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Ask Us About XF

A New Must-Have with Tallysman's GNSS Antenna eXtended Filtering Interference Mitigation Techniques

Worldwide, radio frequency (RF) congestion at frequencies above and below the protected Global Navigation Satellite System (GNSS) frequency bands threatens the clear reception of GNSS signals, and the problem continues to get worse! Figure 1 shows GNSS constellations and frequency bands.

The primary sources of interference are LTE and 5G mobile networks, plus Iridium, Globalstar, and to some extent, the Inmarsat uplink frequencies (1626.5 MHz to 1660.5 MHz). New LTE signals in Europe [Band 32 (1452 MHz to 1496 MHz)] and Japan [Bands 11 and 21 (1476 to 1511 MHz)] are also potentially significant interferrors. Examples of out-of-band interference signals near GNSS bands are shown in Figure 2.

The amplitude of potential received interferrors is a function of the frequency and distance between a potential transmitter and the GNSS antenna. For example, in North America, a 5G network is planned in a lower segment of the Inmarsat downlink (1525 MHz to 1536 MHz), and it is quite conceivable that a GNSS antenna could be physically close to an operating smartphone or handset. This new 5G network especially threatens L-band corrections services broadcast (1539 MHz to 1559 MHz).

GNSS RF Interference Sources

Most commonly, in-band interference results from distortion of high-amplitude signals due to non-linearity in the antenna low noise amplifier (LNA), or occasionally, from a jamming device used to disable tracking. In either case, once present, there is no filter, digital or analog, that can filter it out; prevention is the only cure.

Strong out-of-band signals can generate in-band interference by saturating the antenna LNA or by cross multiplication with other strong signals. For example, a single strong signal at 800 MHz could cause a "comb" of harmonics, each offset by the signal carrier frequency, including a harmonic signal at 1600 MHz, which falls close to the center of the GLONASS-G1 band.

Cross multiplication can generate in-band intermodulation products, generally characterized by the equation n.f1 ± m.f2, where n and m are integers, and f1 and f2 are the signal carrier frequencies. Typically, the low-order intermodulation products are the stronger of the series. Figure 3 shows some of the possible harmonic signals and intermodulation combinations.

Tallysman XF antennas will continue to provide pure GNSS reception in both low and high GNSS bands (1165 MHz to 1300 MHz; 1540 MHz to 1610 MHz) in the presence of interfering signals that are up to 90 dB stronger than the wanted -120 dBm GNSS signals, offset just a few tens of MHz from the band edge.

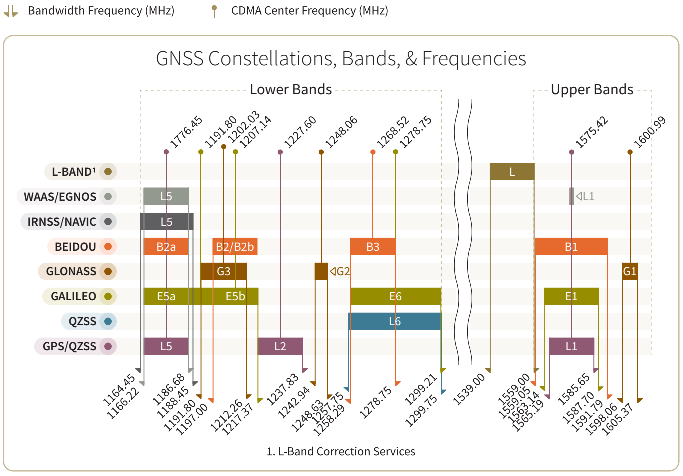

Figure 1. GNSS Constellations, Bands and Frequencies

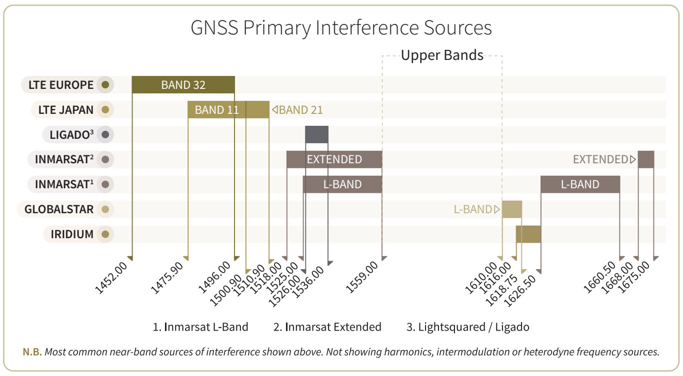

Figure 2. Near GNSS Band Interference Sources

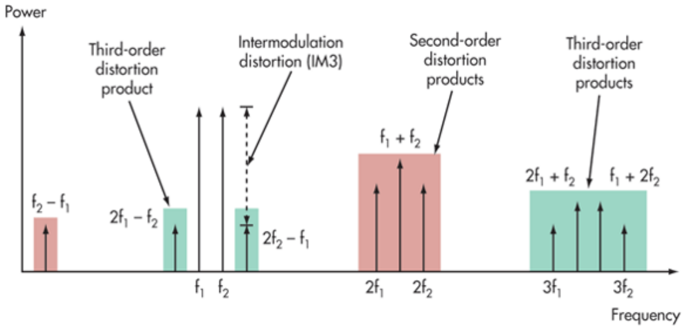

Figure 3. Examples of Unintentional Interference (Source: Novatel)

Mitigating Radio Frequency Interference

As above, prevention is the only cure for the in-band interference that results from very high out-of-band signals that push the antenna LNA into non-linearity. Clearly, higher linearity is indicated but that comes at the cost of higher bias currents and supply voltages, and even then, is ultimately limited. So, the only way to prevent the distortion is to strongly attenuate those high amplitude signals with RF filters and make the LNAs as linear as possible.

It sounds easy, but is not! Ideal bandpass RF filters are entirely linear and have 0 dB insertion loss (i.e. lossless), sharply defined corners at band edges, plus extremely steep skirts to provide deep rejection just a few MHz offset from the passband edges. In practice, depending upon the technology, filters have insertion losses ranging from 0.8 dB to 3.0 dB, with quite rounded corners at band edges and finite roll-off.

Historically, antenna LNAs have included one or more passband RF filters, usually placed after the first or second of the two or three amplifier stages. In simpler times, this provided the best achievable C/No (signal-to-noise ratio) because the filter loss did not contribute to the noise figure. However, it left the front-end open to saturation, which was not a problem in the absence of today's high-amplitude out-of-band interferrors.

> Tallysman XF products have **high-linearity front-end amplifiers with additional pre-filters** for each frequency band, right at the antenna element feed, integrated with the diplexer for dual/triple-band antennas and with additional in-line filters.

This has the advantage that the first and subsequent amplifier stages are protected, but at the cost of a somewhat higher noise figure because of the pre-filter insertion loss. There is no free lunch! Single-band antennas also feature a pre-filter, but the diplexer is not required.

Both surface acoustic wave (SAWs) and dielectric filters are suitable for this purpose, with convenient form factors. SAWs have small footprints, are low cost, but have temperature coefficients of around -40 ppm/°C (partially temperature compensated versions are also available), and insertion losses from 1.5 dB to 3.0 dB, depending on the bandwidth and steepness of the skirts. On the other hand, dielectric filters have relatively large footprints, insertion losses around 1 dB, or better, and almost zero temperature coefficients.

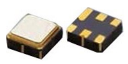

Figure 4a. TC-SAW Filter
(not to scale)

Figure 4b. Ceramic Filter
(not to scale)

Both filter types introduce a group delay variation (GDV) as a function of the frequency over the passband, which impairs signal dispreading in the receiver. Typically, for a full-band GNSS antenna, the GDV is smallest (2 to 3 ns) in the center of the bands, increasing toward the band edges. For example, a deeply-filtered full-band antenna might have a GDV of 12 to 15 ns at the passband edges compared with the band centre. GDV can be temperature sensitive because SAW filters have finite temperature coefficients.

The necessity to use different filters to cover the various GNSS bands results in unequal group delays between the bands, introducing an effect known to the reference antenna community as Differential Code Bias (DCB).

Tallysman uses SAW filters in the Accutenna® and Helical antenna lines and a combination of dielectric and SAWs RF filters in our high-end antennas (VeroStar™, VeraPhase®, and VeraChoke®). Multiple dielectric filters are also used for very high rejection triple-band members of the Accutenna line (TW3972XF, TW3967XF, etc.).

Tallysman's eXtended Filtering (XF) Line

Tallysman's custom XF filtering has been demonstrated to mitigate interference from existing and new LTE sources in Europe, Japan, and North America (including Ligado).

XF filtering enables the antennas to produce clean and pure GNSS reception. The deep XF filter technology is currently available in the **TW3000 family** (see Figure 5) and soon available in all Tallysman's product lines.

Figure 5. Accutenna® Triple-Band GNSS Antenna with eXtended Filter (TW3972XF)

For all your precision applications, discover Tallysman's future-proof line of eXtended Filter GNSS antennas.

E info@tallysman.com
T +1 613 591-3131

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www.tallysman.com