PathWave Signal Generation (PWSG) for GNSS Embedded Application

Key Features

- Create Keysight validated real-time signals that simulate single or multiple satellites for GPS, Galileo, and BeiDou
- Accelerate the signal creation process with a user interface embedded in the signal generator
- Simulate dual-band GNSS receiver testing: GPS (L1 + L5), Galileo (E1 + E5), and BeiDou (B1C+B2a) (requires bandwidth option B5X or above in instrument)
- Simulate up to 96 channels for line-of-sight satellite with various real-time displays, including Sky View, Power View and Trajectory View
- Support user-defined scenario generation for stationary receivers or moving receivers
- Provide real-time control for individual satellites, including visibility and power controls
- Provide antenna pattern testing with pattern data files recall/save
- Provide trajectory generator for moving receiver testing
- Support various orbit data types, including Almanac, RINEX and Mixed RINEX
- Support user-defined Leap Seconds
- Add calibrated AWGN for control of Carrier-to-Noise (C/N) ratio (requires AWGN option in instrument)
- Provide 1pps and 1ms outputs
- Support test automation with SCPI commands

Simplify Global Navigation Satellite Systems (GNSS) Signal Creation

N7609APPC PathWave Signal Generation for GNSS embedded application is a flexible signal creation tool that will reduce the time you spend on signal simulation and enables you to easily create test signals through its multi-touch graphic user interface.

Using live off-the-air satellite signals for GNSS receiver verification is unreliable because of the high variability and non-repeatability of these signals. N7609APPC PathWave Signal Generation for GNSS application allows you to simulate satellites from the U.S. Global Positioning System (GPS), the European Galileo system, and the BeiDou system from China, create a mix of singles from many different satellites in an accurate and repeatable manner.

Receiver Testing using Real-Time Signals

Figure 1. Generate real-time GNSS signals to test your receiver with PathWave Signal Generation for GNSS

N7609APPC PathWave Signal Generation for GNSS is a real-time signal simulation application capable of generating the GNSS signals required for reliable, repeatable, and flexible GNSS receiver testing. These signals can be used to perform simple receiver tests, such as the receiver's ability to detect, identify, and track the satellite signal, test the receiver's sensitivity, or test Time to First Fix (TTFF), location accuracy and 1 PPS timing accuracy.

N7609APPC PathWave Signal Generation for GNSS application operates in real-time mode. You can create user-defined scenarios for stationary receivers or moving receivers and control the visibility and power of individual satellite during the scenario simulation. N7609APPC PathWave Signal Generation for GNSS application provides various models for Troposphere and Ionosphere.

N7609APPC PathWave Signal Generation for GNSS application can simulate up to 96 channels for line-of-sight satellite with various real-time status displays, including Sky View, Power View and Trajectory View.

N7609APPC PathWave Signal Generation for GNSS application also supports calibrated AWGN for control of varying C/N ratios to provide a complete suite of signals for full verification of GNSS receivers. In addition, SCPI commands support for all parameters enables test automation for your receiver testing.

Typical receiver measurements

- Time to First Fix (TTFF)
  - Cold, warm, and hot start conditions
- Receiver sensitivity
  - Acquisition sensitivity
  - Tracking sensitivity
- Location accuracy
- 1 PPS timing accuracy

Multi-Band GNSS Receiver Testing

Having two or more bands signal received will facilitate the GNSS receiver to reduce the pseudo-range error and therefore improve the location accuracy. The Keysight M9484C VXG with option B5X (bandwidth 500 MHz) is a perfect choice to support multi-band GNSS signal generation on a single instrument.

N7609APPC PathWave Signal Generation for GNSS application, running on the M9484C VXG, enables you to easily configure multi-constellation and multi-frequency satellite signals for receiver verification tests. By simply selecting the desired bands, the multi-band configuration will apply to the generated signals. The following table lists the supported bands for GPS, Galileo and BeiDou.

GPS transmits navigation signals on L1 band (1575.42 MHz) as well as L5 band (1176.45 MHz). Galileo signals broadcast on E1 band (1575.42 MHz) and E5 band (1176.45 MHz). BeiDou transmits navigation signals on B1C band (1575.42 MHz) and B2a band (1176.45 MHz), as well as B1I band (1561.098 MHz).

Band Selection	Frequency
GPS	
L1 C/A	1575.42 MHz
L5 I	1176.45 MHz
L5 Q	1176.45 MHz
Galileo	
E1 OS	1575.42 MHz
E5a	1176.45 MHz
E5b	1207.14 MHz
BeiDou	
B1I	1561.098 MHz
B1C	1575.42 MHz
B2a	1176.45 MHz

Figure 2, Figure 3 and Figure 4 show the user interfaces of GPS Settings, Galileo Settings and BeiDou settings, respectively. During the simulation, the settings change is applied to the output signal in a real-time manner. The instrument frequency will be set to L1 (or E1, or B11) when generating multi-band signals, with the baseband signals automatically adjusted to account for that.

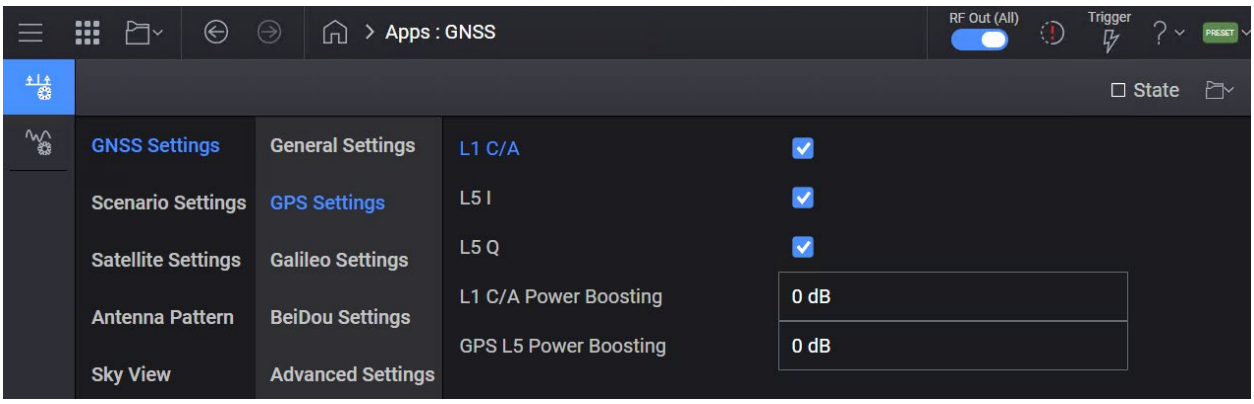

Figure 2. User interface of the GPS settings

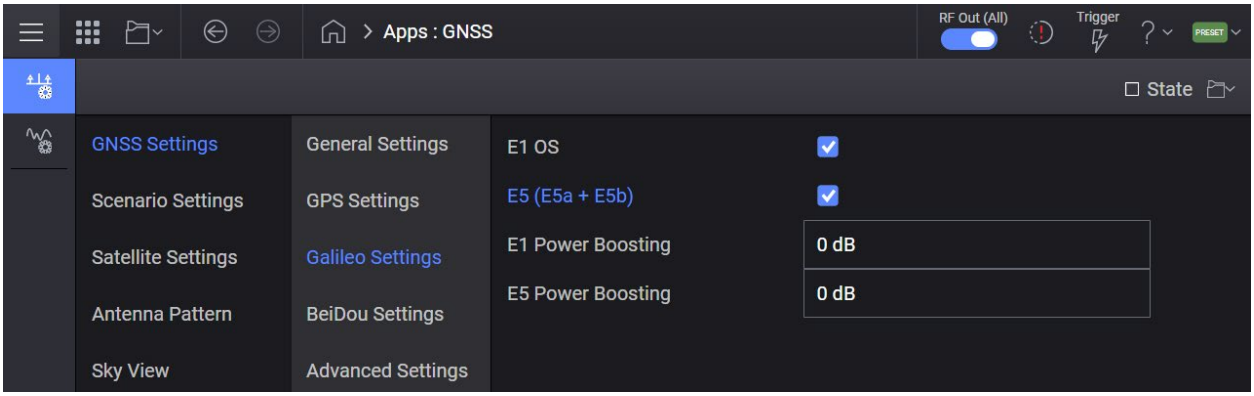

Figure 3. User interface of the Galileo settings

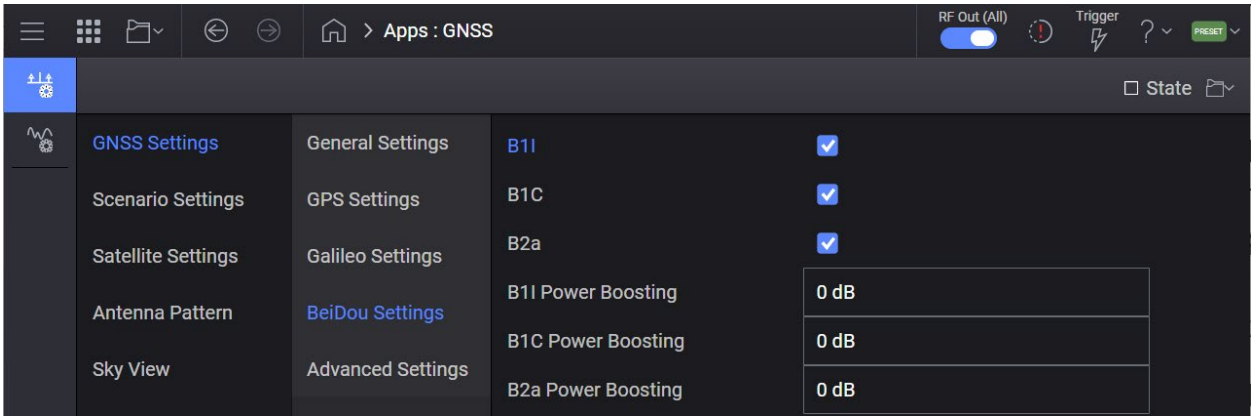

Figure 4. User interface of the BeiDou settings

Scenario Generation

The N7609APPC PathWave Signal Generation for GNSS application supports user-defined scenario generation for GNSS receivers testing. A scenario includes all the visible satellite signals for a given date time at the particular location(s). When the scenario is played, individual satellites are displayed in real-time, showing parameters such as power level, elevation, azimuth, Doppler shift and pseudorange.

Three scenario types are supported:

- Static: For a stationary receiver, this option specifies a fixed location defined by longitude, latitude, and altitude.
- User Trajectory File: For a moving receiver, this option requires a *.gga or *.csv file containing a time-stamped sequence of receiver locations. GGA files can be recorded from a GNSS receiver, generated using a trajectory utility, or converted from a Google Earth KML file.
- Trajectory Generator Settings: Configured within the Trajectory Generator, this option includes General Settings (such as receiver position, initial velocity and so on) and Trajectory Settings for creating custom movement patterns.

A configurable elevation mask allows you to include only satellites above a specified elevation angle. Atmospheric modeling is supported for both ionosphere and troposphere. The selected troposphere model applies to all constellations, while ionospheric parameters can be set individually for each constellation.

For orbit data, you can select an Almanac or RINEX file for each constellation, or a Mixed RINEX file when combining multiple satellite formats. The Almanac file contains the orbit parameters for each satellite at a given time to calculate its position. When the Almanac file is loaded, the Start Time parameter updates automatically.

- GPS Almanac files are updated daily by GPS navigation center (https://www.navcen.uscg.gov).
- Galileo Almanac files are available from the European GNSS Service Centre (https://www.gsc-europa.eu/gsc-products/almanac).

After configuring the scenario, simply turn on GNSS State from the tool bar, and the satellite signals corresponding to that scenario will be generated at the RF output port.

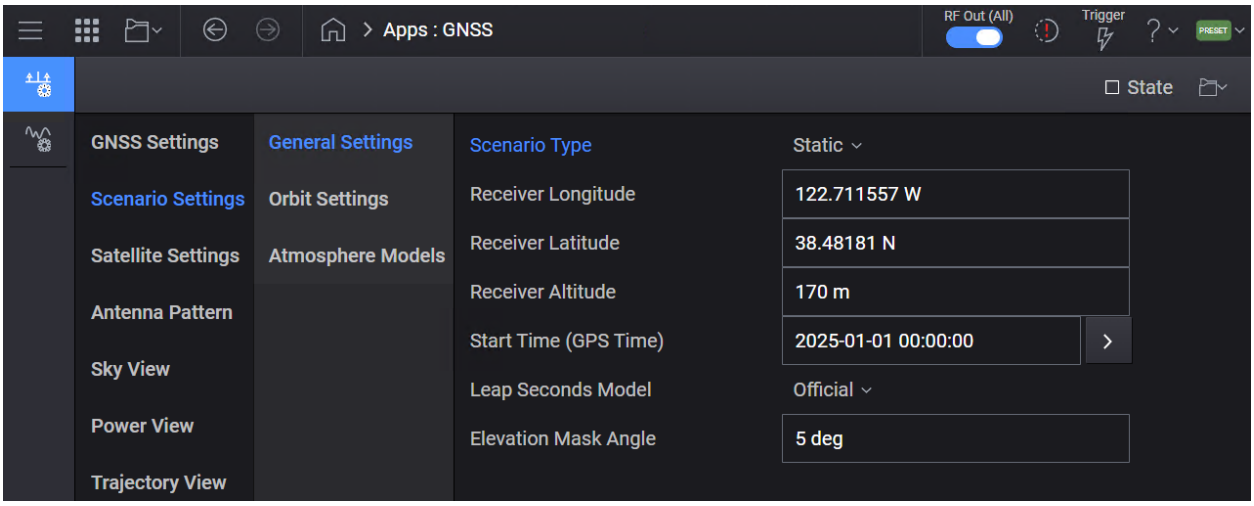

Figure 5. User interface of scenario parameters settings

Real-Time Control of Satellite Signals

The Satellite Settings tab provides a comprehensive view of all visible satellites grouped by each constellation and allows real-time control of the visibility and power of individual satellite (see Figure 6).

View-only parameters include:

- SVID: A unique identifier for each satellite. Prefix letters indicate the constellation, ‘G’ for GPS, ‘E’ for Galileo and ‘B’ for BeiDou.
- Elevation and Azimuth: Show the instant position of a satellite in the sky, relative to the receiver.
- Pseudorange: Represents the estimated range from satellite to the receiver, including propagation uncertainties.
- Doppler Shift: Indicates the frequency shift caused by relative motion.

Configurable parameters include:

- Enabled: Toggle satellite visibility on or off.
- Relative Power and Absolute Power: Adjust signal strength to simulate real-world conditions.

This real-time control capability allows you to model impairments such as loss or reduced power due to obstructions and immediately observe the impact on the receiver’s performance.

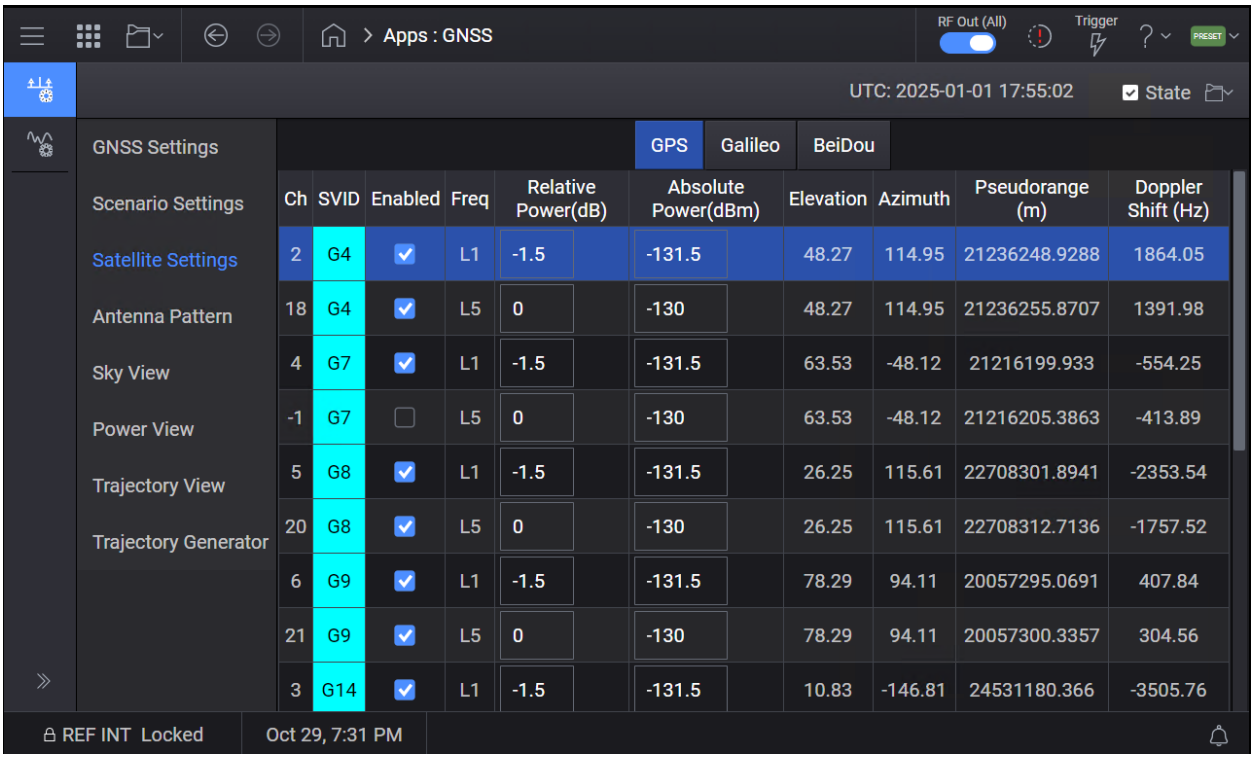

Figure 6. User interface of real-time satellite settings

Real-Time Status Displays

The GNSS application provides several intuitive graphical views that display real-time scenario information from the receiver's perspective — ideal for monitoring stimulation status.

- Sky View: Shows the position of all visible satellites in real time (see Figure 7). Satellite positions update continuously as elevation and azimuth change over time. Hovering over a satellite displays a tooltip with detailed information, including SVID, position, frequency, power, pseudorange, and Doppler shift. Position is expressed as elevation and azimuth angles, representing vertical and horizontal directions. Instant HDOP and PDOP values are also shown in this view.
- Power View: Displays the instantaneous power of all visible satellites in a bar chart, grouped by constellation (see Figure 8). Each frequency band is represented by a separate bar. Hovering over a bar reveals detailed information, including SVID, frequency band, and absolute power level.
- Trajectory View: Shows the historical trajectory of the current scenario (see Figure 9). Additional details include UTC, longitude, latitude, altitude, heading, and velocity. The map view can be customized by specifying the center point coordinates and deviation value. An Auto button automatically scales the trajectory to fit the map view.

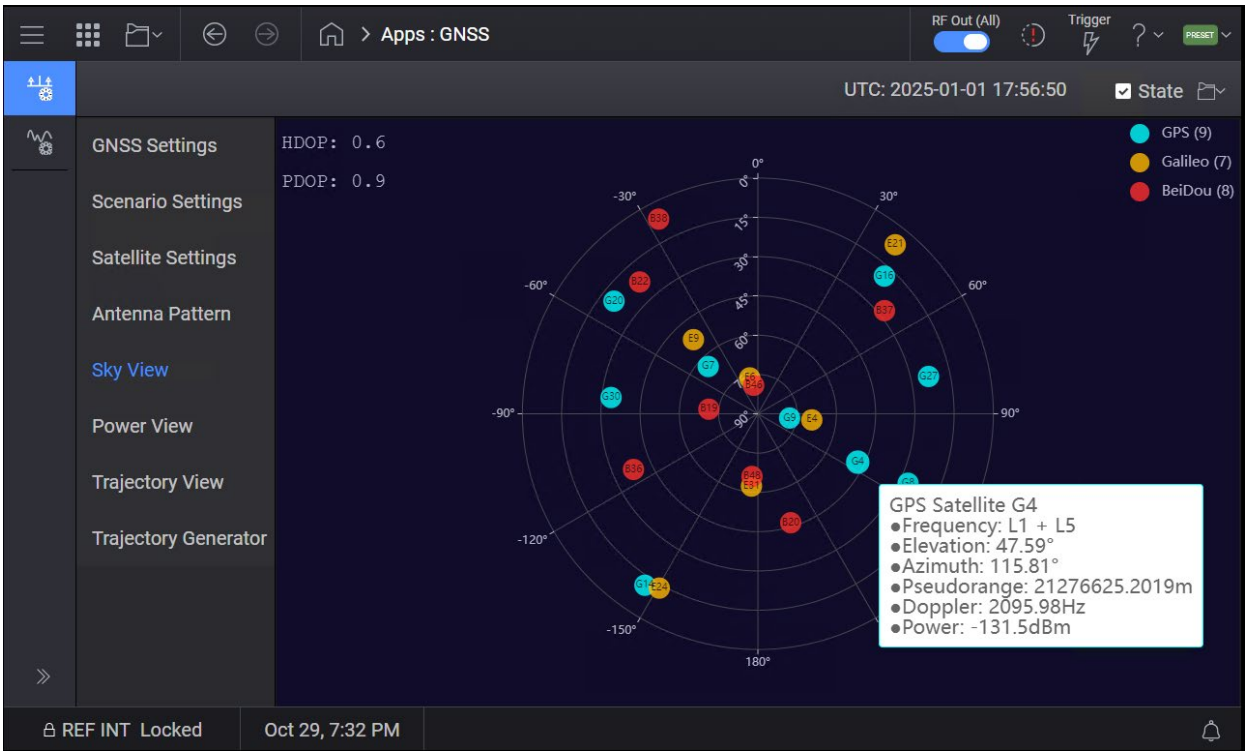

Figure 7. Real-time sky view display with tool-tips showing detailed satellite information. For GPS L1+L5 satellite, the tooltip displays L1 data including pseudorange, Doppler shift and power. For Galileo E1+E5, it shows E1 data. For BeiDou B1I+B1C+B2a, it shows B1I data.

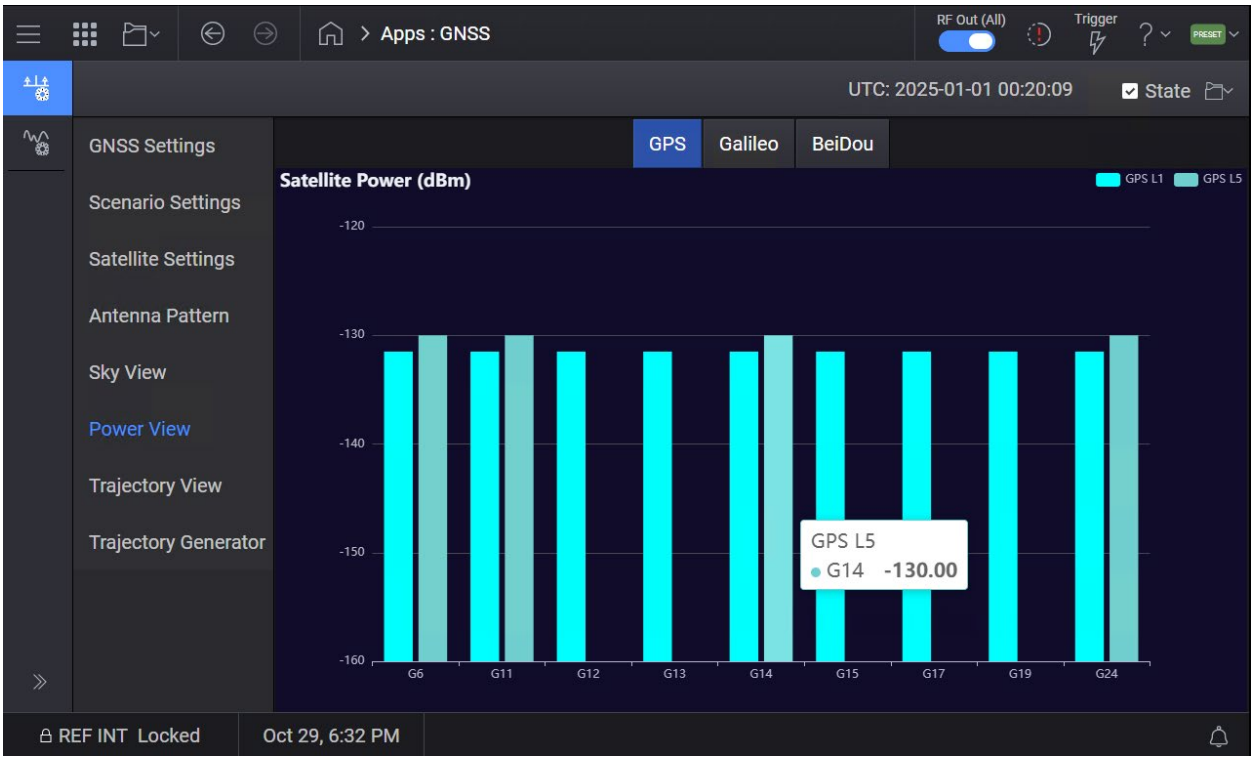

Figure 8. GPS real-time power view display with tool-tip showing the absolute power of each satellite

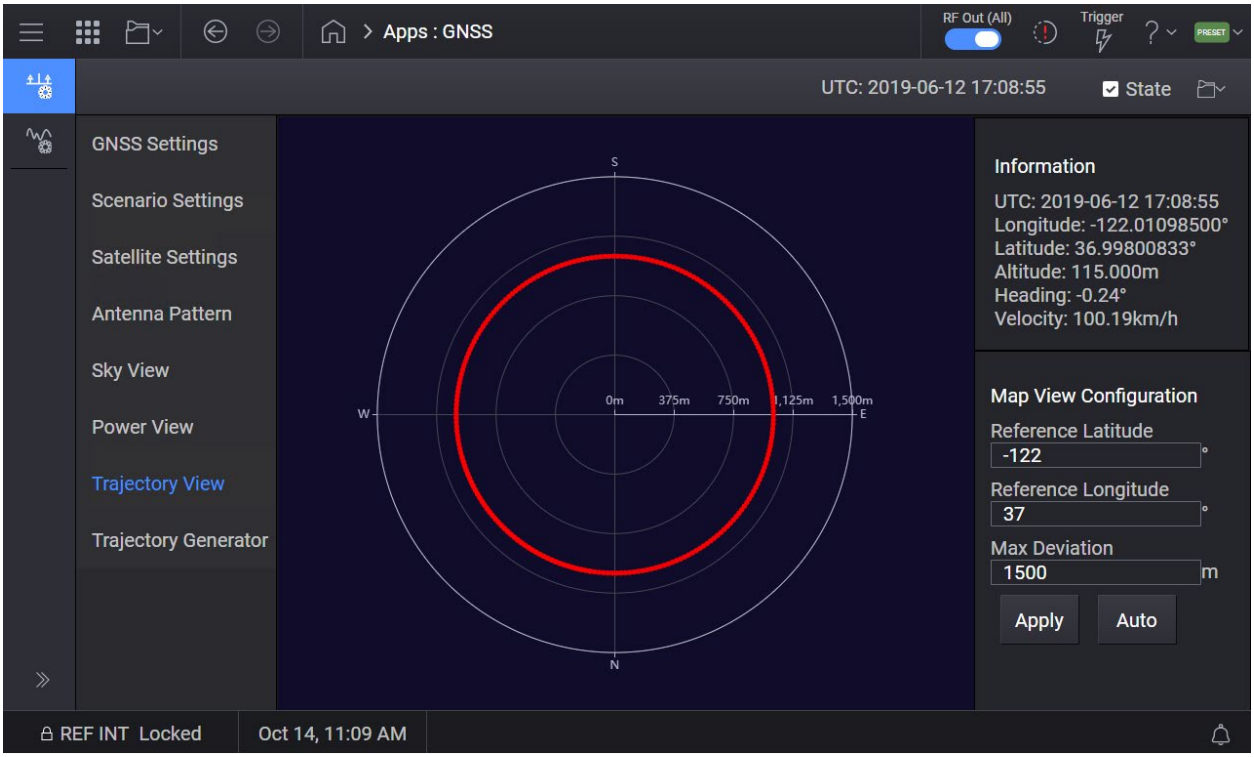

Figure 9. Real-time trajectory view display showing the history trajectory of the playing scenario

Antenna Pattern Testing

The Antenna Pattern view allows you to define antenna response patterns to simulate the characteristics of a receiver's antenna, or the effects of environmental obstructions. Once the Antenna Pattern function is enabled, you can enter power loss values for selected regions and apply them to GNSS signals or load a predefined pattern from a data file.

Elevation and azimuth grid makes it easy to specify power offsets for a cell, circle, sector, or any combination of these. Available operations include:

- Enable or disable the antenna pattern modeling during simulation
- Select regions by single or double click on the grid (highlighted in gray)
- Save or recall antenna pattern data in .csv format

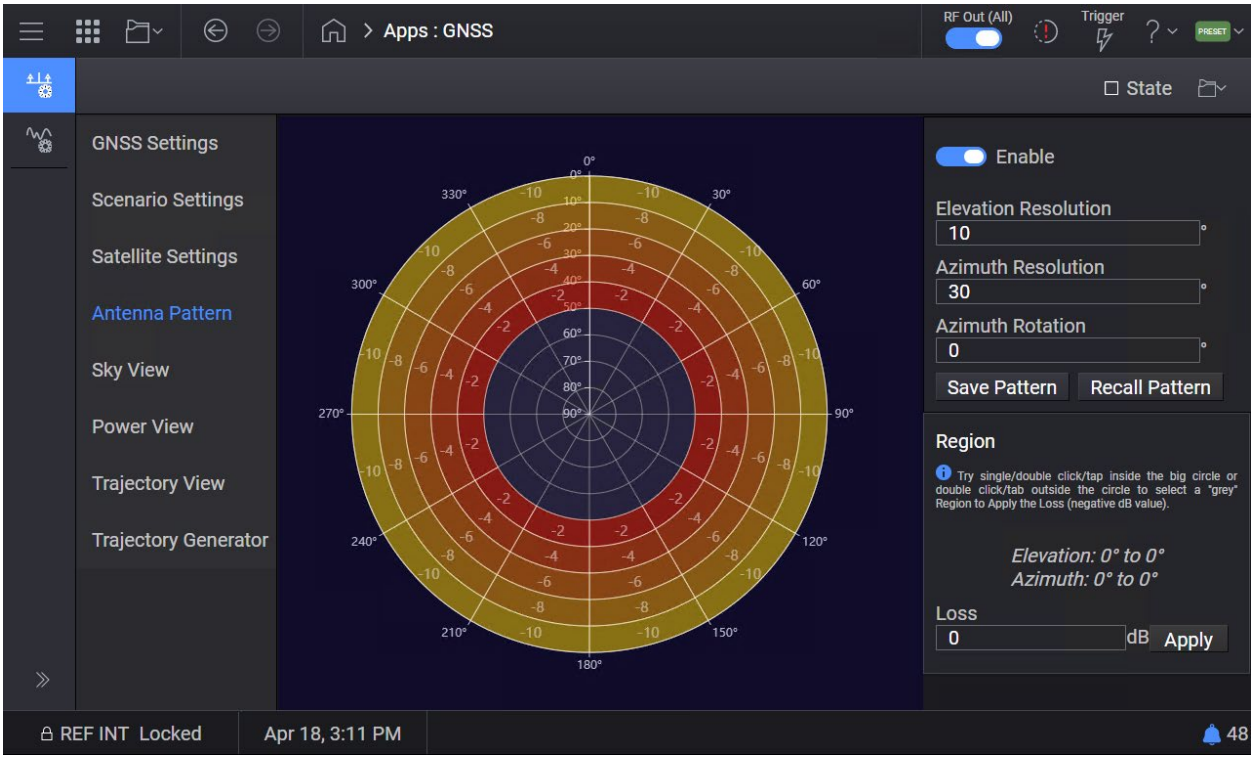

Figure 10. Antenna Pattern view for simulating receiver antenna characteristics or environmental obstructions

Trajectory Generator

The Trajectory Generator enables you to create custom trajectories for simulating a moving receiver. Specify general settings, such as receiver's position, initial velocity and initial direction. Then build the trajectory by combining segments, Wait, Straight and Turn, or by selecting a predefined shape. Once the trajectory is complete, you can view it in Trajectory Preview and export it as a .csv file for future use.

This feature makes it easy to create movement patterns required by GNSS receiver test specifications.

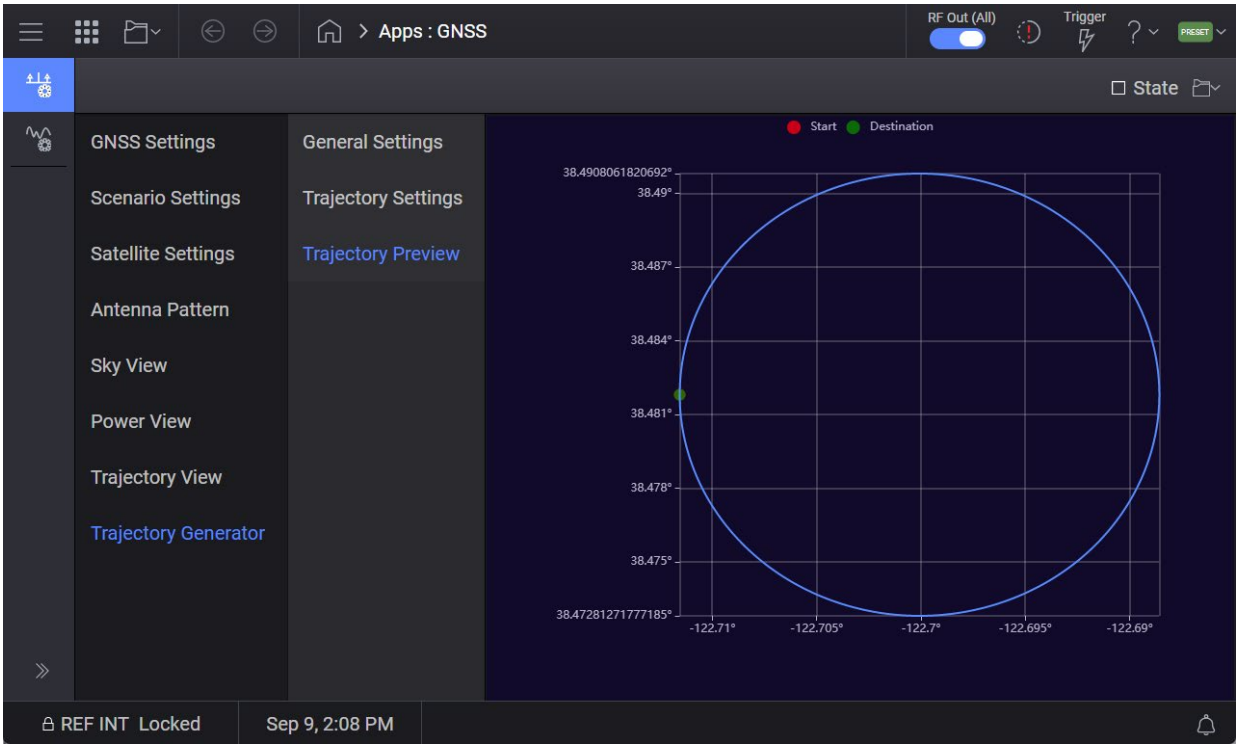

Figure 11. Trajectory Generator view: preview the generated trajectory

Feature Summary

PathWave Signal Generation for GNSS allows you to create GNSS standard-compliant signals.

Features	Firmware Version
Real-Time Signal Generation	
Simulate GPS dual-band for L1 C/A plus L5I and/or L5Q	A.16
Simulate Galileo dual-band for E1 OS plus E5 (E5a + E5b)	A.17
Simulate BeiDou multi-band for B1I, B1C and B2a	A.18
Provide 96 channels for line-of-sight satellites	A.16
Support user-defined scenarios generation for stationary receivers or moving receivers	A.16
Ionospheric and tropospheric modeling	A.16
Provide real-time control for individual satellites, including satellite visibility on/off, absolute and relative satellite power adjustments	A.16
Add calibrated AWGN for control of C/N ratio (requires AWGN option in instrument)	A.16
Provide 1 pps and 1 ms outputs	A.16
Support test automation with SCPI commands for all the parameters	A.16
Support Antenna pattern testing	A.17
Support Trajectory Generator	A.18
Support various orbit data types: Almanac, RINEX, Mixed RINEX	A.18
Support user-defined leap seconds	A.18
Real-Time Status Display	
Real-time sky view of visible satellites	A.16
Real-time satellite power per constellation	A.16
Real-time simulation of receiver trajectory	A.16

Supported Standards and Test Configurations

Constellation	Specification	Firmware Version	License version
GPS	Interface Specification IS-GPS-200E, Navstar GPS Space Segment/Navigation User Interfaces (2010)	A.16	2024.1119
Galileo	European GNSS (Galileo) Open Service Signal In Space Interface Control Document (OS SIS ICD), Issue 1.1 (2010)	A.17	2025.0201
BeiDou	BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1I (Version 3.0) Open Service Signal B1C (Version 1.0) Open Service Signal B2a (Version 1.0)	A.18	2025.0901

Ordering Information

PWSG embedded 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

PathWave Signal Generation for GNSS Embedded Application License N7609APPC [1] for M9484C VXG

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	SW1000-LIC-01	SW1000-SUP-01
Transportable time-based [1]	SW1000-SUB-01	Included

1. Support M9484C VXG vector signal generator with firmware version A.16 and late. On the M9484C VXG, N7609APPC also enables the playback of GNSS waveforms generated by N7609C Signal Studio for GNSS

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 software and use it free for 30 days to do evaluation for your test. Request your free trial license today:

www.keysight.com/find/signalstudio_trial

Additional Information

Hardware Configurations

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

www.keysight.com/find/SignalStudio_platforms

www.keysight.com/find/M9484C

Websites

PathWave Signal Generation

www.keysight.com/find/PWSG

PathWave Signal Generation for GNSS embedded application:

www.keysight.com/find/n7609appc

Signal Studio for GNSS:

www.keysight.com/find/n7609c

Literature

PathWave Signal Generation, Brochure, 5989-6448EN

GPS Receiver Testing, Application Note, 5990-4943EN

GNSS Technologies and Receiver Testing, Application Note, 5991-2288EN

N7609C Signal Studio for Global Navigation Satellite Systems (GNSS), Technical Overview, 5992-2740EN