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Integration guidelines for the Ignion GNSS Antenna Solution

Engineering Reference for RF Design Teams

Table of Contents

Introduction

There is ongoing debate regarding the necessity of RFFE (Radio Frequency Front-End) circuitry between the antenna and the GNSS receiver. A GNSS receiver is a sophisticated electronic component featuring a high-sensitivity radio with a very low dynamic range. These receivers often integrate internal LNA (Low Noise Amplifier) and filter circuitry.

However, in GNSS systems, a passive antenna with low efficiency (below 20%) cannot be compensated for signal-to-noise ratio (SNR) by an LNA alone —just like in cellular or other wireless protocols. Optimal reception begins with high antenna efficiency, regardless of whether active compensation is added later in the chain.

This document aims to provide easy-to-follow steps, tips and recommendations for the integration of Ignion´s GNSS antenna solution. We hope that through these guidelines, we may help fast-track deployments and minimize failures.

For more challenging requirements, we at the Ignion customer support team are always on hand to provide expert assistance to ensure a successful project deployment.

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Passive Antenna Integration

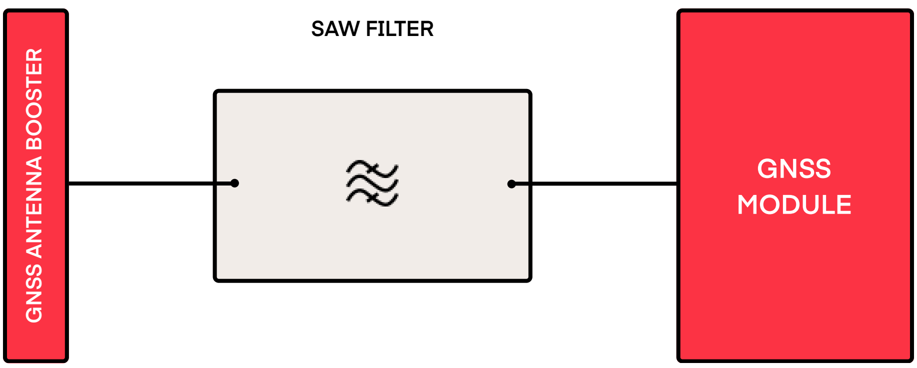
Ignion's GNSS antenna solution is currently composed of passive components, highly dependent on the ground plane, and doesn't offer inherent RHCP (Right-Hand Circular Polarization). Even though Ignion's antennas lack RHCP, their omnidirectional linear radiation pattern allows them to remain unaffected by device orientation in the field[1]—an advantage in mobile and non-fixed installations or high multipath environments.

For cost-sensitive wireless consumer and IoT devices, it is critical to verify whether a SAW (Surface Acoustic Wave) filter has been implemented in the GNSS receive path (ahead of the radio module). This helps to mitigate multipath noise and onboard noise, a problem otherwise handled by the integrated filter and LNA in an active patch antenna.

The objective is to **suppress radiated spurious emissions below the GNSS receiver's noise floor** using the passive Ignion antenna booster combined with a SAW filter. This setup offers the added benefit of lower power consumption, ideal for battery-powered GNSS applications.

In most embedded board implementations, where the passive antenna is surface-mounted directly next to the module with <10 cm transmission line on the same PCB, a SAW filter is generally sufficient to suppress:

- Environmental Thermal noise
- Out-of-band RF noise from PCB electronics



[1] Jaime Gui et al, 'Linearly Polarized Antenna Boosters versus Circularly Polarized Microstrip Patch Antennas for GPS Reception in IoT Devices.' (MDPI, 2022) Accessed 29 April 2025.

Active Antenna Integration

Ignion´s passive GNSS antennas are not designed with an integrated SAW filter and LNA. Some GNSS receivers are specifically designed to work only with active antennas. In these cases, it's important to consult the receiver datasheet to propose the most suitable configuration.

In scenarios where longer cable runs or off-board antennas are used, active front-end design becomes essential.

Adding extra LNAs unnecessarily may saturate the receiver, **causing 1 dB compression and reducing gain**. As a general rule:

- 15 dB of receiver gain is sufficient for GNSS cable lengths under 5 meters, without an onboard LNA.

However, if the antenna-to-receiver connection exceeds 10 cm or involves long coaxial runs:

- An LNA + SAW Filter configuration is required.
- The LNA at the antenna offsets the noise figure introduced by coax losses and preserves the SNR.

In active designs:

- 5V DC supply is typically provided through the coaxial cable using a bias-T
- Current consumption is usually around 20 mA.

Filter ordering recommendations:

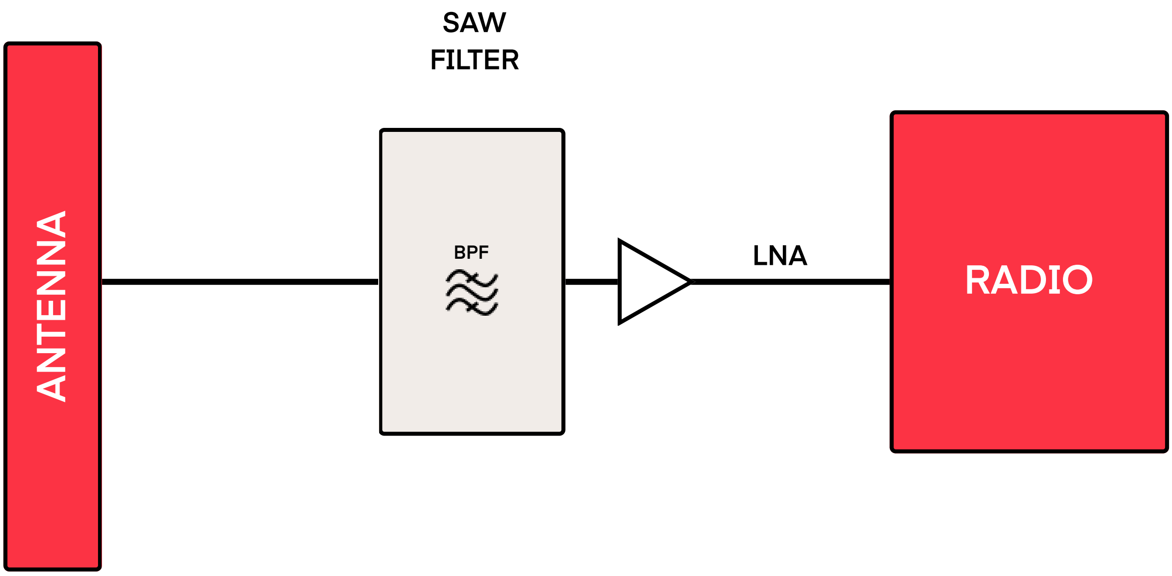
- The lowest-noise, highest-gain component should come first.
- In cases with strong out-of-band signals, like a co-located cellular transmitter, placing the SAW filter before the LNA may be better.

Generally, the configurations below are recommended for co-located cellular transmitters:

1. Antenna > SAW Filter > LNA > GNSS module - If the module requires an external LNA in the first place, otherwise the receiver will saturate quickly at the 1dB compression point and there goes the sensitivity.

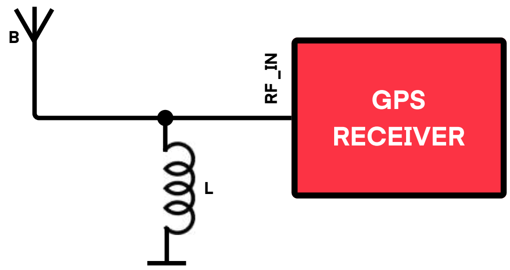
2. Antenna > SAW filter > GNSS module - This is usually sufficient, but it is important to check with the module specifications.

3. Antenna > SAW Filter > LNA > SAW filter > GNSS module - When there is a terrible receiver with insufficient gain i.e.< than 15dB due to long cable insertion losses.

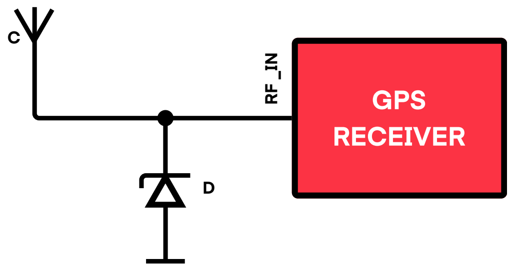


ESD (Electrostatic discharge) Protection for Active Antennas

For passive antennas (>2 dBic or performance sufficient), a shunt inductor is enough as a DC short to redirect excessive voltage and current away from sensitive GNSS components.



Meanwhile, for active antennas, the example below shows how a diode may likewise act as a protective barrier.



Key notes:

• LNAs typically tolerate max input power between 10–15 dBm.

• If they are placed after the SAW filter, sensitivity drops ~1 dB, but maximum input power increases (up to 25 dBm).

GNSS receivers are **extremely sensitive to interference from onboard components,** as the satellite signal received on Earth is inherently weak. For further insights, check out the section about amplifiers in the first block of the Virtual Antenna® Academy.

Absolute Measurements

Similar to cellular modules, GNSS systems require **Design Verification Testing (DVT)** to confirm proper functionality.

Due to satellite signal variability by time and location, controlled, repeatable lab tests are essential.

Required Lab Equipment:

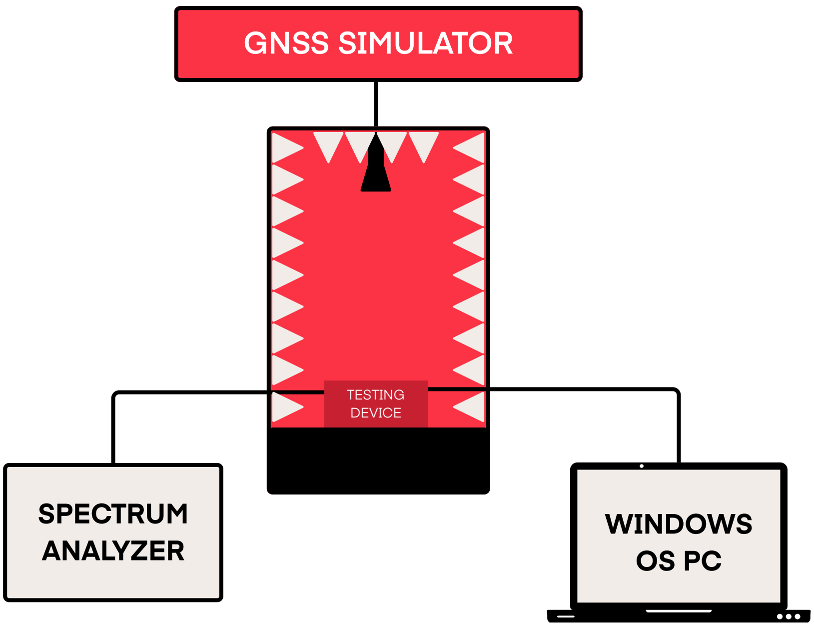
- GNSS Simulator (to emulate satellite signals)
- Anechoic Shielded Chamber
- PC (Windows 10 minimum)
- Vector Network Analyzer (VNA) for path loss calibration
- Spectrum Analyzer

Anechoic Testing & Procedure

To perform a full lab evaluation, two functional devices are required:

1. One for passive impedance verification

2. One for active system DVT



Passive Impedance Measurement

To validate the antenna's matching and identify any sources of interference from the PCB, the first step in GNSS lab testing involves measuring the passive impedance and scanning for unwanted signals.

This ensures that the antenna is operating as expected in its integrated environment.

Steps:

- Disconnect the antenna from the device.
- Measure its impedance after the matching network using a Vector Network Analyzer (VNA).
- Confirm that the return loss and total passive efficiency are optimized and within the expected range.

Once the impedance measurement is complete, move on to identifying emissions coming from the PCB:

- Place the powered device inside the anechoic chamber.
- Connect the same disconnected antenna to a spectrum analyzer.
- Perform a broadband frequency sweep across the GNSS bands and surrounding frequencies. The objective is to detect and isolate any onboard noise sources that could interfere with GNSS operation. This step is critical for identifying early design issues before proceeding to full system testing.

Tracking Sensitivity Measurement

After confirming the passive antenna performance, the next step is to **assess the tracking sensitivity of the complete device under controlled GNSS** signal conditions. This test validates the real-world capability of the GNSS receiver to lock and maintain signals from space.

Use the GNSS simulator together with the second fully functional device for this test.

Device Requirements:

- Fully assembled and operational, including:
    - PCB(s)
    - Batteries
    - Cable interfaces
    - LCD displays
    - Final housing/enclosure

The GNSS receiver must be easily accessible and controllable through a standard interface:

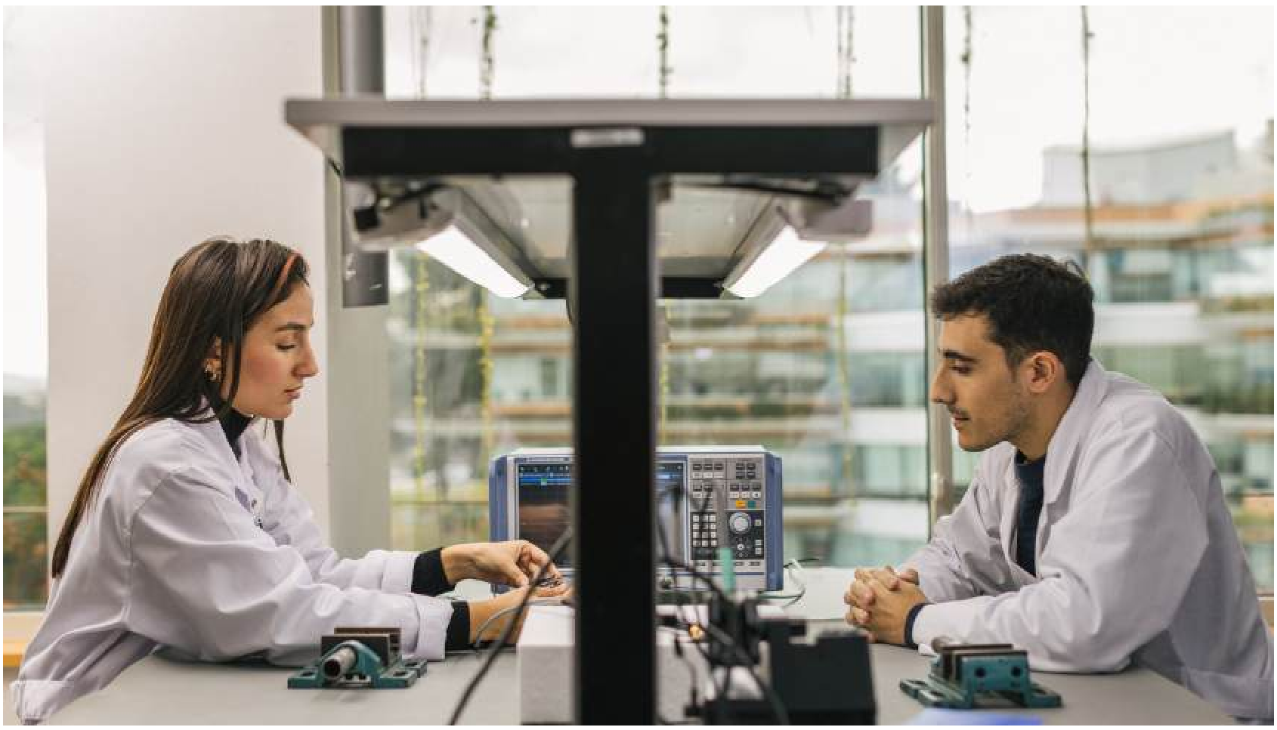
- UART (DB9)
- Ethernet
- USB or RS-232 (customers must provide the necessary drivers and software)
- The GNSS interface must show up as a logical COM port on a Windows PC

Additional requirements

- GNSS firmware must support the standard NMEA output format to interpret signals from the GNSS simulator.
- The device must be able to output NMEA strings to a COM port on the host PC for real-time monitoring.
- The host microcontroller must not interfere with the GNSS receiver during the measurement. It should not initiate communication or polling during radiated sensitivity testing.

Required design documentation:

- 2D ASCII Gerber files (PCB layout)
- 3D CAD files in STEP format
- Full circuit schematics (preferably in Altium)
- Details on PCB stack-up, layer thickness, finishes, and complete Bill of Materials (BOM)



Testing Workflow

The full testing process brings together all elements of the setup for final evaluation. This allows for a reliable and repeatable assessment of GNSS receiver sensitivity and system performance.

Follow these steps:

- Use the GNSS constellation simulator and anechoic chamber to perform radiated tracking sensitivity measurements.
- Apply the gain transfer method to calculate and calibrate chamber path loss.
- Measure signal strength at the GNSS receiver input.

Compare the measured results with:

- Previously characterized customer reference boards
- GNSS module datasheet performance levels

If the performance is within expected levels, no further action is needed.

Otherwise, start a **systematic mitigation process to identify sources of degradation**—often by shielding circuit sections such as external LNAs, power rails, or RF modules with metal cans or Faraday cages.

Interference Identification and Mitigation

Identifying sources of interference from onboard components is critical for ensuring GNSS system performance.

- Out-of-band interference can be managed using proper filtering.
- In-band noise lies within the GNSS signal bandwidth and must be eliminated at the source, not via filters.

Common Interference Sources

Once poor GNSS performance is confirmed, targeted debugging becomes necessary.

Here are the most common culprits and how to isolate and resolve them:

1. Power Supply

Poorly regulated DC power supplies are a frequent source of radiated or conducted interference into the GNSS receiver.

How to test:

- Bypass the onboard regulator by injecting the rated voltage using a lab DC supply (with current limit).
- If interference disappears, the regulator is likely the source.

Further steps:

- Measure the output noise of 3.3V or 5V regulators directly with a spectrum analyzer.
- Ensure proper decoupling from AC noise using ceramic capacitors.
- Add RF choke inductors on power lines feeding sensitive RF components.
- Shield the entire power supply circuit using a metal can with no perforations, securely grounded to the PCB ground plane.

2. LCD and Memory Interfaces

LCD displays and their flexible cables often radiate harmonics that can fall directly within GNSS bands.

How to test:

- Disconnect the LCD and observe the frequency spectrum before and after using a spectrum analyzer.
- If interference vanishes, the display is confirmed as the source.

Mitigation:

- Add RF chokes to LCD cables.
- Consider shielding or re-routing high-frequency display or memory buses.

3. Co-located Transmitters

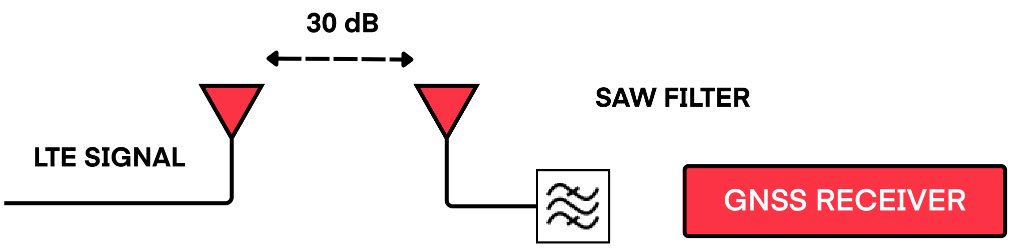
GNSS receivers are highly sensitive and can be easily desensitized by nearby cellular transmitters, especially when sharing the same board.

Problem:

- Cellular transmitters can output up to +23 dBm.
- GNSS receiver max input is typically around –5 dBm.

Solution:

- Ensure ~10 dB isolation via physical separation or board layout.
- Add a SAW filter on the GNSS input to introduce 20 dB of filtering (total ~30 dB attenuation). Recommended filters: Murata or Qorvo 1060 L1.



4. General Best Practices

Even if no immediate interference is present, applying these foundational RF hygiene practices will help avoid issues later in development or in production environments:

- Shield all high-frequency modules, including radios and microcontrollers.
- Use SAW filters to manage out-of-band noise before it reaches the GNSS front-end.
- For multilayer PCBs:
  - Ensure all signal and power planes are bounded by ground plane extensions.
  - Maintain proper layer symmetry and grounding throughout the board.

Ignion Recommended RFFE Components for GNSS Antenna Integration

SAW Filters - Qorvo

1. QPQ1060: L1 Low Loss GPS SAW Filter

2. QPQ1063: L1/L2 Low Loss GPS SAW Diplexer

3. QPQ1061: L2 Low Loss GPS SAW Filter

4. QPQ1062: L5 Low Loss GPS SAW Filter

5. QPQ1028: Dual-Use GPS L1/L2 Dual Filter

LNAs - Infineo

- Infineon-BGA123N6
- Infineon-BGA855N6
- Infineon-BGA525N6

SkyWorks

- SKY55950-11_206099A_PS

AWINIC

- AW15745DNR: L1 L2 L5 - Low Noise Amplifier for GNSS
- AW15645DNR: L1 and L5
- AW5105DNR: L1 BDS/GPS/GNSS Integrated Front-end Module with Low Noise Amplifier and FilterNR: L1 and L5

SPK Electronics SAW Filter

- SPK-FT1575.42MHZ-73

About the author

Born in Zimbabwe and raised in the USA and India, Sifiso has more than 20 years of experience in the design, testing and manufacturing of RF products for commercial and military applications. Some of the companies Sifiso has worked at include Ericsson, CommScope and Qorvo.

Sifiso has had tremendous experience in antenna and RF development having worked in South Africa, China, Taiwan, the UK and USA, Ireland, the Netherlands and now Spain during his much-travelled professional career.

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