

GPS Multiple-Satellite Signal Generation

NI GPS Simulation Toolkit for LabVIEW

- Generate 24 hours of up to 12 satellite C/A codes (L1)
- Define custom motion trajectories for mobile simulation
- Adjust individual satellite power levels for scenario-specific test
- Achieve automatic satellite simulation from almanac and ephemeris files
- Take advantage of manual control of satellite pseudorange, Doppler, and power-level information



Overview

With the NI GPS Simulation Toolkit for LabVIEW, you can create simulated L1 coarse acquisition (C/A) global positioning system (GPS) waveforms for use with NI RF vector signal generators to produce customized signals for repeatable GPS receiver test. You can use the flexible application programming interface (API) to customize motion profiles for scenario-specific mobility testing, adjust individual satellite power levels, and incorporate real-time feedback from the GPS receiver into your test system. With the GPS Simulation Toolkit, you can stream a simulated signal as it is created using a vector signal generator and adjust signal characteristics during generation or create predefined scenario tests for up to 24 hours of nonrepeating GPS data for reliable and low-cost GPS test.

Measurements

The combination of the GPS Simulation Toolkit and an NI PXIe-5673 or PXIe-5672 vector signal generator provides a flexible solution for design validation and production testing of GPS receivers by helping you perform common test measurements such as sensitivity, time to first fix (TTFF), position, and tracking accuracy.

1. Sensitivity

- Programmable power levels down to -145 dBm
- Power accuracy better than ± 1.0 dB down to -127 dBm
- Single-satellite and multiple-satellite modes that can be used for C/N measurements – receiver does not lock in single-satellite mode

2. Time to first fix (TTFF)

- Multiple-satellite generation that allows the receiver to achieve position fix
- Generation of up to 12 satellites for up to 24 hours of extended GPS simulation playback time, which is particularly useful for long-duration validation and verification simulations or extended BER testing
- Ability to adjust satellite power level, Doppler shift, and pseudorange information (note that the receiver may not achieve a position fix if unrealistic information is provided)

3. Position and tracking accuracy

- Multiple-satellite generation that allows the receiver to achieve position fix
- Position simulation in both ECEF and LLA formats for position accuracy test
- Simple trajectory mode for fixed velocity or acceleration tracking accuracy test
- Simple trajectory mode for tracking and accuracy tests with fixed velocity or acceleration

Applications

You should perform the measurements described in the previous section under a variety of signal impairments. With the GPS Simulation Toolkit, you can create a variety of environments to introduce impairments such as satellite dropout, Doppler shifts associated with various receiver motions, and the presence of interference or jamming signals.

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1. Receiver in motion
 - Simulate motion using simple trajectory mode for maximum speed and acceleration tests
 - Implement the script trajectory mode for motion-specific tests using directions and waypoints
2. Satellite dropout or low satellite power level
 - Adjust satellite power levels during signal generation
 - Lower satellite levels to simulate heavy foliage or urban canyons
 - Drop satellite power levels to simulate satellite dropout or to improve dead-reckoning techniques
3. Extended position and tracking accuracy
 - Generate up to 24 hours of simulated GPS signals for extended position and tracking accuracy verification
4. Interference or jamming signal
 - Use simulated data from the GPS Simulation Toolkit along with two vector signal generators to combine the signal with interference or spoofing signals from the second vector signal generator

GPS Waveform Creation

You can use the GPS Simulation Toolkit to create a simulated waveform and save it to disk for generation at a later time or to stream the waveform directly to a vector signal generator for immediate generation. For a GPS receiver to return a position fix, at least four satellite signals are required. With the GPS Simulation Toolkit, you can simulate real-world scenarios that use from one to 12 satellites. All scenarios involve the creation of a baseband waveform, and the waveform requires almanac and ephemeris files to provide satellite information. Sample almanac and ephemeris files are included in the installer, but you can also download them directly from the following sites:

- Almanac information (The Navigation Center of Excellence)
<http://navcen.uscg.gov/gps/almanacs.htm>
- Ephemeris information (NASA Goddard Space Flight Center)
http://cddis.gsfc.nasa.gov/gnss_datasum.html#brdc

These files contain information such as satellite location, trajectory, and health from a specific date and time. Note that in addition to downloading these files, you can create them, provided you format the files appropriately. The accepted almanac file format is SEM and the accepted ephemeris file format is RINEX 2.0.

When creating GPS waveforms, you can operate the toolkit in either automatic or manual mode. In automatic mode (Figure 1), the toolkit determines up to 12 optimal satellites based on different criteria such as valid pseudorange, valid Doppler shift, acceptable elevation angle, and satellite health captured from the given ephemeris file. These criteria ensure a position fix at the receiver if enough satellites are found. In manual mode, the receiver may not be able to give a position fix depending on the input data, but you can access a variety of low-level GPS satellite details to simulate specific conditions.

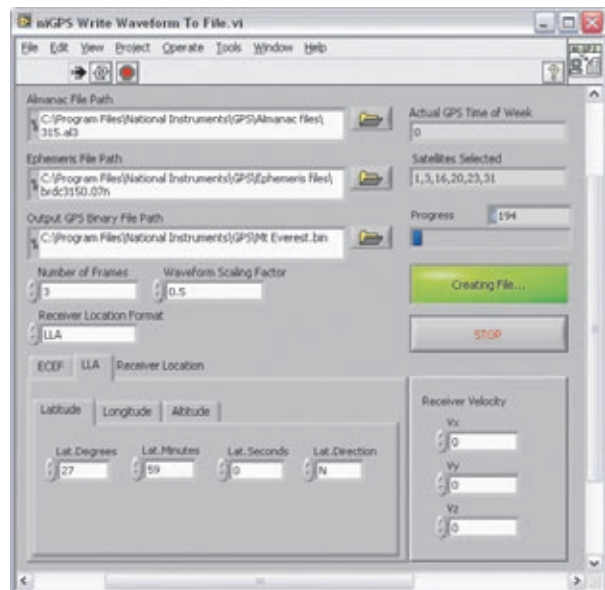


Figure 1. Front Panel of niGPS Write Waveform to File VI

You can use the toolkit to create stationary (fixed-location) simulation files or custom motion trajectory simulations for simulated drive tests. When simulating GPS receiver motion, you can operate the toolkit in simple or script trajectory mode. Simple trajectory mode is useful for maximum-speed testing, where you specify a fixed initial velocity or acceleration and determine the speed at which the receiver loses lock. For more tailored tests, you can use script mode to provide direction-based motion using the straight, arc, and halt commands or you can provide LLA waypoints using the waypoint command.

The toolkit allows for both the direct streaming generation as well as the storage of created waveforms on disk. When operating in streaming mode, you have the option to adjust signal characteristics on the fly such as relative satellite power levels to create scenario-specific simulations.

GPS Waveform Generation

GPS baseband waveforms are sampled at a rate of 1.5 MS/s (complex data type). Each sample contains two I16 values, representing the I and Q waveforms, which translates into 6 MB/s of data. Stored as binary files, the data has a maximum file size of 518 GB (or 24 hours). You can generate GPS waveforms as you create them by streaming them directly to a vector signal generator, or, once you create the file, you can generate the waveform by streaming from file (Figure 2).

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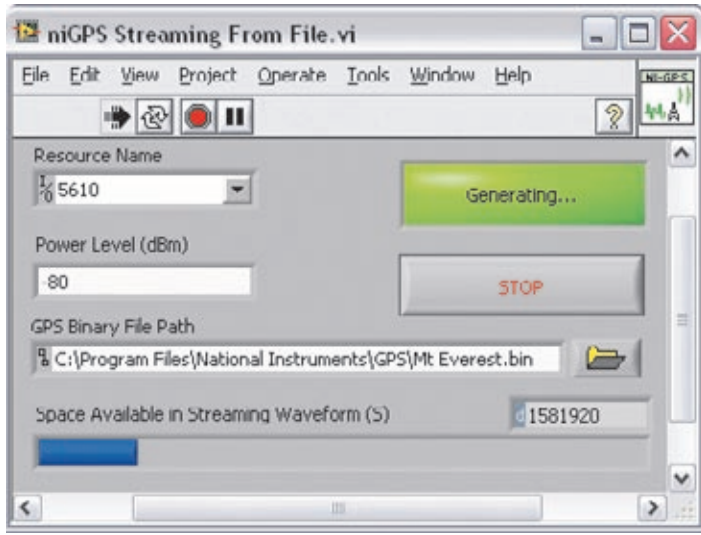


Figure 2. Front Panel of niGPS Streaming From File VI

Note that you can use the same playback method to generate single- and multiple-satellite GPS signals. As a result, you can easily perform common receiver measurements such as sensitivity, TFFF, and position and tracking accuracy.

The GPS Simulation Toolkit is designed for use with the NI PXIe-5673, PXIe-5672, and PXI-5671 RF vector signal generators. Both the NI PXIe-5672 and PXI-5671 implement a superheterodyne architecture for best out-of-band RF performance and use FPGA-based digital upconversion to stream files from disk at the full output rate of the instrument. Stream-from-disk technology is one of the primary benefits of the PXI platform, which provides each instrument access to a high-speed data bus. The NI PXIe-5673 and PXIe-5672 feature direct streaming generation to allow for immediate generation of simulated waveforms and on-the-fly adjustments to signal characteristics. In addition, as general-purpose RF vector signal generators, the NI PXIe-5673, PXIe-5672, and PXI-5671 are capable of generating a variety of signal types including GPS, GSM/EDGE, Wi-Fi, and DVB-T. For GPS-specific generation, the RF vector signal generator is programmed to a center frequency of 1.57542 GHz. Key specifications for the NI GPS Simulator are shown in Table 1. For more information on NI RF hardware at other power and frequency levels, refer to the RF signal generator’s detailed specifications at ni.com/rf.

Parameter	Specification
GPS Frequency (L1)	1575.42 MHz
Number of Satellite Channels	12
Navigation Data Type	GPS C/A Code at 50 bps BPSK
Doppler Shift Range (Manual Mode)	±600 kHz
Maximum Velocity ¹	>514 m/s
Position Accuracy ¹	<5 m
Peak Power Range	-145 to +10 dBm
Power Resolution	0.02 dB
Power Accuracy	±1.0 dB, -80 to -127 dBm
Phase Noise	-96 dBc at 10 kHz
Frequency Range (NI PXIe-5672)	250 kHz to 2.7 GHz
Frequency Resolution	355 nHz
Reference Stability	<50 ppb

¹Based on SiRFStarIII GPS receiver (max velocity of 514 m/s, position accuracy <2.5 m).

Table 1. Key Specifications for the NI GPS Simulator

External Padding

NI recommends using 40 dB of external attenuation to minimize the noise floor at the output of the instrument. This ensures that the noise density at the input of the receiver is as close to -174 dBm/Hz (thermal noise floor) as possible, effectively eliminating noise contribution to the receiver.

Ordering Information

NI GPS Simulation Toolkit for LabVIEW.....780314-01
 Requires NI LabVIEW Version 8.0 or later and
 the NI Modulation Toolkit for LabVIEW Version 4.0 or later.

Recommended Hardware

RF Vector Signal Generators with Digital Upconversion

- NI PXI-5671, 512 MB.....779079-04
- NI PXIe-5672, 512 MB.....779900-03
- NI PXIe-5673, 512 MB.....780418-02

Hardware includes NI Modulation Toolkit for LabVIEW.

External RAID Systems

- NI HDD-8263, 1 TB.....780065-01
- NI HDD-8264, 3 TB.....780066-01

In-Chassis Data Storage

- NI PXI-8260780980-01

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