APN-090

Application Note

Using NovAtel Receivers With GNSS Simulators

HEXAGON AUTONOMY & POSITIONING DIVISION
PROPRIETARY DATA

Contents

Introduction

NovAtel receivers can interface with GNSS simulators for the purposes of testing and research for many applications. There are many different simulators and simulator manufacturers available in today's market. This application note is not to discuss different simulators or how to use them, but rather how to use NovAtel products with a simulator to ensure smooth operation. A user should consult with their simulator's operator manual and/or technical support group to become familiar with basic simulator functionalities prior to following the instructions below.

Simulator setup

Establishing a noise floor

In a typical simulation setup, the receiver is directly connected to the RF output of the simulator:

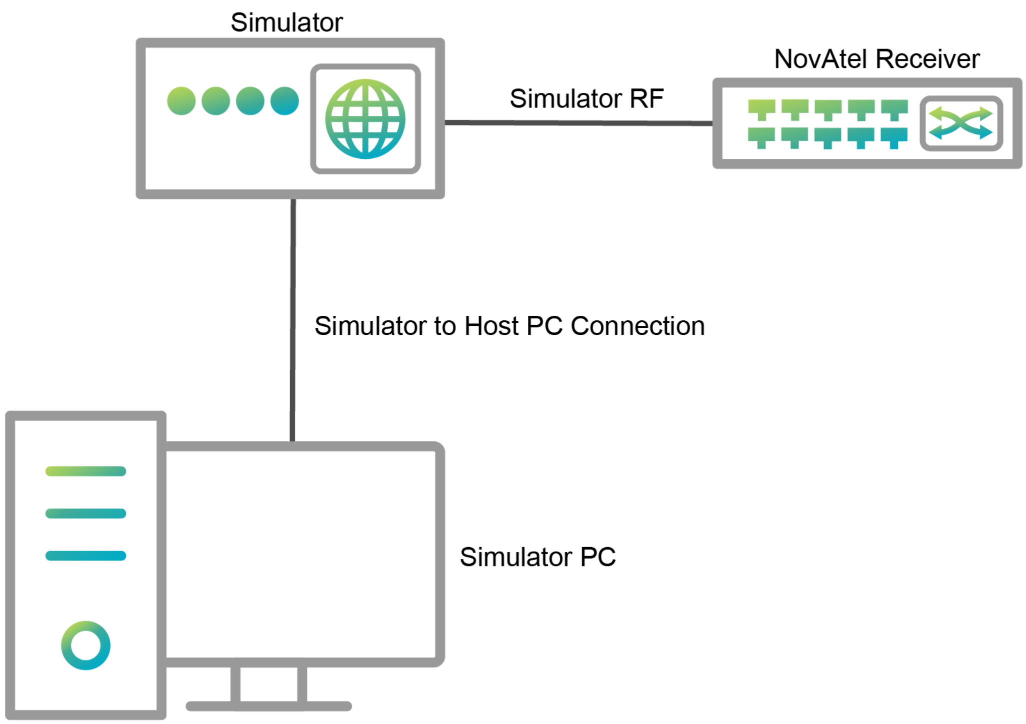

Figure 1: Typical simulation setup with a NovAtel receiver

In some cases, this may be sufficient, but note that simulator RF may not contain additional noise that is inherent in live GNSS signals. If the simulator is broadcasting a GNSS signal with very little or no noise, receivers can still track these signals. However, it will skew the receiver's AGC (Automatic Gain Control) away from the ideal gain settings that are common when tracking live signals. If a user desires, there are ways to add noise to simulator signals and these will be discussed in the next few sections.

Low-Noise-Amplifier (LNA)

Adding a Low-Noise-Amplifier between the receiver and simulator can add sufficient noise to the signal. Indeed, the amplifier will inherently boost the RF of the simulator signal. However, power of the simulator can be controlled and lowered to offset the gain of the amplifier. Manually applying attenuators before amplifying is another solution if adjusting the simulator output power level is not an option. An example LNA is the Mini Circuits ZRL 2000 series amplifiers, which can be used to establish a noise floor.

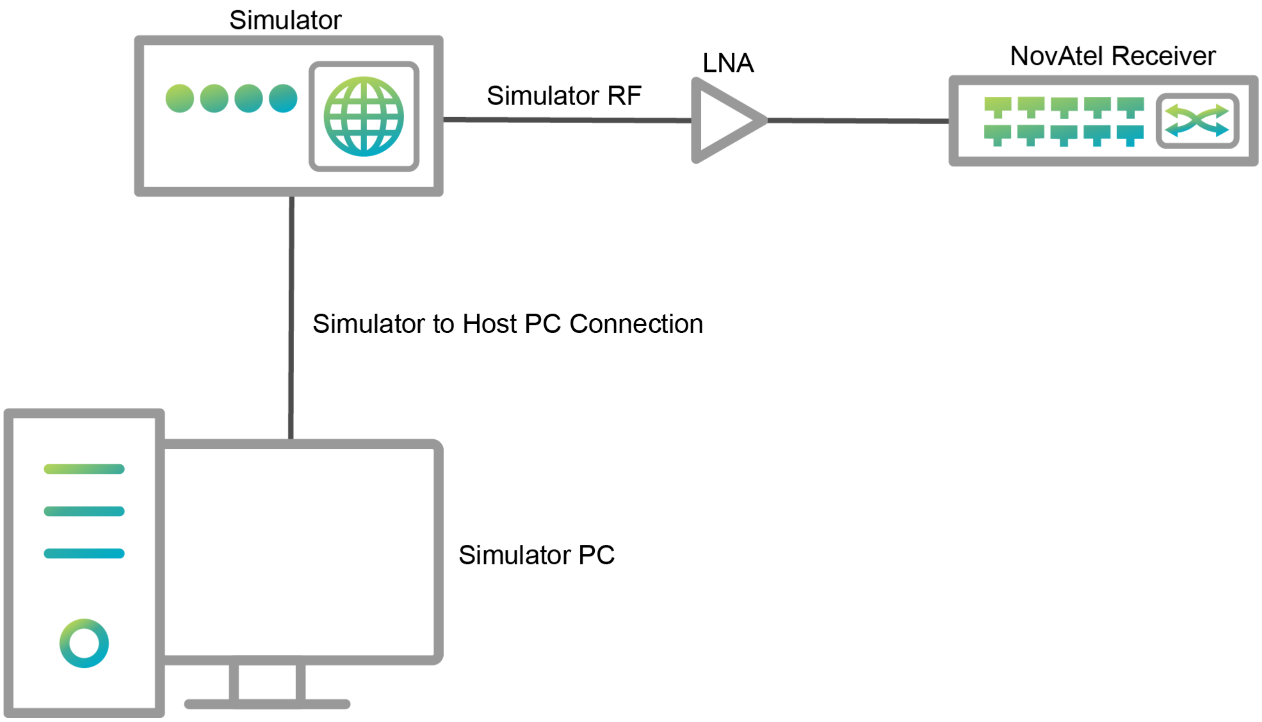

Figure 2: Typical simulation setup with an LNA in the RF path

Adding a noise source

More sophisticated control over the noise can be achieved through a noise source module. A small but effective noise source (such as the Noisecom NC1113B module) can be placed between the simulator and receiver. Software commands can be sent to the noise source module to attenuate the noise to a desired level.

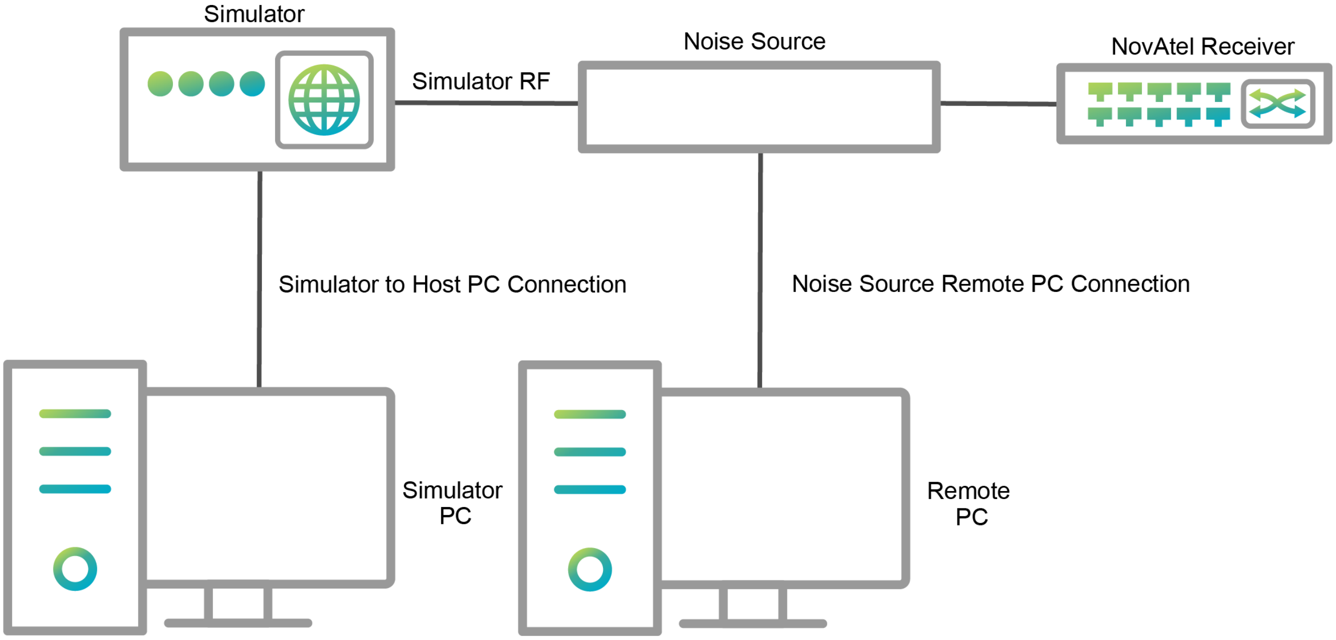

Figure 3: Typical simulation setup with a noise source module enhancing the control of the RF path

Regardless of the noise source used with a simulator setup, the target input noise density to the receiver should be between -160 dBm/Hz to -130 dBm/Hz. A value of -142 dBm/Hz is ideal. This can be measured using a spectrum analyzer.

Simulator power

Simulators can broadcast a variety of power levels to meet the customer needs. It is essential that the power from the simulator is set correctly because:

- If the power is too low, it will result in noisy measurements and positions, or the receiver won't be able to acquire the GNSS signals.
- If the power is too high, this will result in signal cross-correlation (i.e. tracking the wrong GNSS signals), or problems with acquisition due to false skysearch hits.

The correct power level should be set first before acquiring GNSS signals to avoid the issues described above. Once GNSS signals are acquired, then the simulator power and/or noise can be adjusted (preferably slowly) to test lower or higher signal powers.

The target input simulator power is based on the noise input noise density from the previous section. For acquiring signals, the target Carrier-to-Noise-Density (C/No) should be around 41-55 dB-Hz, while once tracking a broader range may be desirable in some application. The C/No of each tracked signal on the NovAtel receiver can be monitored in the RANGE or TRACKSTAT logs.

For instance, if the noise density is -142 dBm/Hz, the input simulator power should be -97 dBm to theoretically obtain a C/No of 45 dB-Hz:

-142 dBm/Hz + 45 dB-Hz = -97 dBm

Note that this does not accurately reflect power due to changes with RF cable loss, amplifiers, or other factors.

Other setup considerations

By default, the receiver provides power out of its own RF port to the antenna. However, when connected to a simulator, that port is connected to the RF output of the simulator. Although the simulator should have protective mechanisms against this input voltage, precautions should be taken as follows:

- Issue the "ANTENNAPOWER OFF" command to the receiver to disable the antenna voltage; and/or
- Put a DC block between the simulator and receiver RF connections.

Simulation configuration

All GNSS simulators offer the ability to change the date and time to meet the needs of a variety of test applications. With real satellites in space, it is expected that GNSS time shall be continuous without sudden changes or interruptions, as this will affect measurement and position performance of the receiver.

It is best practice to issue a factory reset FRESET command to the receiver any time there could be drastic time changes observed by the receiver, such as when:

- Switching between a live GNSS RF signal and a simulator GNSS RF signal.
- Starting a simulator scenario, then stopping it to rewind to the beginning and rerunning (the receiver will not behave properly if it concludes it has gone back in time).
- Obtaining time through other means such as from time transfer mechanisms or PTP, and then switching to a simulator GNSS RF signal.

The use of FRESET in such circumstances is important, because in reality, time is continuous forward, and the navigation data (almanacs, ephemerides) are based on real time. The RESET command works with live signals; and if a simulator is continuously running and keeps running, it is sufficient to RESET the receiver rather than FRESET it. However, as soon as the simulator stops and the scenario is rewound, FRESET must be issued to clear navigation data before the receiver may be subjected to drastic time changes.

Base week

GPS Time is reported in weeks since Jan. 6, 1980. The GPS ICD defined navigation data format limits the number of weeks before a roll over to 1023. This means that roughly every 19 years the GPS week goes back to zero and starts incrementing again. In order for the receiver to determine the actual calendar date, before firmware version 7.08.14 NovAtel pre-configured a reference date to figure out the current GPS "era" (pre- 1999, 1999-2019, or post 2019). This date was regularly updated in the firmware. If a simulation is too far in the past or future, then the receiver continues to function, but the reported week differs from the simulated week by a multiple of 1024.

In 7.08.14 and later OEM7 firmware versions, the receiver stores and updates the week number in NVM to automatically maintain GPS week era. If a simulation is too far in the past or future, then the stored week number may not be valid and lead to the reported week differing from the simulated week by a multiple of 1024, and also cause the stored week number to be updated to an incorrect value. For simulations, it is recommended to use the hidden command SETBASEWEEK <week> at startup to ensure the correct week. The <week> is since Jan. 6, 1980, so in the 2019-2038 era it is 2048 + current GPS week. After the simulation is complete, it is recommended to use the hidden command FRESET BASE_WEEK to revert the reference date to the pre-configured value.

Almanacs and signals

NovAtel OEM receivers assign channels based on the SV config code (block number) in the almanac and idles channels when the signal is not broadcast. For example, in space GPS PRN 11 is a Block IIR satellite that doesn't broadcast GPS L1C, L2C, or GPS L5, so once an almanac is obtained the GPS L1C, L2C, and GPS L5 channels are idled.

This can be problematic with simulator scenarios, since by default they may set satellites to a block number that isn't the same as the signal in space. For example, if all satellites are set to block IIR, then once the receiver has an almanac it will stop tracking GPS L1C, L2C and L5 signals. To prevent this, the block number should be configured to a higher block number (e.g. block III) to allow the receiver to track the modernised signals. Or if the desire is for the simulator to be the same as the satellites in space, then the simulator should be configured to match the current status at United States Coast Guard Navigation Center.

Acceleration and jerk

The receiver will maintain tracking with a jerk of up to 10 g/s. For this reason, acceleration should be applied gradually rather than instantly (which leads to infinite jerk).

High speed applications

A NovAtel receiver will stop tracking and enter an error state when the velocity is at the COCOM limit of 1000 knots (600m/s velocity limit in NovAtel OEM7 products). In the error state, the receiver stops tracking and stops outputting a position until it is reset or power-cycled.

For configuration of the receiver for high speed/Low-Earth-Orbit (LEO) applications when utilising GNSS simulators, please contact NovAtel Support.

Support

To help answer questions and/or diagnose any technical issues that may occur, the NovAtel Support website is a first resource.

Remaining questions or issues, including requests for test subscriptions or activation resends, can be directed to NovAtel Support.

Before contacting Support, it is helpful to collect data from the receiver to help investigate and diagnose any performance-related issues. A list of appropriate troubleshooting logs can be found on the OEM7 Documentation Portal (the LOG command with the recommended trigger and data rate is included with each log).

The data can also be collected using NovAtel Application Suite.

Documentation

For any questions on logs and commands, please visit the OEM7 Documentation Portal.

Contact Hexagon | NovAtel

support.novatel@hexagon.com 1-800-NOVATEL (U.S. and Canada) or 1-403-295-4900

For more contact information, please visit novatel.com/contact-us