Datasheet

ZRD-C042XX3B

Embedded 5G PCB chip antenna

The Joymax ZRD-C042XX3B antenna is an embedded, chip-style, surface-mount monopole antenna designed for use in 5G New Radio FR1, LTE, and Cellular IoT (LTE-M, NB-IoT) networking applications with broad bandwidth coverage from 617 MHz to 7125 MHz. The antenna also supports CBRS (3550 MHz to 3700MHz), Public Safety (4940 MHz to 4990 MHz), and a growing number of C-band applications.

The embedded antenna features compact package and low profile to be directly mounted on the edge of the main PCB of end-users device. Connection is made to the radio through microstrip transmission lines.

Features

- Bandwidth 617 MHz to 7125 MHz
- Performance at 617 MHz to 698 MHz
  - VSWR: ≤ 2.8
  - Peak Gain: 1.4 dBi
  - Efficiency: 47%
- Omnidirectional radiation
- Direct surface-mount attachment
- Compact package, low profile

Applications

- 5G NR FR1, 4G, 3G, 2G, CBRS
- Cellular IoT: LTE-M (Cat-M1), NB-IoT
- CBRS Private Network (3550 to 3700MHz)
- C-Band applications (3700 to 4200MHz)
- Public Safety networks (4940 to 4990MHz)
- Internet of Things (IoT) devices
- Smart sensing or monitoring devices
- Gateways

Ordering Information

Part Number	Description
ZRD-C042XX3B	5G/LTE Cellular Surface-Mount PCB chip antenna
ZX-F003-A	ZRD-C042XX3B antenna evaluation kit

Available from Joymax Electronics and select distributors and representatives.

Table 1: Electrical Specifications

ZRD-C042XX3B	5G NR / LTE Bands (MHz)					
Frequency Range	617~960	1710~2690	3300~4200	4400~5000	5150~5850	5925-7125
VSWR (Max)	2.8	3.0	2.4	2.3	2.8	2.5
Peak Gain (dBi)	1.4	4.8	3.1	3.3	4.8	3.7
Average Gain (dBi)	-3.3	-2.2	-2.8	-2.0	-2.4	-2.6
Efficiency (%)	47	60	52	62	58	55
Polarization	Linear					
Radiation	Omni directional					
Max Power	1 W					
Wavelength	¼-λ					
Electrical Type	Monopole					
Impedance	50 Ω					
ESD Sensitivity	NOT ESD Sensitive					

Electrical specifications and plots measured with the antenna mount on a 140 mm long antenna evaluation board.

Table 2: Mechanical Specifications

Parameter	Value
Connection	Surface Mount—Solder pad
Operating Temp.	-40℃ to +85℃
Weight	1.9 g
Dimension	42.0 mm x 7.5 mm x 3.2 mm
Antenna Color	Black
Ingress Protection	N/A

Antenna Ground Plane

The ZRD-C042XX3B is a 1/4-wave monopole antenna which requires ground plane to achieve high performance, especially in lower frequency (sub 1GHz bands). We recommend a minimum **140 x 50 mm** board because quarter wavelength of **617 MHz** is about **122 mm**.

The C042 should be mounted at a distance of **6 mm** from the edge of the ground plane (see **Figure 3**) , and none of the ground plane should be underneath the antenna. If the ground plane is placed too close to the antenna it may impair antenna function rather than promote it. Other ground plane sizes and antenna mounting locations are possible. 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.

Product Dimensions

Figure 1 provides dimensions of the ZRD-C042XX3B in mm measurement unit. The antenna can be directly mounted on the main PCB of end-users wireless device. Connection is made to the radio through microstrip transmission lines.

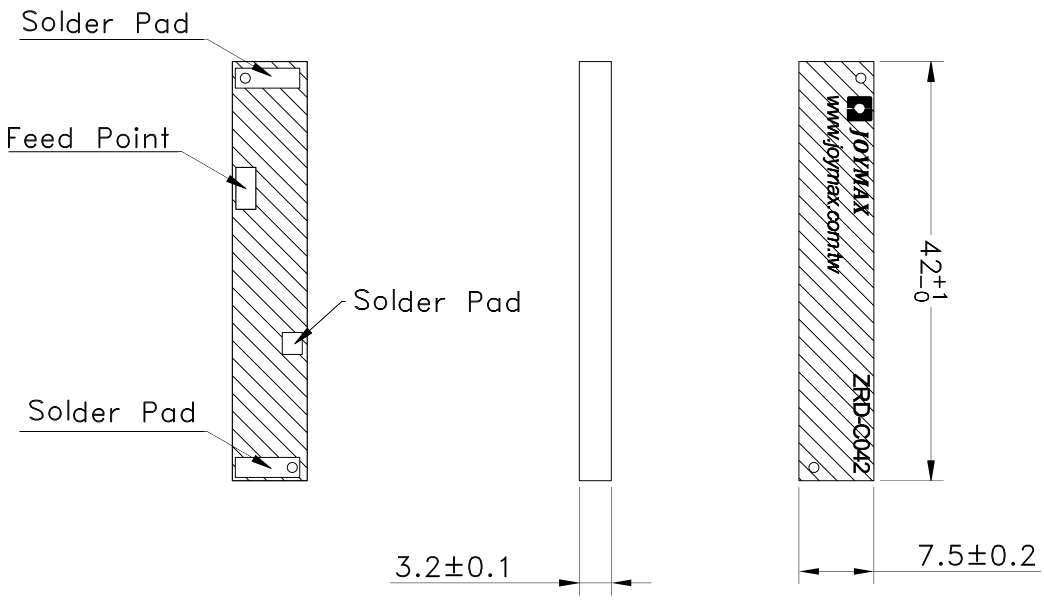


Figure 1. Antenna Dimensions

Tape and Reel Packaging Information

Figure 2 shows the dimensions of the tape and reel in which the ZRD-C042XX3B is packaged. 1000 pcs per reel. 2 reels packed in a carton box size 400 mm x 400 mm x 215 mm (15.7 in x 15.7 in x 8.5 in), with total weight 6.08 kgs (13.4 lb). Distribution channels may cut the tape and make lower quantity available for sample order.

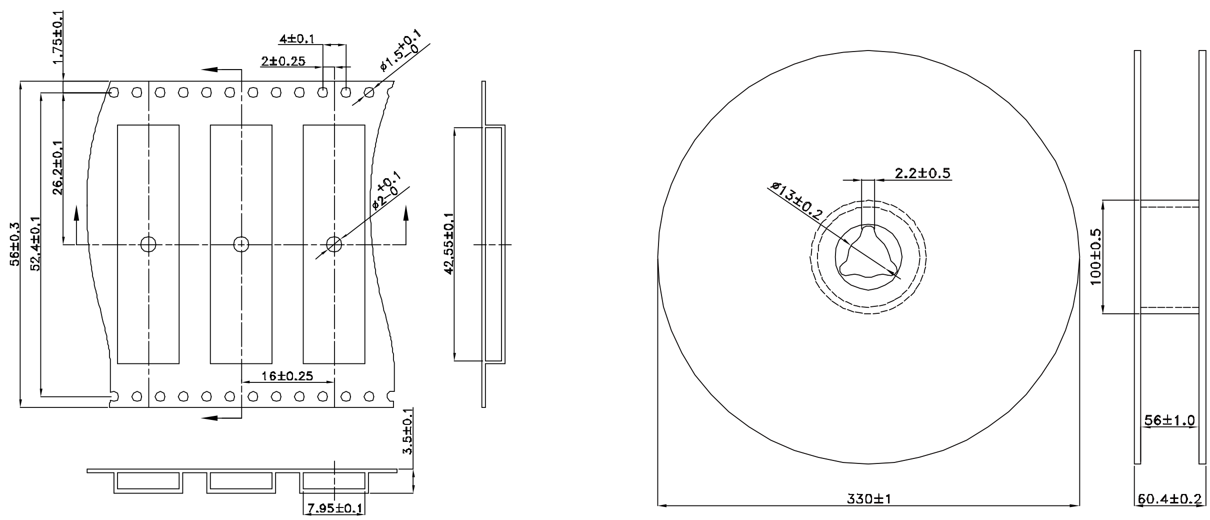
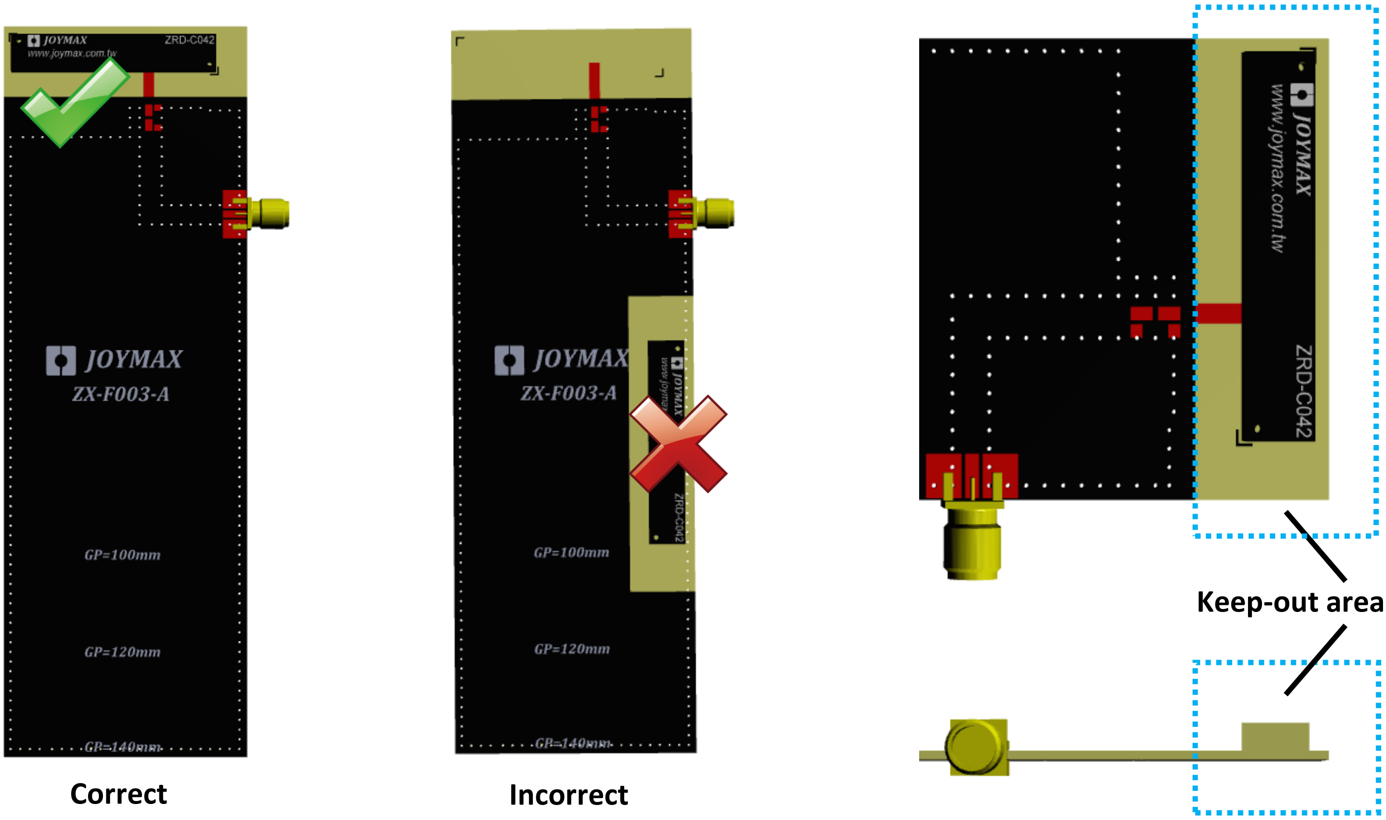


Figure 2. Tape and Reel Dimensions

Antenna Placement and Keep-out area

The ZRD-C042 should be placed at the edge of the short side of the main board as shown in **Figure 3** . This utilizes the longer side of the main board as ground plane to increase antenna efficiency. The antenna requires keep-out/clearance area ideally at least **6 mm** in all direction. Please note less keep-out area will degrade antenna performance.



Correct Incorrect

Figure 3. Antenna Placement and Keep-out area

Transmission Lines For Embedded Antennas

For most designs, we recommends a microstrip transmission line for the C042. 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 C042 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

Antenna Evaluation Kit and Test Setup

The ZRD-C042XX3B antenna is a chip antenna designed to attach on 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 most common PCB size and integrated the antenna design reference to an evaluation kit as shown in **Figure 4**. The charts on the following pages represent data taken with the antenna mount on antenna evaluation board in free space.

Figure 4. Antenna Evaluation Kit and Test Setup

VSWR

Figure 5 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.

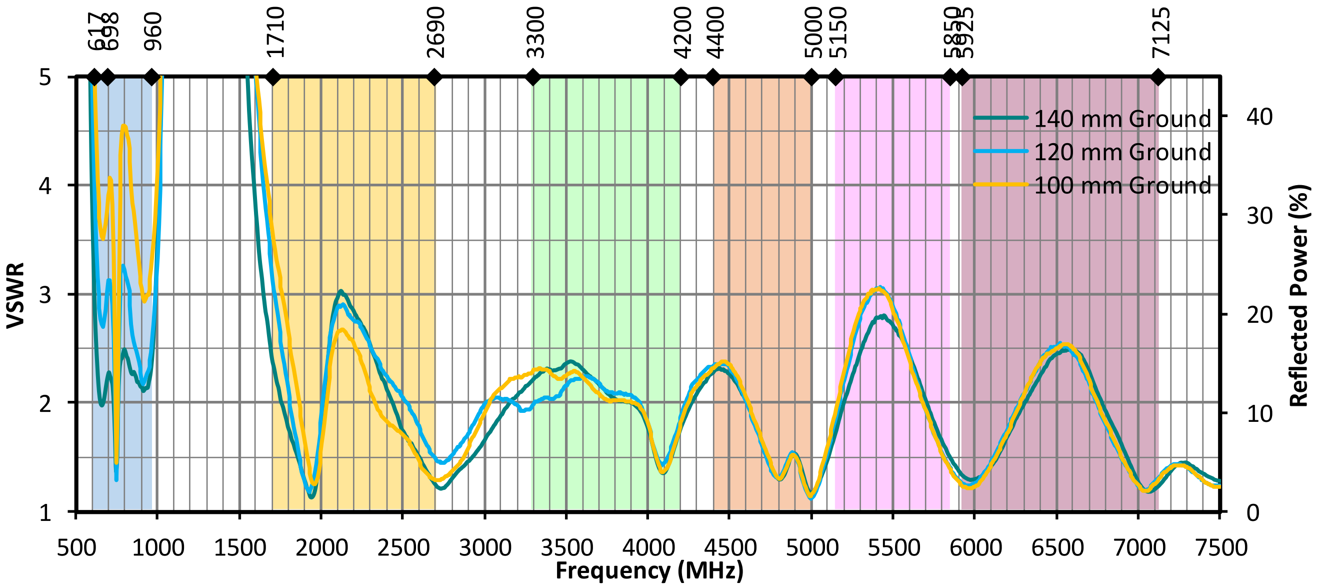


Figure 5. Antenna VSWR, Evaluation Kit

Return Loss

Return loss (**Figure 6**), 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.

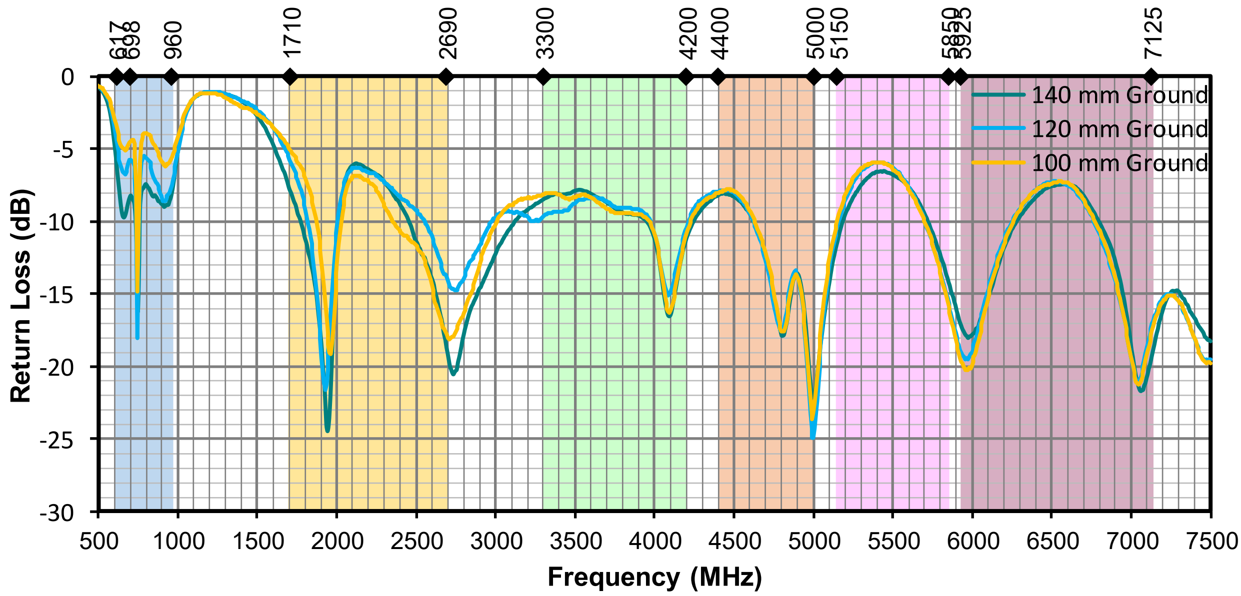


Figure 6. Antenna Return Loss, Evaluation Kit

Peak Gain

The peak gain across the antenna bandwidth is shown in **Figure 7**. 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.

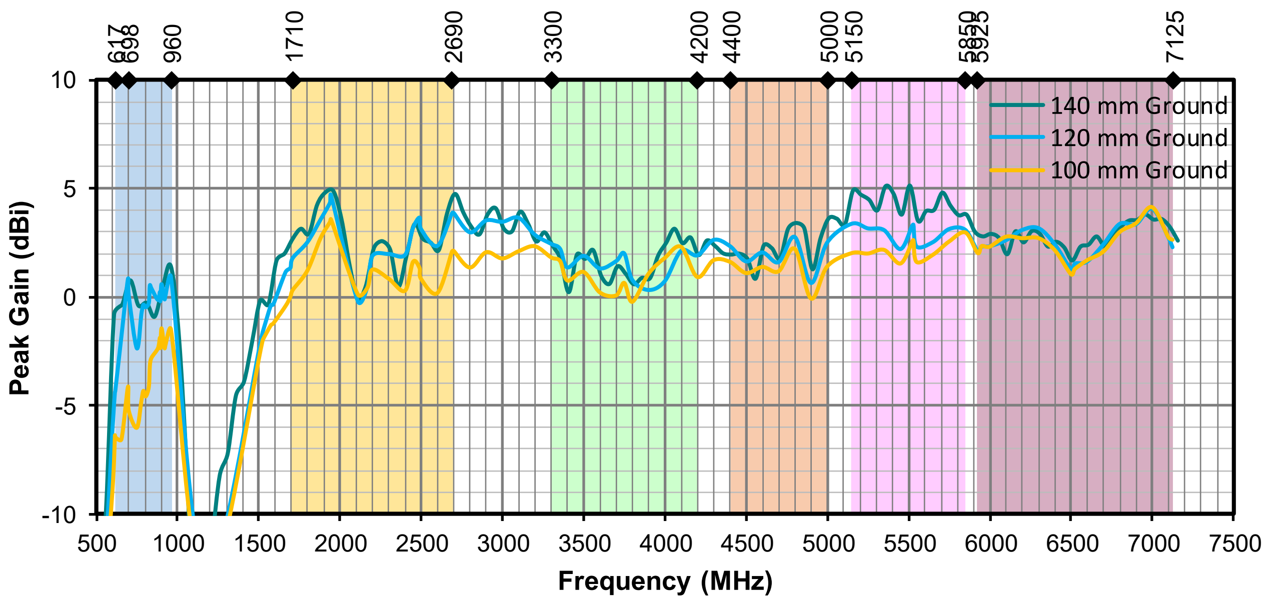


Figure 7. Antenna Peak Gain, Evaluation Kit

Average Gain

Average gain (**Figure 8**), is the average of all antenna gain in 3-dimensional space at each frequency, providing an indication of overall performance without expressing antenna directionality.

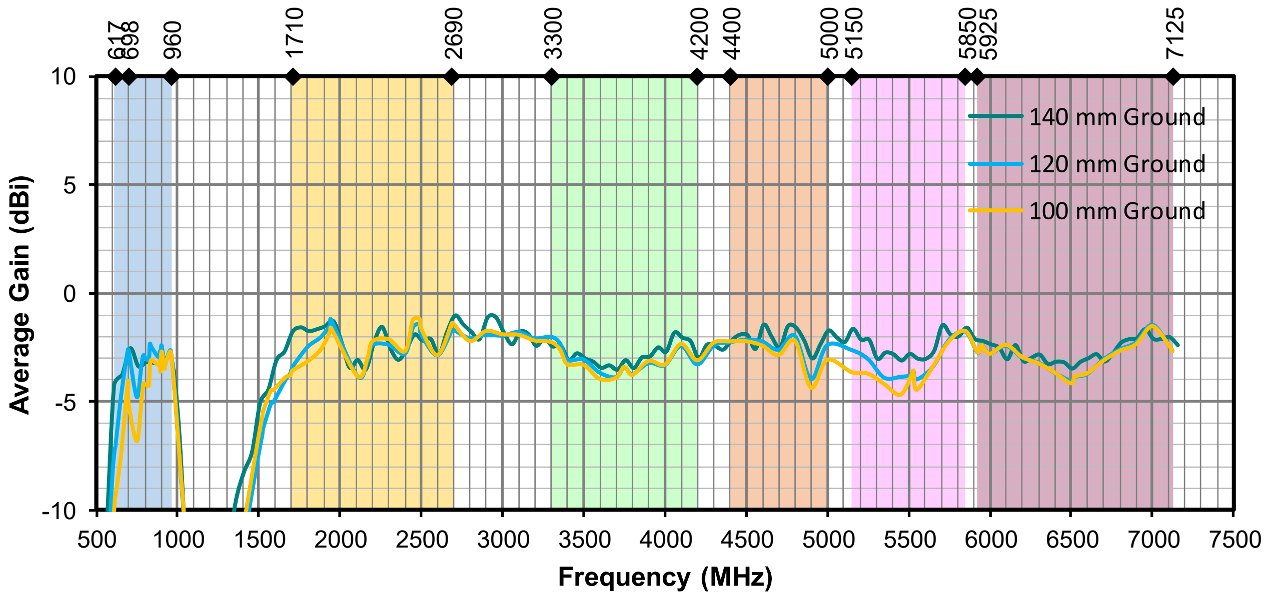


Figure 8. Antenna Average Gain, Evaluation Kit

Radiation Efficiency

Radiation efficiency (**Figure 9**), 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.

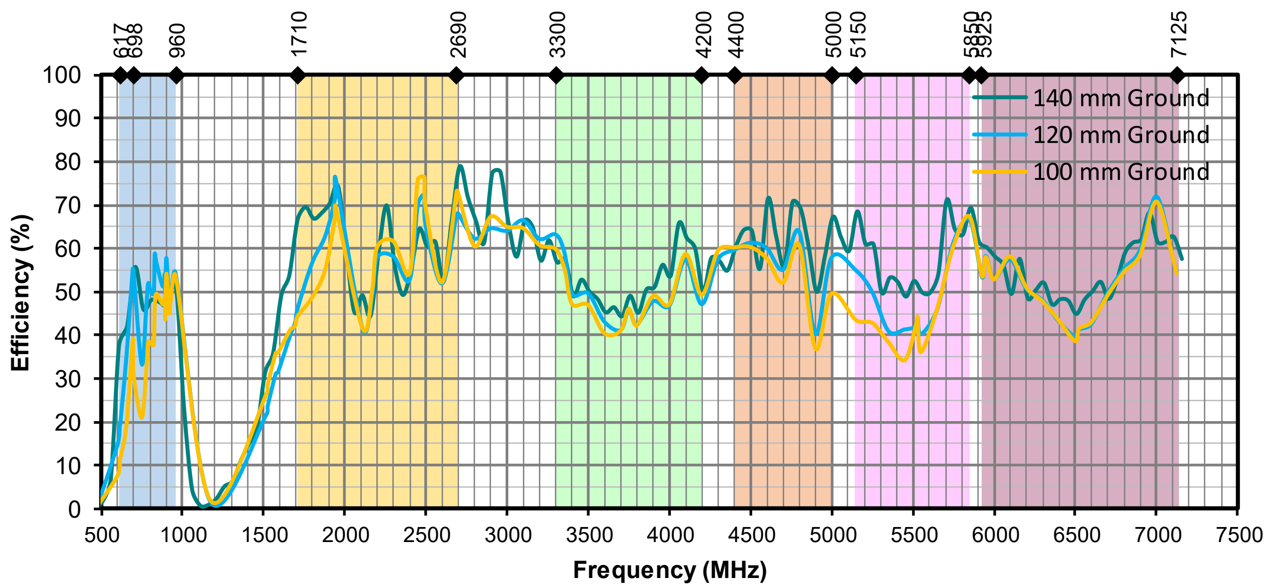
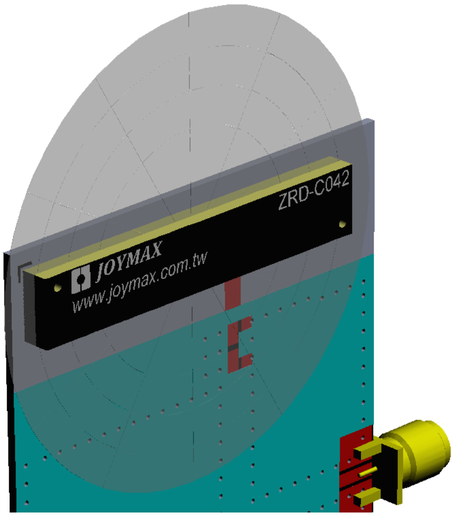


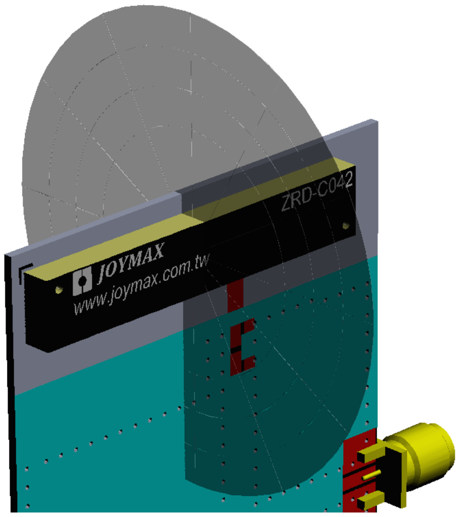
Figure 9. Antenna Efficiency, Evaluation Kit

Radiation Patterns

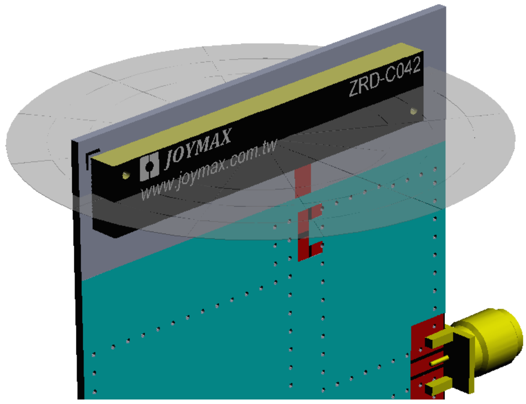
Radiation patterns provide information about the directionality and 3-dimensional gain performance of the antenna by plotting gain at specific frequencies in three orthogonal planes. Antenna radiation patterns for antenna EVB are shown in **Figure 10** using polar plots covering 360 degrees. The antenna graphic at the top of the page provides reference to the plane of the column of plots below it.



XZ-Plane Gain

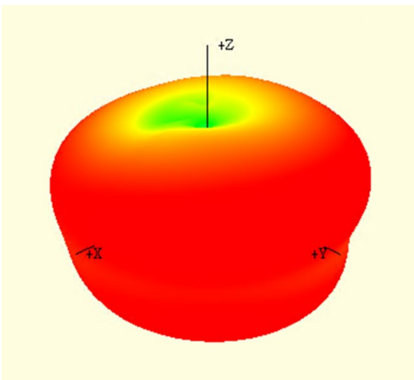


YZ-Plane Gain

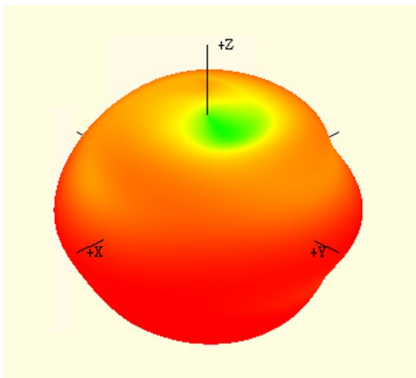


XY-Plane Gain

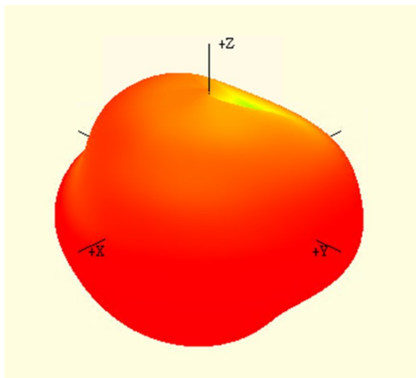
617 MHz to 960 MHz (778 MHz)



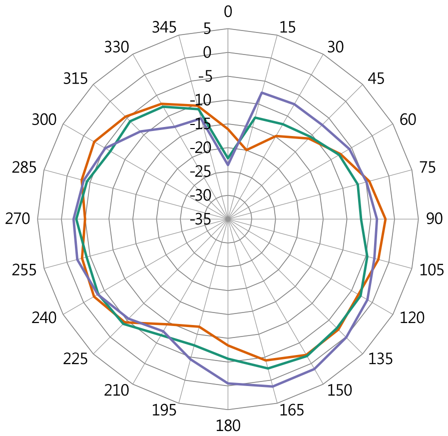
617 MHz



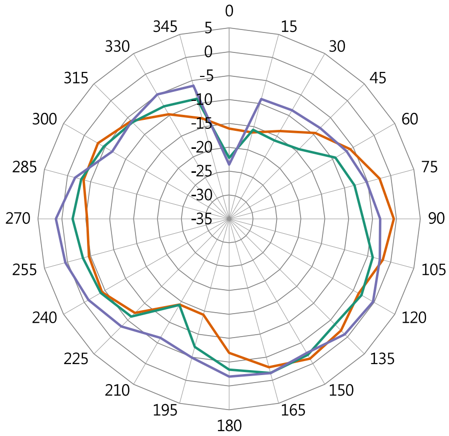
778 MHz



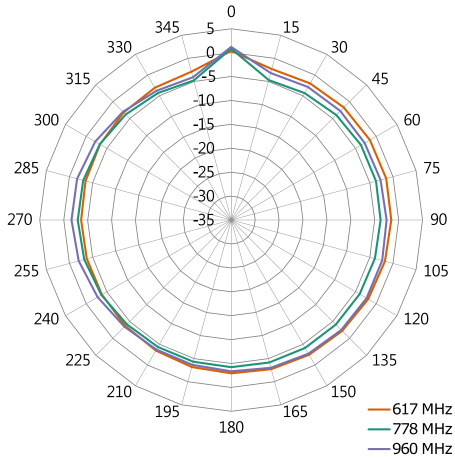
960 MHz



XZ-Plane Gain



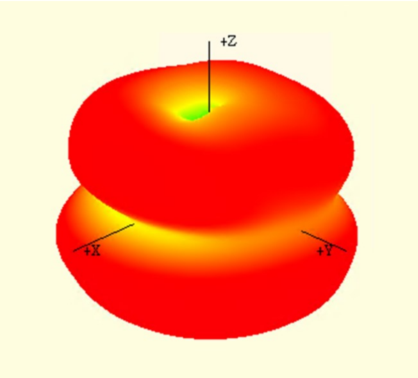
YZ-Plane Gain



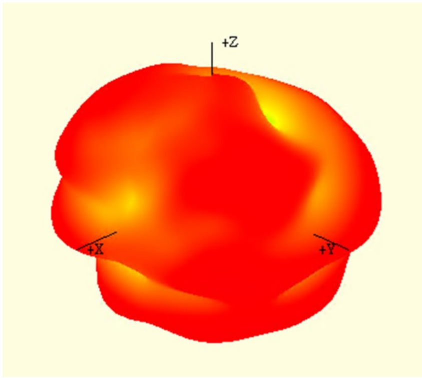
XY-Plane Gain

Figure 10. Antenna Radiation Patterns, Evaluation Kit

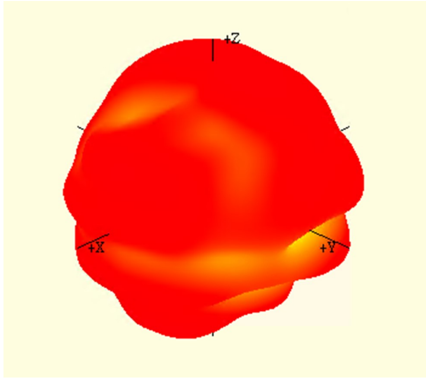
1710 MHz to 5000 MHz (3355 MHz)



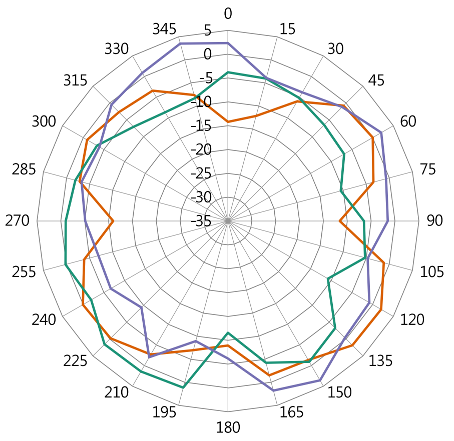
1710 MHz



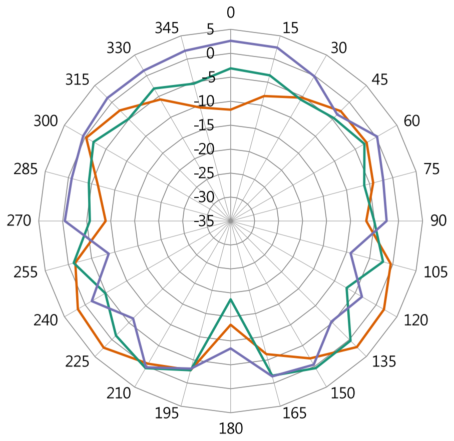
3355 MHz



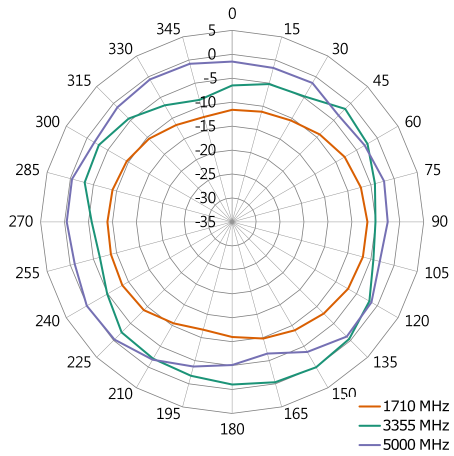
5000 MHz



XZ-Plane Gain

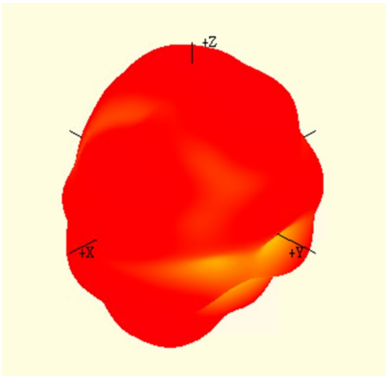


YZ-Plane Gain

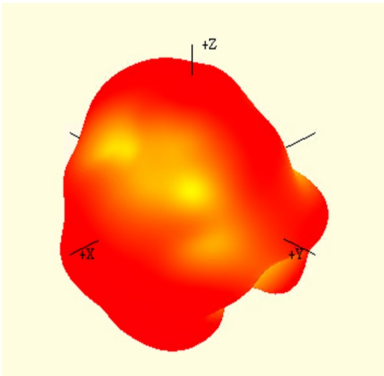


XY-Plane Gain

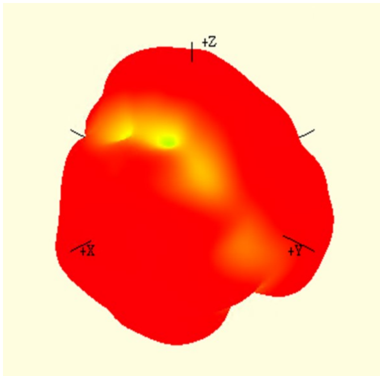
5150 MHz to 5850 MHz (5550 MHz)



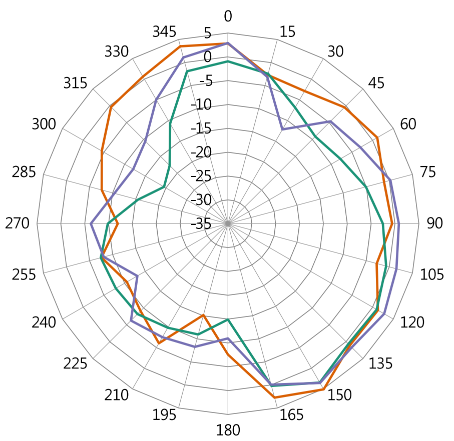
5150MHz



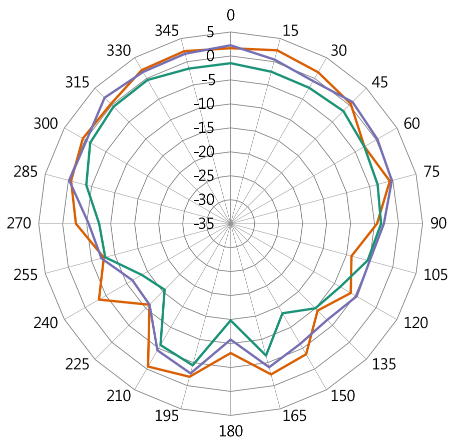
5500 MHz



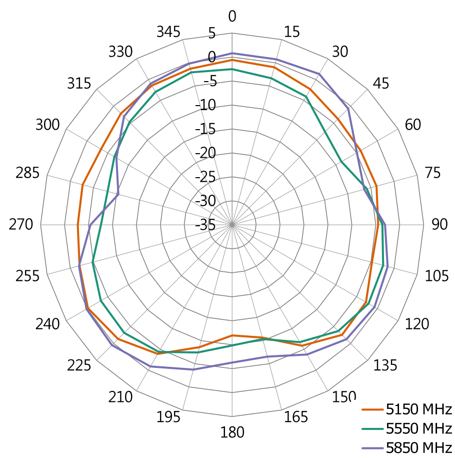
5850 MHz



XZ-Plane Gain

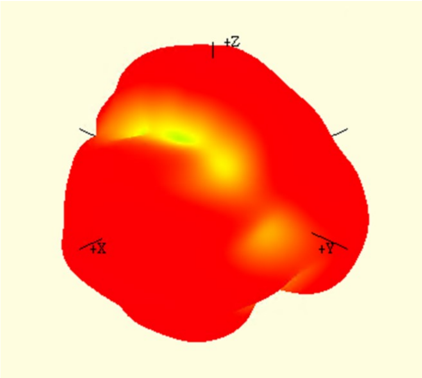


YZ-Plane Gain

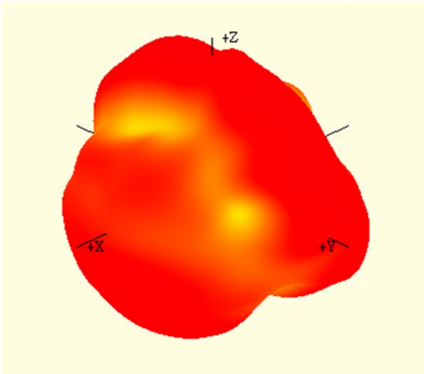


XY-Plane Gain

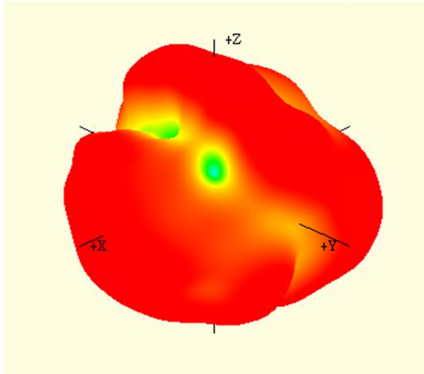
5925 MHz to 7125 MHz (6525 MHz)



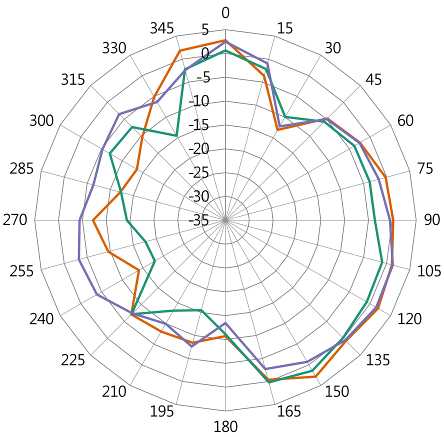
5925 MHz



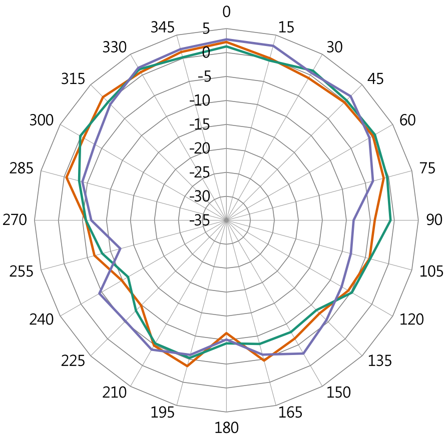
6525 MHz



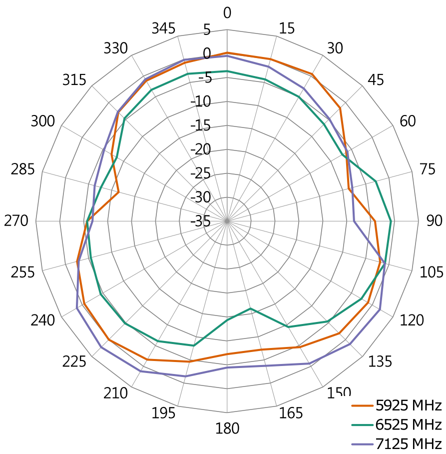
7125 MHz



XZ-Plane Gain



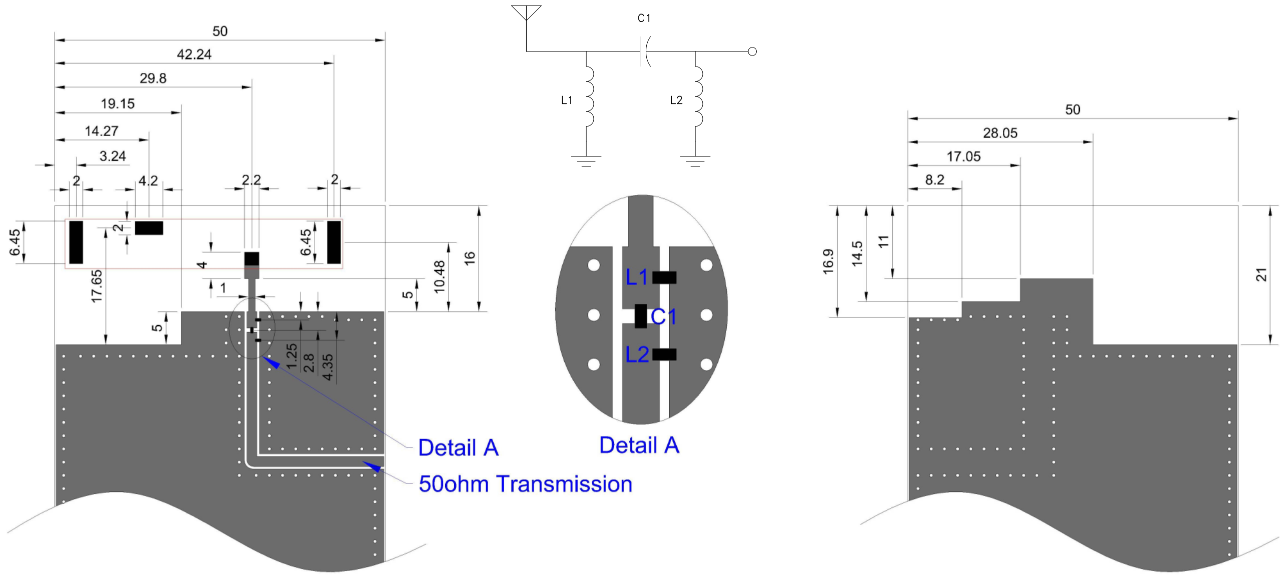
YZ-Plane Gain



XY-Plane Gain

Recommended PCB Footprint Layout

The recommended printed circuit board (PCB) layout for the C042 is shown in **Figure 11**. This layout is used for the C042 evaluation board which is available for purchase as listed under Ordering Information. Contact Joymax Electronics for availability of PCB layout design files. The recommended layout includes a matching network, ground plane and PCB transmission line from the antenna to the matching network, and 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. Joymax recommends inclusion of at least a 3-element, surface mount π (pi) matching network of two parallel inductors, (L1, L2) and one series capacitor, (C1) in all designs. Surface mount components should be 0603 size. 0402 size components are also supported.



Front view Bottom view

Figure 11. Recommended PCB Footprint Layout

Antenna Matching Circuit

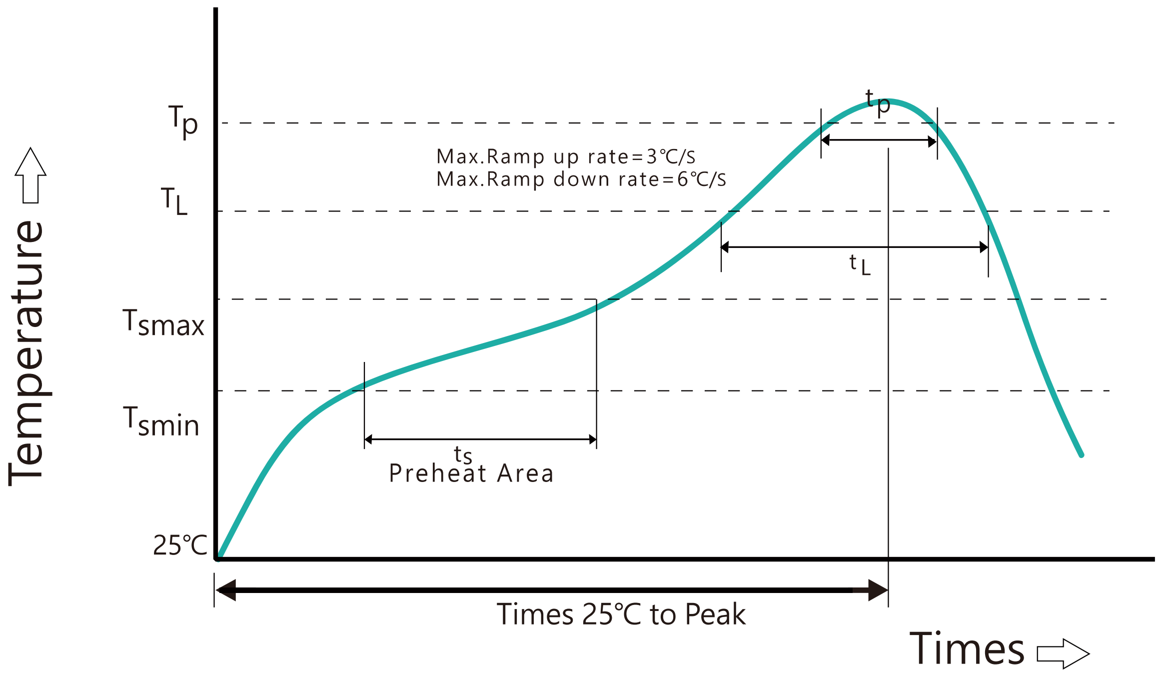
Wireless devices are often designed based on antenna performance measured on an clean evaluation board. In practice, however, many wireless devices are used in the presence of materials near the antenna which were not present during evaluation. These materials, such as batteries, components on the PCB, or even metal screws, can cause a shift in the frequency performance of the antenna, resulting in less than optimal device performance. The shift in the frequency performance can be quite dramatic, especially for monopole (1/4 wavelength) antennas.

The C042, as designed, does require matching to improve end-product antenna performance depending on the effects of the enclosure, PCB and other electronic components. Please contact Joymax for complimentary 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 inductor positions. Here is the configuration of the Joymax evaluation board as supplied.

Symbol	Size (inch)	Spec
L1	0603	10 nH
L2	0603	Not fitted
C1	0603	3.9 pF

Reflow Solder Profile

The C042 uses a typical RoHS solder reflow profile **Figure 12**. Reflow soldering is the most common method of attaching surface mount electronic components to a circuit board. The goal of the reflow process is to melt the solder and heat the conductive surfaces, without overheating or damaging any electrical components. In the conventional reflow soldering process, there are four distinct stages, or zones, having specific thermal profiles: preheat, thermal soak, reflow, and cooling. For high-volume assembly, surface mount components are generally auto-placed by machine



Phase	Profile Features	Lead-free Solder Profile
Preheat	Temperature Min. (T_S Min.) Temperature Max. (T_S Max.) Time (T_S Min. to T_S Max.)	100 ℃ 150 ℃ 60 to 120 seconds
Ramp-up	Avg. Ramp-up Rate (T_S Max. to T_P)	3 ℃ / second Max.
Reflow	Temperature (T_L) Total time above TL (t_L)	217 ℃ 30 to 100 seconds
Peak	Temperature (T_P) Time (t_P)	260 ℃ 10 to 20 seconds
Ramp-down	Rate	6 ℃ / second Max.
Time From 25℃ to Peak Temp.		8 minutes Max.

Figure 12. Recommended Reflow Solder Profile

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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05/24 RevA

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