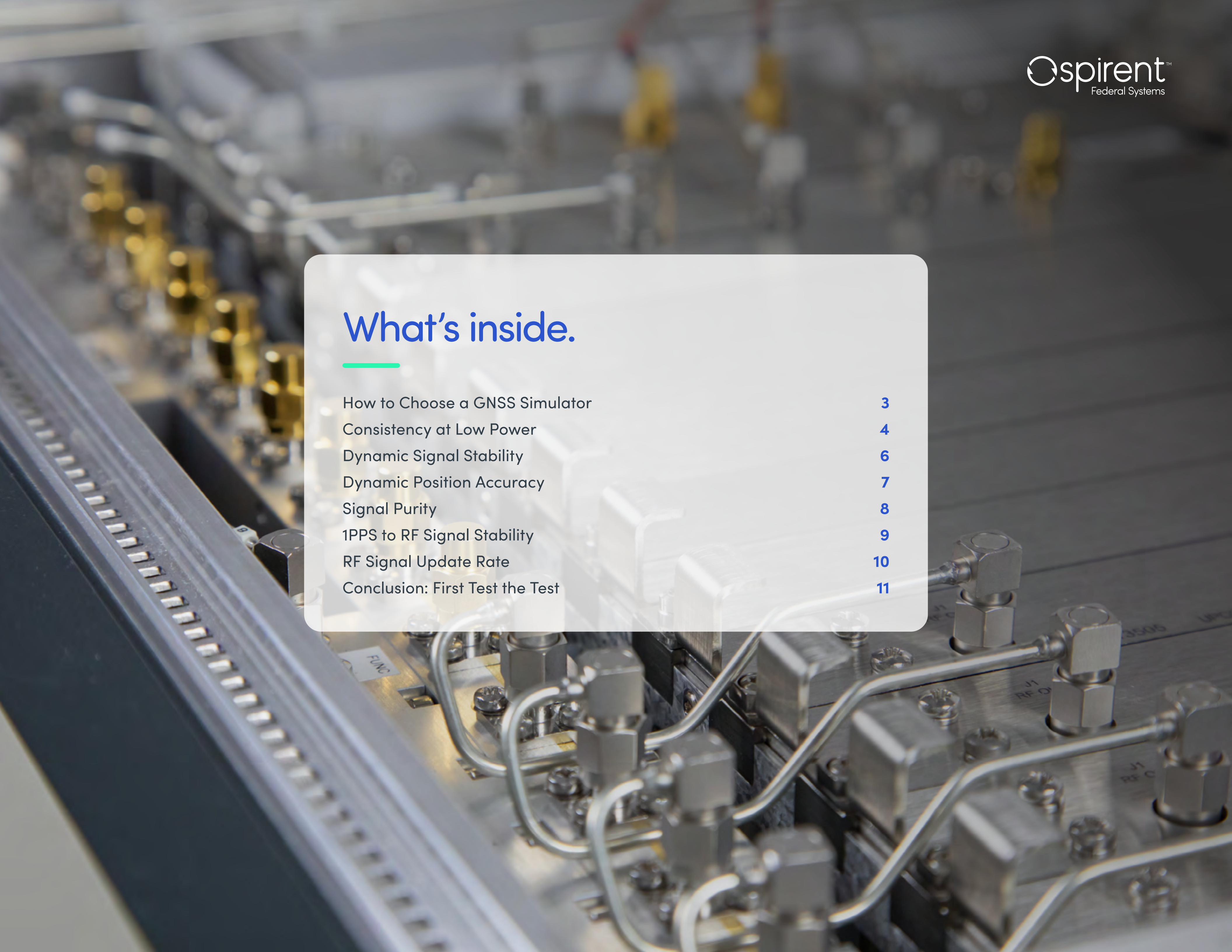
Spirent Federal Systems

A SPIRENT E-BOOK

How to Choose a GNSS Simulator



Spirent Federal Systems

What's inside.

How to Choose a GNSS Simulator

There is significant variety in the quality, accuracy, and reliability of signals produced by GNSS simulation systems. And, confusingly for many development and integration engineers, the lengthy specification lists supplied by manufacturers apply more to features and capability than to accuracy and performance—so the breadth of the frequency dial and number of channels, rather than any measure of the quality of results.

This presents an important issue in the development of a functional product, as poor test signal simulation could lead to:

- Poor choices in the selection and integration of receivers, chipsets, antennas, and protocols;
- Long delays in new product introduction—redesigning devices for no reason;
- Damaging quality control issues between manufacturers and tier one suppliers;
- Functional devices being wasted after needlessly failing production line tests.

For any test to be meaningful, there needs to be no possibility of confusing errors in the device with inaccuracies introduced as part of the test itself.

Accordingly, all test apparatus must always be an order of magnitude more accurate than the device under test.

What this means is that if a device is expected to be accurate to within 10m, the test equipment should be reliable to within 1m. If the device's acceptable margin of error is centimetres, then the test resolution should be millimetres.

Unfortunately, simulator accuracy is hard to quantify in a bite-sized, specification-sheet format. So, we ran several illustrative tests.

Consistency at Low Power

GNSS positioning signals are received at low power, where the ratio of signal to noise makes them difficult to identify. This is a key issue in many consumer product applications, where a device might be expected to work well surrounded by buildings or tree cover, in a vehicle, indoors, or in an environment with significant RF interference.

A good GNSS simulator for consumer device use should therefore be able to give consistent signal accuracy, even at the low extremes of its operating spectrum. Some multi-use RF signal generators not designed specifically for satellite positioning use, for instance, struggle to maintain accuracy as the power level is dialled down.

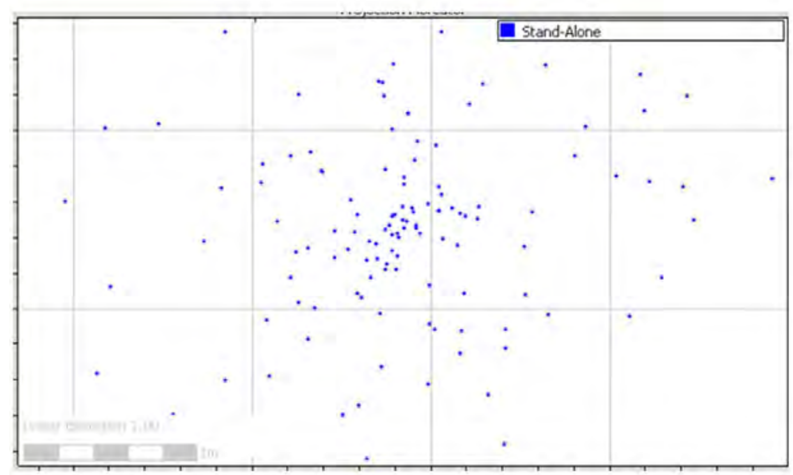
Scenario	Received RF Power Level (dBm)—Typical Values
Open Sky, no multi-path— ideal signal environment	-125 to -130
Light urban, with multi-path— weak signal environment	-125 to -145
Dense urban, with multi-path— weak signal environment	-125 to -155
Indoors— very weak signal environment	-150 to -165

To demonstrate, we performed parallel tests on the same industry standard satellite receiver at a signal level equivalent to that a consumer device might receive a few feet indoors. Everything was identical, except the simulator: one a Spirent simulator, the other an unnamed alternative.

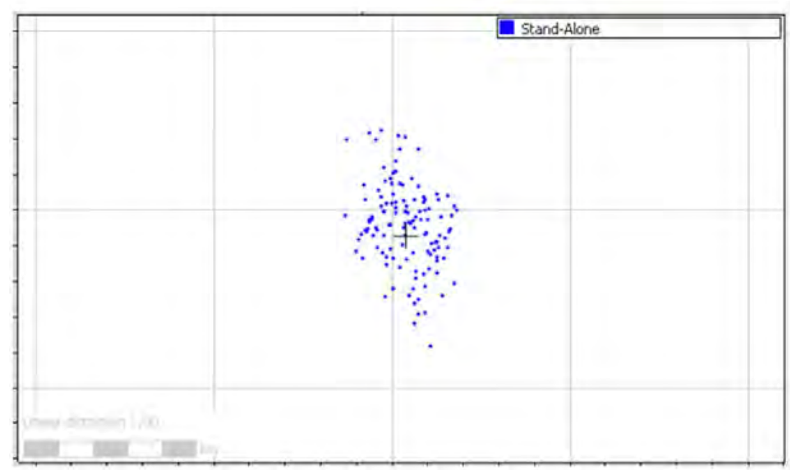
The positioning results from 100 samples plotted on a graph:

Due to a phase noise issue, the low-quality simulator introduced inaccuracies of several metres.

If such a standard test were performed with the low-quality simulator in development lab conditions, an integration engineer might easily assume this poor performance was due to the receiver, potentially jeopardising a supplier relationship, or delaying a new product's introduction for no reason.



Competitor Simulator



Spirent Simulator

Dynamic Signal Stability

We repeated the procedure, with a simple test that might commonly be used to prove a device's dynamic navigation accuracy, coping with both velocity and dynamics.

This time, we set the simulation as a moving consistent circle, 200m in diameter, at a speed of 45 m/s. To make matters easier, we increased the signal power slightly.

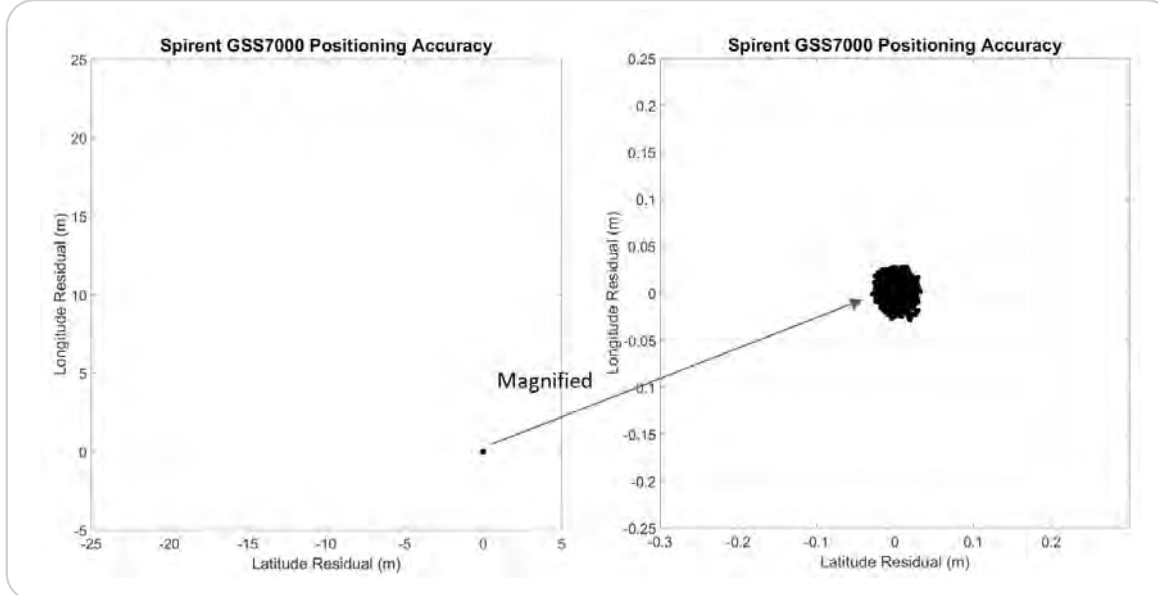
With the Spirent simulator, the receiver produced an accurate circle. But with the alternative test set simulating the signals, the receiver failed to achieve satellite lock at all. Again, under development conditions, this second result could be interpreted as a serious fault in the device under test, when in fact the issue is with the simulator itself.

Spirent Simulator

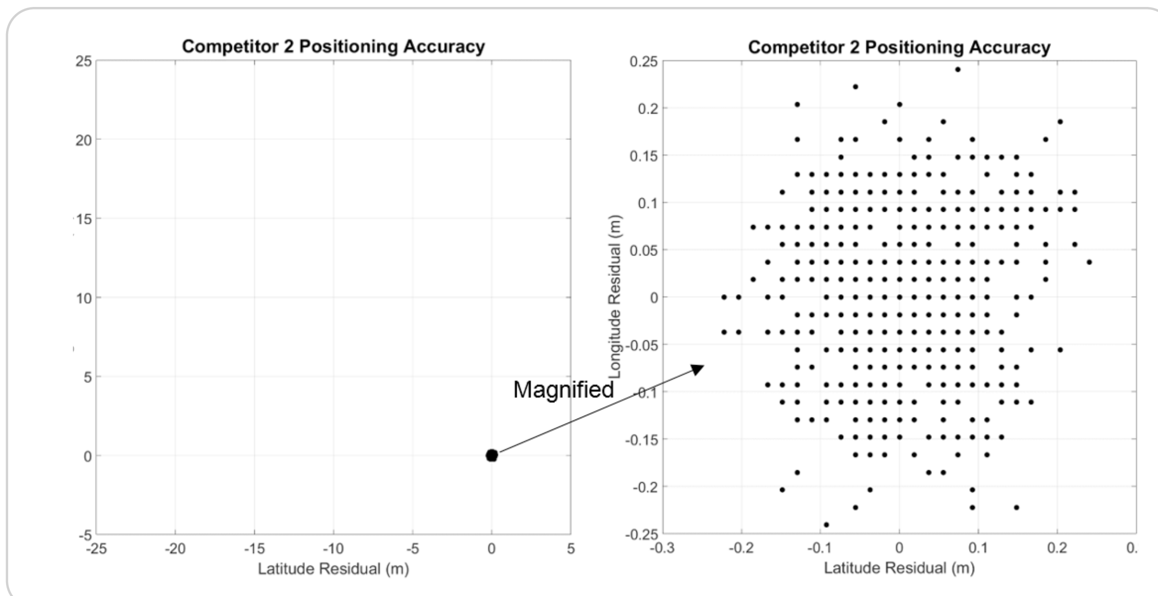
Dynamic Position Accuracy

This is the most universal of all the tests – the overall accuracy that can be achieved by the simulator when used in conjunction with a receiver. Poor performance in this evaluation test would be a catastrophic failure of the test equipment and make it unfit for purpose.

Spirent simulators can achieve an accuracy of 0.05m. Without the atmospheric and environmental factors being present the receiver should be able to output a very high level of accuracy from simulated signals. The specifics on what output data is good and bad is dependent on the receiver, and the best way to judge is to perform the same tests with the same receiver on different simulators and compare the errors.



Spirent GSS7000 simulator Circular Motion Plan Error measured with high-end GNSS receiver



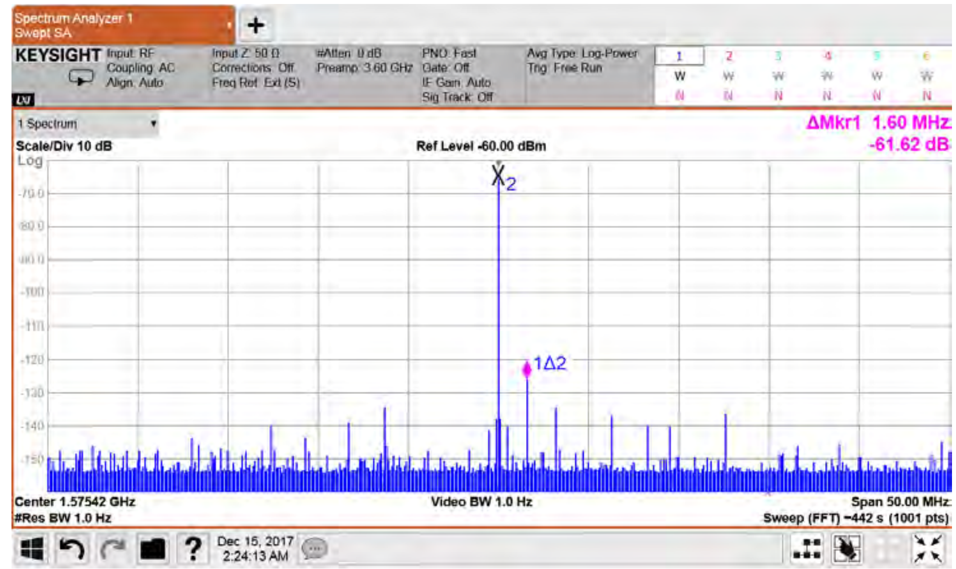
Competitor Circular Motion Plan Error with high-end receiver

Signal Purity

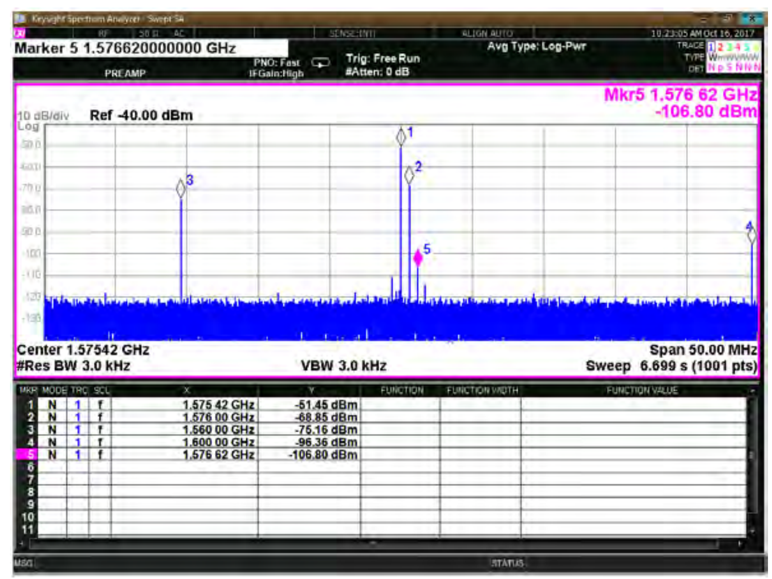
Spurious emissions can have a significant impact on device performance. This test helps to demonstrate the level of spurious emissions created by the simulator – using a spectrum analyzer.

Spurious emissions can introduce significant pseudorange errors into testing, giving a false picture of the performance of the device under test. At a relatively low level this is less important to consumer grade chipset users, as many do not have a front end that goes beyond the main lobe. It is most important for any receiver that has a wider front end, and any application using such a receiver. Having said that, in all cases lower spurious emissions are desirable.

The greater the delta between the signal and any spurious spike, and the fewer significant spurious spikes, the better.



An example of the GSS7000 spurious sweeps @ 50MHz span



An example of spurious sweeps @ 50MHz span on a competitor simulator

1PPS to RF Signal Stability

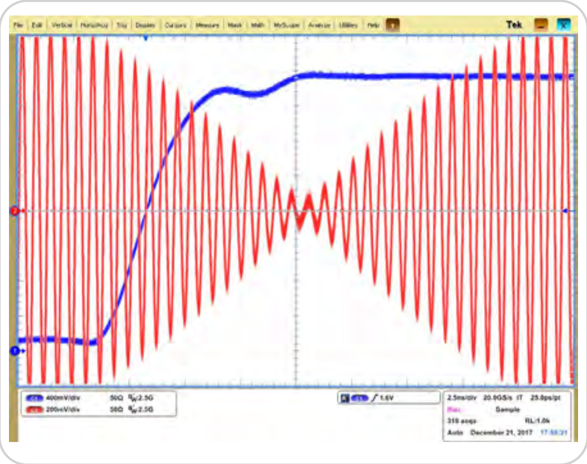
This test highlights the stability of, and control over, the code and carrier phase of the signals generated by a simulator. Variations are introduced to ensure the stability is retained when conditions are changed, and that the variations introduced are represented accurately.

This test is one of the most important when evaluating simulators, across a broad range of applications. Primarily, it is important for allowing test repeatability. Avoiding varied phase conditions is essential in performing scientific tests.

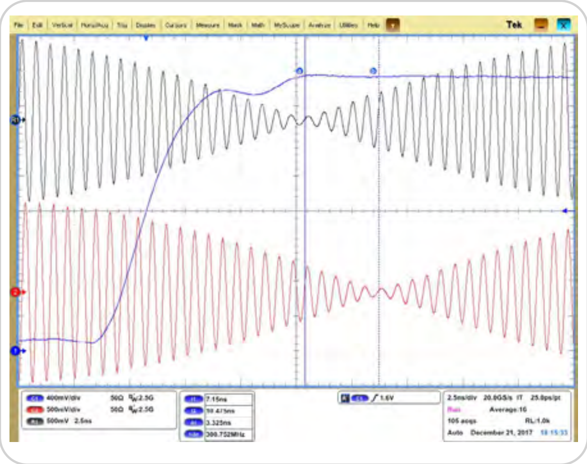
Other examples for which this test is vital include:

- Timing receiver development and evaluation
- Testing downstream systems that utilise GNSS-derived 1PPS
- Evaluation of certain spoofing mitigation techniques
- Test of RAIM with controllable pseudorange ramps delivered on command
- When using multi-box test systems for the evaluation of anti-jam antennas

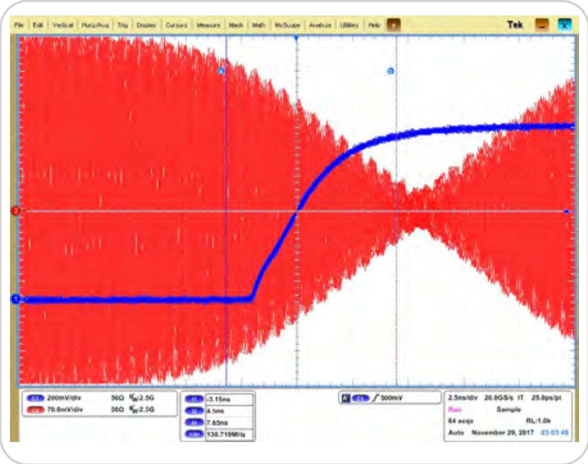
On a poor simulator the carrier will drop out of phase. Introducing a pseudorange ramp the signal shift will not correlate to the size of the ramp. The outcome in either case would be a static/inconsistent/blurred carrier displaying on the oscillator.



An example of a stable carrier wave (using a GSS7000)



An example of the stable pseudorange ramp introduction (10mm)



An example of poor code and carrier phase stability (from an unnamed competitor simulator)

RF Signal Update Rate

The purpose of this test is to assess the rate at which a simulator can update the RF signal. This can vary greatly from simulator to simulator and can be extremely important in certain scenarios.

What is it important for?

Simulation Iteration Rate (SIR) is key for hardware-in-the-loop (HIL) configurations. In any situation in which the DUT is moving quickly, or with high jerk, a high update rate is required. If the update rate is not fast enough it can result in a significant pseudorange error, or the receiver losing tracking of satellites.

Examples of use cases with high dynamics might be:

- HIL – flight simulation / car simulation / equipment for similar industries
- Automotive
- Drones
- Aviation
- Wearables
- Handheld devices

Evaluation

For higher-dynamic applications you would want an update rate of 100Hz-1,000Hz. This is most critical for flying objects such as missiles and drones. A lower update rate can be fine for static or slow-moving vehicles – in these cases 10Hz is acceptable.

The only universal fail criteria on this test is that the simulator under evaluation does not have the update rate it is advertised as offering.

The Latency Consideration

When using GNSS simulation equipment as part of a greater closed (motion source such as flight, car or drone simulator) HIL system, latency of motion input to RF output becomes an important issue to consider. The nature of closed loop simulation means that the data is always late, so it is imperative that the change in pseudoranges / doppler due to the motion is computed and represented as quickly as possible at RF, so that all systems within the HIL setup are synchronized—and in real time.

When a high dynamic jerk is induced in the motion stream that could not be predicted—a crash situation or a highly dynamic maneuver, for instance—low latency becomes particularly important. As an example, in such an event the GSS9000 takes 4ms at most to simulate that change at RF.

Conclusion: First Test the Test

While it is accepted that simulation is by far the most reliable way to measure the positioning parameters that will matter to a consumer in the field, not all simulators are made equal. The accuracy and consistency of the simulated signal can make a huge difference to the test regime and, ultimately, to the product in development.

Before you test your device, you must first test the test apparatus itself

This process is essential for establishing a confident benchmark, and is less daunting than it might first appear. Any reputable GNSS simulation manufacturer will usually agree to practical demonstrations and a side-by-side trial, and give you personalised advice on which kind of test regime and equipment is best suited to your unique application.

Finally, if you are in any doubt at all, please do not hesitate to ask an expert. Your investment in GNSS testing is significant, and the potential damage from making a poor choice over testing could be even more so.

Our engineers deal with this technology every day, and are more than happy to ensure you have the right test framework in place to work with confidence at every stage of your development, integration, and production.

About Spirent Communications
Spirent Communications (LSE: SPT) is a global leader with deep expertise and decades of experience in testing, assurance, analytics and security, serving developers, service providers, and enterprise networks. We help bring clarity to increasingly complex technological and business challenges. Spirent's customers have made a promise to their customers to deliver superior performance. Spirent assures that those promises are fulfilled. For more information visit: www.spirent.com

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