Application Report
SWRU120D–April 2007–Revised January 2019

2.4-GHz Inverted F Antenna

ABSTRACT

This document describes a printed-circuit board (PCB) antenna design that can be used with all 2.4-GHz transceivers and transmitters from Texas Instruments™. The maximum gain when used on the reference board is measured to be +3.3 dBi, and the overall size requirements for this antenna are 25.7 × 7.5 mm (not including ground plane).

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1 Description of the antenna Design

It is important to make an exact copy of the antenna dimensions to obtain optimum performance. The easiest approach to implement the antenna in a PCB CAD tool is to import the antenna layout from a gerber file or a DXF file. Such files are included in CC2430DB reference design [1]. The gerber file is called Inverted_F_Antenna.spl and the DXF file is called Inverted_F_Antenna.dxf. If the antenna is implemented on a PCB that is wider than the antenna, avoid placing components or having a ground plane close to the end points of the antenna. If the CAD tool being used does not support importing gerber or DXF files, see Figure 1 and Table 1.

The antenna impedance is tuned to 50 ohm on the reference board. The impedance will however be affected by different size and shape of the ground plane, objects in the antenna nearfield such as mechanical assemblies (housing, batteries, etc.), PCB thickness, PCB material and so on. It is therefore recommended to add a pi-network close to the antenna feedpoint for impedance matching.

The results presented in this document are based on an antenna implemented on a PCB with a 1-mm thickness using standard FR-4 material.

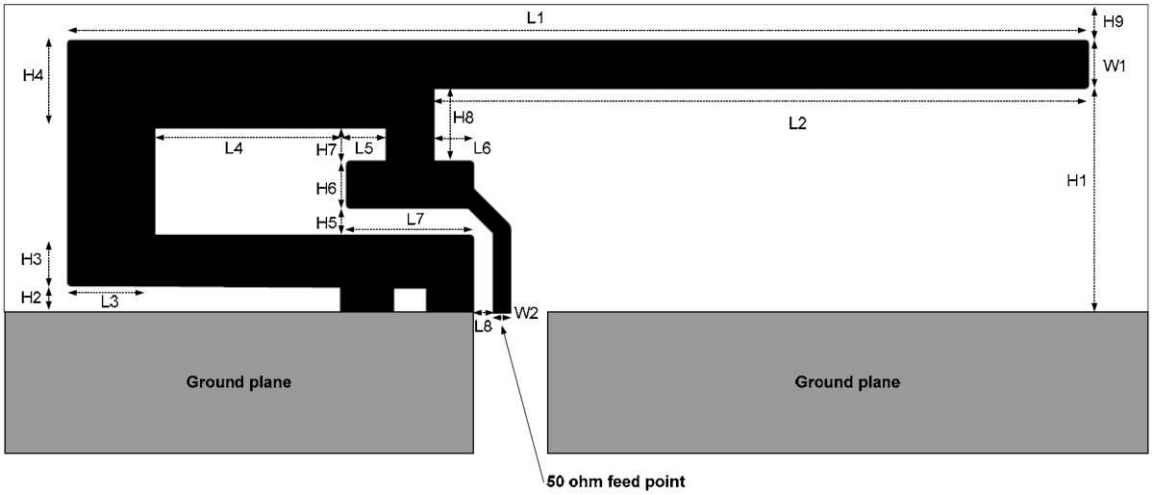

Figure 1. IFA Dimensions

Table 1. IFA Dimensions

H1	5.70 mm	W2	0.46 mm
H2	0.74 mm	L1	25.58 mm
H3	1.29 mm	L2	16.40 mm
H4	2.21 mm	L3	2.18 mm
H5	0.66 mm	L4	4.80 mm
H6	1.21 mm	L5	1.00 mm
H7	0.80 mm	L6	1.00 mm
H8	1.80 mm	L7	3.20 mm
H9	0.61 mm	L8	0.45 mm
W1	1.21 mm		

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2 Measurement Results

All of the results presented in this section are based on measurements performed with the CC2430DB [1] evaluation board.

2.1 Radiation Pattern

Figure 2 shows how to relate all of the radiation patterns to the orientation of the antenna. The radiation patterns were measured with the CC2430 device programmed to 0-dBm output power.

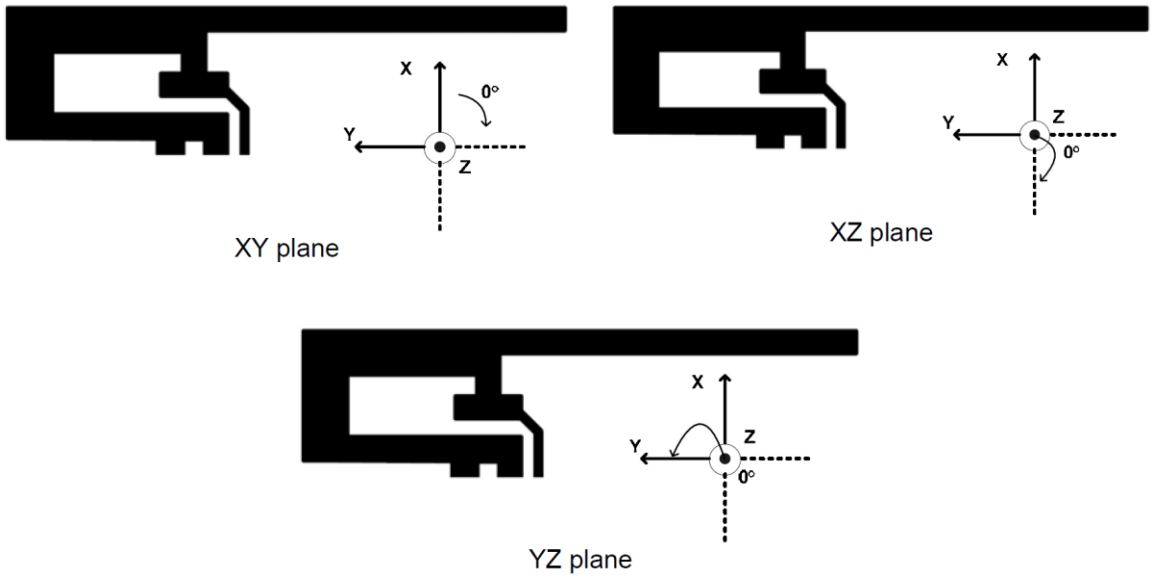

Figure 2. Relating Antenna to Radiation Patterns

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Figure 3 shows the XY plane vertical polarization.

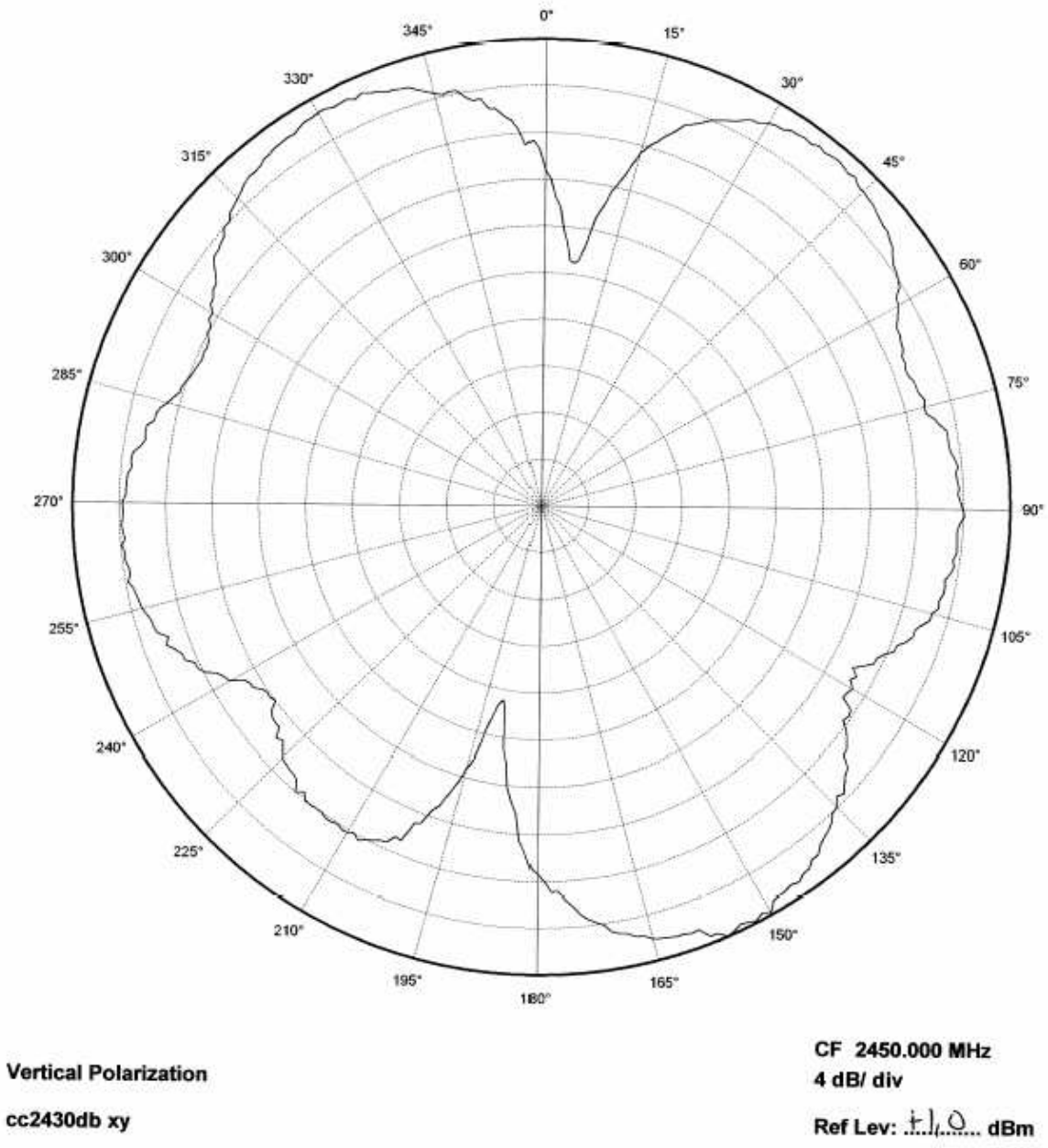

Figure 3. XY Plane–Vertical Polarization

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Figure 4 shows the XY plane horizontal polarization.

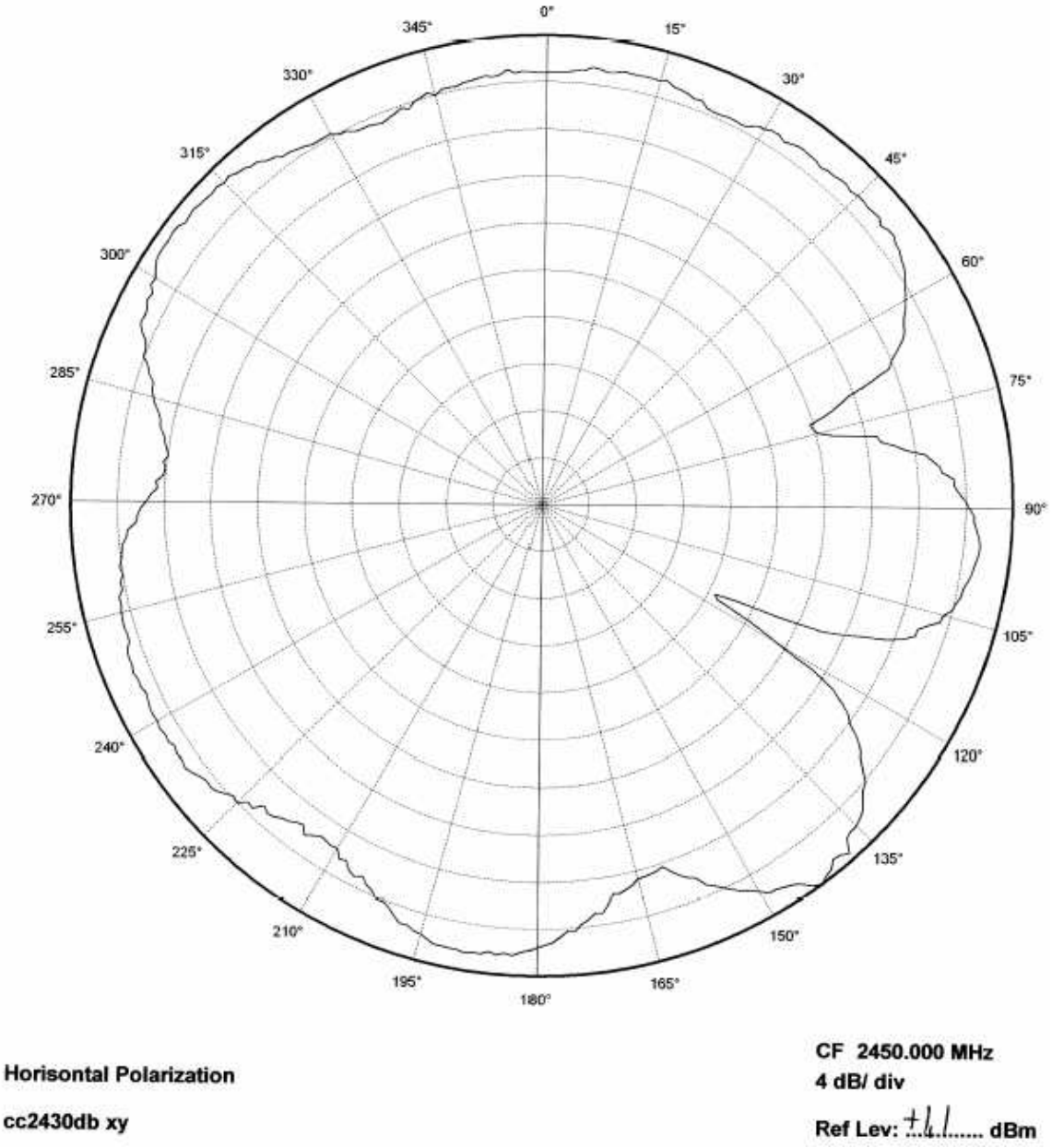

Figure 4. XY Plane–Horizontal Polarization

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Figure 5 shows the XZ plane vertical polarization.

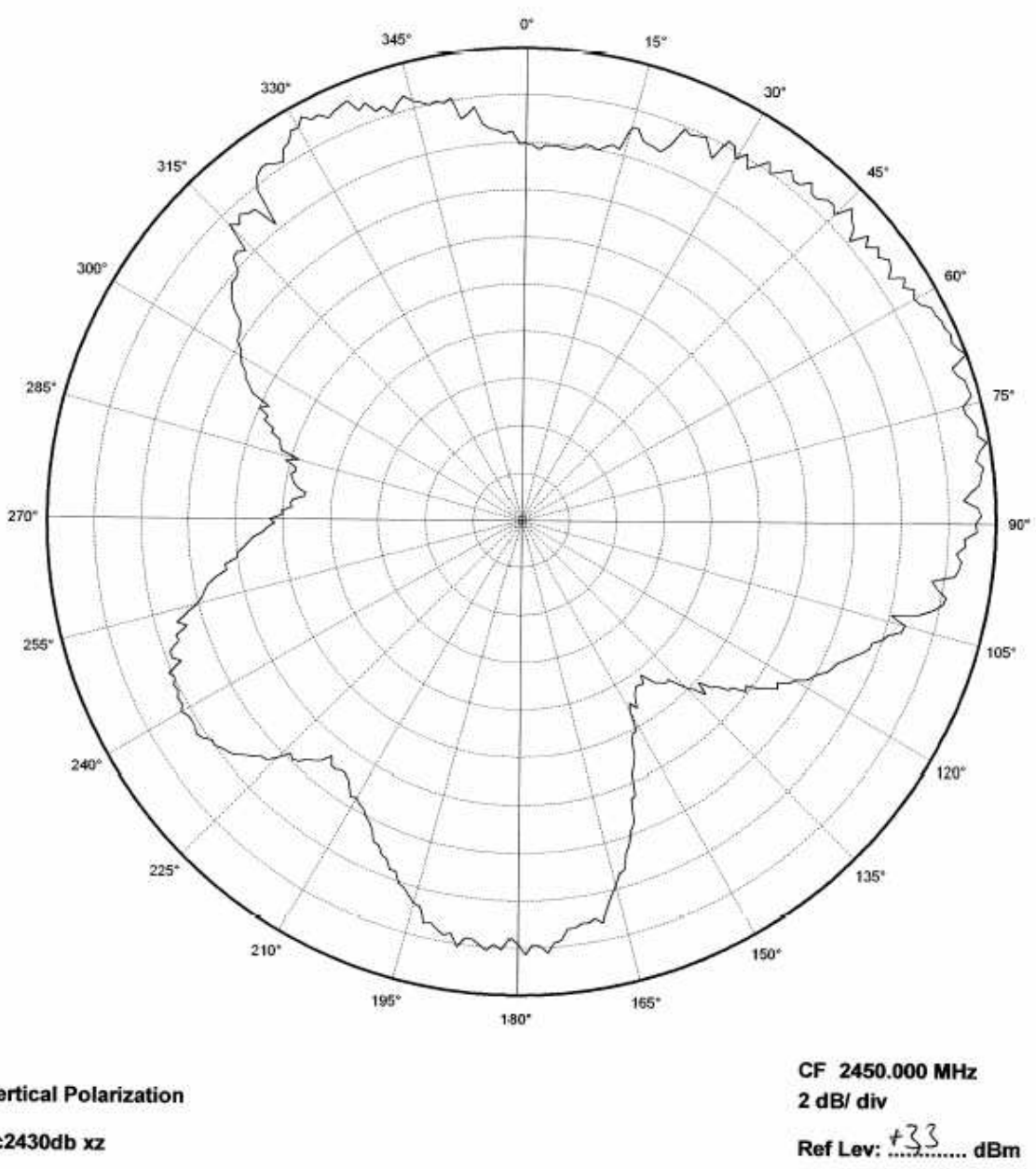

Figure 5. XZ Plane–Vertical Polarization

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Figure 6 shows the XZ plane horizontal polarization.

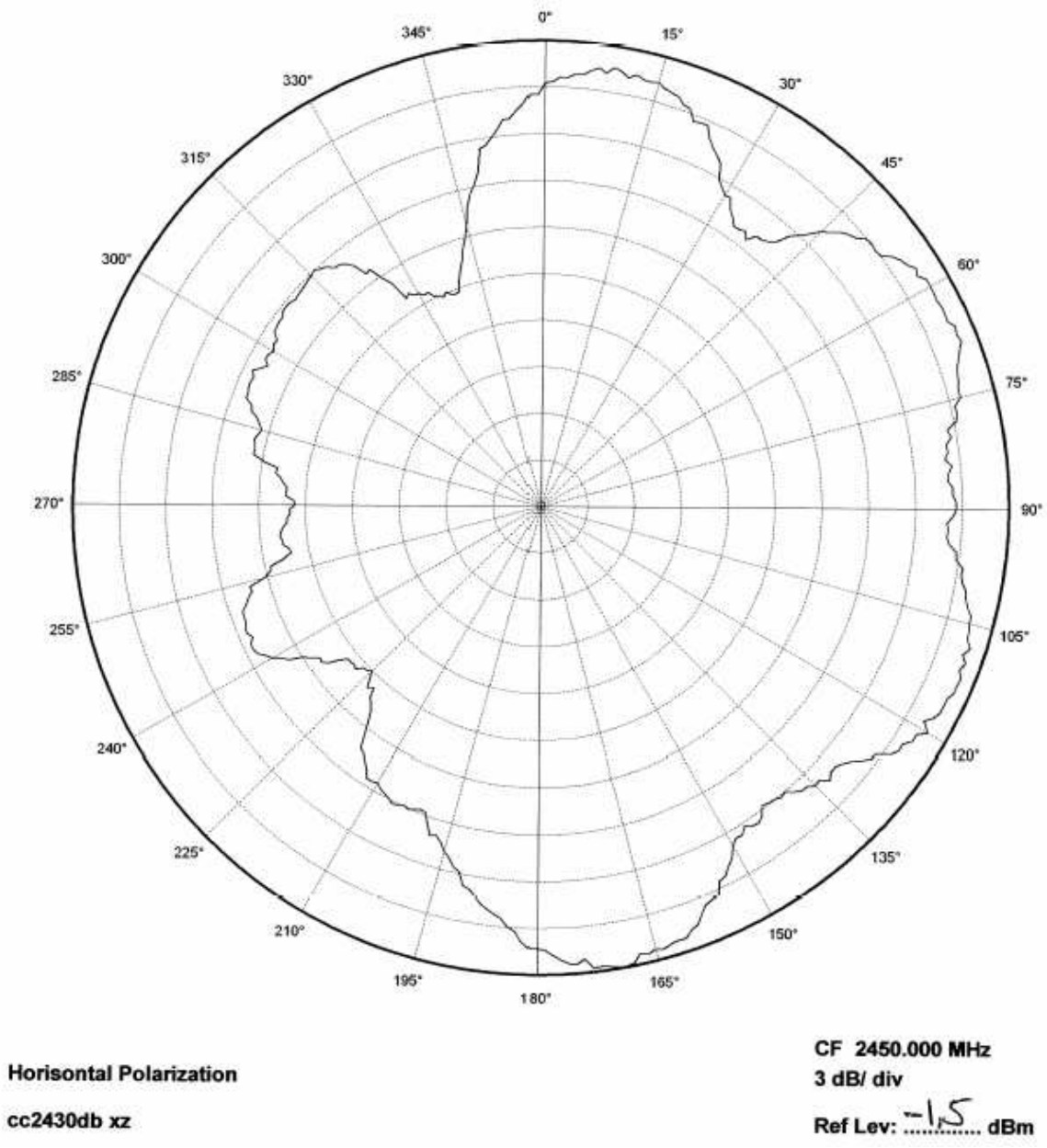

Figure 6. XZ Plane–Horizontal Polarization

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Figure 7 shows the YZ plane vertical polarization.

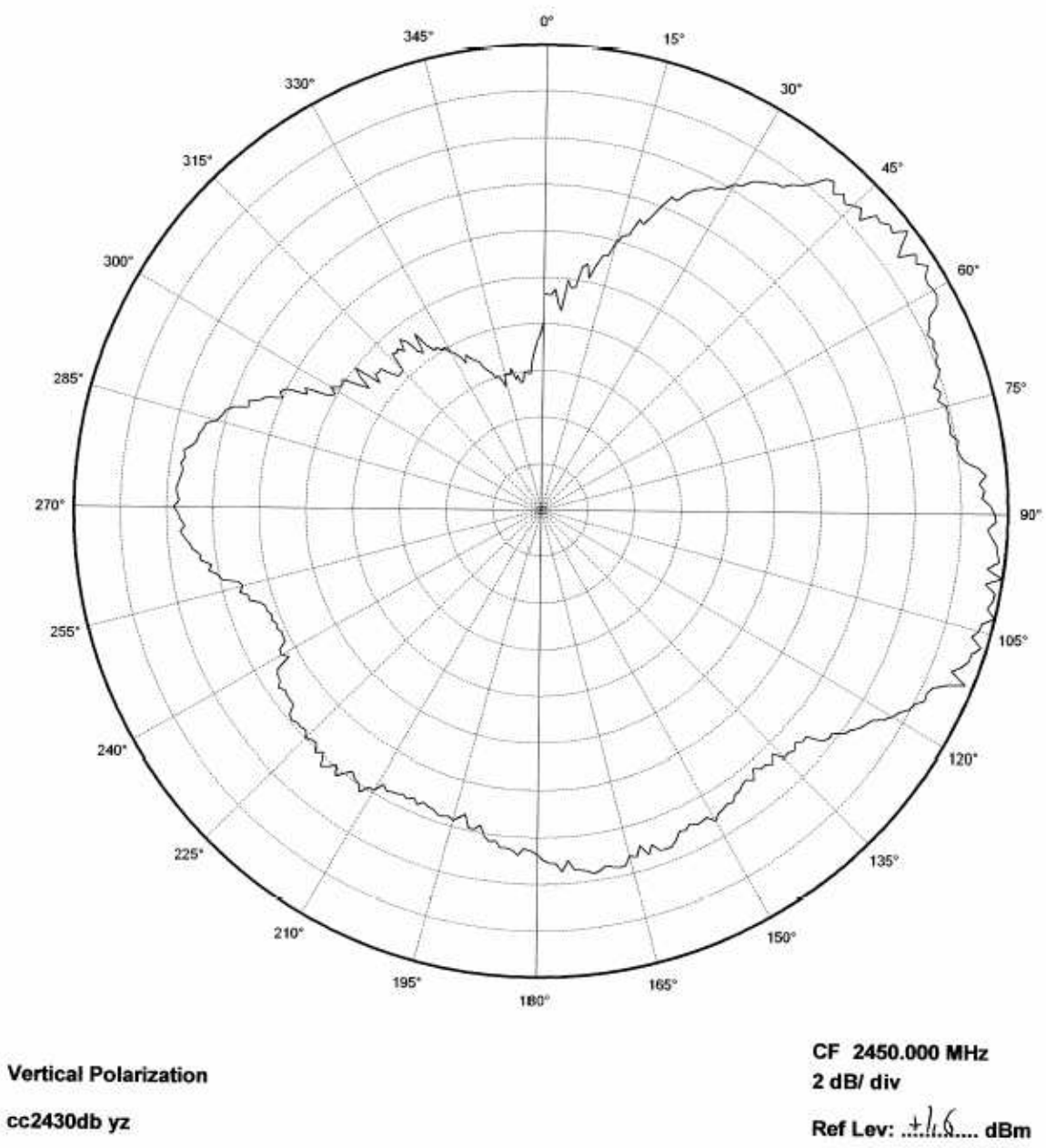

Figure 7. YZ Plane–Vertical Polarization

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Figure 8 shows the YZ plane horizontal polarization.

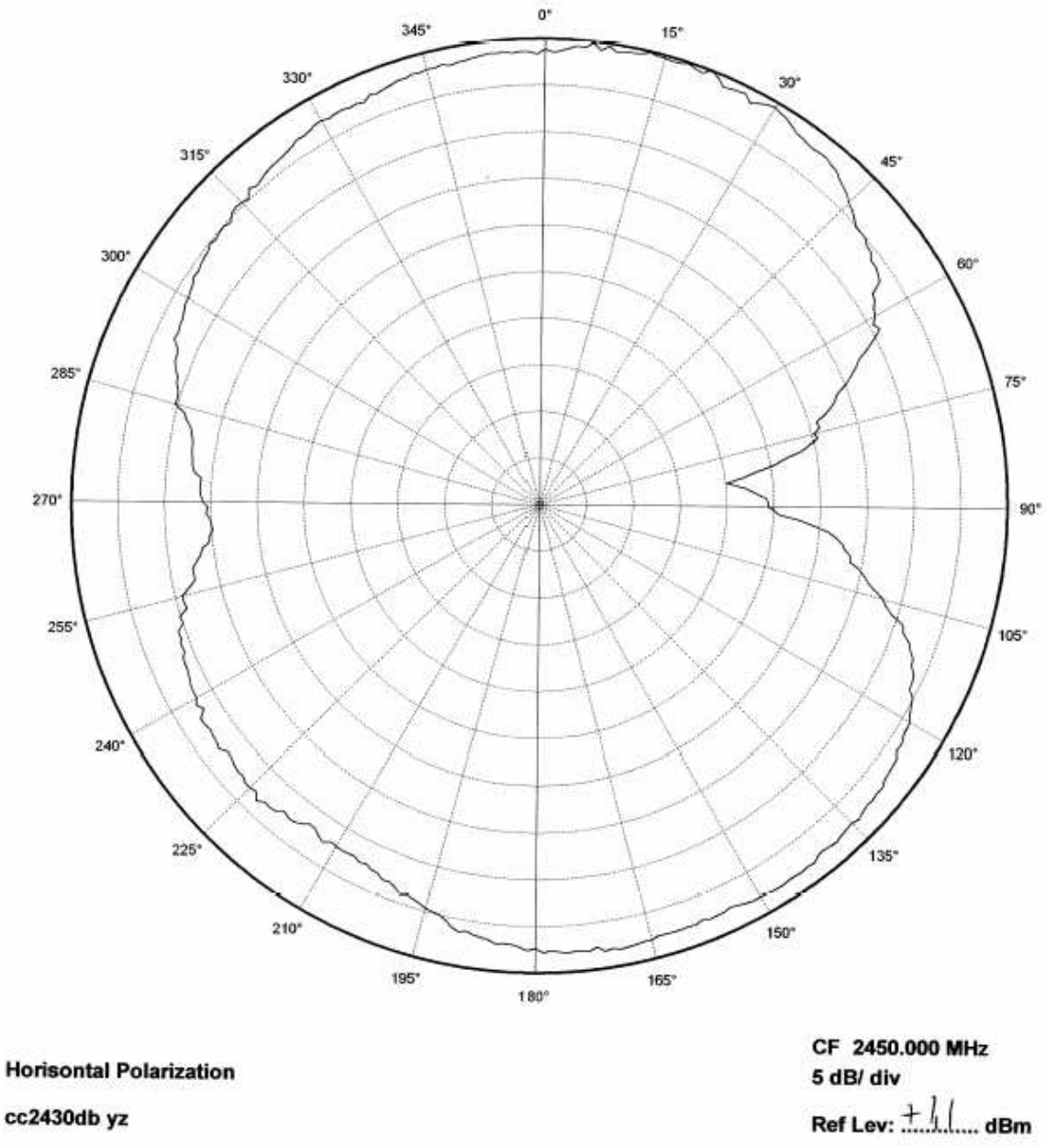

Figure 8. YZ Plane–Horizontal Polarization

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2.2 Reflection

Figure 9 shows that the IFA ensures less than 10% reflection of the available power for a bandwidth of more than 300 MHz. A large bandwidth makes the antenna less sensitive to detuning because of plastic encapsulation or other objects in the vicinity of the antenna.

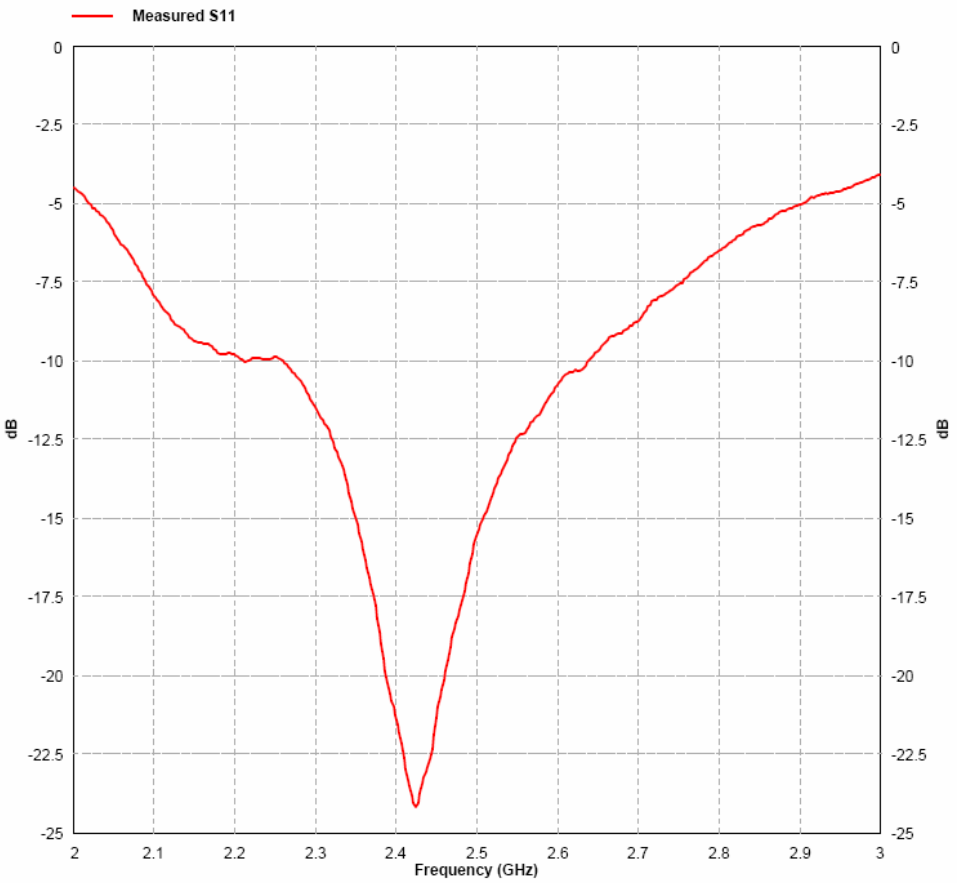

Figure 9. Measured Reflection at Feed Point of Antenna

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2.3 Bandwidth

Another way of measuring the bandwidth after the antenna is implemented on a PCB and connected to a transmitter is to write test software that steps a carrier across the frequency band of interest. By using the maximum hold function on a spectrum analyzer, the variation in output power across frequency can easily be measured.

Figure 10 shows how the output power varies on the IFA when the PCB is horizontally oriented and the receiving antenna has horizontal polarization. This measurement was not performed in an anechoic chamber, thus the graph shows only the relative variation for the given frequency band.

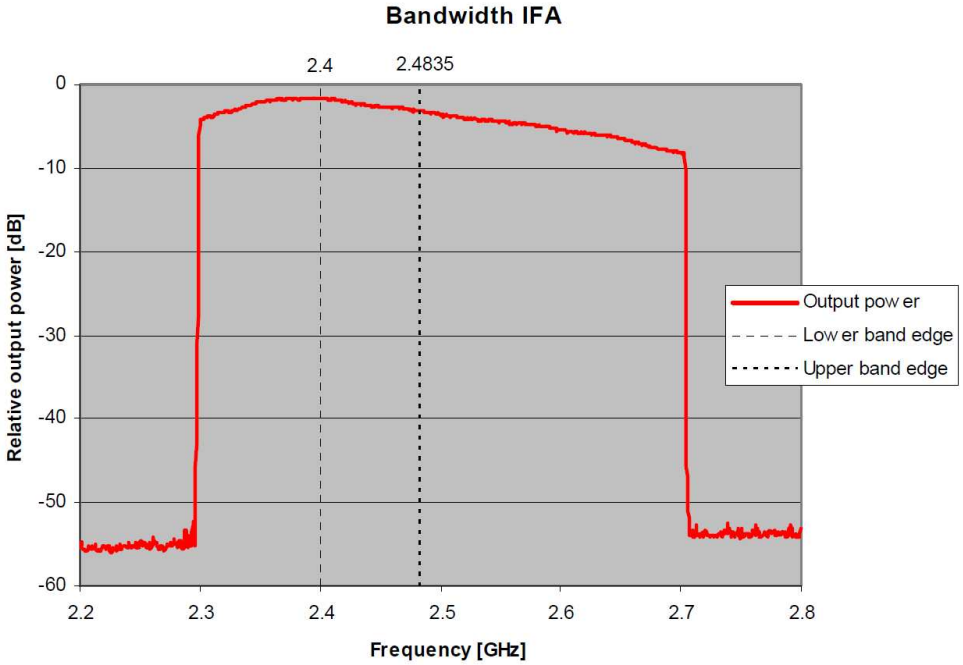

Figure 10. Bandwidth of IFA

3 Conclusion

The PCB antenna presented in this document performs well for all frequencies in the 2.4-GHz ISM band. Except for two narrow dips, the antenna has an omni directional radiation pattern in the plane of the PCB. These properties will ensure stable performance regardless of operating frequency and positioning of the antenna. Table 2 lists the most important properties for the IFA.

Table 2. Summary of IFA Properties

Gain in XY plane	1.1 dBi
Gain in XZ plane	3.3 dBi
Gain in YZ plane	1.6 dBi
Reflection	< –15 dB
Antenna size	25.7 × 7.5 mm

4 References

1. *CC2430DB Reference Design*

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Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from C Revision (February 2017) to D Revision	Page
• Update was made in the Abstract of this document.	1
• Update was made to Section 1.	2

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