



Using NovAtel Receivers with GNSS Simulators

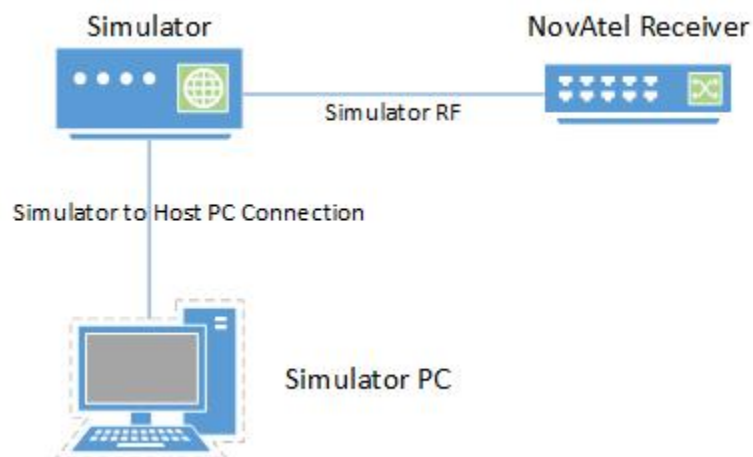
Introduction

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

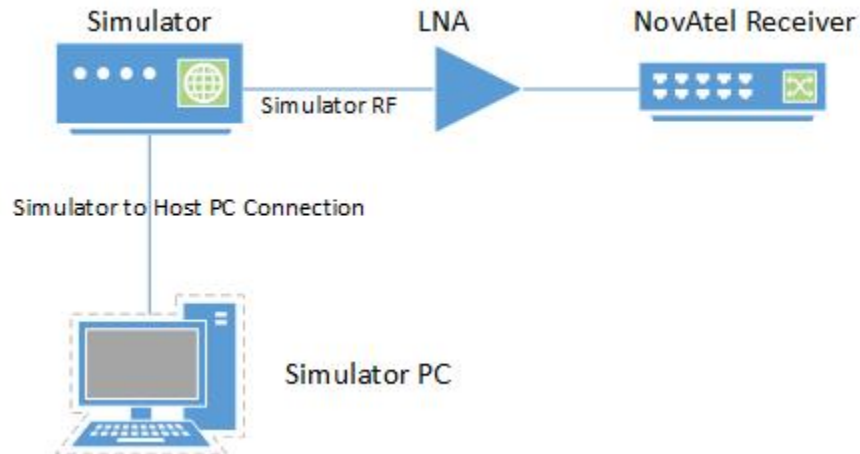
In a typical simulation setup, the receiver is directly connected to the RF output of the simulator:



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 bin and 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.

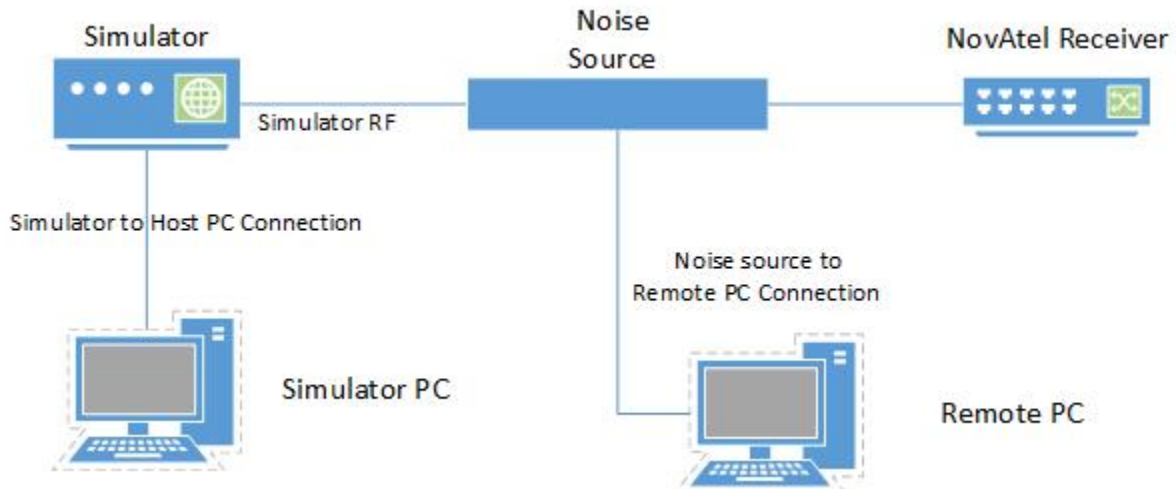
Low-Noise-Amplifier (LNA)

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 using the simulator 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.



Adding a noise source

More control over the noise can be achieved through a noise source module. A small but effective noise source (such as the Noisecom NC113B 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.



Regardless of the noise source used when using a simulator, the target input noise density into 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 wide variety of power levels to meet the needs of its customers. It is important 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 can be observed in the [RANGE](#) or [TRACKSTAT](#) logs.

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

$$-142 \text{ dBm/Hz} + 45 \text{ dB-Hz} = -97 \text{ dBm}$$

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

Other Setup Considerations

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

- Issuing the [ANTENNAPOWER](#) OFF to the receiver to disable the antenna voltage; and/or
- Putting 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 [FRESET](#) command to the receiver any time there could be drastic time changes observed by the receiver, such as:

- Switching between a live GNSS RF signal to a simulator GNSS RF signal
- Starting a simulator scenario, then stopping it and rewinding the scenario to the beginning again (the receiver will not behave properly if it thinks it has gone back in time).
- Other means of obtaining time (such as from time transfer mechanisms or PTP), then switching to a GNSS RF simulator signal.

In reality, time always continues forward, and the navigation data (almanacs, ephemerides) are based off these times, so it is ok to issue a [RESET](#) command without consequences with live signals.

The same is true for simulators. If a simulator is continuously running and keeps running, it is ok to [RESET](#) rather than FRESET. As soon as the simulator stops and the scenario is rewound, a [FRESET](#) must be issued before the receiver receives simulator or live signals again.

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, NovAtel has historically pre-configured a reference date to figure out the current GPS "era" (pre-1999, 1999-2019, or post 2019). From time to time NovAtel has updated the pre-configured date in a new firmware version to allow the receiver to determine to correct era for the next 18 years. If the simulation is too far in the past or future, then the receiver will continue to function but the reported week will differ from the simulated week by a multiple of 1024.

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 modernized 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 in <https://www.navcen.uscg.gov/?Do=constellationstatus>.

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 (514 m/s, 1852 km/h, 1150 mph). 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 utilizing GNSS simulators, please contact NovAtel customer support.



Customer Service Contact Information

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