Brochure

CALIAN®
Confidence. Engineered.

# eXtended Filtering Plus (XF+) Technology

## Cleaner signals. Superior interference mitigation. XF+ eXtended Filtering for modern GNSS demand.

As Radio Frequency (RF) congestion rises worldwide, Calian's XF+ technology delivers powerful out-of-band protection and resilient dual-channel amplification to keep Global Navigation Satellite Systems (GNSS) signals clear and reliable in the toughest spectrum environments.

## eXtended Filtering Plus (XF+)

Calian's eXtended Filtering Plus (XF+) technology features > 80 dB of out-of-band rejection from 700MHz to 2500MHz (See Figure 1) and separates the LNA's upper and lower signal amplification channels; if one channel is jammed the other remains usable (see Figure 1a). In North America, planned Ligado signals between 1525 - 1536 MHz can especially impact GNSS a1nt1ennas that support space-based L-band correction services (1539 - 1559 MHz). New LTE signals in Europe [Band 32 (1452 - 1496 MHz)] and Japan [Bands 11 and 21 (1476 – 1511 MHz)] have also been observed to interfere with GNSS signals. In addition, Iridium satellite communication from 1616 to 1626 mHz and Inmarsat signals from 1626.5 to 1660.5 mHz can saturate standard GNSS antennas. Calian's AJ979XF+ MAR provides strong rejection of both these signals and supports reliable GNSS in the contested environment.

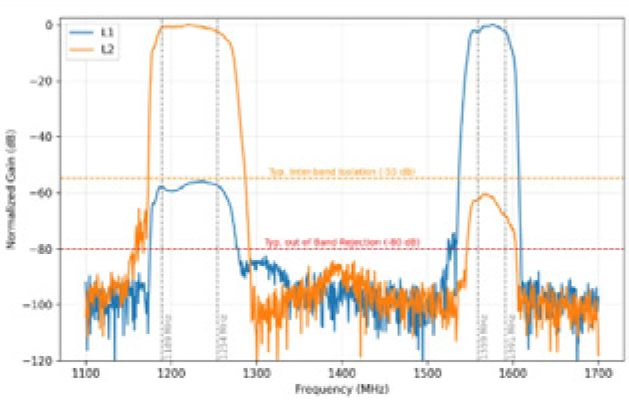



Figure 1. Near GNSS Band Interference Sources

## 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 2 shows some of the possible harmonic signals and intermodulation combinations.

Calian 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. See Figure 3.

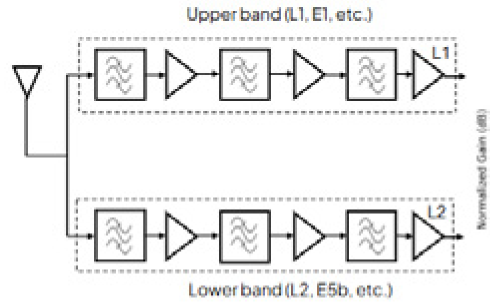



Figure 1a. Additional filtering stages for >80dB out of band rejection

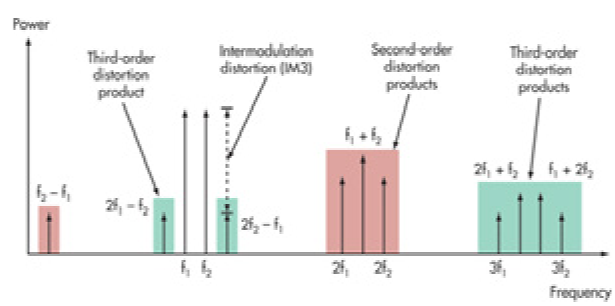



Figure 2. Examples of Unintentional Interference (Source: Erdogdu, G. TR, June 2012)

## Mitigating Radio Frequency Interference

Preventing in-band interference caused by strong out-of-band signals driving the antenna LNA into non-linearity requires two things: highly linear LNAs and strong RF filtering. Since LNA linearity is limited by power and design constraints, the most effective solution is to attenuate unwanted signals before they reach the amplifier.

Ideal bandpass filters would be lossless and sharply selective, but real-world filters introduce 0.8–3.0 dB of insertion loss and have finite roll-off. Historically, filters were placed after the first amplification stages to preserve noise figure, but this left the LNA vulnerable to saturation from today's much stronger interferers. Moving filters to the front end protects the LNA at the cost of a small increase in noise figure—an unavoidable tradeoff.

SAW and dielectric filters are commonly used: SAWs are compact and cost-effective but have higher insertion loss and temperature sensitivity, while dielectric filters offer lower loss and excellent stability at the expense of larger size. Both introduce group delay variation across the passband, which increases toward band edges and can differ between GNSS bands, creating differential code biases. Calian optimizes performance by using SAW filters in Accutenna® and Helical antennas, and a combination of dielectric and SAW filters in high-end lines like VeroStar™, VeraPhase®, and VeraChoke®.

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.

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).

Calian uses SAW filters (see Figure 4a) in the Accutenna® and Helical antenna lines and a combination of dielectric (see Figure 4b) and SAWs RF filters in our high-end antennas (VeroStar™, VeraPhase®, and VeraChoke®).

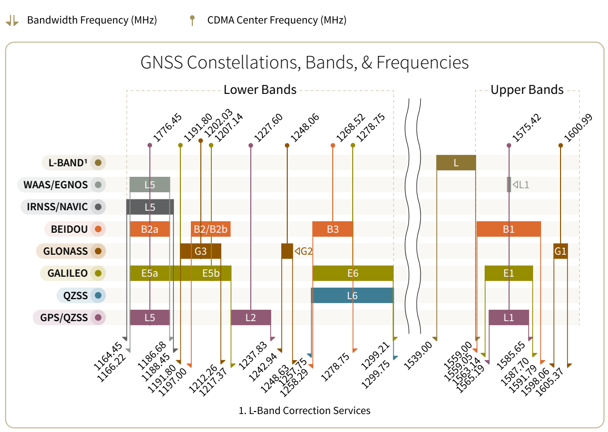



Figure 3. GNSS Constellations, Bands and Frequencies

Figure 4a. TC-SAW Filter

Figure 4b. Ceramic Filter

# eXtended Filtering Plus (XF+)

**Calian's XF+ technology delivers over 80 dB of out-of-band rejection and dual LNA paths to keep GNSS signals usable even under heavy interference.**

**XF+ filtering mitigates rising global threats such as Ligado and new LTE bands in Europe and Japan. It also blocks strong L-band sources like Iridium and Inmarsat, ensuring clean, reliable GNSS performance in demanding environments.**

AJ979XF+ MAR

AJ977XF+

CR8894SXF+

## Explore GNSS Precision with Calian

Calian provides an affordable line of high performance, precision GNSS antennas focused on supporting a broad range of satellite-based positioning, navigation, and data applications. In addition to the VeroStar® family of antennas, here is a list of additional GNSS technologies from the Calian Precision Portfolio.

To learn more, visit **calian.com/gnss**

### Accutenna® Technology

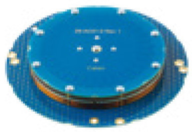
Outperforms single-feed patch antennas, providing superior multi-path signal rejection thereby providing unmatched precision for its size and price.

### Helical Technology

Designed for applications that require high performance and versatility, with an absolute minimum of weight, such as Unmanned Aerial Vehicles.

### VeroStar™ Pole Mount

Designed for high-precision (2mm PCV) land survey rover applications. Full- and triple-band models are available.



### AC4990EXF-114 Embedded AC4

Designed for precision GNSS, the AC4990EXF-114 is a compact embedded antenna supporting all major constellations and L-band corrections, delivering excellent multipath rejection and tight phase centre stability, while XF filtering ensures reliable performance in contested RF environments.

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For over 40 years, Calian has delivered mission-critical solutions when failure is not an option. Trusted worldwide, we empower organizations in critical industries to overcome obstacles, manage risks and drive progress. By combining the expertise of our people, proven industry insight, cutting-edge technology, bold innovation and global reach, we deliver tailored solutions that solve complex challenges. Headquartered in Ottawa, Canada, with over 5,000 people around the world, Calian's solutions protect lives, strengthen security, foster global connectivity and drive economic progress, making a lasting impact where and when it matters most.



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