Datasheet

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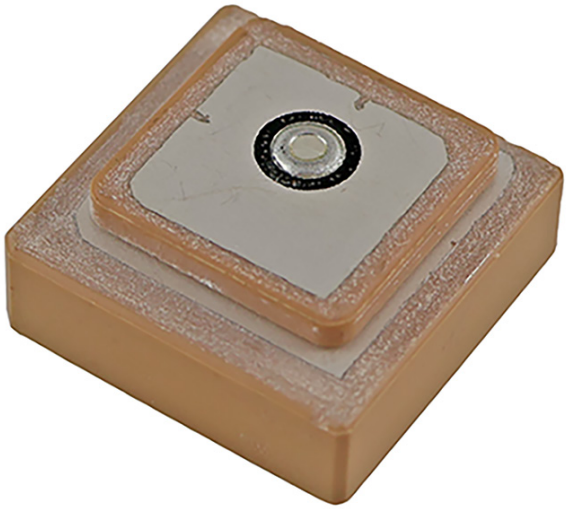
PPX-C020L15B

GNSS L1 L5 Ceramic Patch Antenna

The Joymax PPX-C020L15B antenna is an embedded, RHCP, adhesive plus PCB through-hole pin solder mount, stacked ceramic patch antenna designed for use in 1176.45 MHz, 1575.42 MHz frequency bands supporting Global Navigation Satellite System (GNSS) including GPS (L1, L5), GALILEO (E1, E5a), BeiDou/Compass (B1C, B2a), QZSS (L1, L5) and IRNSS (NavIC) for navigation, location, timing applications.

The ceramic antenna offers extended operating temperature range to +105˚C and features compact package and low profile to be directly mounted on the main PCB of end-devices. Connection is made to the radio through soldering pad and microstrip transmission lines.



Features

- Bandwidth 1176.45 MHz and 1575.42 MHz
- Performance at 1176.45 MHz
  - VSWR: ≤ 2.3
  - Peak Gain: 1.5 dBi
  - Efficiency: 61%
- Right Hand Circularly Polarization (RHCP)
- Directional radiation orthogonal to antenna surface
- Solder-mount board attachment
- Compact package, low profile
- AEC-Q200 compliance

Applications

- Global Navigation Satellite System (GNSS)
  - GPS (L1, L5)
  - GALILEO (E1, E5a)
  - BeiDou/Compass (B1C, B2a)
  - IRNSS/NavIC (L5)
  - QZSS (L1, L5)
- Navigation, Timing, Location
- RTK (Real Time Kinematic) high accuracy positioning.
- UAV (Unmanned Aerial Vehicle)

Ordering Information

Part Number	Description
PPX-C020L15B	GNSS L1 L5 Ceramic Patch Antenna, 20 mm x 20 mm x 6 mm
ZX-F006-C	PPX-C020L15B Antenna Evaluation Kit

Available from Joymax Inc. and select distributors and representatives.

Table 1: Electrical Specifications

PPX-C020L15B	GNSS L1, L5 Band (MHz)	
Frequency Range	1176.45 (L5)	1575.42 (L1)
VSWR (Max.)	2.3	1.5
Peak Gain (dBi)	1.5	1.6
Average Gain (dBi)	-2.1	-4.1
Efficiency (%)	61	39
Polarization	RHCP (Right Hand Circularly Polarization)	
Radiation	Directional	
Max. Power	1 Watt	
Wavelength	½-λ	
Electrical Type	Radiating Ceramic Patch	
Impedance	50 Ω	

Electrical specifications and plots measured with a 60 mm x 60 mm (2.36 in. x 2.36 in.) reference ground plane.

Table 2: Mechanical Specifications

Parameter	Value
Connection	Solder Pad Board Attachment with Adhesive
Dimension	20 mm x 20 mm x 8 mm
Weight	14.6 g (0.5 Oz)
Operating Temp.	-40˚ C to +105˚C
Antenna Color	Light Brown
Storage Temp.	-40˚ C to +105˚C

Antenna Ground Plane and Ceramic Patch Antenna Work Methodology

The PPX-C020L15B is a ceramic patch antenna which requires ground plane to achieve high performance. The larger ground plane, generally the higher antenna gain. However, bigger ground plane would also result in narrower signal beam. We recommend the ground plane size shown in the Electrical Specifications table to achieve performance similar to that shown in this datasheet.

Ceramic patch antennas feature directional radiation. The antenna silver surface should always face sky to receive satellites signal, and none of the metallic parts should cover the antenna surface. Metal plate on top of the antenna silver surface will block/shield the antenna from receiving satellites signal. Please contact Joymax for simulation performance data with different ground plane sizes and customer enclosure. Joymax offer complimentary PCB design reviews to help optimize solution performance.

The antenna silver surface may oxidize in the atmosphere, turning rust/yellow color. This does not affect antenna performance. To clean antenna silver surface, simply use a rubber to wipe the silver surface.

GNSS Constellations and Frequency Bands

As of 2026, there are 4 Global Navigation Satellite System (GNSS) in operation as shown in **Figure 1**. United States' GPS (Global Positioning System), European Union's Galileo system, Russia's Glonass and China's BeiDou/Compass system. Satellite-Based Augmentation System (SBAS) are designed to enhance the accuracy of GPS, including Japan's QZSS (Quasi-Zenith Satellite System), India's GAGAN and European EGNOS. IRNSS (Indian Regional Navigation Satellite System) operationally also known as NavIC is a stand alone Regional Navigation Satellite System (RNSS).

GNSS Frequency Bands					
GPS	L1 ✓ 1575.42 MHz	L2 1227.6 MHz	L5 ✓ 1176.45 MHz		
Galileo	E1 ✓ 1575.42 MHz	E5a ✓ 1176.45 MHz	E5b 1207.14 MHz	E6 1278.75 MHz	
Glonass	G1 1602 MHz	G2 1246 MHz	G3 1202 MHz		
BeiDou (Compass)	B1 1561 MHz	B1C ✓ 1575.42 MHz	B2a ✓ 1176.45 MHz	B2b 1207.14 MHz	B3 1268.52 MHz
QZSS	L1 ✓ 1575.42 MHz	L2 1227.6 MHz	L5 ✓ 1176.45 MHz	L6 1278.75 MHz	
SBAS	L1/E1/B1C ✓ 1575.42 MHz	L5/E5a/B2a 1227.6 MHz	G1 1602 MHz	G2 1246 MHz	G3 1202 MHz
IRNSS (NavIC)	L5 ✓ 1176.45 MHz				

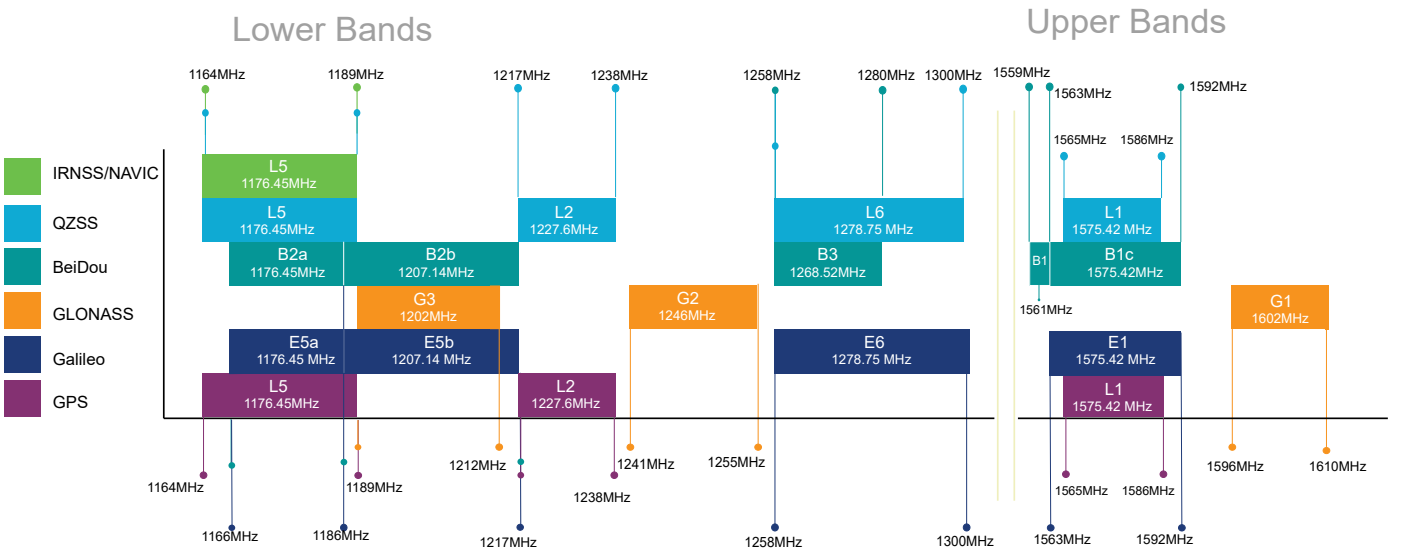


Figure 1. GNSS Frequency Bands

Product Dimensions

Figure 2 provides dimensions of the PPX-C020L15B in mm measurement unit. The antenna is designed to directly mount on the main PCB of end-devices. Connection is made to the radio through microstrip transmission lines.

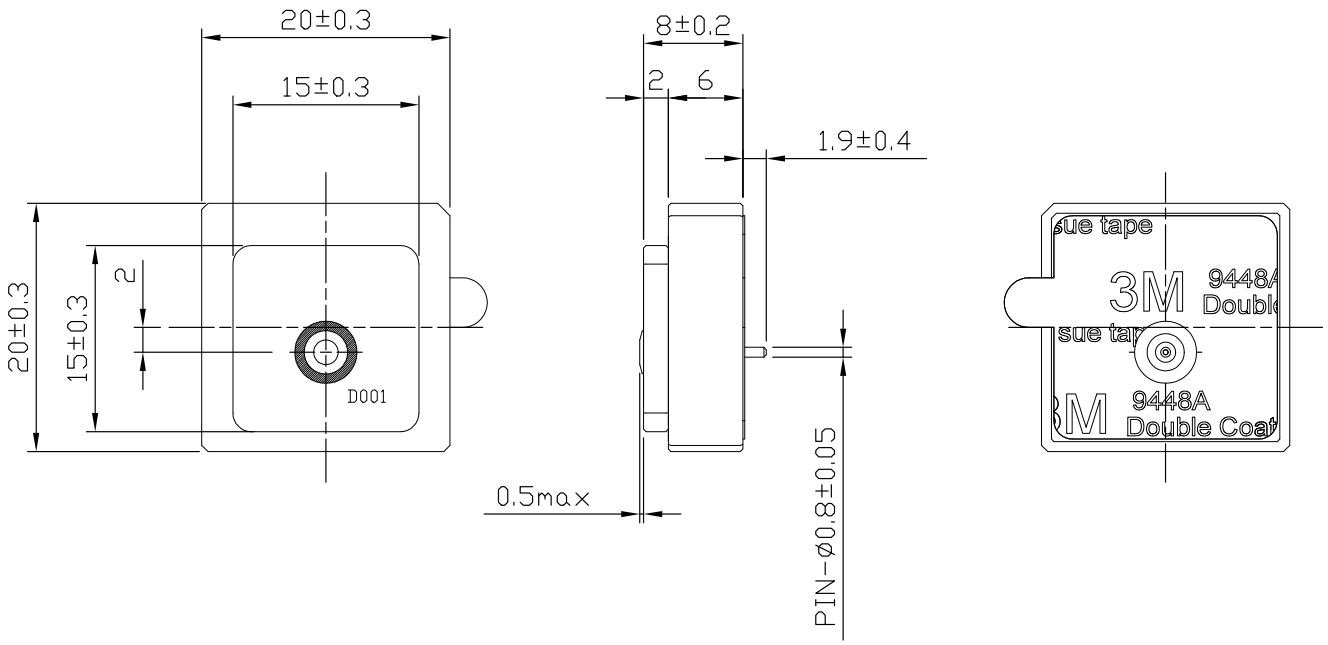
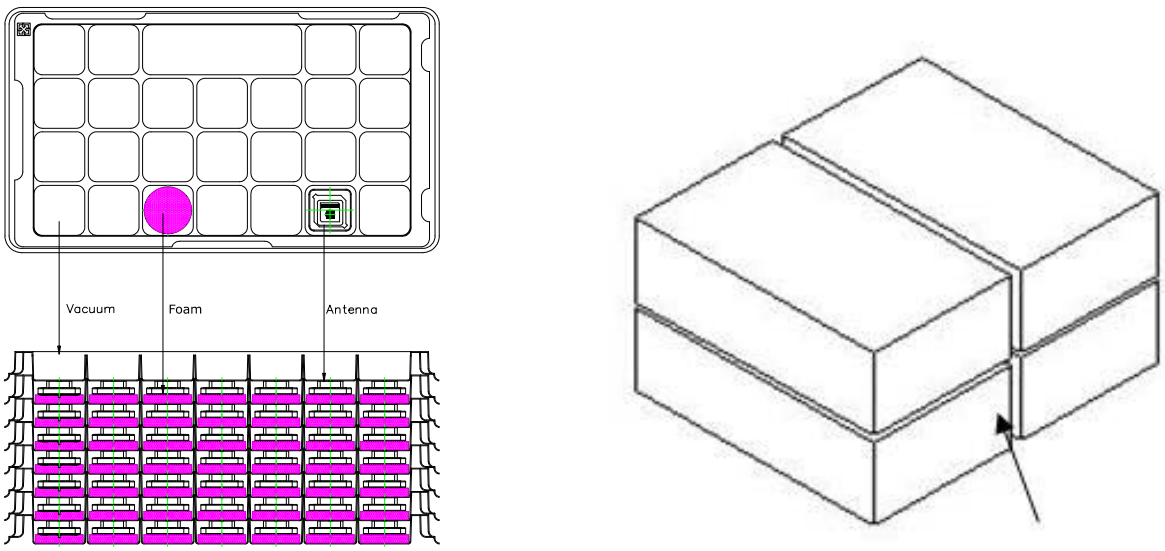


Figure 2. Antenna Dimensions

Packaging Information

The PPX-C020L15B are bulk packaged onto plastic trays as shown in **Figure 3**. 25 pcs per tray, 7 trays (175pcs) packed into a box, 4 boxes packed into a shipping carton box size 390 mm x 260 mm x 330 mm (15.4 in x 10.2 in x 13.0 in) with total weight 12.7 kgs (28 lb). Distribution channels may offer alternative packaging options.



25 pcs / Tray

4 boxes / carton

Figure 3. Antenna Packaging

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Antenna Placement and Keep-out Area

The PPX-C020L15B antenna should be mounted at the center of the main board for best performance as shown in **Figure 4**. This utilizes the main board as ground plane to reflect and collect satellites signal to the antenna to achieve higher gain and efficiency. The antenna requires symmetrical clearance/keep-out area ideally around the antenna at least **6 mm**. Please note less keep-out area will degrade antenna performance.

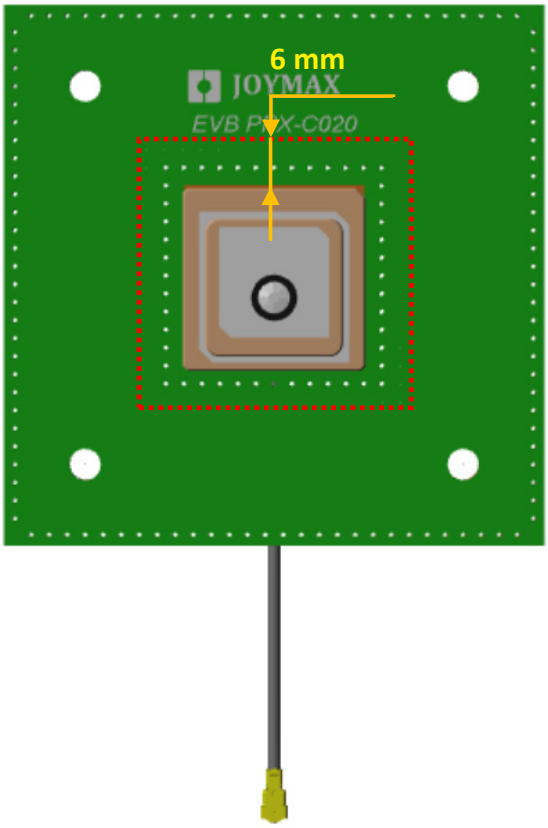


Figure 4. Antenna Placement and Keep-out Area

Transmission Lines For Embedded Antennas

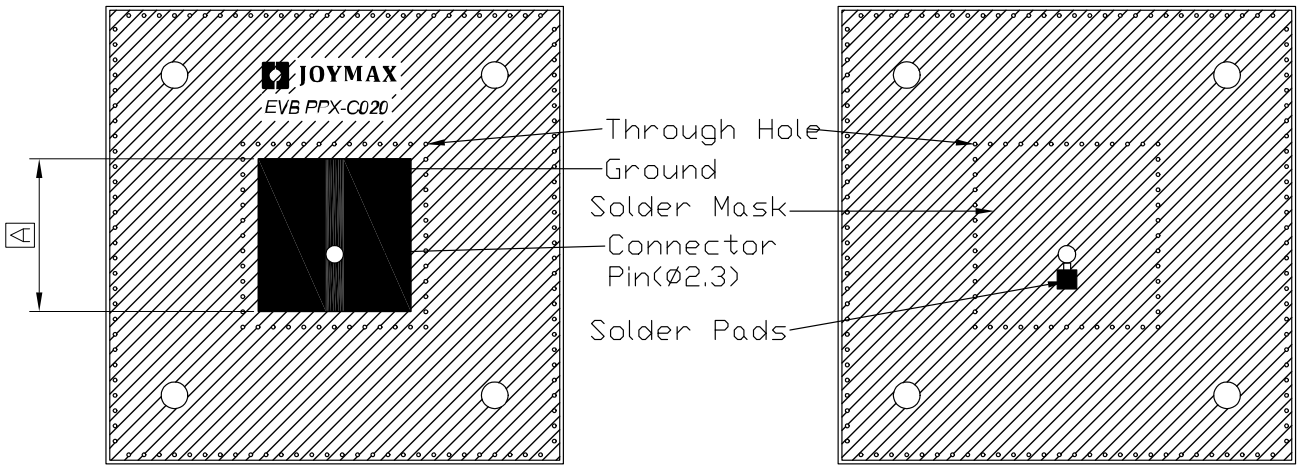
For most designs, we recommends a microstrip transmission line for the PPX-C020L15B. A microstrip transmission line is a PCB trace that runs over a ground plane to maintain the characteristic impedance for optimal signal transfer between the antenna and radio circuitry. Joymax designs all antennas with a characteristic impedance of **50 Ω**. Important practices to observe when designing a transmission line are:

- Keep all transmission lines to a minimum length to reduce loss for best signal performance.
- Use RF components that also operate at a **50 Ω** impedance.
- If the radio is not on the same PCB as the antenna, the microstrip should be terminated in a connector, as exemplified on the PPX-C020L15B evaluation board, enabling a shielded cable to complete the antenna connection to the radio.
- For designs subject to significant electromagnetic interference, a coplanar waveguide transmission line may be used on the PCB. The design of a PCB transmission line can be aided by many commercially available software packages which can calculate the correct transmission line width and gap dimensions based upon the PCB thickness and dielectric constant used. Joymax offers PCB design reviews to help optimize solution performance.

Recommended PCB Footprint Layout

The recommended printed circuit board (PCB) layout for the PPX-C020L15B is shown in **Figure 5**. This layout is used for the PPX-C020L15B evaluation board which is available for purchase as listed under **Ordering Information**. Contact Joymax Inc. for availability of PCB layout design files.

The recommended layout includes ground plane, through hole which should keep out metal at all layers of the main board around the pin (RF feed point), and PCB transmission line from the antenna feed point (pin) to the connector or radio circuitry. The connector used for the evaluation board is optional, the transmission line may be run directly to the radio if on the same PCB.



Symbol	A
Size(mm)	□20±0.2

Figure 5. Recommended PCB Footprint Layout

Antenna Matching Circuit

The PPX-C020L15B, as designed, does not require matching circuit. However to allow Joymax engineering team to get involved to assist improving the antenna performance with different end-device enclosure, PCB and environment,, it is recommended to add a 3-element "π" (pi) matching circuit of 2 parallel capacitors (C1, C2) and 1 serial inductor (L1) as shown in **Figure 6** next to feed point. Please contact Joymax for complimentary design review and matching circuit support. If no matching is necessary, the series element may be populated with a zero-Ohm resistor and no components in the two parallel capacitor/inductor positions.

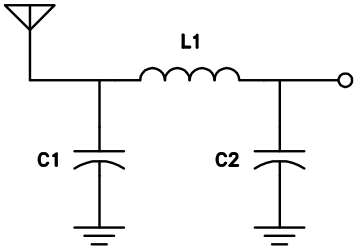


Figure 6. Recommended 3-element "π" (pi) Matching Circuit

Antenna Test Setup

The PPX-C020L15B antenna is a surface-mount antenna designed to attach at the short side of the edge of the main PCB of IoT end-products. There are many different wireless devices with different size main PCB in IoT. So we assumed a most common PCB size 53 mm x 38 mm and integrated the antenna design reference to an evaluation kit as shown in **Figure 7**. The charts on the following pages represent data taken with the antenna mount on antenna evaluation board in free space.

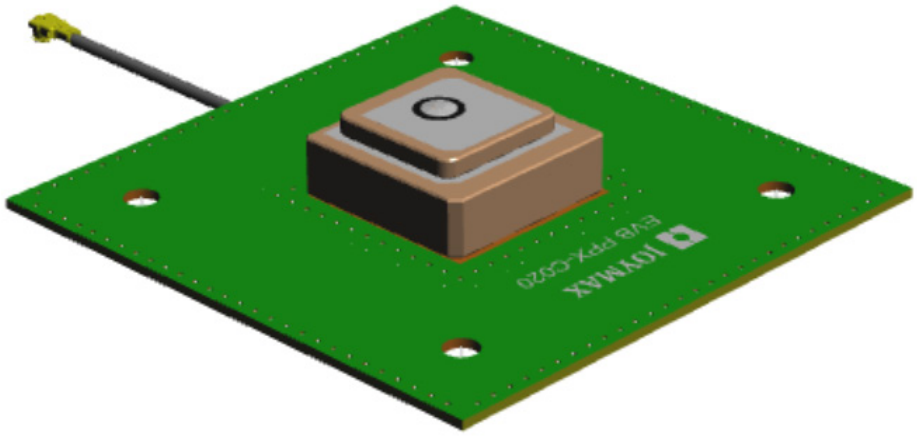


Figure 7. Antenna Evaluation Kit and Test Setup

VSWR

Figure 8 provides the voltage standing wave ratio (VSWR) across the antenna bandwidth. VSWR is a function of the reflection coefficient, which describes the power reflected from the antenna back to the radio. A lower VSWR value indicates better antenna performance at a given frequency. Reflected power is also shown on the right-side vertical axis as a gauge of the percentage of transmitter power reflected back from the antenna.

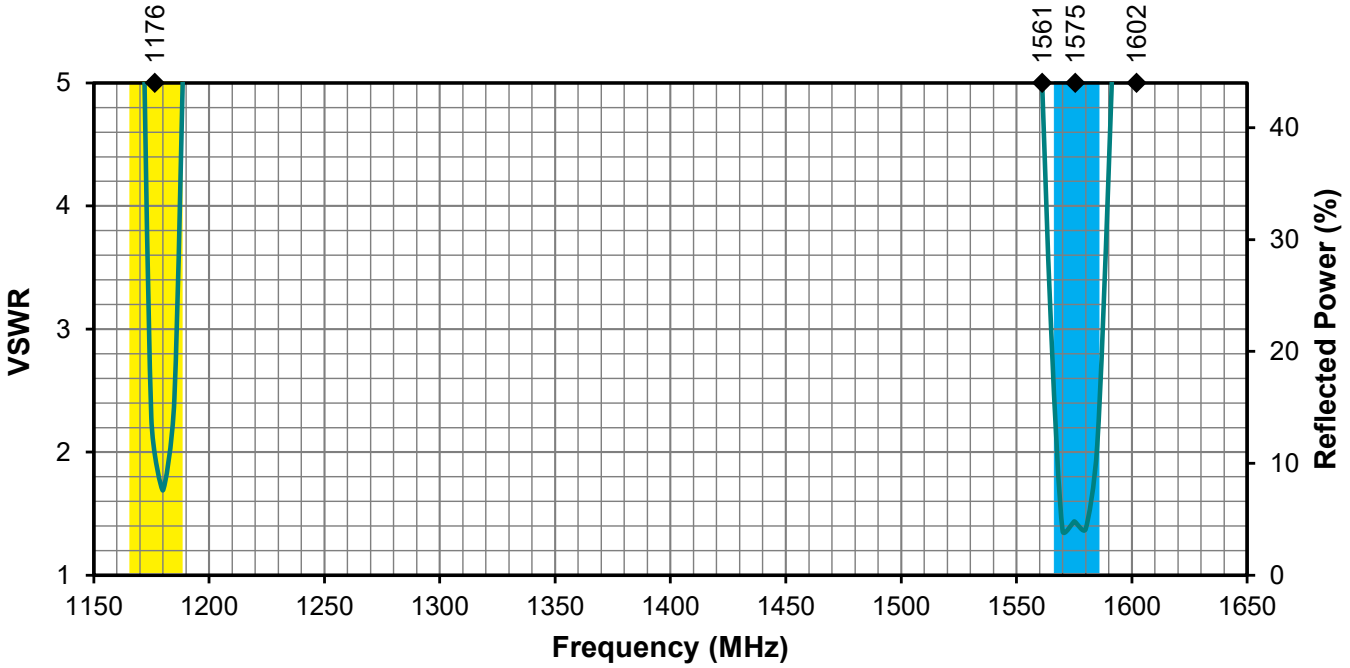


Figure 8. Antenna VSWR

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Return Loss

Return loss (**Figure 9**), represents the loss in power at the antenna due to reflected signals. Like VSWR, a lower return loss value indicates better antenna performance at a given frequency.

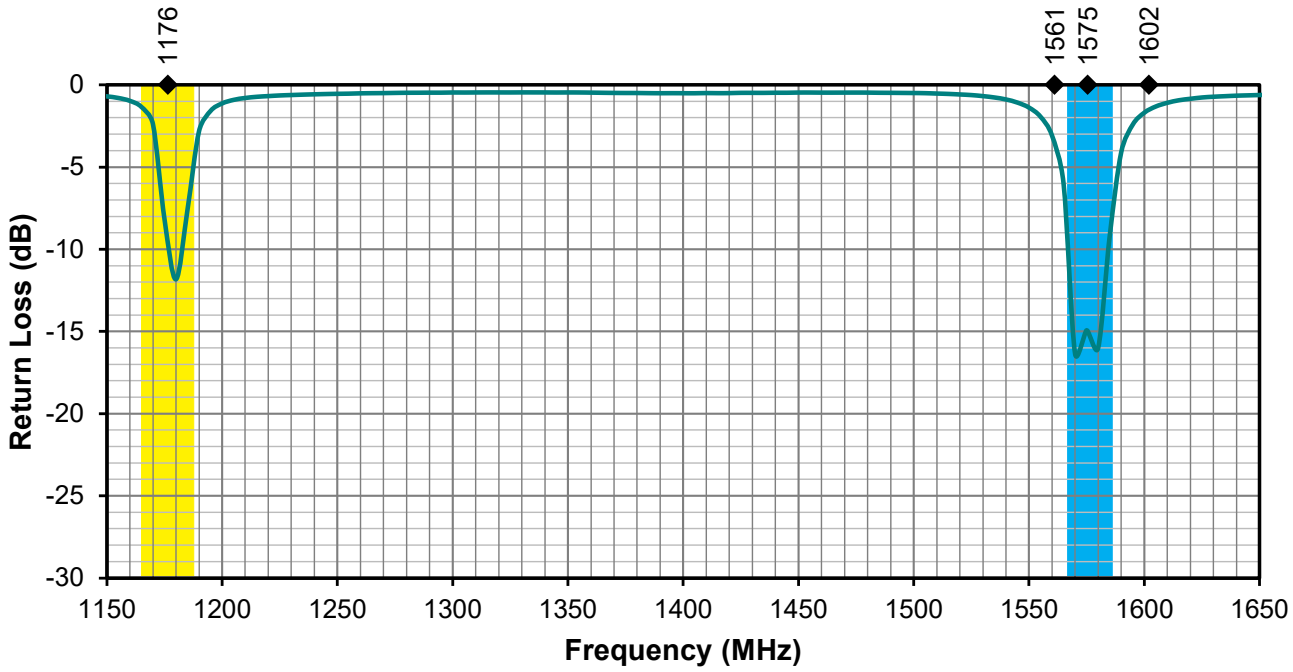

Figure 9. Antenna Return Loss

Peak Gain

The peak gain across the antenna bandwidth is shown in **Figure 10**. Peak gain represents the maximum antenna input power concentration across 3-dimensional space, and therefore peak performance at a given frequency, but does not consider any directionality in the gain pattern.

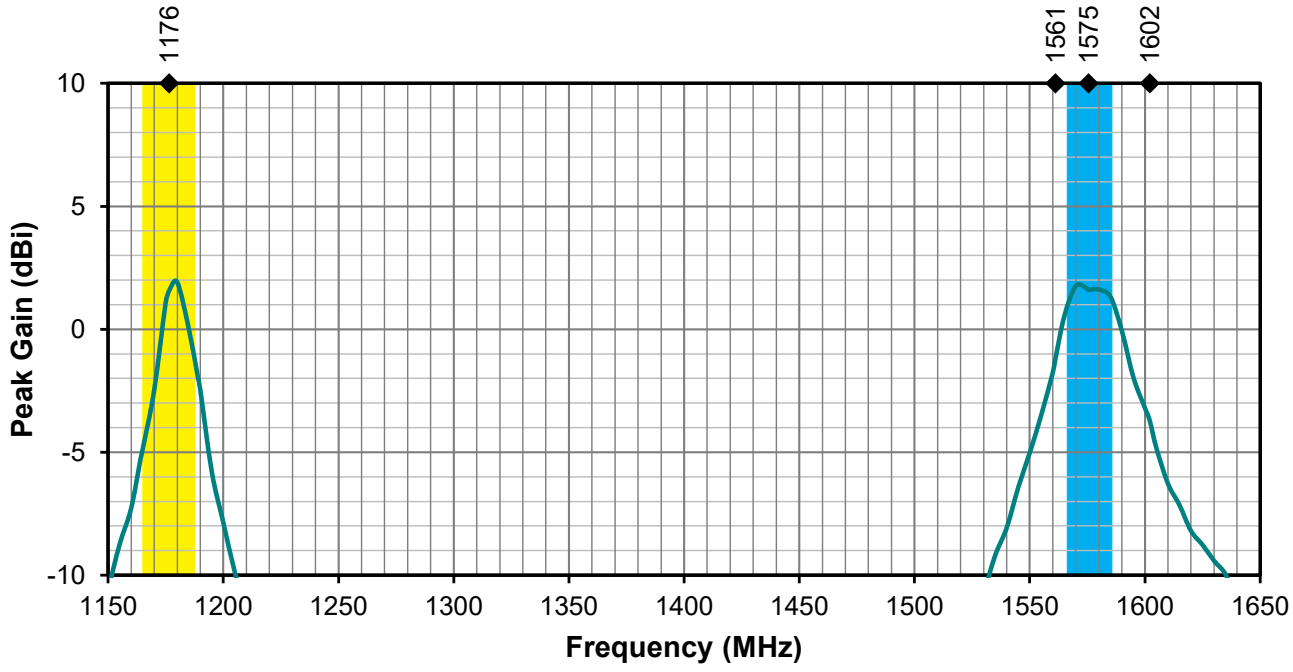

Figure 10. Antenna Peak Gain

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Average Gain

Average gain (**Figure 11**), is the average of all antenna gain in 3-dimensional space at each frequency, providing an indication of overall performance without expressing antenna directionality.

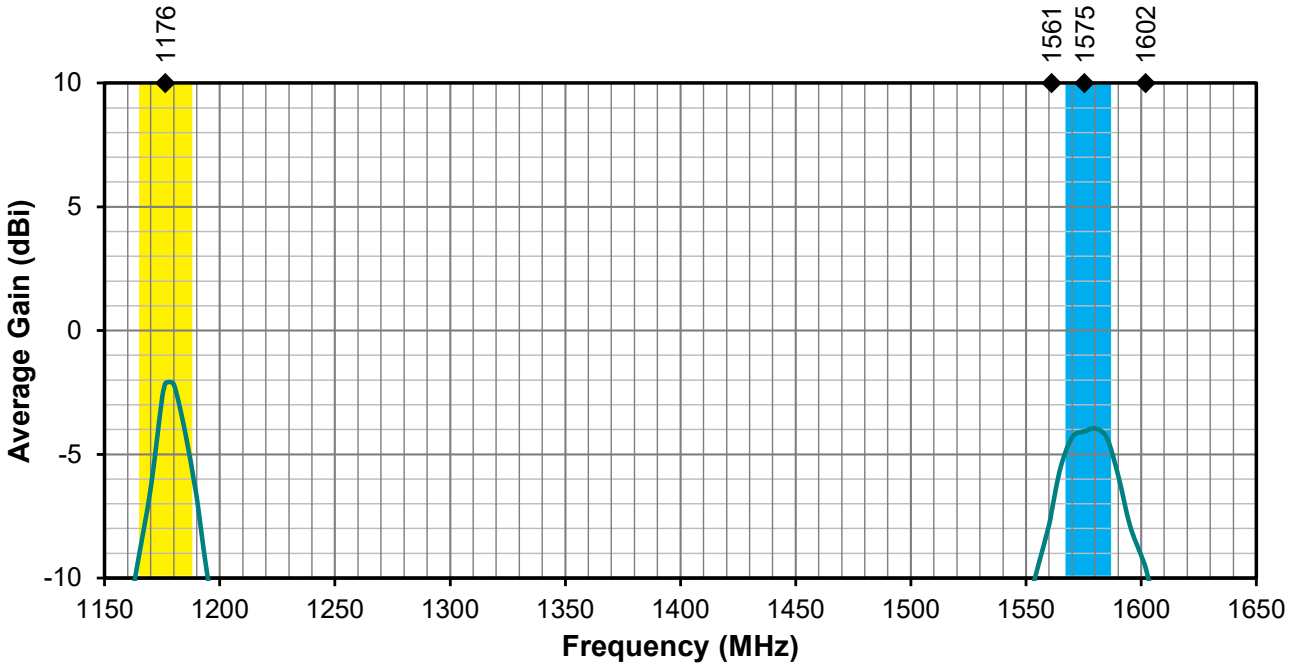

Figure 11. Antenna Average Gain

Radiation Efficiency

Radiation efficiency (**Figure 12**), shows the ratio of power radiated by the antenna relative to the power supplied to the antenna, expressed as a percentage, where a higher percentage indicates better performance at a given frequency. An ideal antenna has 100% efficiency. But in really world, usually an external antenna radiates only 50~60% of power supplied to it.

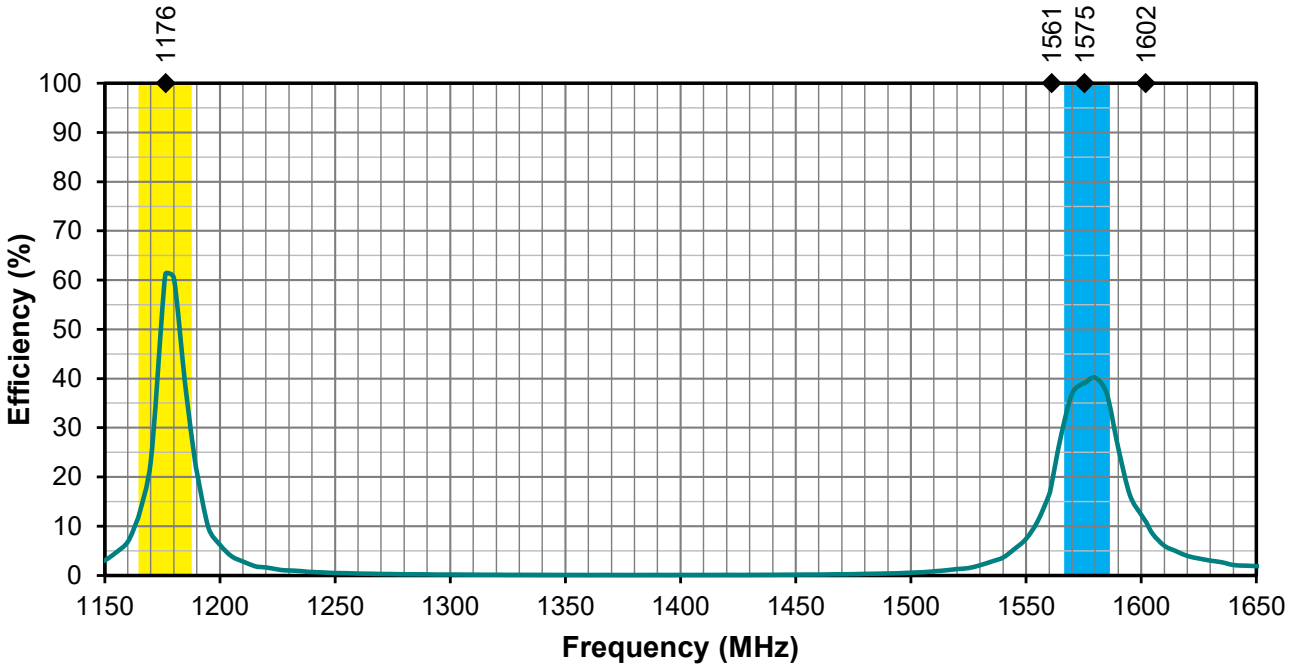

Figure 12. Antenna Efficiency

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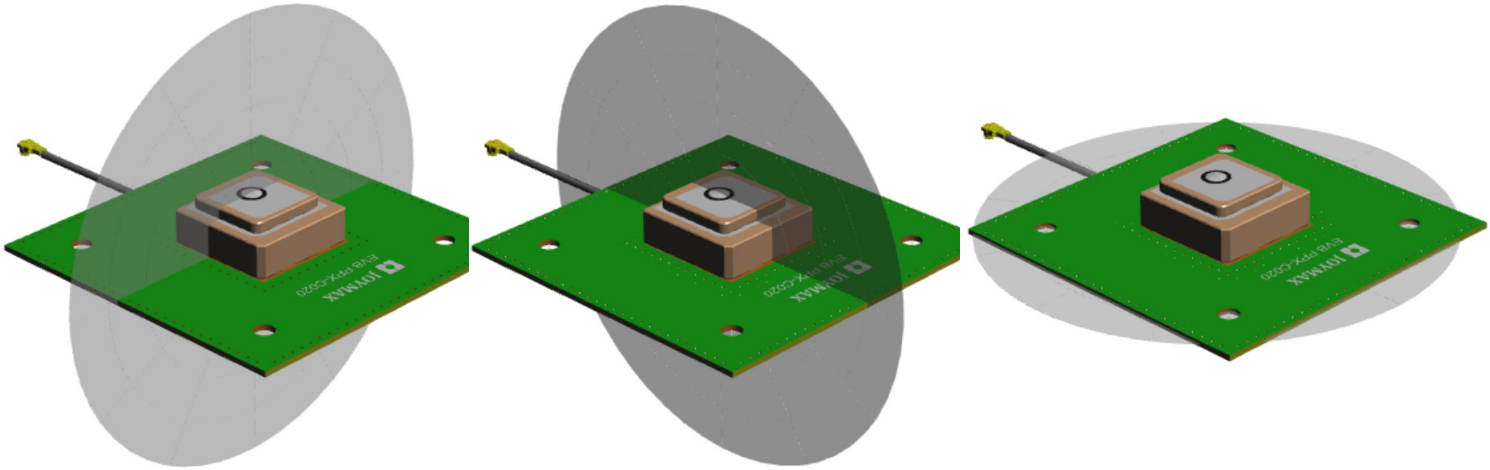
Radiation Patterns

Radiation patterns provide information about the directionality and 3-dimensional gain performance of the antenna by plotting gain at specific frequencies in three orthogonal planes. Antenna evaluation kit radiation patterns are shown in **Figure 13** using polar plots covering 360 degrees. The antenna graphic at the top of the page provides reference to the plane of the column of plots below it.



XZ-Plane Gain YZ-Plane Gain XY-Plane Gain

L5: 1164 MHz to 1189 MHz (1176.45 MHz)

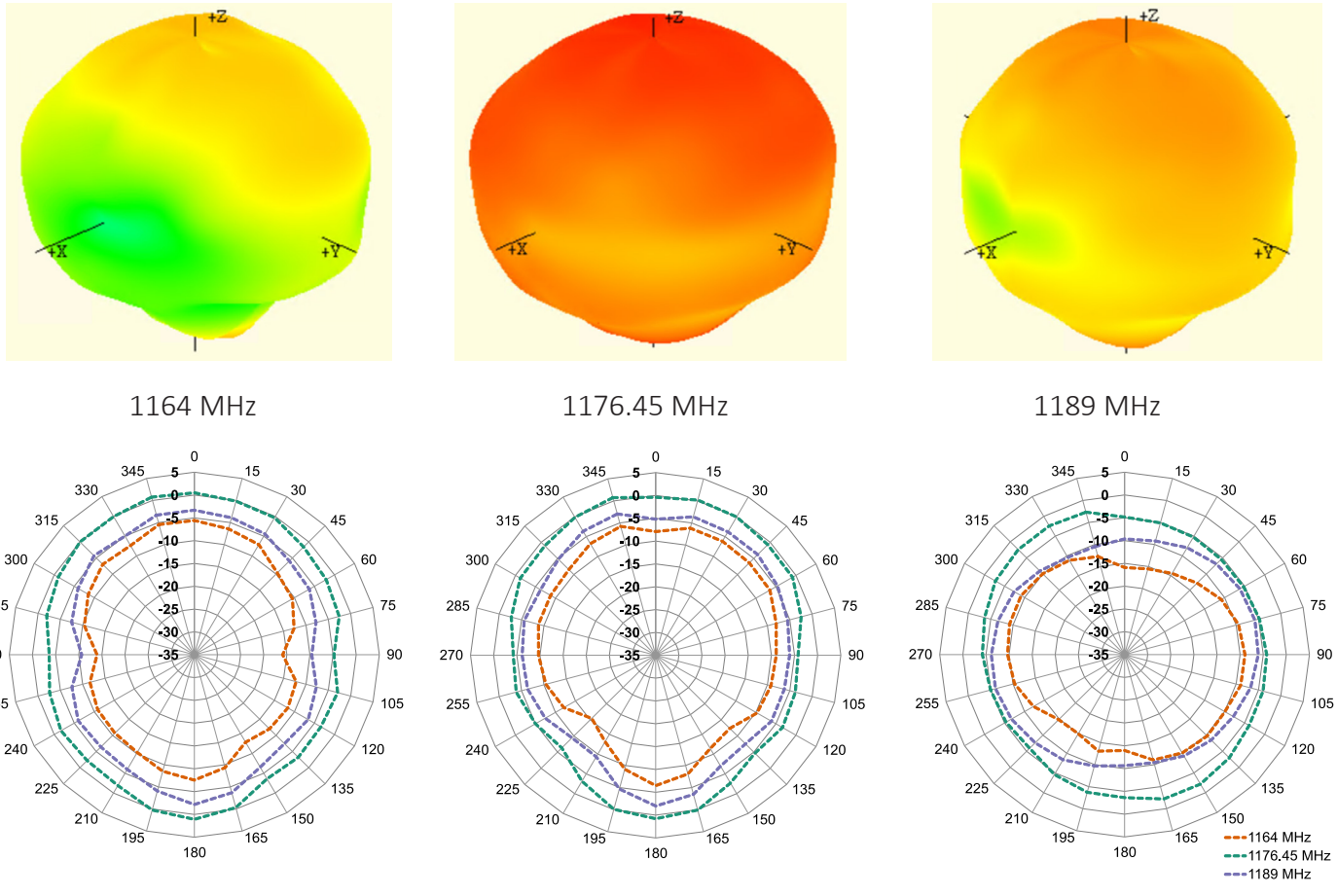


Figure 13. Antenna Radiation Pattern

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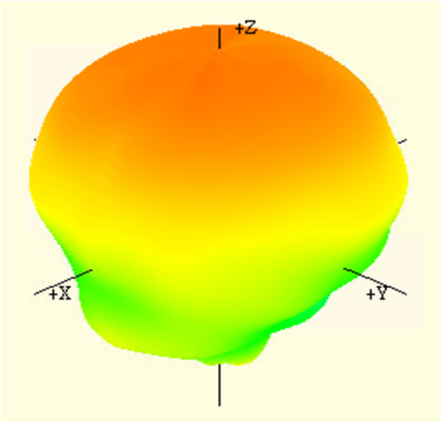
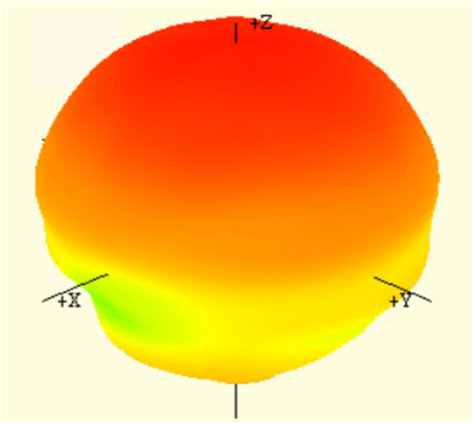
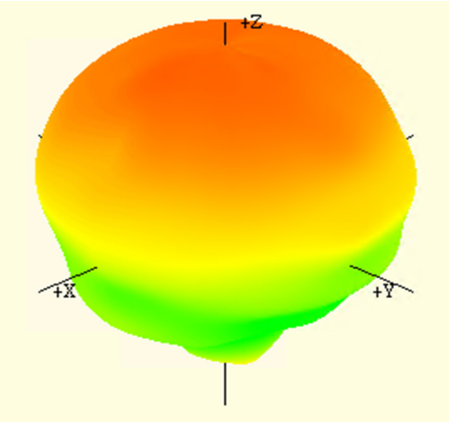
L1: 1561 MHz to 1602 MHz (1575.42 MHz)



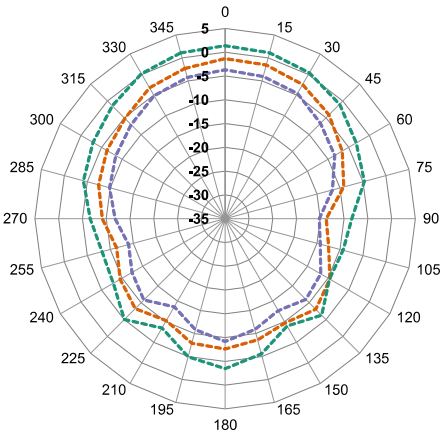
1561 MHz



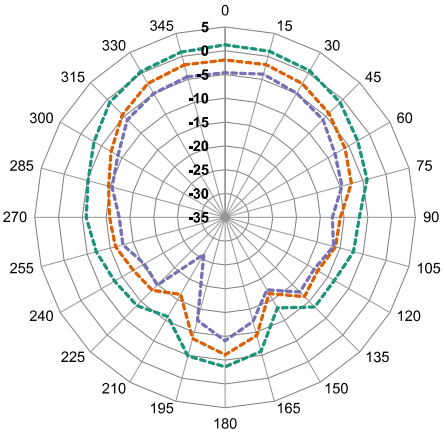
1575.42 MHz



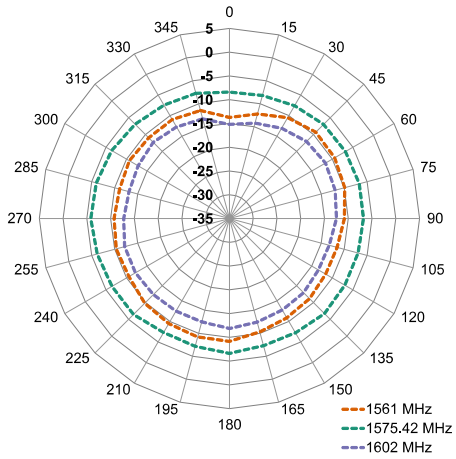
1602 MHz



XZ-Plane



YZ-Plane



XY-Plane

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Antenna FAQs

Q: What is an antenna?

An antenna is used for transmission or reception of radio signals in wireless communication.

Q: How do antennas work?

Electricity flowing into the transmitter antenna makes electrons vibrate up and down it, producing radio waves. The radio waves travel through the air at the speed of light. When the waves arrive at the receiver antenna, they make electrons vibrate inside it.

Q: Does antenna size matter?

A bigger antenna, properly designed, will always have more gain than a smaller one. And it will be the best kind of gain, much better than using a small antenna and simply over-amplifying it, because a small antenna just won't pull in truly weak signals like this gigantic one will.

Q: What is the advantage of external antennas?

External antennas usually offer better bandwidth and high performance due to the nature of their larger size. This often results in a higher rated gain (dBi) than their internal counterparts. Due to its smaller size, an internal antenna would not function well to support lower frequencies.

Ease of integration – an external antenna requires fewer design resources and shorter time to integrate to allow for a more rapid time-to-market. An internal antenna's performance is influenced by device environment – PCB ground plane, nearby metal part, and enclosure. That would require much more effort such as impedance matching network to complete antenna design.

Q: Why is most antenna impedance 50 Ohm?

50 Ohm is an industry standard of coax cables and power amplifiers. It was chosen as a tradeoff between maximum power handling for the transmit coax and the copper losses. The optimum would have been anyway in the range of 30 to 100 ohm with average at 50 Ohm.

Q: Why does GNSS require RHCP (Right-hand-circularly-polarized) antennas?

Satellite's signal has a low power density, especially after propagating through the atmosphere (ionosphere affect radio wave). Polarized waves oscillate in more than one direction, which deliver satellite's signal to receiver on Earth surface more effectively.

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