We protect you against jammers and spoofers like no one else can.

Available on all of our receivers and OEM boards.

There are daily news of spoofers worldwide.

JAVAD

www.javad.com

Front

SPOOFING SUMMARY ...

As we explained in inside pages, in addition to the shape of spectrum and AGC, there are eight indicators that show the health status of GNSS signals:

The eight indicators for each signal are:

1. Number of signals tracked.

2. Diversion of SNR from its expected value.

3, 4. Level of additional power and its RMS.

5, 6. Diversion of AGC from its normal value and its RMS.

7. Extra noise.

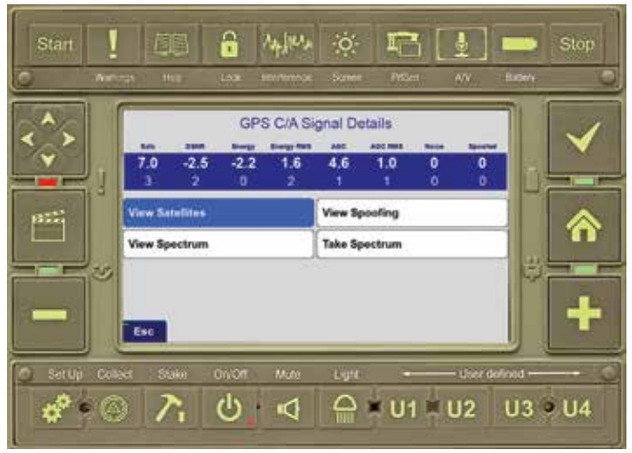
8. Number of signals spoofed.

The figure on the top right is a compact view of status of all GNSS signals in our TRIUMPH-LS receiver, showing **normalized** values of the above eight indicators. “0” means “good” and “9” means “bad”.

The figure below it shows the normalized **weighted average** of the above indicators. It is to show a general view of the status of that band at a glance.

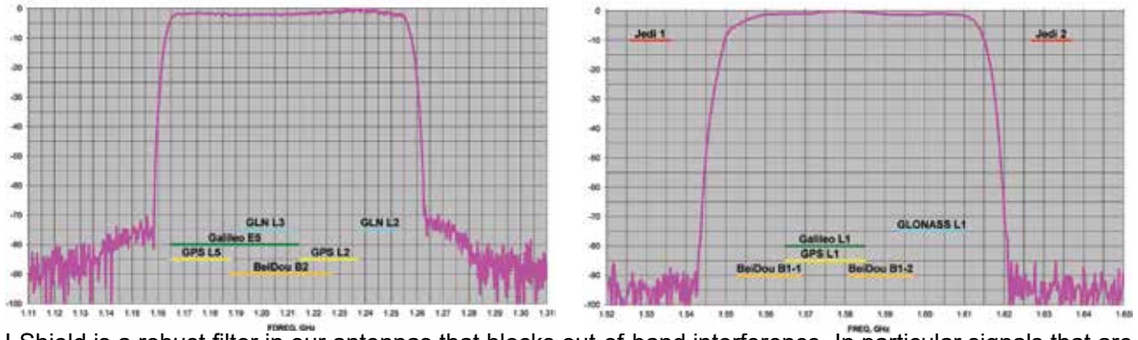
Click on any of the signal buttons to see the actual and normalized values of the eight indicators for that signal.

Click on the action buttons shown to see:
Details of all signals,
View Spoofing details,
View Spectrum screens,
and take new spectrum.



FL

J-Shield Filters
and Near Band Interference

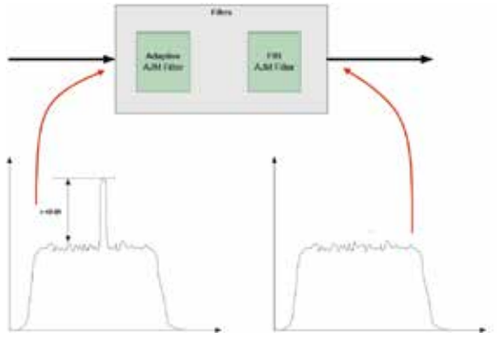


J-Shield is a robust filter in our antennas that blocks out-of-band interference. In particular signals that are near the GNSS bands like the LightSquared signals. The above graphs show the protection characteristics of our J-Shield filters. They a sharp 10dB/KHz skirt which provide up to 100 dB of protection. It makes the precious near band spectrums available for other usages and protects GNSS bands now and in the future.

Antijam Digital Filters

We have sixteen 255th order FIR antijam digital filters to protect against **static** in-band interference, like harmonics of TV and radio stations, or against illegitimate in-band transmissions.

Also we have sixteen adaptive 80th-order digital filters to protect against **dynamic** interference. These AJM-filters can be combined in pairs for complex signal processing. These filters can simultaneously suppress several interference signals.



In-Band noise
Measurement

We measure the level of interference as percentage of noise above the normal condition. The above left screenshot shows the condition in a clean environment. 8 GPS satellites were visible (according to the almanac). 8 C/A, 6 P1, 6 P2, 6 L2C and 2 L5 GPS signals were tracked. The noise level is 2% on C/A and L5, and 0% on P1,P2,and L2C. The screenshot on the right shows 290% noise in GPS C/A and %121 on Galileo E1. Only one of 8 GPS C/A code and none of 5 Galileo E1 signals were tracked due to this level of interference.

Spectrum Shape

We have a very powerful spectrum analyzer within our GNSS TRIUMPH chip. Each spectrum shows the power and the shape of the interfering signals and jammers. This is more powerful and more efficient than a $30,000 commercial spectrum analyzer to evaluate the environment. The screenshot on the right shows the shape of the GPS L1 band spectrum when the band is not jammed. The GPS C/A code peak at the 2-MHz center of the L1 band is visible. The height of the spectrum is 11.2 dB.

This is an example of GPS L1 spectrum with a commercial $30,000 spectrum analyzer.

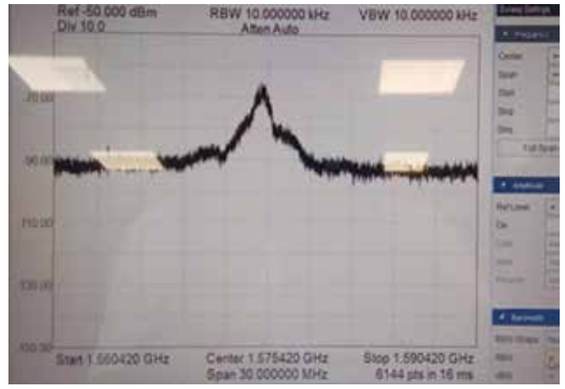
Our integrated spectrum analyzer has the advantage that it monitors the spectrum inside the chip where it matters. It has effective bandwidth of 1 KHz.

Our embedded spectrum analyzer also has the advantage that it can be programmed to automatically record the spectrum (and other information) periodically or according to the set conditions, and monitor the environment continuously.

This is the spectrum example of a GPS L1 band when it is jammed. There is a huge peak in the center where the C/A code is. The number on the bottom left is the height of the peak.

The height of the spectrum is 21.1 dB, which compared to the calm 11.2 dB, indicates about 10dB of jammer.

Average energy and its RMS are shown in the graphs.



AGC
Automatic Gain Control

In addition to the spectrum, we also keep record of Automatic Gain Control which is another indicator of external signals.

The AGC monitors the environment and adjusts the gain to keep the voltage at a certain level. The change in AGC is an indicator of interference.

The narrow orange line in the middle of the band in this screenshot shows a quiet AGC. Average AGC and its RMS are shown in the top left of the graphs.

AGC in the second screenshot shows there are activities in this band which our AGC was able to defend against it.

Our AGC mitigates the effect of such interference completely.

Spoofers & 2 Peaks

Spoofers are quite different from jammers. They don't disturb the environment and the spectrum shape. They broadcast a GNSS-like signal to fool the GNSS receivers to calculate wrong positions.

We detect spoofers by digital signal processing. With 864 channels and about 130,000 Quick Acquisition Channels in our TRIUMPH chip, we have resources to assign more than one channel to each satellite to find ALL signals that are transmitted with that GNSS PRN code.

If we detect more than one reasonable and consistent correlation peak for any PRN code, we know that we are being spoofed and can identify the spoofer signals. Figure on the right is an example of two peaks. We isolate and ignore the wrong peak.

The screenshot on the right shows details of each signal peaks. The first six lines in this screenshot show the spoofed signals that we detected as soon as they appeared (numbers "1" in those line). The two section columns represents the characteristics of each peak. Second SS column show if the second peak is a consistent signal.

While six satellites were spoofed, there was no indication on the noise level (0%) and no indication on the spectrum shape and level as shown on the screenshot on the right below the chart.

If the spoofer strategy is to cover the real satellite signal and then put the fake signal on top of it to produce only one peak, we notice that by more that 200% of noise level that it has to introduce.

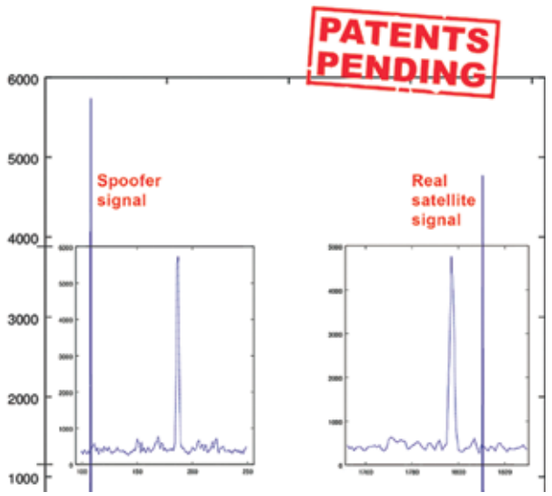
We reject infected signals and then among all the available GPS, GLONASS, Galileo, BeiDou, IRNSS and QZSS multiple signals we use the healthy ones.

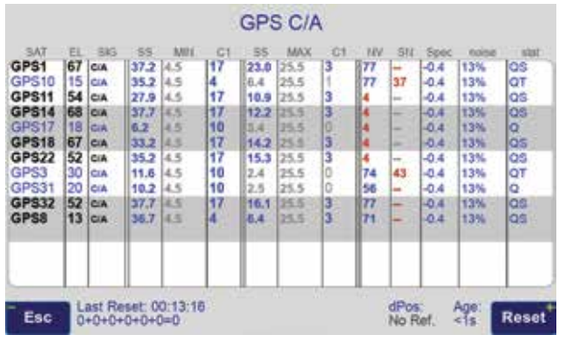
Usually there are over 100 signals available at any given time, and we need only four good signals to compute position. In rare cases that all signals are affected, we inform the user and guide them to use compass and altimeter to get out of the Jammed area.

There is extremely unlikely that we can be spoofed without our knowledge. We will immediately recognize and take corrective actions

In the Spoofing Summary screenshots on the right, 10 GPS satellites were visible (according to the Almanac). 6 of the 9 GPS satellites that we tracked were spoofed, as indicated by the red number, while the noise level was 0% in the GPS C/A band.

In the second screenshot, 5 of the 6 GPS C/A signals were spoofed while the noise in the band was only 2%.





This above screenshot shows details of each signal. In the last column (T) indicates the signal was tracked by the main channels, (Q) by the Fast Acquisition Channels and (U) signal was used in position calculations.

Percentage numbers show the percentage of interference above the normal level.

In the above example seven GPS signals are spoofed.

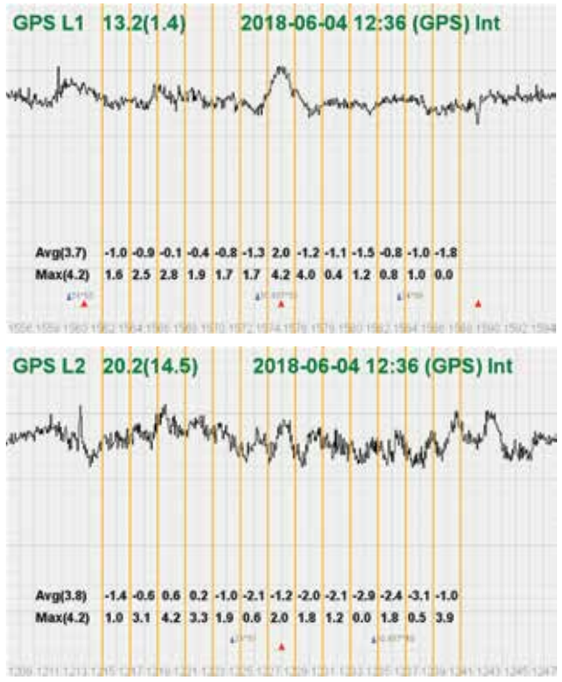
The "SN" color coded column shows the signal-to-noise ratio of tracked signals. Blue is perfect, green is 3 dB down, and red is 6 or more dB down.

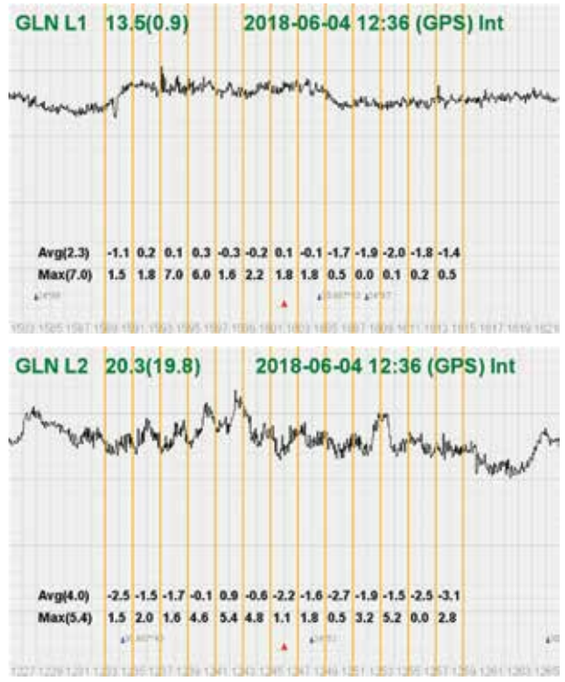
Deviation of SNR from the expected value is another important indicator of interference

And Examples of when the world is peaceful.

Jamming and Spoofing protection option is available in all of our products and OEM Boards.

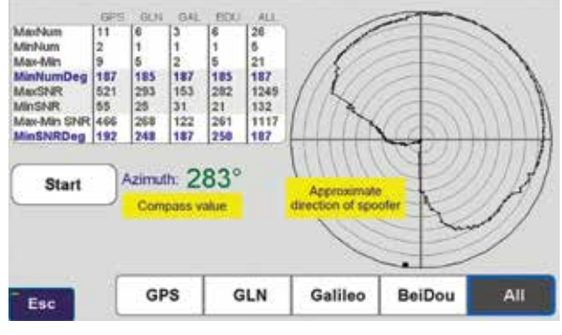
All screenshots are from our TRIUMPH-LS Receiver.



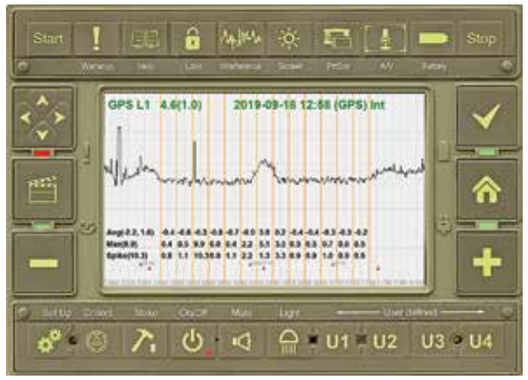


When you detect that spoofers exist, you can also try to find the direction that the spoofing signals are coming from. For this, hold your receiver antenna (e.g. TRIUMPH-LS) horizontally and rotate it slowly (one rotation about 30 seconds) as shown in the picture and find the direction that the satellite energies become minimum. This is the orientation that the spoofer is behind the null point of the antenna reception pattern.

After one or more full rotations observe the resulting graph that shows approximate orientation of the spoofer as shown in figure below.



... and TRIUMPH-LS



30 MHz-wide spectrum of the signal.

Two-peak information and spoofer.

Noise and spoofed signals.

Six parallel RTK engines.

Status of RTK survey collection.

Horizontal and vertical result of each engine.

TRIUMPH-3

The new TRIUMPH-3 receiver inherits the best features of our famous TRIUMPH-1M.

Based on our new third generation TRIUMPH chip enclosed in a rugged magnesium alloy housing.

The TRIUMPH-3 receiver can operate as a portable base station for Real-time Kinematic (RTK) applications or as a receiver for post-processing, and as a scientific station collecting information for individual studies, such as ionosphere monitoring and the like.

It includes options for all of the software and hardware features required to perform a wide variety of tasks.

- UHF/Spread Spectrum Radio
- 4G/LTE module
- Wi-Fi 5 GHz and 2.4 GHz (802.11 a, b, g, n, d, e, i)
- Dual-mode Bluetooth and Bluetooth LE
- Full-duplex 10BASE-T/100Base-TX Ethernet port
- High Speed USB 2.0 Host (480 Mbps)
- High Speed USB 2.0 Device (480 Mbps)
- High Capacity microSD Card (microSDHC) up to 128GB Class 10;
- “Lift & Tilt”
- J-Mobile interface

Ideal as a base station

Back