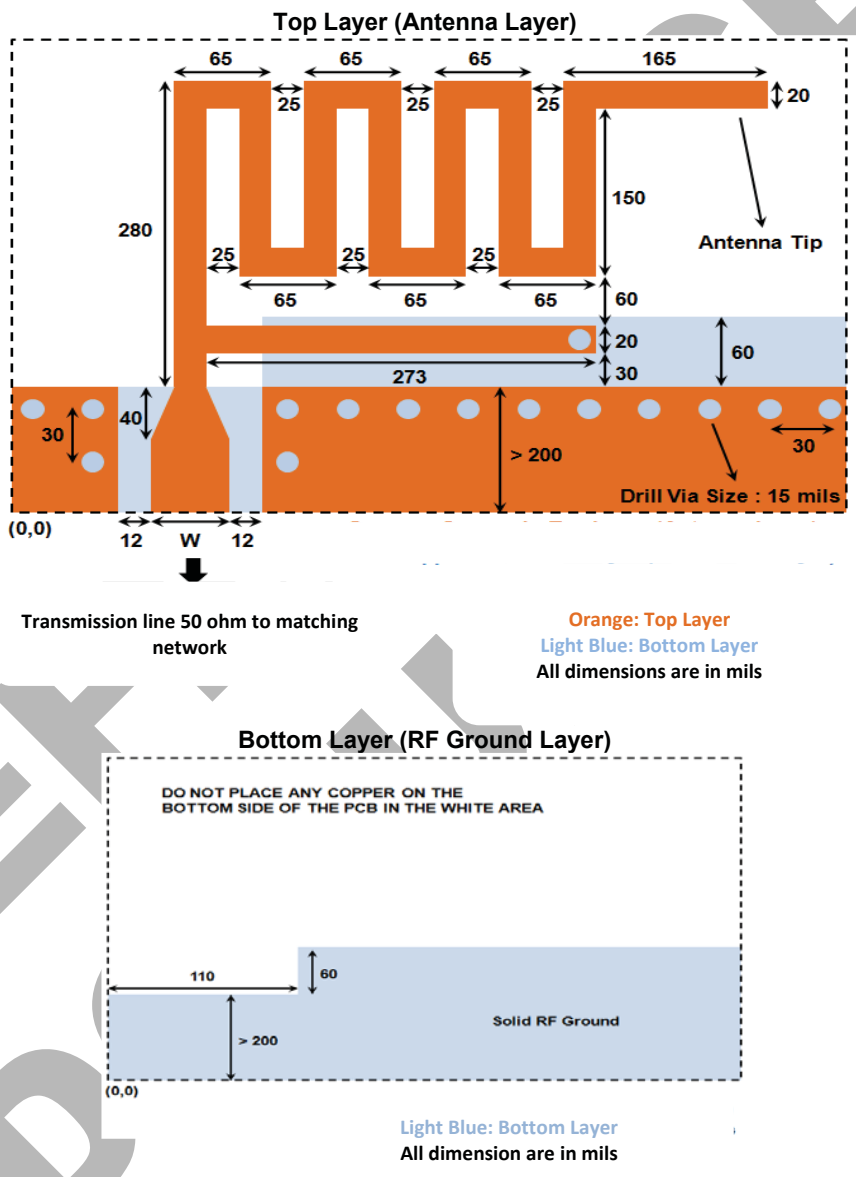
7.1 Meandered Inverted-F Antenna (MIFA)

The MIFA is a popular antenna widely used in human interface devices (HIDs) because it occupies a small PCB area. Cypress has designed a robust MIFA that offers an excellent performance with a small form factor. The antenna size is 7.2 mm × 11.1 mm (284 mils × 437 mils), making it suitable for HID applications such as a wireless mouse, keyboard, or presenter. Figure 10 shows the layout details of the recommended MIFA, both top layer and bottom layer in a two-layer PCB. The antenna trace-width is 20 mils throughout. The main parameter that would change, depending on the PCB stack spacing, is the value of "W," the RF trace (transmission line) width.

Figure 10. MIFA Layout



Note: The Gerber and *.brd* files of MIFA for a FR4 PCB with 1.6-mm thickness are provided in the *AN91445.zip* file at www.cypress.com/go/AN91445.

Note: The flipping of the Antenna pattern (along with ground and keep out area) is fine. The only impact is the rotation of the radiation pattern.

7.2 Antenna Feed Consideration

Table 2 provides the “W” value for different PCB thicknesses between the top and bottom layers for a two-layer FR4 substrate (relative dielectric constant = 4.3) for coplanar waveguide model. The top layer contains the antenna trace; the bottom layer is the immediate next layer containing the solid RF ground plane. The remaining PCB area of the bottom layer can be used as a signal ground plane (for the PRoC/ PSoC and other circuitry). Figure 11 relates the PCB thickness to “W” for a typical two-layer PCB.1

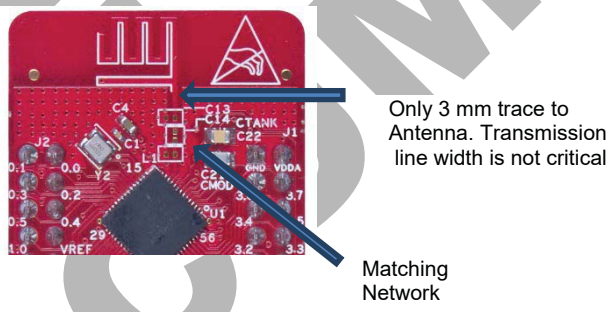
Table 2. Value of “W” for FR4 PCB: Thickness Between Antenna Layer and Adjacent RF Ground Layer

Thickness (mils)	W (mils)
60	65
50	59
40	52
30	44
20	33

Figure 11. Clarification of PCB Thickness

For the small length of PCB trace that feeds the antenna, the width requirement can be relaxed. Ensure that the antenna trace width and the antenna feed connection have the same width. Figure 12 shows one such case where the trace width feeding the antenna is not as wide as recommended in Table 2.

Figure 12. Antenna Feed Width for Short Trace



However, if it is a long transmission line approximately 1 cm from the matching network to antenna or back to the ANT pin of the PRoC/PSoC BLE device, Cypress recommends a transmission line (TLine) type of layout, having a specific width “W” over a bottom ground plane for the feed.

Note: See the coplanar wave guide calculator in Appendix B for the calculation of width for Coplanar transmission line.

Figure 13 plots S11 of the MIFA. The MIFA has a bandwidth (S11 ≤ –10 dB) of 230 MHz around 2.44 GHz.

Figure 13. S_{11} of the MIFA (Return Loss = $–S_{11}$)

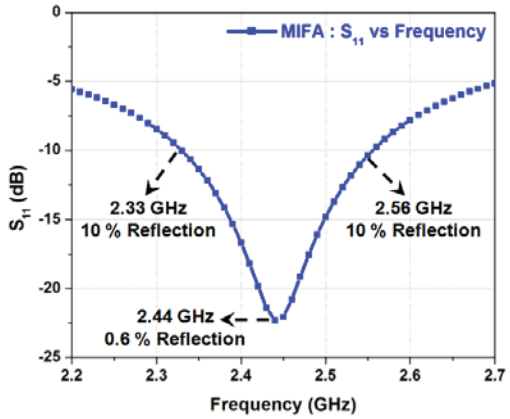
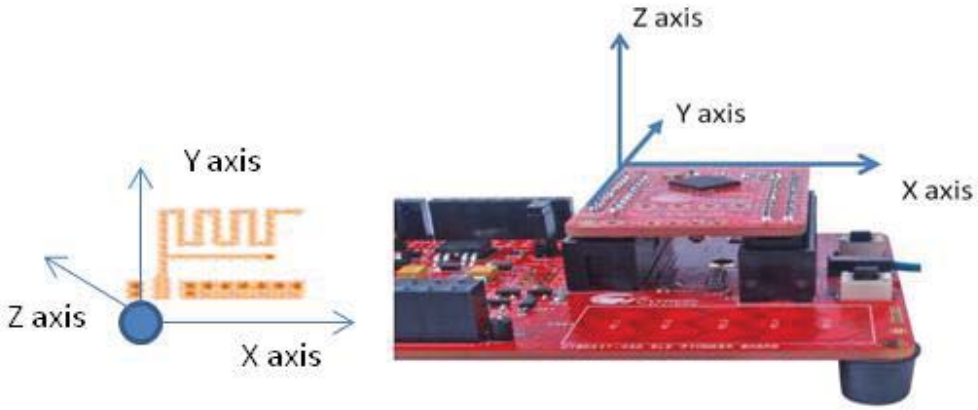
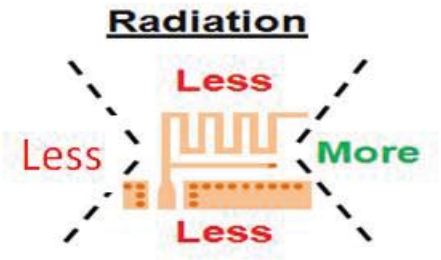
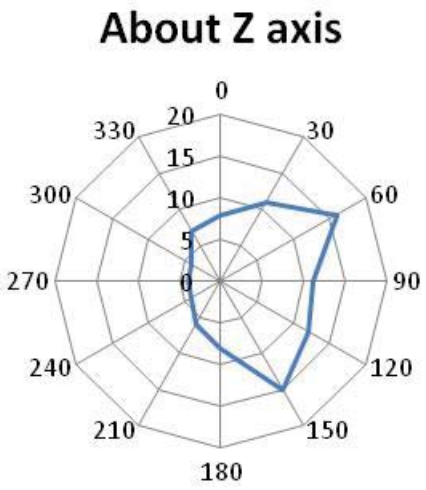


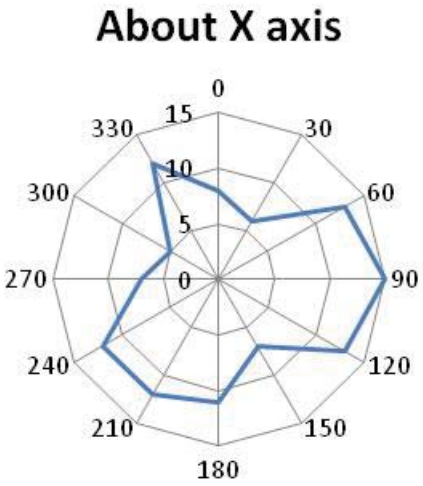
Figure 14 shows the complete 3D radiation-gain pattern of the MIFA at 2.44 GHz. This information is helpful in placing the MIFA for custom applications to maximize the radiation in the desired direction. In this diagram, the antenna is in the XY plane; the Z-axis is vertical to it.

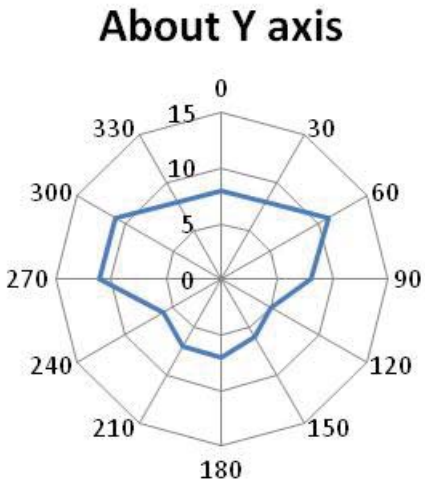
Figure 14. 3D Radiation-Gain Pattern for MIFA











The radiation pattern is tested with a 30-degree angular resolution on a Pioneer Board carrying a module with a MIFA antenna. The connecting headers are metals. In a bare board, the radiation pattern is different than what is shown; this is for illustration only to show how to position the antenna in a PCB. You are encouraged to measure similar pattern in your final product assembly to determine the best place for the antenna.

7.3 Antenna Length Considerations

Depending on the PCB thickness, the MIFA antenna should be length-adjusted to adjust the antenna radiation impedance and frequency selectivity. Cypress recommends the values listed in Table 3 for antenna lengths for various board thicknesses.

Figure 15. Length of MIFA

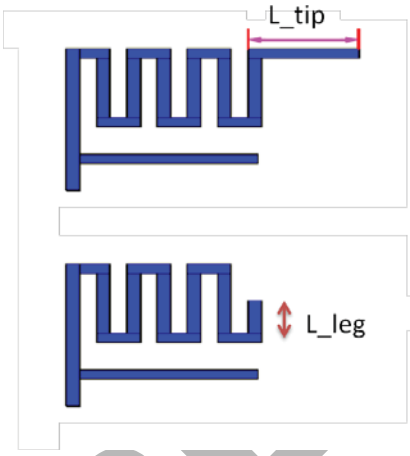


Table 3. Leg and Tip length

PCB Thickness	Antenna L_Tip / L_leg
16 mils	L_tip= 353 Mils
31 mils	L_tip= 165 Mils
47 mils	L_tip= 125 Mils
62 mils	L_leg= 115 Mils

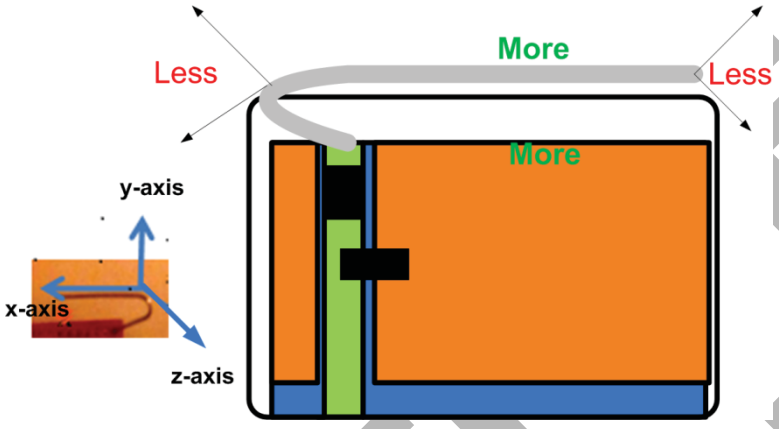
Figure 15 shows two MIFA antennas for two different board thicknesses. Antenna designers should refer to Table 3 for adjusting the length of the MIFA antennas for a specific board thickness.

Please note that the original antenna should start with the full length of antenna. Depending on board thickness the antenna needs to be length adjusted. You cannot increase length as easily in a board than cutting the length. Table 3 should be taken as a guideline to check final length of the antenna for a given board thickness than an exact figure.

The length cutting is a quick method to tune the antenna. If the customer has space to put matching network component and competency for antenna tuning, Cypress recommends putting matching network instead of length adjusting.

A wire antenna is the best in RF performance. They have the best antenna efficiency and directivity compared to other antennas. See Figure 24 for the qualitative radiation pattern out of wire antenna.

Figure 24. Qualitative Radiation Pattern Out of Wire Antenna



10 Antenna Comparison

Use Table 5 as a quick reference to select the appropriate antenna for your application.

Table 5. Comparison of MIFA, IFA, Chip, and Wire Antennas

Properties at 2.44 GHz	MIFA	IFA	Chip Antenna	Wire Antenna
Appearance				
Recommended Applications	Less Area (Mouse, Keyboard, Presenter)	Height Constrain (Heart Rate Monitor)	Small Area (Nano Dongle, BLE Module)	More Height (6 mm) (3D) (Sensor Hub)
Dimensions (mm)	7.2 × 11.1	4 × 20.5	3.2 × 1.6	6 × 30
Dimensions (mils)	284 × 437	157.5 × 807	126 × 63	250 × 1200
Gerber File	Web	Web	Refer to datasheet	
Cost (US$)	Minimal	Minimal	0.1–0.5	0.1
Bandwidth (MHz) ($S_{11} \leq -10$ dB)	230	220	200	200
Gain (dBi)	1.6	1.1	0.5	2