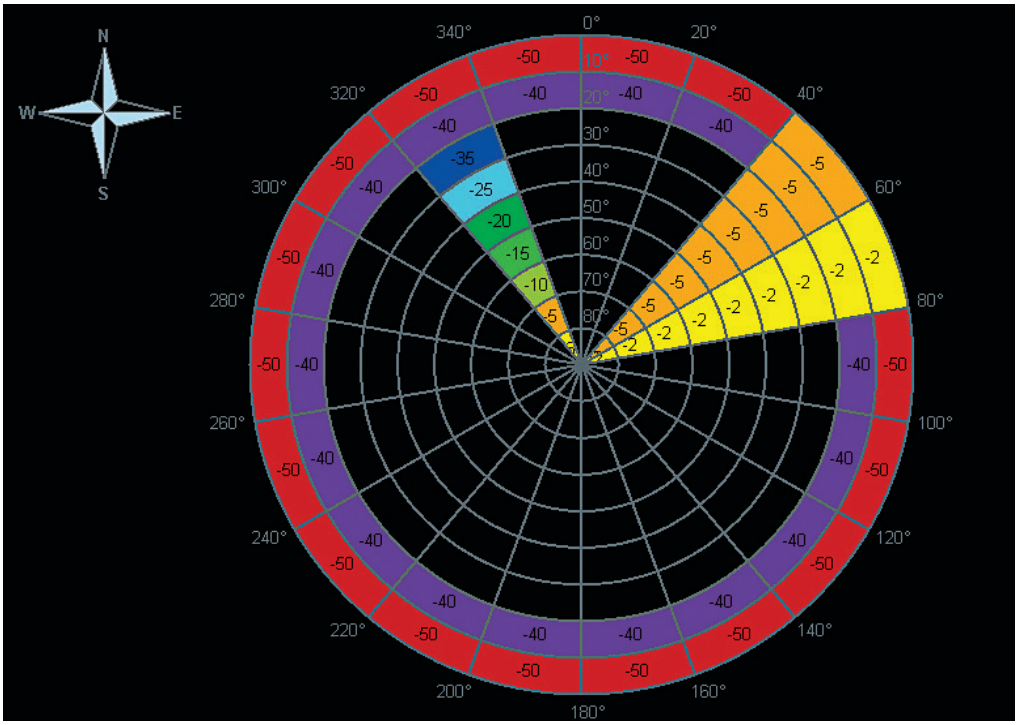


Figure 2. Antenna pattern view: elevation and azimuth grid allows you to specify the power offset for a cell, circle, sector, or any combination of these.

The scenario generator function enables you to create and play back custom scenario files. You can specify the location, date, time and duration for a scenario to simulate a stationary or moving GNSS receiver. Moving receiver scenario generation requires an NMEA (GGA format) message file containing the trajectory path information. These GGA message files can be recorded from a GNSS receiver, created using the trajectory generator utility in the software, or converted from a Google Earth KML format file.

Optional parameters for scenario generation include elevation mask angle and ionospheric and tropospheric atmospheric modeling effects. The elevation mask allows you to select only those satellites that are above a certain angle above the horizon to be used in the scenario. The ionospheric model (Klobuchar) and tropospheric model (NATO) parameters are put into the navigation message and the signal is impaired according to these settings. For Galileo, the scenario generator allows some parameters in the navigation message to be edited. The software also provides an antenna pattern gain mask that can be applied to the GNSS signals. This gain mask can be used to simulate the characteristics of a receiver's antenna, or to simulate the effects of obstructions in the environment.

Scenario files can also be modified with the scenario editing function which provides these capabilities:

- Delete Channel: deletes a channel from the scenario
- Apply Power Offset: applies a power offset to a channel over some time period
- Equalize Power: sets the power for all channels to be the same
- Create Multipath: creates a multipath signal based on a visible satellite's channel
- Trim: creates a new scenario file that contains a portion of time from the selected file

The scenario graphics display allows you to visualize the scenario parameters such as satellite visibility, playback time, and channel designation (represented satellite). It also contains a record of the changes that have been made during the editing session (see Figure 3).

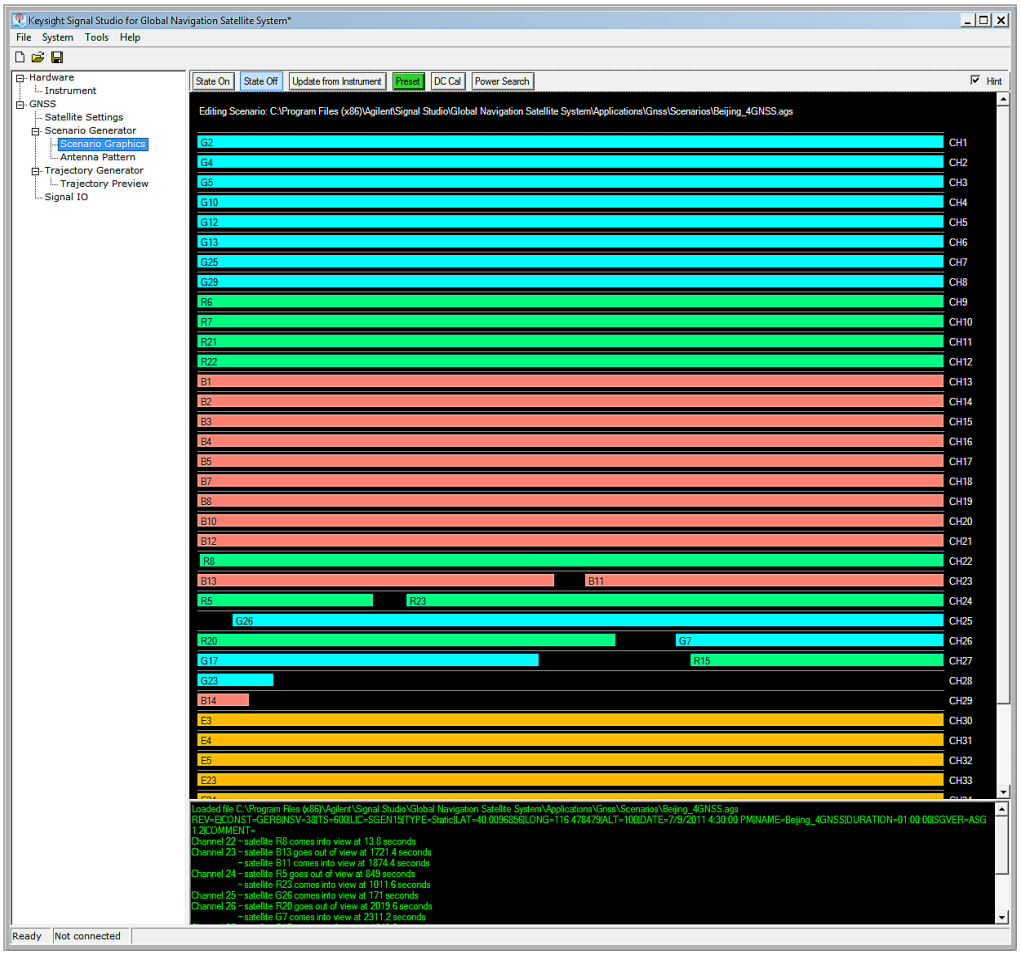


Figure 3. Graphical display of scenario parameters and editing changes.

Real-time scenario information displays

Real-time scenario information displays provide several intuitive views that convey the current scenario playing status from a receiver's point of view. Real-time sky view displays the location of all visible satellites in the sky. The location of a satellite is updated in real-time as its elevation/azimuth changes over time. When a user moves the mouse onto a particular satellite, a tool-tip will be displayed to show detailed real-time information about the satellite, including SVID, power, psudorange, doppler and multipath taps. Instant DOP values (HDOP and PDOP) and number of satellites for each constellation are also displayed in this view (see Figure 4). The real-time power view displays the instant power of all visible satellites in a bar view. The real-time trajectory view displays the history trajectory of the playing scenario. Detailed information including UTC, longitude, latitude, altitude, heading, and velocity are also provided in the text.

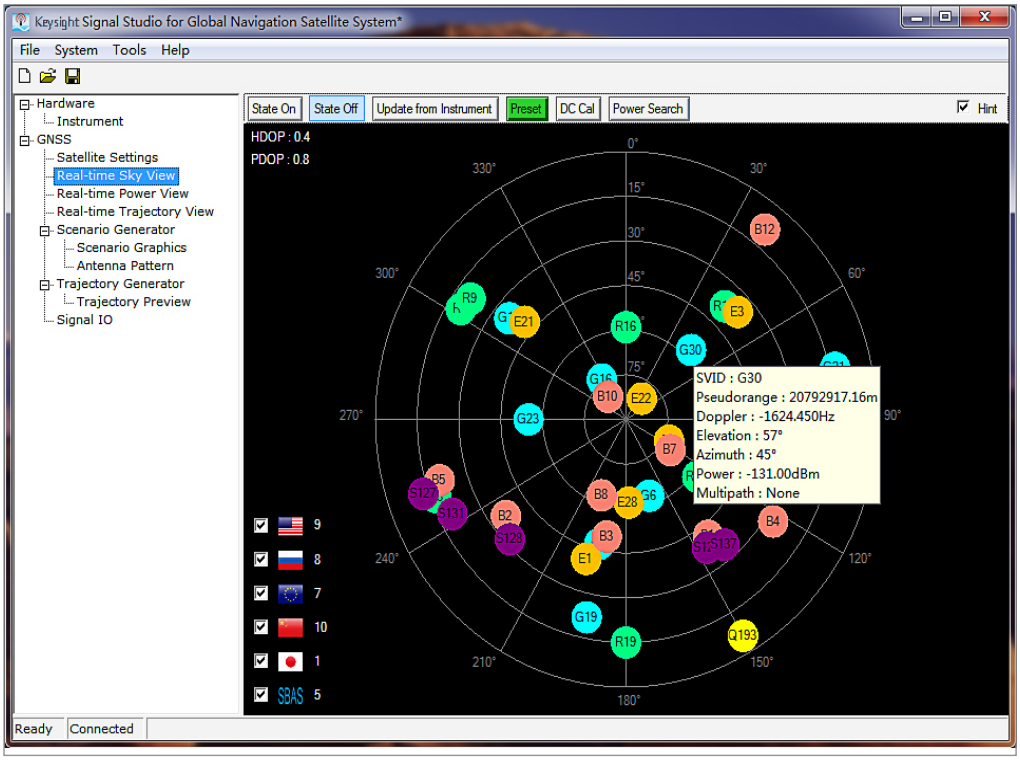


Figure 4. Real-time sky view display with tool-tip showing detailed real-time satellite information in the sky.

Receiver test using waveform playback

Signal Studio's basic single and multi-satellite waveform capability allows you to create and play back waveform files that simulate a single static GNSS satellite with a fixed Doppler shift or simulate multiple satellites. These signals can be used to perform simple receiver tests, such as testing the receiver's ability to detect, identify, and track the satellite signal, test receiver sensitivity, or test Time To First Fix (TTFF) and static location accuracy. When used with an instrument that has the calibrated AWGN option, the receiver can be tested with varying C/N ratios. This basic capability provides a more economical solution for manufacturing test.

For single-satellite waveforms, users can select the SV ID (PRN) and Doppler shift for simulating GPS, Galileo, Beidou, SBAS, or QZSS. For GLONASS, users can select a frequency channel and Doppler frequency, which will be used to set the frequency of the signal. Since the same C/A code is used for all GLONASS satellites, the same waveform file is generated for all GLONASS settings, but the frequency of the signal generator is set based on the satellite channel.

For multi-satellite waveforms, users first need to select a scenario file and then choose one constellation inside the scenario file from among GPS, GLONASS, Galileo, Beidou, SBAS or QZSS, or choose a multi-GNSS scenario from among GPS+SBAS+QZSS, GPS+Beidou, or GPS+Galileo. Users can specify the scenario start time, satellite power from either range based or equal power, sample rate and waveform length up to 120 seconds. ARB memory of at least 256 MSa is required, based on the chosen constellation.

Both single satellite and multi-satellite waveform files can be used with waveform 5-pack or 50-pack licenses in compatible instrument platforms.

Features Summary

GNSS	Receiver testing	
	Basic waveform playback mode	**Advanced real-time mode**
Single satellite waveform	Simulate single satellite with C/A code for GPS, GLONASS, Galileo, Beidou, SBAS (WAAS, EGNOS, MSAS, GAGAN), or QZSS	
	Specify SV ID (PRN) for all constellations except GLONASS	
	Specify the frequency channel for GLONASS	
	Specify the dynamic pattern: Static, constant velocity, constant acceleration or sinusoidal	
	Specify the navigation message as PN9, PN15 or a user defined pattern	
	Add calibrated AWGN for control of C/N ratio (requires AWGN option in instrument)	
Multi-satellite waveform	Simulate multi-satellite signals	
	Choose the single constellation from GPS, GLONASS, Galileo, Beidou or multi-constellation from GPS+SBAS+QZSS, GPS+Beidou or GPS+Galielo (requires at least 256 MSa ARB memory)	
	Specify the satellite power, sample rate and waveform length	
	Add calibrated AWGN for control of C/N ratio (requires AWGN option in instrument)	
GPS, GLONASS, Galileo, Beidou, SBAS or QZSS real-time signal generation		Simulate up to 15 line-of-sight satellites for each constellation: GPS L1 C/A , GLONASS L1 C/A, or Beidou B1
		Simulate GPS dual-band for L1 C/A plus L5I and/or L5Q
		Provides 40 channels for line-of-sight satellites and multipath combined for GPS, GLONASS, Beidou, and/or SBAS/QZSS
		Simulate up to 16 line-of-sight or multipath Galileo satellite signals (Option UFP)
		Supports static scenarios for stationary receivers or dynamic scenarios for moving receivers
		Up to 24 hours of playback using scenario files
		Provides real-time control for individual satellites, including satellite on/off, absolute or relative satellite power, adding multipath, and applying a pseudorange error
		Add calibrated AWGN for control of C/N ratio (requires AWGN option in instrument)

Features Summary (Continued)

GNSS	Receiver testing	
	Basic waveform playback mode	Advanced real-time mode
Scenario generation and editing		Create custom scenarios with your choice of location, date, time, and duration for either static or moving receivers
		Continuous scenario generation for simulations longer than 24 hours (for N7609C running directly with EXG/MXG, continuous LAN or GPIB connection to the EXG/MXG is required)
		Ionospheric and tropospheric modeling
		Elevation mask for controlling satellite visibility
		Graphical display to show editing results
		Leap seconds information editing
		Edit Galileo navigation message parameters
		Antenna pattern modeling
		Scenario editor to add multipath channels, apply power offsets to a channel, delete a channel, or trim the scenario length in a scenario file
		Trajectory generator to create NMEA GGA format message files for moving receiver scenarios, with utility to convert Google Earth (*.kml) file into an NMEA GGA message file
		Support the xml file format as Galileo almanac
		Support Rinex file format as Galileo ephemeris input
		A-GNSS assistance data for each scenario
		Output raw scenario data (truth data) for comparison with receiver test results
SBAS		Provide the SBAS message editor to configure the SBAS message for Type1 (PRN Mask), Type2-5 (Fast Correction), Type7 (Fast Correction Degradation Data Factor), Type12 (Network Time), Type18 (IGP Mask), Type25 (Long Term Correction), and Type26 (Ionosphere Correction).
Real-time CW interference		Add CW interference signal to real-time GNSS signals within GPS, GLONASS or Beidou bands
		Up to 4 CW interference signals can be added, which share the 16 channels of the Galileo constellation
Real-time display		Real-time sky view of visible satellites
		Real-time satellite power per GNSS
		Real-time simulation of receiver trajectory

Supported Standards and Test Configurations

The following standards are supported by the N7609C Signal Studio for GNSS application.

Constellation	Specification	Release date
GPS	Interface Specification IS-GPS-200E, Navstar GPS Space Segment/Navigation User Interfaces	2010
GLONASS	Global Navigation Satellite System (GLONASS) Interface Control Document, Edition 5.1	2008
Galileo	European GNSS (Galileo) Open Service Signal In Space Interface Control Document (OS SIS ICD), Issue 1.1	2010
Beidou	BeiDou Navigation Satellite System Signal In Space Interface Control Document, Open Service Signal B1I, Version 1.0	2012
SBAS	Federal Aviation Administration Specification For the Wide Area Augmentation System (WAAS)	2001
QZSS	Quasi-Zenith Satellite System Navigation Service Interface Specification for QZSS (IS-QZSS) V1.4	2012

Test configurations for general GNSS receivers

For typical GNSS modules or receivers that are integrated into products that are not cellular devices, receiver verification can be performed using one of the configurations shown in Figure 1. For manufacturing test applications using basic waveform playback mode, Configuration 1 may be used with the EXG, MXG, ESG, or PSG vector signal generators, the M9381A PXIe VSG, or E6640A wireless test set.

Test configuration for assisted GPS (A-GPS) and assisted GLONASS for cellular devices

Keysight's GS-9000 A-GPS design verification test systems allow you to verify that your UMTS or cdma2000® mobile device meets CTIA standards for A-GPS operation and integrates seamlessly into cellular networks. The GS-9000 systems include both hardware and software to enable mobile device A-GPS testing in a conducted environment. The hardware includes an 8960 wireless communications test set for base station emulation and a GNSS simulator to emulate the GPS satellites. The GNSS simulator may consist of the N7609C Signal Studio for GNSS with either the EXG/MXG or the PXB with an RF signal generator, or an E4438C ESG vector signal generator with the Option 409 GPS Personality.

Similar testing will likely be required for mobile devices that support A-GLONASS and other A-GNSS in the future. The N7609C scenario generator provides assistance data and ephemeris files to support this testing.

Performance Characteristics

Definitions

Characteristic performance:

Non-warranted value based on calculated values for expected performance. This data is not warranted and is subject to change without notice.

Features	Characteristic values
Doppler shift frequency range	± 125 kHz
Doppler resolution	0.02 Hz
Doppler accuracy	± 0.01025 Hz
GPS reference frequency (f0) default	1.023 MHz
Code phase accuracy	± 3.8 ns
Signal dynamics:	
– Maximum relative velocity	600 m/s (Scenario generator supports higher velocities but accuracy has not been verified)
– Maximum relative acceleration	100 m/s2 for GPS, Galileo, or Beidou; 50 m/s2 for GLONASS
Pseudorange error	± 0.002 m RMS (averaged over 1 minute)
Amplitude resolution	See data sheet for RF signal generator (N5172B EXG, N5182A/B MXG, or E4438C ESG)
Amplitude (output power) range	See data sheet for RF signal generator (N5172B EXG, N5182A/B MXG, or E4438C ESG)
Amplitude level accuracy	See data sheet for RF signal generator (N5172B EXG, N5182A/B MXG, or E4438C ESG)

Ordering Information

Software licensing and configuration

Signal Studio 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.
- **Time-based:** License is time limited to a defined period, such as 12-months.

Try before you buy!

Free 30-day trials of Signal Studio software provide unrestricted use of the features and functions, including signal generation, with your compatible platform. Redeem a trial license online at

www.keysight.com/find/SignalStudio_trial

N7609C Signal Studio for Global Navigation Satellite Systems (GNSS)

Signal Studio for Global Navigation Satellite System (GNSS) (N7609EMBC)

Signal Studio for GNSS Secondary Band Real-time (N7609EM1C)

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

KeysightCare Software support subscription for perpetual licenses [3]

Support contract	Description
R-Y6B-001-z [2]	KeysightCare support subscription for node-locked licenses
R-Y6B-004-z [2]	KeysightCare support subscription for transportable licenses
R-Y6B-501	1-month of support for node-locked licenses (extension after 1st year)
R-Y6B-504	1-month of support for transportable licenses (extension after 1st year)

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.

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 Signal Studio. www.keysight.com/find/SignalStudio_pc

Model numbers and options

To learn more about Signal Studio licensing, model numbers and options, please visit: www.keysight.com/find/signalstudio_model

Additional Information

Websites

www.keysight.com/find/SignalStudio

Comprehensive Online Documentation

www.keysight.com/find/signalstudio_support

Signal Studio for GNSS

www.keysight.com/find/N7609C

Keysight's GNSS test solutions

www.keysight.com/find/eCall

Signal Studio and Signal Creation Software

www.keysight.com/find/signalstudio_software

Literature

GPS Receiver Testing - Application Note, 5990-4943EN
Signal Studio Software Simplify Signal Creation - Brochure, 5989-6448EN

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