

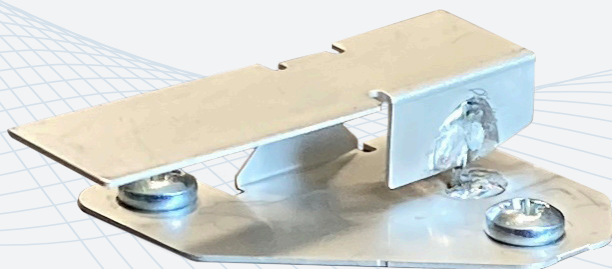


## INSTALLATION AND INTEGRATION GUIDE

# EMB-910002

Tri-Band Inverted-F Antenna  
for 2.4/5/6 GHz Wi-Fi

Embedded Wi-Fi Antennas



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# Referenced Documents

| Document                    | Description                                       |
|-----------------------------|---------------------------------------------------|
| PCTEL® EMB-910002 Datasheet | Tri-Band Inverted-F Antenna for 2.4/5/6 GHz Wi-Fi |

## 1. Overview

EMB-910002 is a low-profile, tri-band antenna assembly that covers the 2.4 GHz, 5 GHz, and 6 GHz Wi-Fi bands. Its mixed-polarized, broad radiation patterns are ideal for many applications including indoor high-density access point deployments and high-ceiling deployments common in retail and industrial settings. In general, the element is designed to support applications that require wide, hemispherical coverage. The element is terminated in a micro-coaxial cable having a U.FL-style connector and is fastened to an external metallic surface in the host product using two #3-48 machine screws.

The purpose of this document is to help end users install and properly integrate the assembly to ensure quality RF performance. The forthcoming sections describe how to mechanically secure and properly integrate the antenna assembly.

*Additional information can be found in the PCTEL EMB-910002 Datasheet.*

## 2. Host Interface

EMB-910002 is terminated in a U.FL-style plug connector following a six-inch run of micro-coaxial cable. The host interface must be a surface mount U.FL-style receptacle in order to mate with the plug connector. PCTEL recommends using surface mount receptacle U.FL-R-SMT-1 that is supplied by Hirose Electric Co., Ltd. It is a 50  $\Omega$  characteristic impedance part that can be used to transition from a coaxial transmission line to microstrip or to another planar transmission line.

### 3. Securing the Antenna

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The antenna may be fastened to an external metallic surface (ground plane) using #3-48 pan head machine screws. It is not recommended to mount the antenna to a non-metallic surface. It is important that the base of the element, particularly near the short circuit leg, contacts the ground plane, and this is accomplished easily by mounting the antenna to a flat surface. Additionally, the outer diameter of the clearance hole for the coaxial cable should be 4 [mm] so that the U.FL-style plug connector can pass through into the radio area. Figure 1 shows an exploded view of the antenna assembly and its mounting hardware.

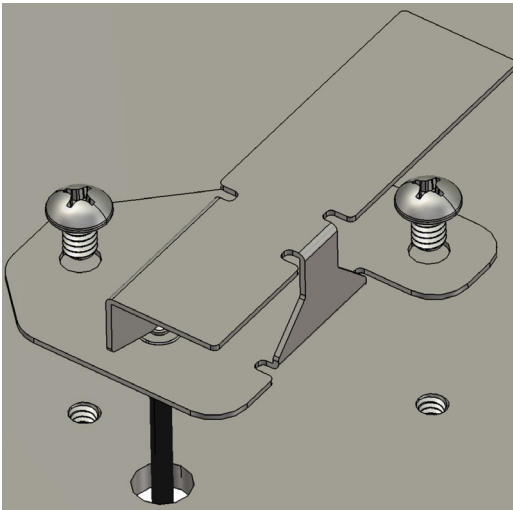


**Figure 1:** Exploded view of EMB-910002 and its associated mounting hardware.

## 4. Integration

### 4.1. Orientation

Care must be taken in the integration of embedded antennas and the first point to consider is the orientation of the antenna element within the wireless product. Proper orientation of an antenna element matches the radiation pattern of the antenna to the target coverage area of the application. The simulated three-dimensional radiation pattern of EMB-910002 at 6 GHz is given below in Figure 2.

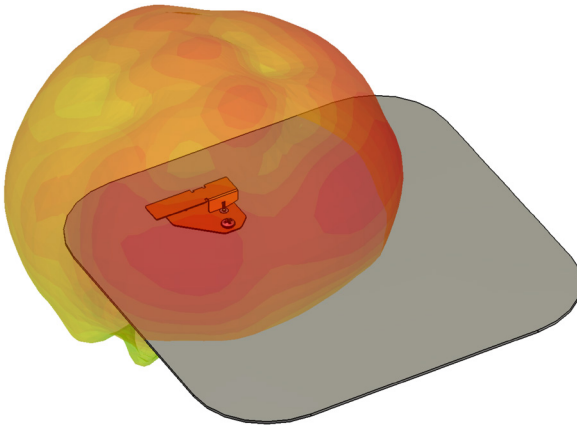


**Figure 2:** Three-dimensional radiation pattern of EMB-910002 at 6 GHz.

Observe that the antenna radiates well over a hemisphere. Hemispherical radiation patterns are suitable for applications requiring coverage over an entire half-space. For example, the pattern shown in Figure 2 would be suitable for an antenna integrated in a product that is deployed on a high ceiling (12' – 30'). The pattern would be inverted from what is depicted in Figure 2 so that the z-axis would point straight down to the floor.

## 4.2. Return Loss Dependence on Radome Separation

The simulated return loss of the antenna is given below in Figure 3 for a variety of radome separations from the top of the antenna. It is assumed that the radome is 2.5 [mm] thick and is a polycarbonate/ABS blend. The radome separation is defined as the distance in millimeters between the bottom of the radome and the top of the antenna. In practice, a radome separation between 4 – 6 [mm] gives the best impedance match. The smallest practical radome offset is limited by the maximum deflection the radome is expected to undergo, either in the field or during mechanical impact testing. Note that the height of the antenna is only 7.4 [mm], so a radome separation of 4 [mm] permits a low-profile industrial design.

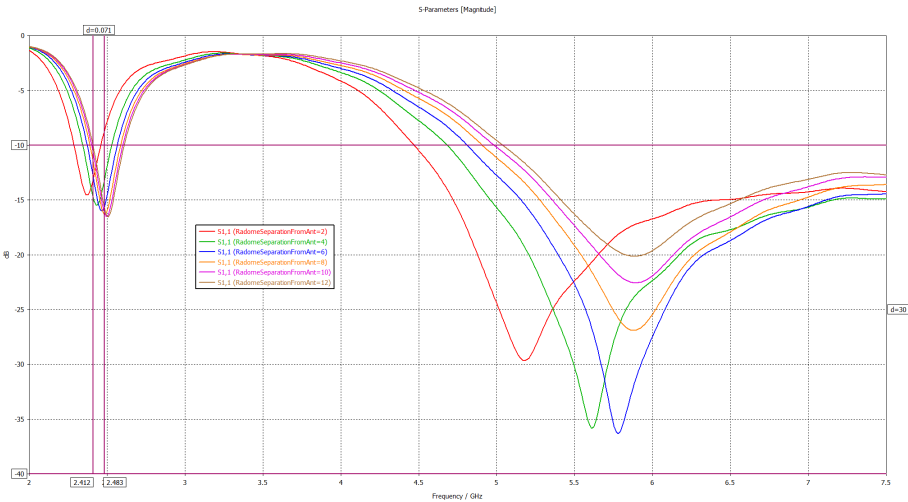


**Figure 3:** Simulated return loss versus radome separation from the top of the antenna.

## 4.3. Ground Plane Placement

The return loss and radiation patterns of EMB-910002 are quite stable regardless of where it is deployed on a ground plane. This is demonstrated below in Figures 4 and 5. We sweep the distance of the antenna from the edge of a 5" square ground plane and monitor the return loss. Observe that the return loss changes little in both bands and is very stable in the low frequency band.

It is important to note that there must be “enough” ground plane surrounding the antenna to achieve efficient operation, especially in the low frequency band. A practical rule of thumb is to place the antenna such that the average extent of the ground plane underneath the antenna over all directions is at least 40 [mm]. This will ensure good return loss and radiation patterns in most cases.

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## 4.4 Managing Obstructions

Metallic obstructions, if large enough, close enough, and oriented properly, will alter the radiation performance of any antenna. With that said, the total efficiency will not be affected by large metallic obstructions that are at least 1" from the surface of the antenna, even if the radiation patterns are changed. Consideration must be given to placing vertically-oriented structures, like screws, near embedded antennas. If long enough, screws can alter the radiation pattern of an antenna. It is good practice to ground screws and to limit the length that protrudes into the antenna area to at most  $\lambda/8$  at the highest frequency of operation. Additionally, the antenna should not be loaded from the top by metal (where the radome is typically located), and, if possible, the volume near the antenna should be kept free from obstructions so the antenna can radiate freely.

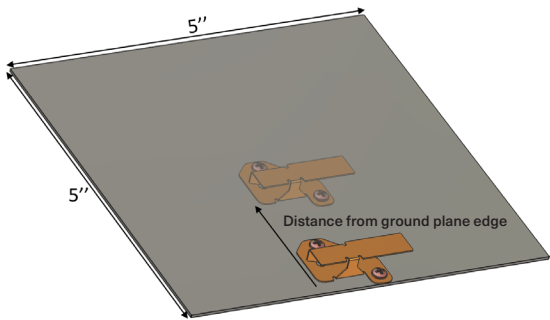


**Figure 4:** Sweeping the distance from the edge of a 5" square ground plane.

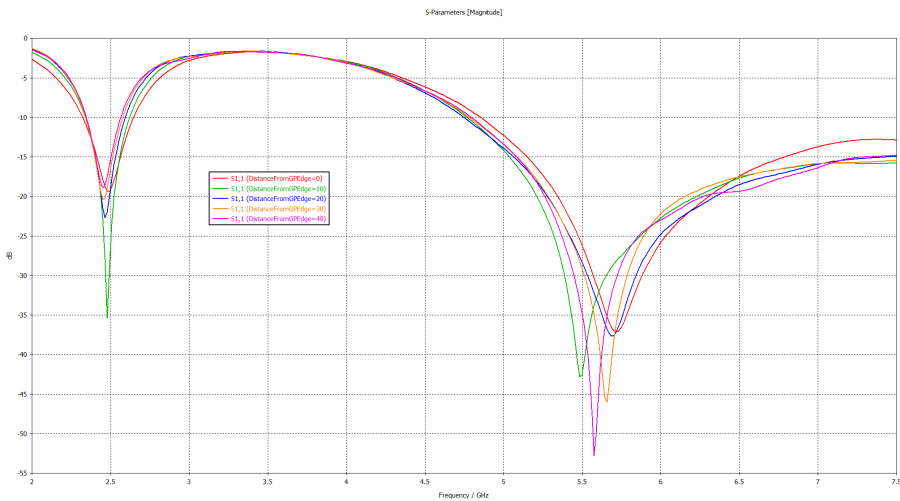


**Figure 5:** The return loss of EMB-910002 versus distance from the edge of a 5" square ground plane.

# 5. Application Example

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Let's consider an application example of a ceiling-mounted access point consisting of four EMB-910002 antennas. This is a low-cost, easy-to-deploy solution that supports 2.4 GHz, 5 GHz, and/or 6 GHz applications. A model of the antenna system is provided below in Figure 6.



**Figure 6:** Tri-band antenna system consisting of four EMB-910002 assemblies.

The placement and orientation of the antennas has been optimized for hemispherical coverage, which is suitable for high-ceiling deployments, such as those found in retail and industrial settings, and high-density deployments that require excellent SNR directly under the access point to achieve high data rates. S-parameters, plane cuts, and a three-dimensional radiation pattern of a single antenna (port #1) are provided below in Figures 7-10, respectively. Note that the antennas are symmetrically deployed on the access point, so the data is identical for all ports under a rotational transformation. Observe that the antenna system exhibits quality s-parameter and radiation performance.

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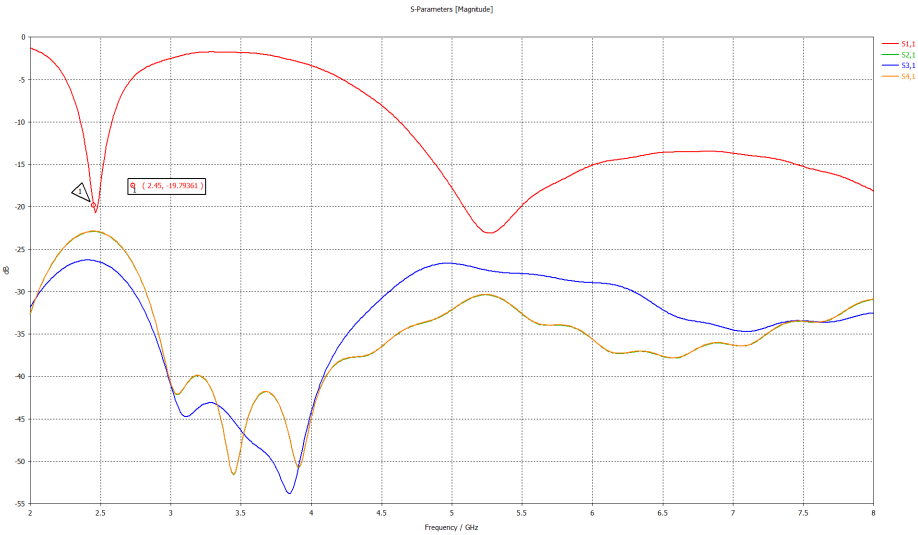


Figure 7: S-parameters of the tri-band antenna system.

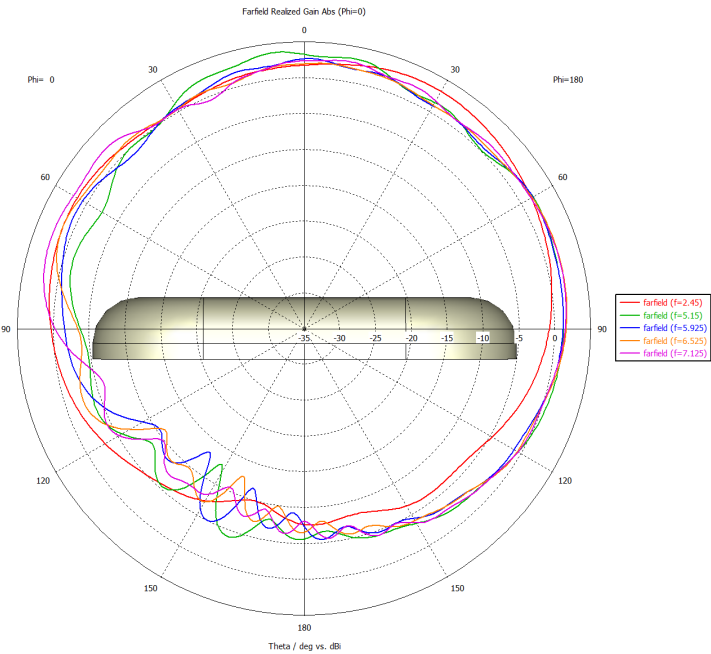


Figure 8:  $\phi = 0^\circ$  cuts of an EMB-910002 assembly over frequency.

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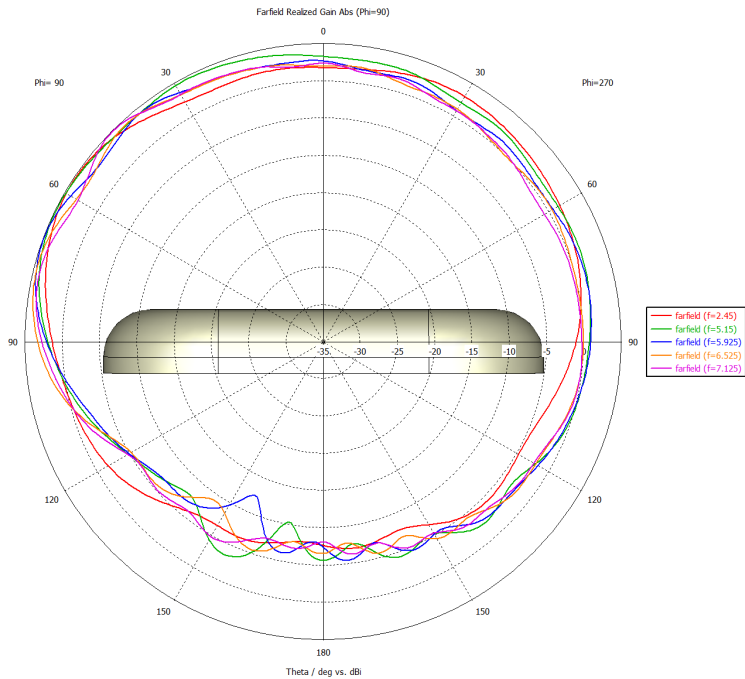


Figure 9:  $\phi = 90^\circ$  cuts of an EMB-910002 assembly over frequency.

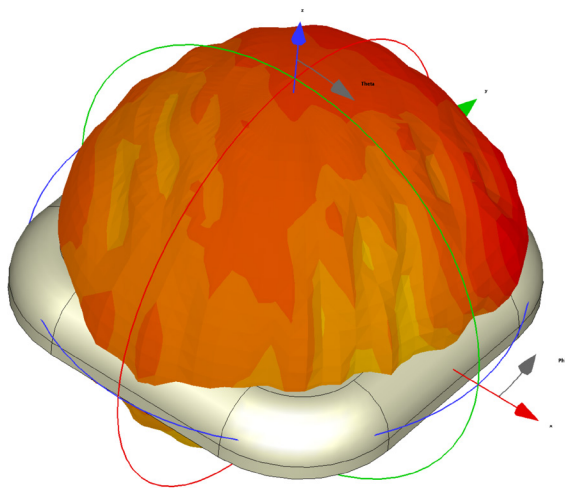


Figure 10: Three-dimensional radiation pattern of an EMB-910002 assembly at 5925 MHz.

## 6. Choosing the Right Embedded Antenna

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The choice and proper integration of an embedded antenna is a custom exercise. Many wireless products possess significant mechanical and material differences that can complicate the integration of embedded antennas. Still, it is oftentimes possible to leverage aspects of the host product to achieve efficient operation and tailored radiation performance for the application. PCTEL is happy to assist with the selection, integration, and customization of embedded antennas. Please contact your local PCTEL sales representative for more information.

# Product Usage

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## **Need help?**

For additional information on the EMB-910002, please contact your local PCTEL distributor:

**> [pctel.com/contact/distributors/](https://www.pctel.com/contact/distributors/)**



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