

GNSS Wi-Fi positioning with external LNA Application Note

Purpose and scope

This document details the use of an external LNA and SAW filter on the GNSS path to improve performance with various antenna configurations.

The Wi-Fi positioning feature is also considered.

Document status
Official

1 General information

1.1 Acronyms and terms

Table 1 Definitions of terms

Term	Definition
DSP	Digital Signal Processor
GNSS	Global Navigation Satellite System
IIP3	Input Intermodulation Product 3 rd Order
IoT	Internet of Things
LNA	Low Noise Amplifier
NF	Noise Figure
PIFA	Patch Inverted F Antenna
SAW	Surface Acoustic Wave
Wi-Fi	Indicative of Wireless connectivity using IEEE802.11 standard

1.2 Reference documents

The documents listed in [Table 2](#) provide further information.

Table 2 Document references

Reference	Document
[1]	AW5005EDNR datasheet
[2]	Murata SAFFB1G57KE0F0A and SAFBA1G56AB0E0A datasheets
[3]	ST87MXX Wi-Fi Scan Application Note
[4]	ST87MXX UM AT commands description
[5]	TAI-SAW TECHNOLOGY TA1954D datasheet

1.3 Revision history

Table 3 Document revision history

Date	Version	Changes
2025-03-21	V1.0	Official version
2025-06-03	V1.1	Updated with SAW
2025-06-04	V1.2	Add Wi-Fi configurations
2025-06-10	V1.3	Added patch antenna configuration
2025-07-02	V1.4	Modified consideration for PIFA antenna
2025-09-02	V2.0	Update for release

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2 Introduction

The ST87MXX is a high-performance module integrating NB-IOT (LTE Cat NB2) 3GPP Release 15 and support GNSS.

The ST87MXX has an embedded RF front-end with a built-in LNA and a dedicated GNSS antenna port. Single antenna configuration is also supported. In this case the same input port is used both for NB-IOT and GNSS thanks to the RF_AUX port.

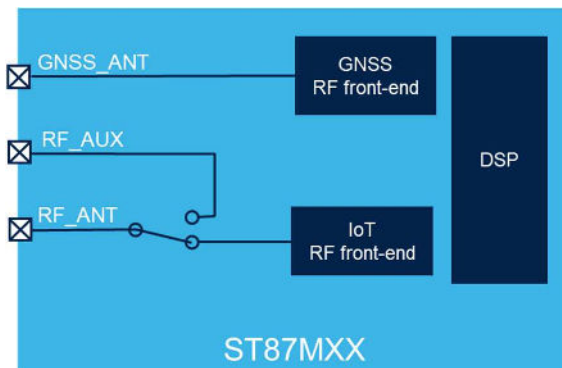


Figure 1. ST87MXX RF ports

GNSS performances are affected by the antenna configuration and their type: linear or circular, active or passive.

- Active antennas typically consist of a ceramic patch antenna that also embeds an LNA to get rid of cable losses,
- Passive antennas do not embed any LNA.

The LNA embedded inside the ST87MXX GNSS front-end is suitable for active antenna but in the case of design with Passive Antenna and poor antenna gain, it is highly recommended to add an external LNA to recover good performances.

3 Antenna Configurations

3.1 “Off-the-shelf” Active Antenna Configuration

This is the configuration that is provided inside the ST87MXX evaluation kit.

This configuration is good for evaluation purposes but is not representative of a final product since it is unlikely that a final product would use an “off-the-shelf” active antenna.

No specific precautions are required, as the AGC loop of the ST87MXX accommodates signals from the external active antenna.

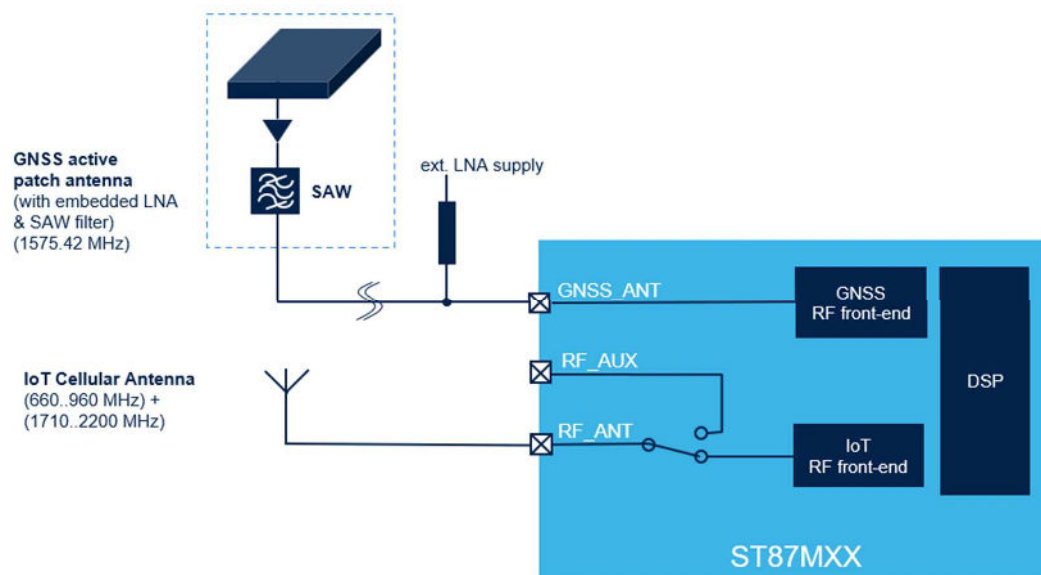


Figure 2. “Off-the-shelf” GNSS Antenna configuration

3.2 Standalone GNSS patch Antenna

If an external passive patch antenna is used, there is no specific precautions to be taken. Effectively, the GNSS patch antenna device acts as a band-pass filter (see 6.2 below Patch antenna vs PIFA antenna).

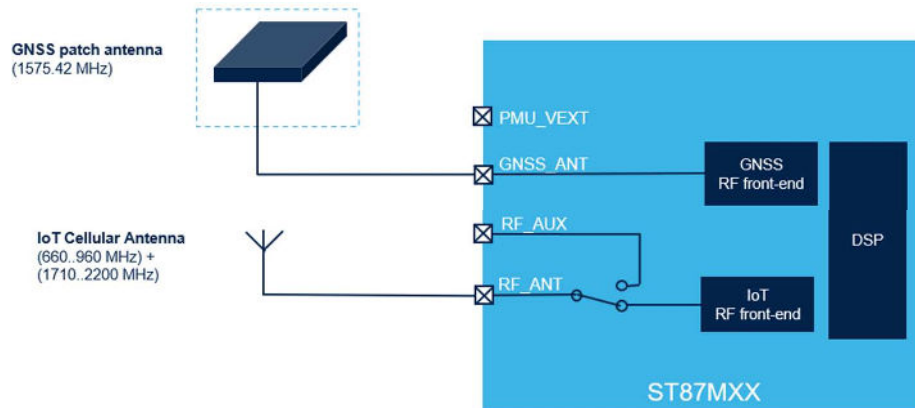


Figure 3. GNSS patch antenna (no LNA)

On the other hand, if the application requires best performances, adding an external LNA can improve sensitivity by approximately 3 dB.

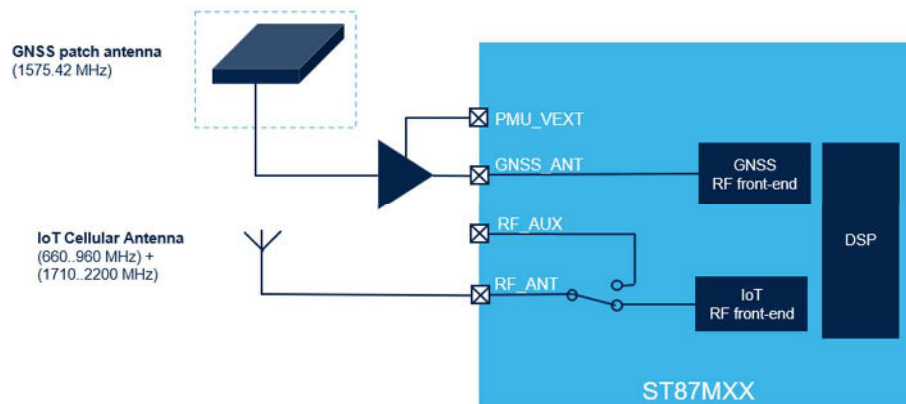


Figure 4. GNSS patch antenna (with LNA)

3.3 Usage of a Linear polarization Antenna for GNSS

Some applications (e.g. small size trackers) have cost and size constraints that prevent the use of an ideal ceramic patch antenna.

A low-cost alternative is a PCB antenna such as the PIFA (Patch Inverted F Antenna). The drawback of such antennas is the lower gain and also a reduced sky opening.

- If the application is used with a suitable ground plane acting as a reflector, a solution without LNA can be evaluated,
- On the other hand, if the antenna has low gain and no suitable ground plane, an external Low Noise Amplifier (LNA) is typically used to overcome or at least improve this situation. Given the high Cellular levels observed in the fields (up to -20 dBm at 100 meters from a base station) a **SAW filter is strongly recommended** at the LNA input to reject unwanted signals would cause interferences. The SAW filter is deliberately placed **before** the LNA to avoid interferences (e.g. mixing inside the LNA itself).

The output of the LNA can be directly connected to GNSS_ANT (pin 31) of ST87MXX module and supplied by the PMU_VEXT pin.

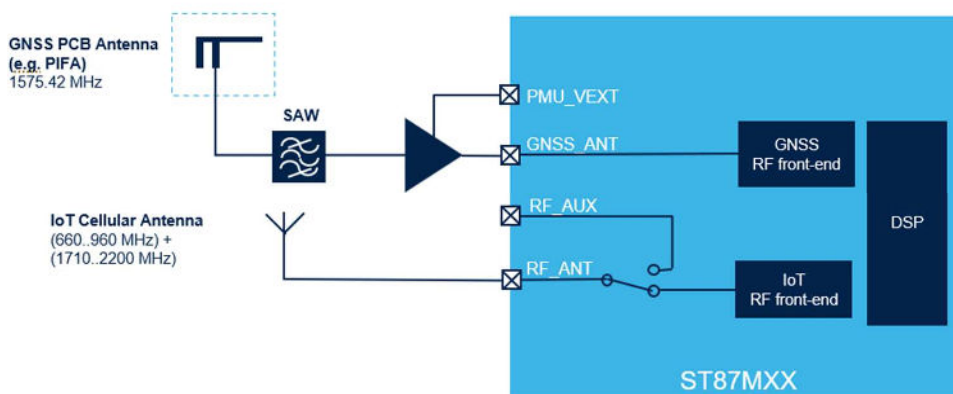


Figure 5. Linear polarization antenna configuration used with SAW+LNA

3.4 Common antenna between GNSS & Cellular (AUX path)

This is the case of designs using combo Cellular + GNSS antenna (in this case a ceramic patch antenna can't be used since it's a narrow band device (see 6.2 below Patch antenna vs PIFA antenna)).

Given the lower performances of this kind of antennas in the GNSS band, it is also highly recommended to use an external LNA.

Also in this configuration, a **SAW filter is strongly recommended** at the LNA input.

The ST87MXX embeds a specific switch that redirects the RF_ANT port to the RF_AUX port with minimal losses (~1 dB). The RF_AUX port is then connected to the external SAW and LNA input.

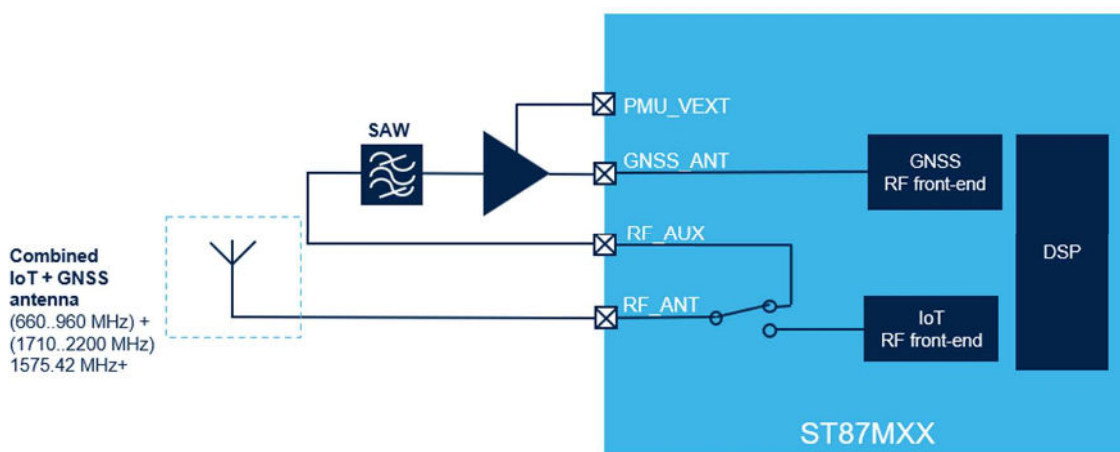


Figure 6. Common antenna configuration

3.5 Wi-Fi positioning case

In applications where Wi-Fi positioning needs to be also supported (using dedicated antenna on GNSS port or common Antenna on AUX port), since a SAW filter is strongly recommended before the LNA input, this prevent using the GNSS path for Wi-Fi positioning.

As a consequence, the Wi-Fi reception needs to use the NBIOT port in both case

From a configuration perspective, this is selected thanks the AT command `AT#WSCAN=4, 1` (refer to Wi-Fi Scan Application Note, section Antenna Input configuration).

Here are below the two possible Antennas configurations:

- **Dedicated GNSS antenna** (patch of PIFA) connected to GNSS port: as mentioned the Cellular port is used for Wi-Fi (since the GNSS antennas are narrow band devices) :

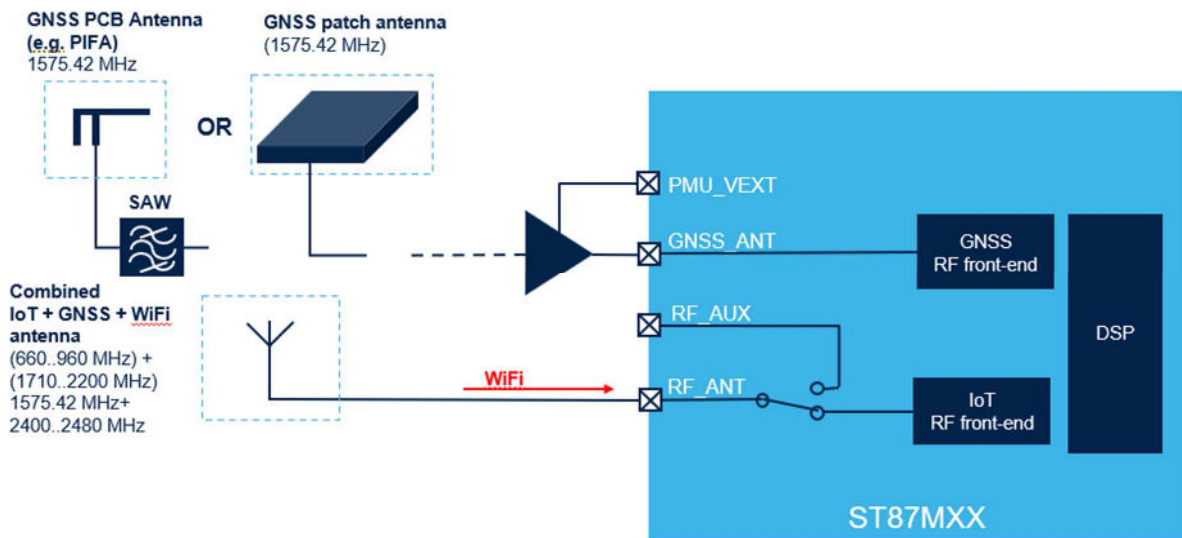


Figure 7. WiFi positioning and GNSS (dedicated ports)

- **Combined IOT/GNSS/Wi-Fi Antenna** : in this case also the Wi-Fi signal is routed on the cellular port since a SAW filter is inserted in the GNSS path.

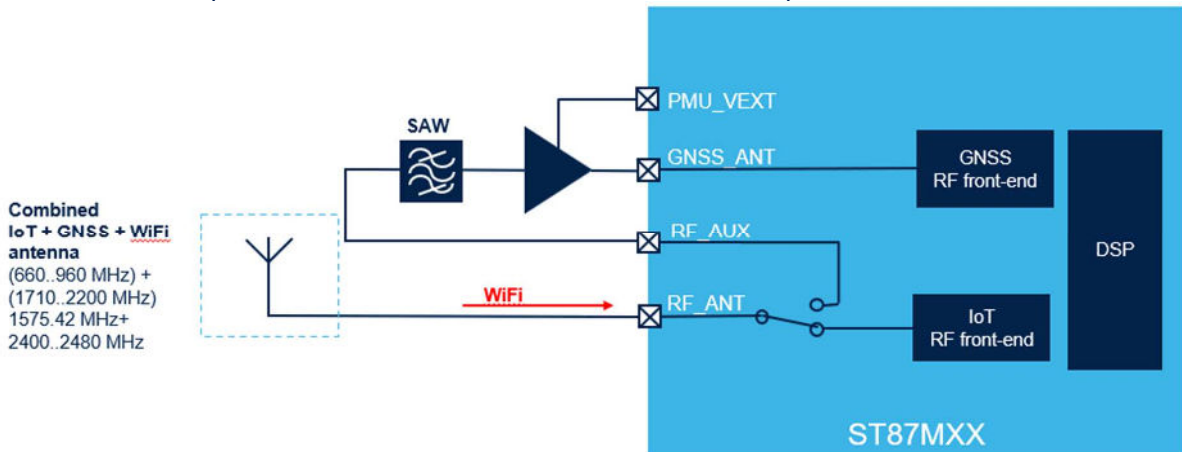


Figure 8. Single antenna for GNSS/Cellular/WiFi configuration

4 External LNA selection

4.1 Generic specifications

The Noise Figure (NF) of the complete Rx path is dominated by the first stage NF whereas the second stage NF is divided by the first stage gain (Friis formula).

⇒ As a consequence, the external LNA should have high gain and low NF.

The table below gives the main specifications

- Low NF < 1 dB @1.575 GHz
- High Gain > 15dB
- Power supply voltage
 - 1.8V +/-5% or 3V +/-5%
 - 1.8V is recommended.
- Power consumption below 10mA

4.2 AW5005EDN4 from Awinic

The LNA AW5005EDNR from Awinic (<https://www.awinic.com/>) fulfils above specifications:

- Vcc range= 1.5 to 3.6V
- NF typ = 0.79dB
- Gain typ = 17.5dB
- IIP3 = -2 dBm
- Supply current typ= 6mA

Its small package (1.5 x 1.0 mm) enables a good integration. It requires also few external components. As documented in the datasheet [1], one input matching component L1 (9.1nH) is needed.

4.3 Power supply & Control

The pin PMU_VEXT (pin 5) of the module is an LDO output. It can be used to supply and control the LNA.

This LDO can be enabled in GNSS receive mode and disabled in other configurations to save power consumption.

The host can control PMU_VEXT using the following command:

```
AT#REGVEXT=<on_off>,<voltage_sel>
<on_off> = 1 to enable LDO ; 0 to disable LDO
<voltage_sel> = 0 for 1.8V ; 1 for 3V (for Vbat=3V, see ST87MXX datasheet for PMU_VEXT
operation limitations)
```

For the complete description of the commands and parameters, please refer to the AT command user manual [4].

The sequence below illustrates the PMU_VEXT usage at 1.8V

```
AT#REGVEXT=1, 0
OK
AT#GNSSINIT
.... Gnss processing...
AT#GNSSDEINIT
OK
#REGVEXT=0
OK
```

5 SAW selection

Tests in real environments show that cellular signals can have high levels and degrade GNSS performance.

Especially:

- Signals from Mid Bands (B3 2100 MHz & B1 1800MHz) are particularly disturbing. Because of 3rd order intermodulation (IM3) at LNA level, they fall in GNSS frequency band.
- Signals from Low Bands (especially B28 at 780 MHz) are also prone to 2nd order intermodulation (IM2) by the LNA and affect GNSS performances.

Mains specifications:

- Low insertion losses to keep a good Noise Figure: < **1.5dB**
- High attenuation in cellular bands: > **35 dB**

Proposed references

The three references below are good choices for SAW filters:

Part#	Insertion Loss	Out of band rejection	Package	comments
Murata SAFFB1G57KE0F0A	1.0 dB (typ)	35 dB (B1 & B3)	1.1x0.9mm	Consumer Grade
Murata SAFBA1G56AB0E0A	1.2 dB (typ)	45 dB (B1 & B3)	0.9x0.7mm	Industrial Grade
TAI-SAW TECHNOLOGY TA1954D	1.2 dB (typ)	55 dB (B1 & B3)	1.1x0.9mm	Industrial Grade

Table 4. recommended SAW filters

6 Annexes

6.1 Matching components recommendation

It is good practice to insert place holder components near the antenna ports to have the flexibility to perform impedance matching.

For the series values, use a capacitor which resonant frequencies is close from the RF frequency involved (usually 33pF is a good trade-off, whatever the size)

The π topology on the antenna allows to accommodate various impedance conditions. Usually only 2 components are really needed.

On the GNSS port side, the 2 elements topology is enough, knowing that if any mismatch is still present it will have a low contribution to the overall system performance since it is placed after the LNA.

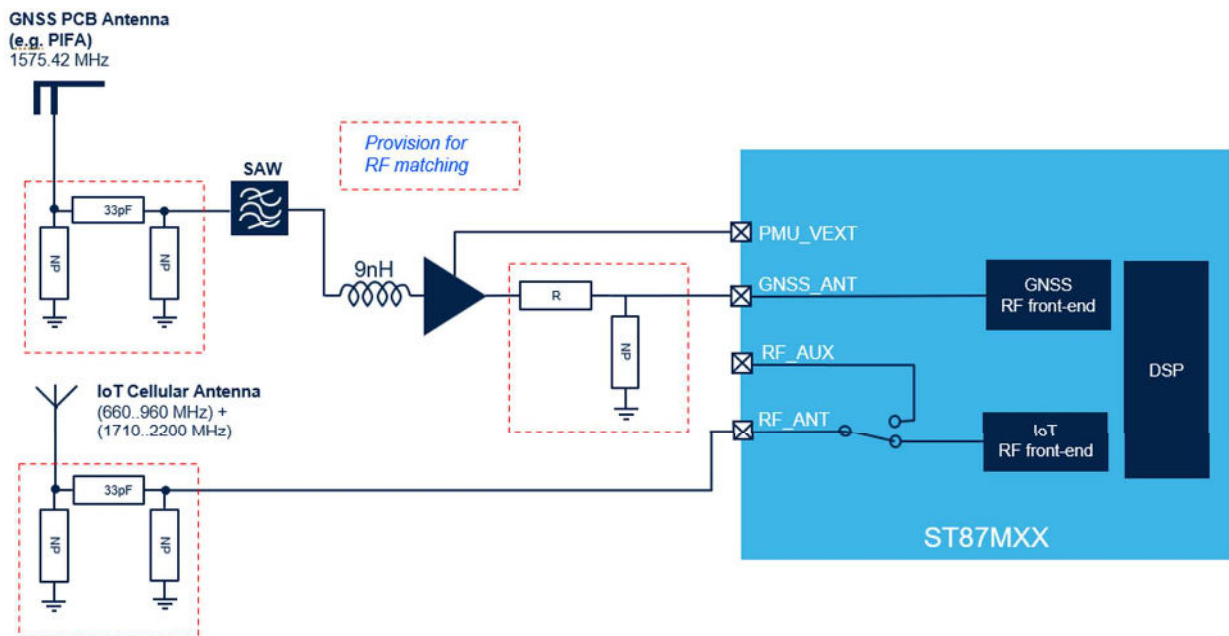


Figure 9. Provision for RF matching components

6.2 Patch antenna vs PIFA antenna

The Figure 10 shows the quantitative gain difference between a Ceramic patch antenna (30x30mm²) and a PIFA PCB antenna.

We notice that:

- The gain response of the ceramic patch antenna acts as a sharp band-pass filter centered on the L1 frequency (1575.42 MHz)
- At cellular frequencies, the gain difference is up to 20 dB (in the low band region 750..960 MHz) and 10 dB (in the mib-band region 1800..2170 MHz)

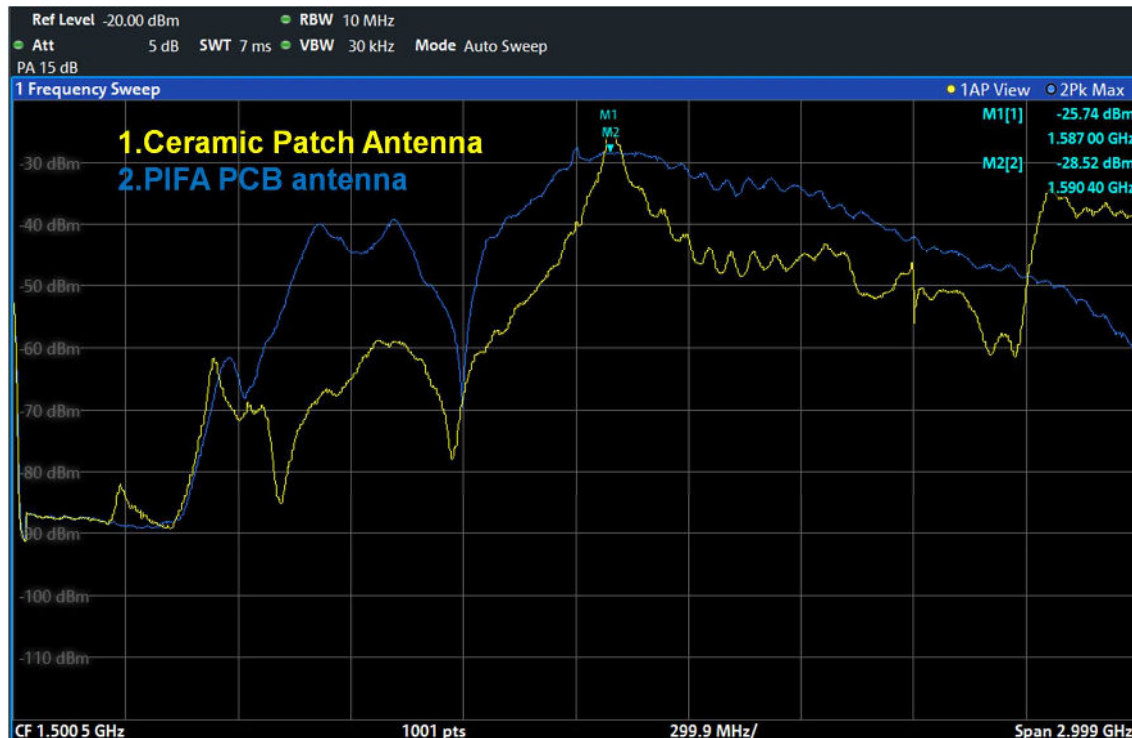


Figure 10. Gain comparison between Patch and PCB planar antennas

Furthermore, compared to the PCB antenna, the ceramic patch antenna has other advantages:

- It uses the same polarization as the GNSS satellites (circular, RHCP) vs the PCB antenna which is typically using a *linear* polarization. Fortunately, these are not incompatible, but this results in a 3 dB lower gain for the PCB antenna compared to the patch antenna.
- The ceramic patch antenna radiation pattern is optimized to have maximum gain in half of the hemisphere, resulting in the ability to receive signals from more satellites.

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