

Application Report

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).

Table of Contents

1 Description of the antenna Design.....2

2 Measurement Results.....3

    2.1 Radiation Pattern.....3

    2.2 Reflection.....10

    2.3 Bandwidth.....11

3 Summary.....11

4 References.....11

5 Revision History.....12

Trademarks

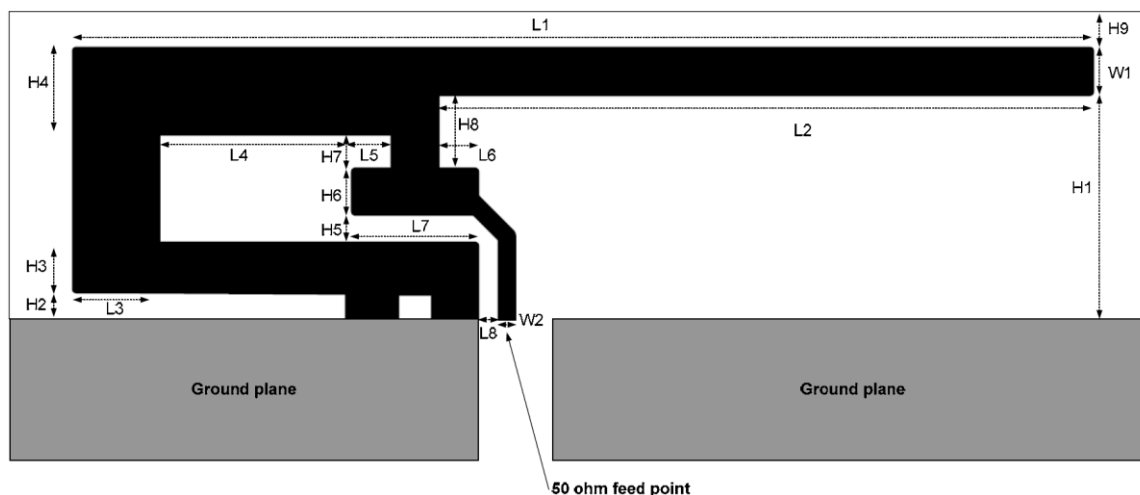
Texas Instruments™ is a trademark of Texas Instruments.  
All trademarks are the property of their respective owners.

## 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 1-1](#) and [Table 1-1](#).

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 1-1. IFA Dimensions**

**Table 1-1. IFA Dimensions**

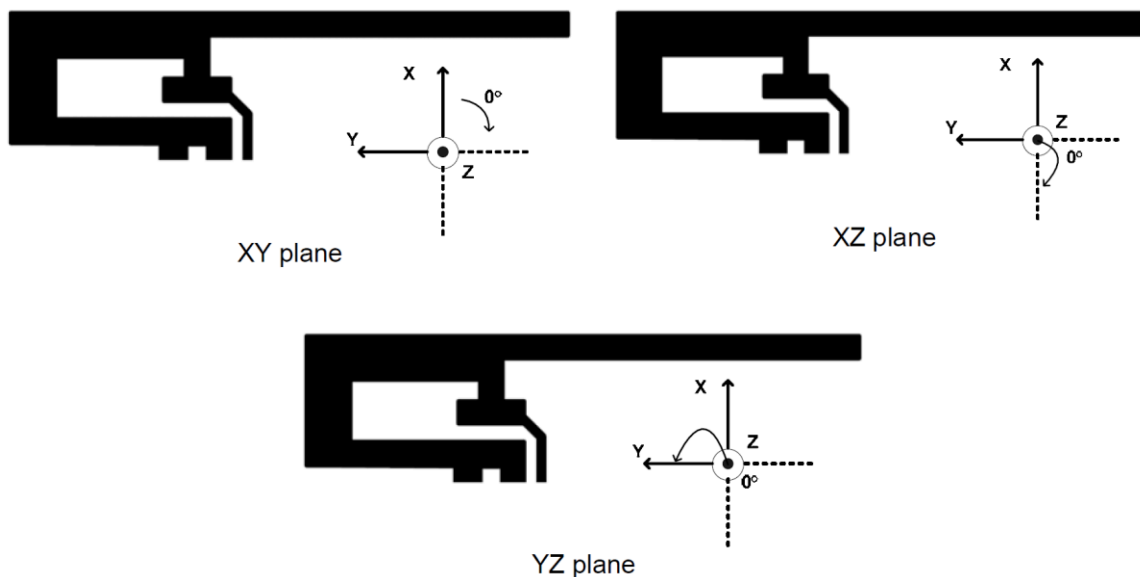
H1	5.70 mm	W2	0.46 mm
H2	0.74 mm	L1	25.58 mm
H3	1.29 mm	L2	16.40 mm
H4	2.21 mm	L3	2.18 mm
H5	0.66 mm	L4	4.80 mm
H6	1.21 mm	L5	1.00 mm
H7	0.80 mm	L6	1.00 mm
H8	1.80 mm	L7	3.20 mm
H9	0.61 mm	L8	0.45 mm
W1	1.21 mm		

## 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 2-1 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 2-1. Relating Antenna to Radiation Patterns**

Figure 2-2 shows the XY plane vertical polarization.

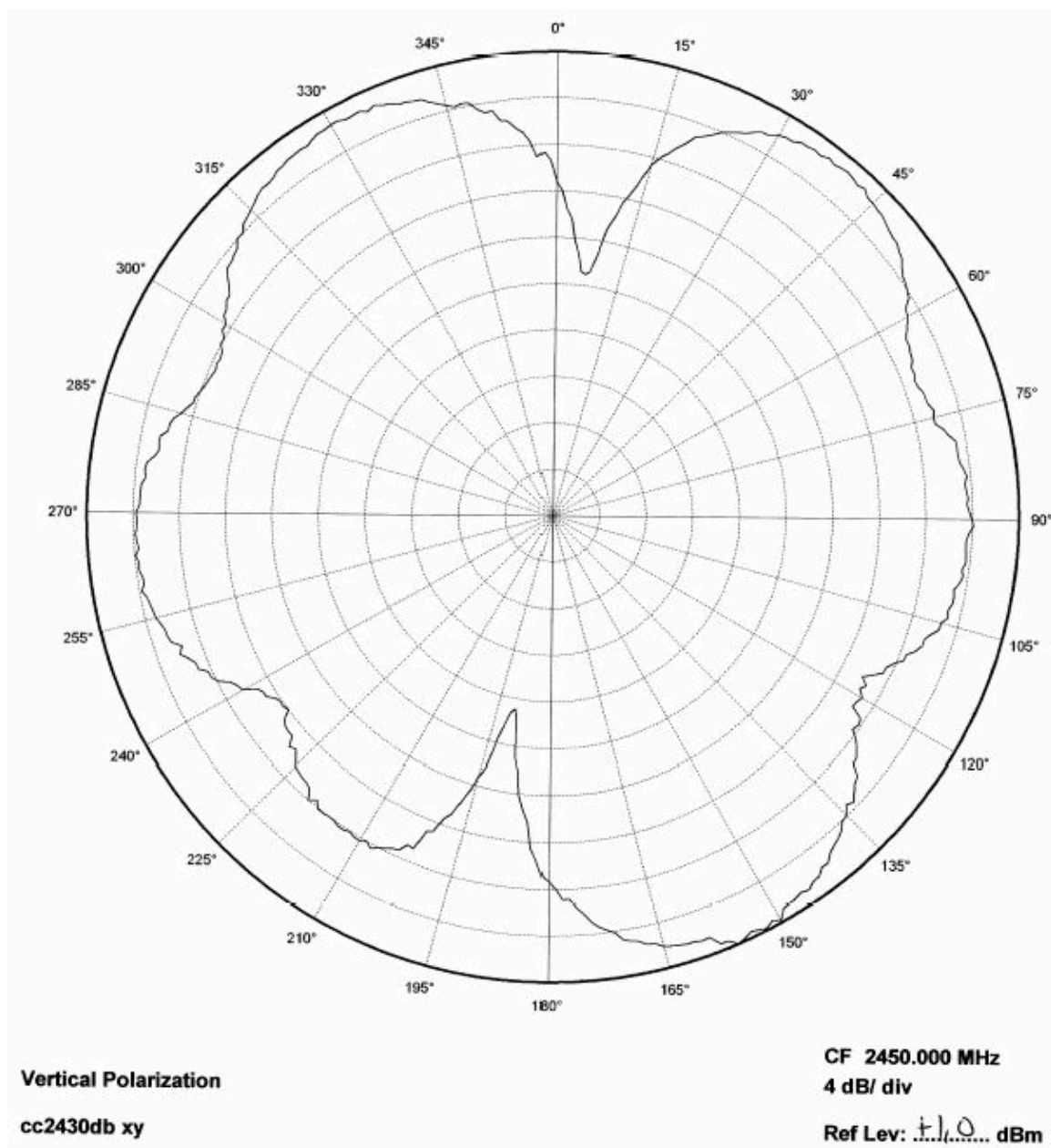


Figure 2-2. XY Plane–Vertical Polarization

Figure 2-3 shows the XY plane horizontal polarization.

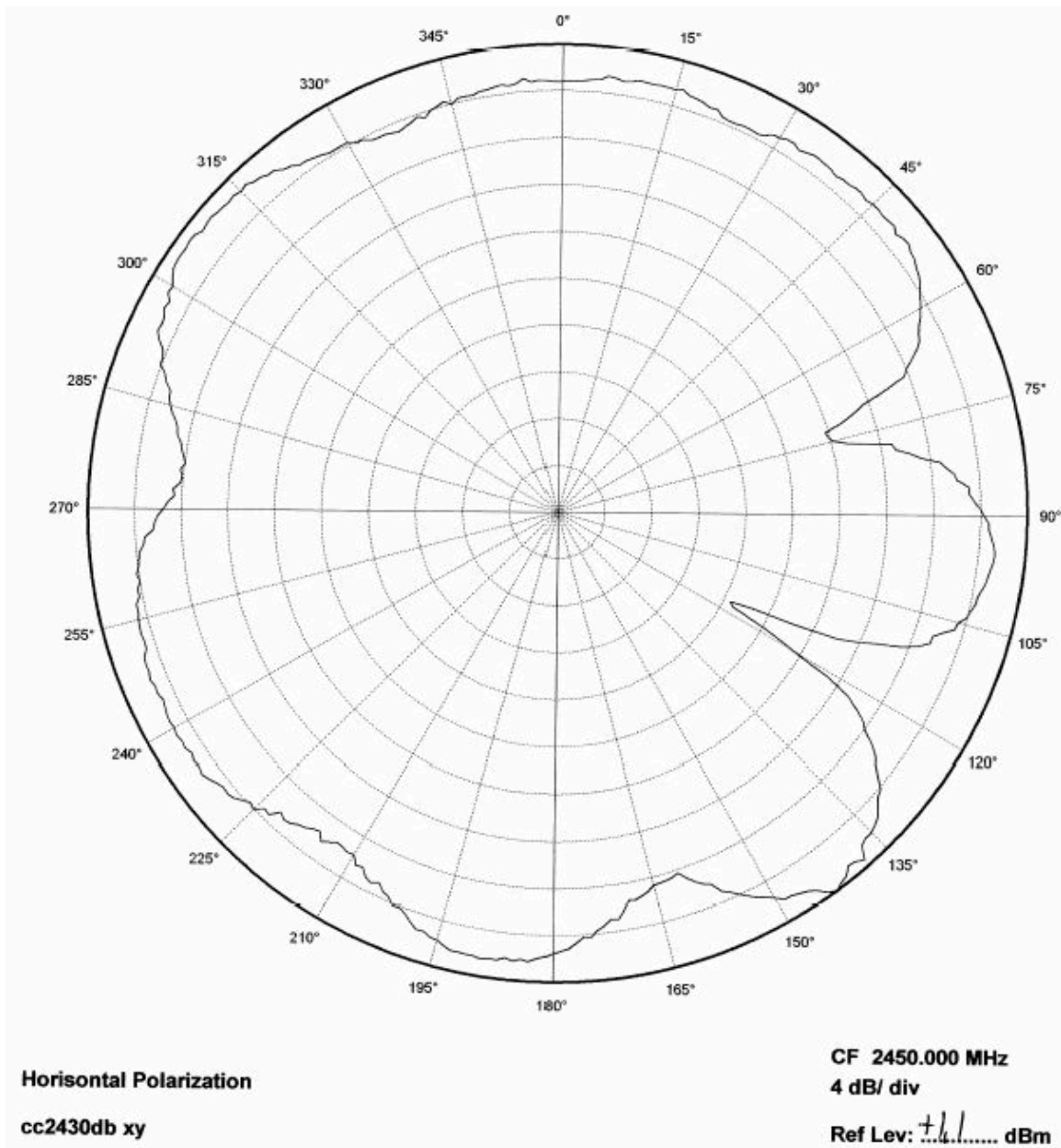


Figure 2-3. XY Plane–Horizontal Polarization

Figure 2-4 shows the XZ plane vertical polarization.

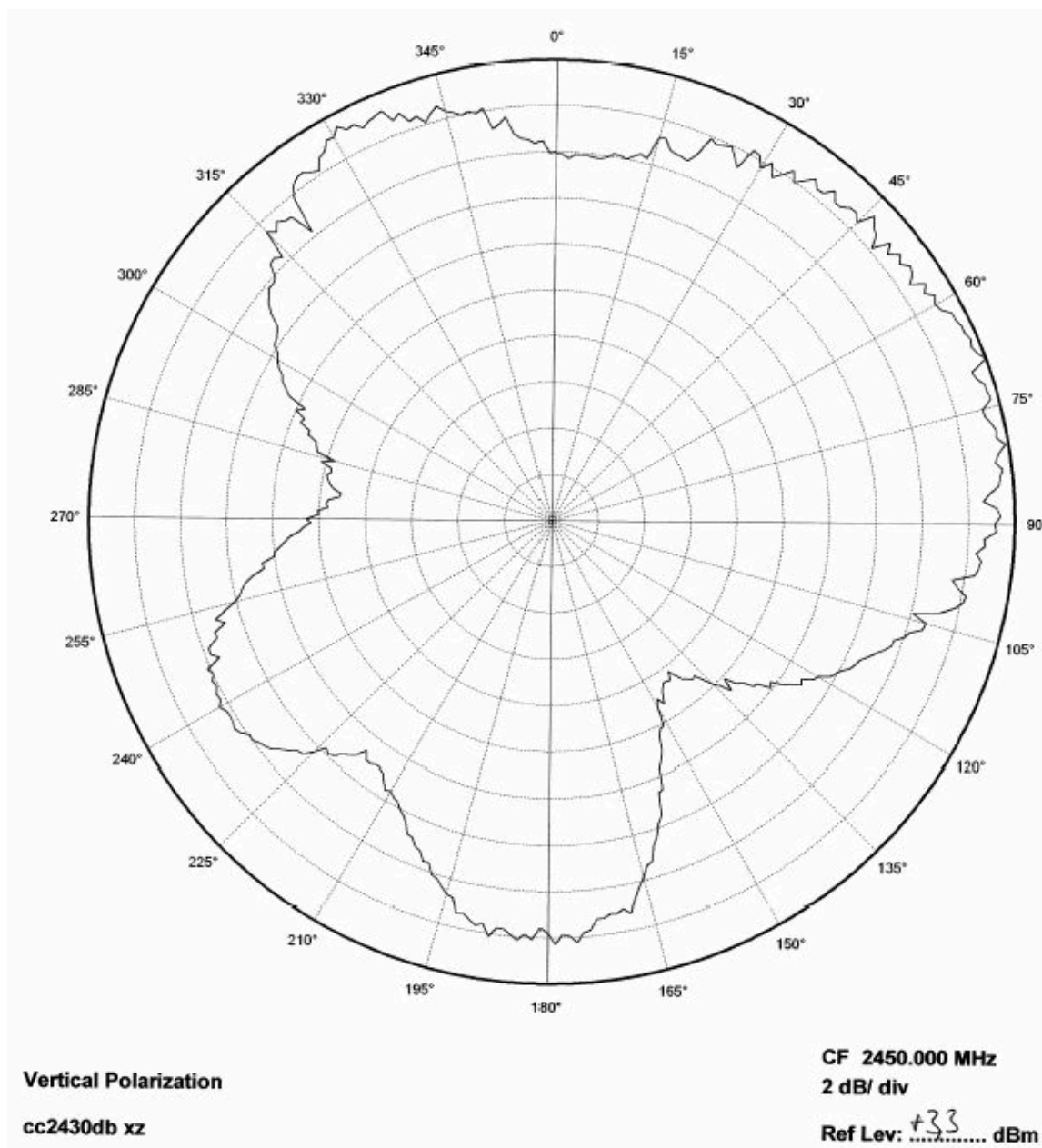


Figure 2-4. XZ Plane–Vertical Polarization

Figure 2-5 shows the XZ plane horizontal polarization.

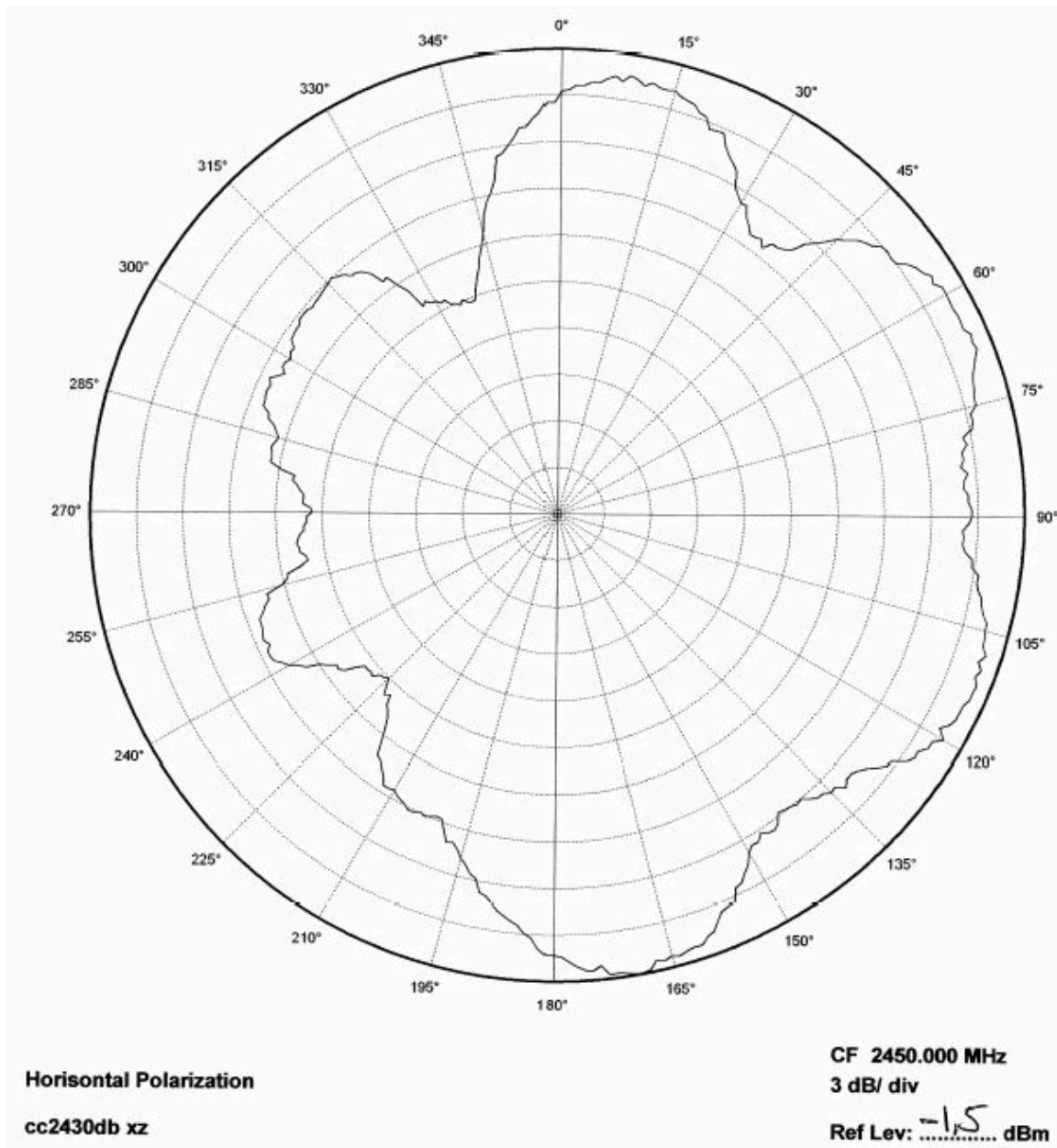


Figure 2-5. XZ Plane–Horizontal Polarization



Figure 2-6 shows the YZ plane vertical polarization.

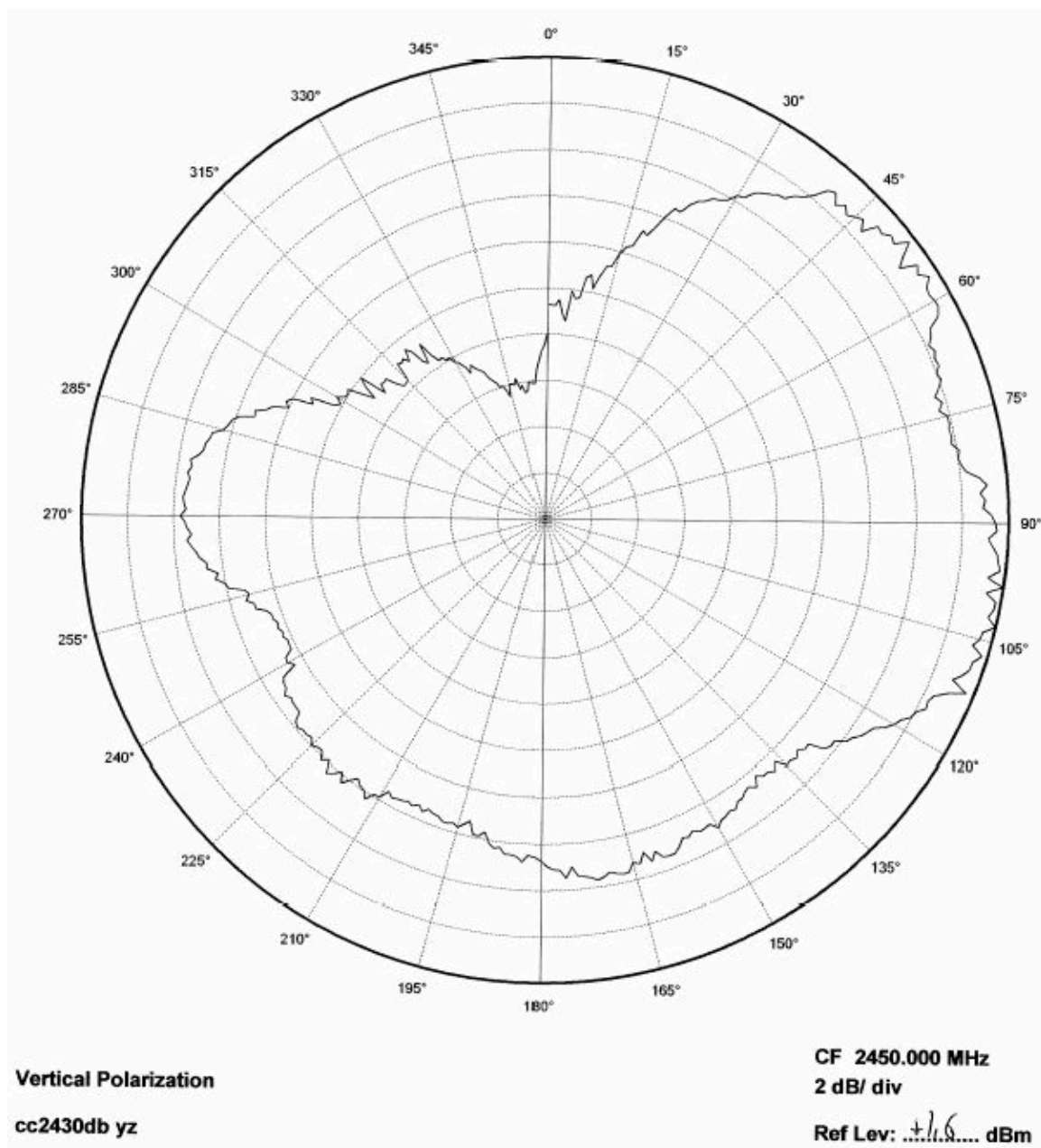


Figure 2-6. YZ Plane–Vertical Polarization



Figure 2-7 shows the YZ plane horizontal polarization.

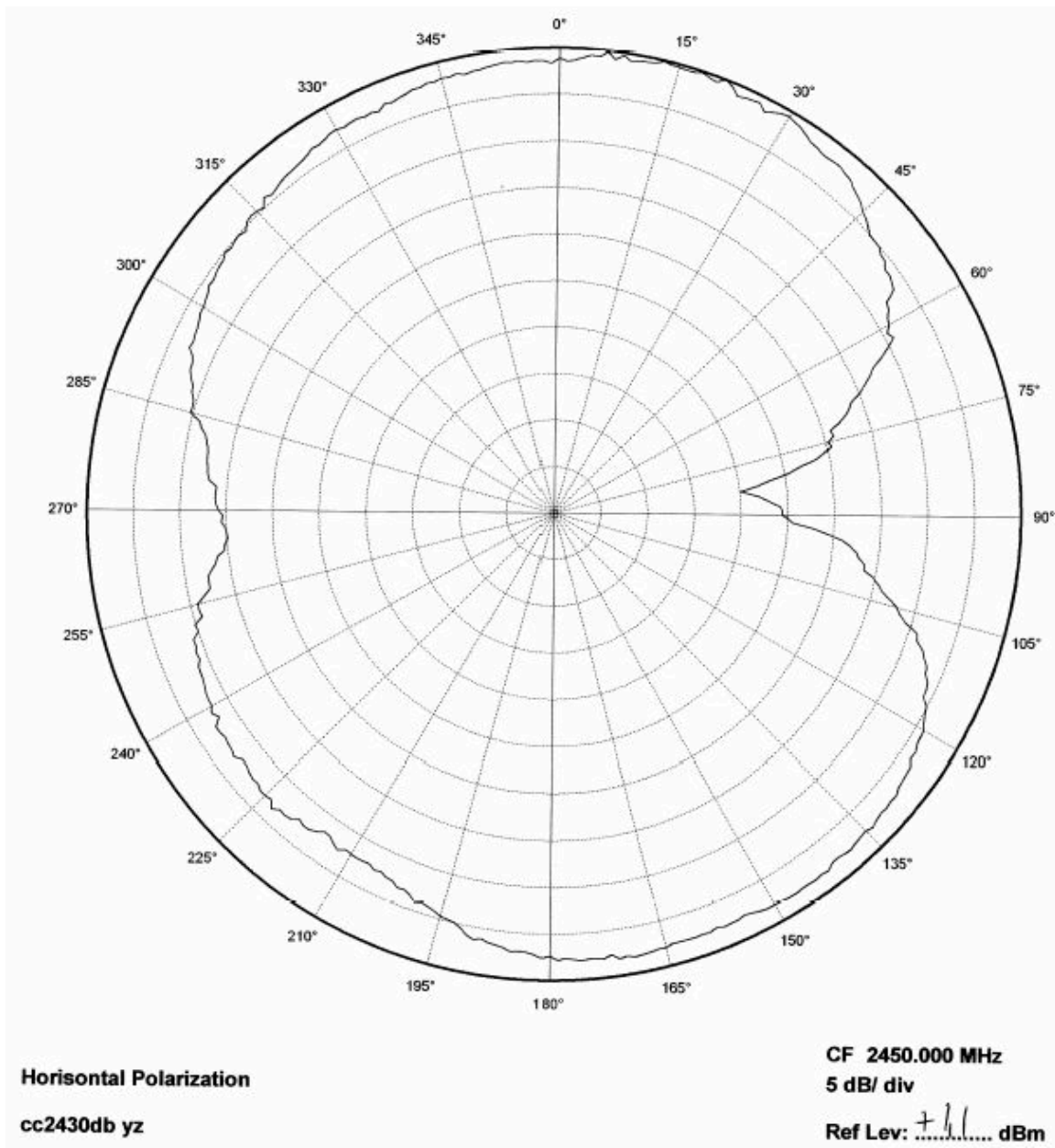


Figure 2-7. YZ Plane–Horizontal Polarization

## 2.2 Reflection

Figure 2-8 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.

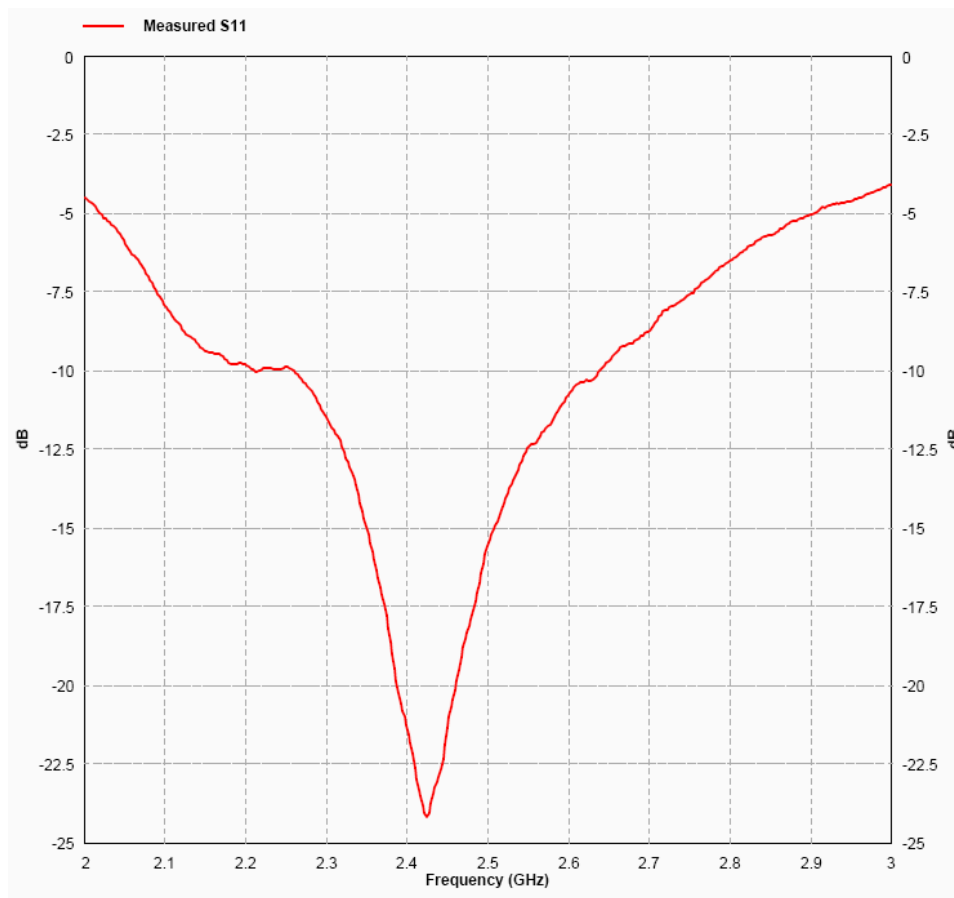
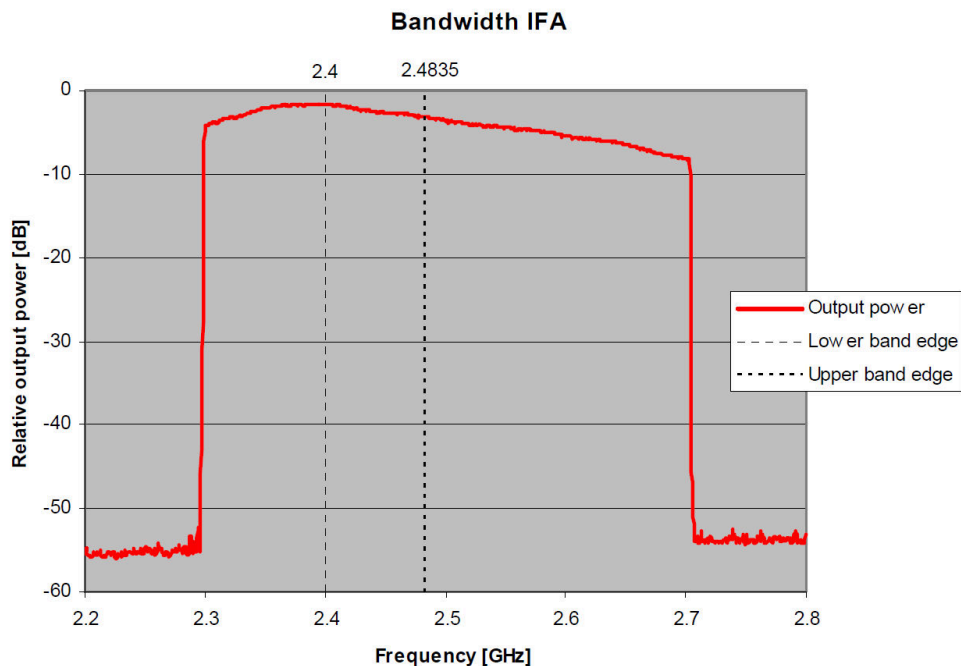


Figure 2-8. Measured Reflection at Feed Point of Antenna

## 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 2-9 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 2-9. Bandwidth of IFA**

## 3 Summary

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 3-1 lists the most important properties for the IFA.

**Table 3-1. 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](#)

## 5 Revision History

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

<b>Changes from Revision C (February 2017) to Revision D (January 2019)</b>	<b>Page</b>
• Update was made in the Abstract of this document.....	<a href="#">1</a>
• Update was made to <a href="#">Section 1</a> .....	<a href="#">2</a>

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2022, Texas Instruments Incorporated