

2.4-GHz Inverted F Antenna

ABSTRACT

This document describes a printed-circuit board (PCB) design that can be used with all 2.4-GHz transceivers and transmitters from Texas Instruments™. The maximum gain is measured to be +3.3 dBi, and the overall size requirements for this antenna are 25.7 × 7.5 mm. Thus, this antenna is compact, low cost, and high performance.

Contents

1	Description of Inverted F Antenna Design.....	2
1.1	Implementation of Inverted F Antenna	2
2	Results	3
2.1	Radiation Pattern	3
2.2	Reflection	10
2.3	Bandwidth	10
3	Conclusion	11
4	References	11

Trademarks

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

1 Description of Inverted F Antenna Design

Because the impedance of the inverted F Antenna (IFA) is matched directly to $50\ \Omega$, no external matching components are required.

1.1 Implementation of Inverted F Antenna

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](#).

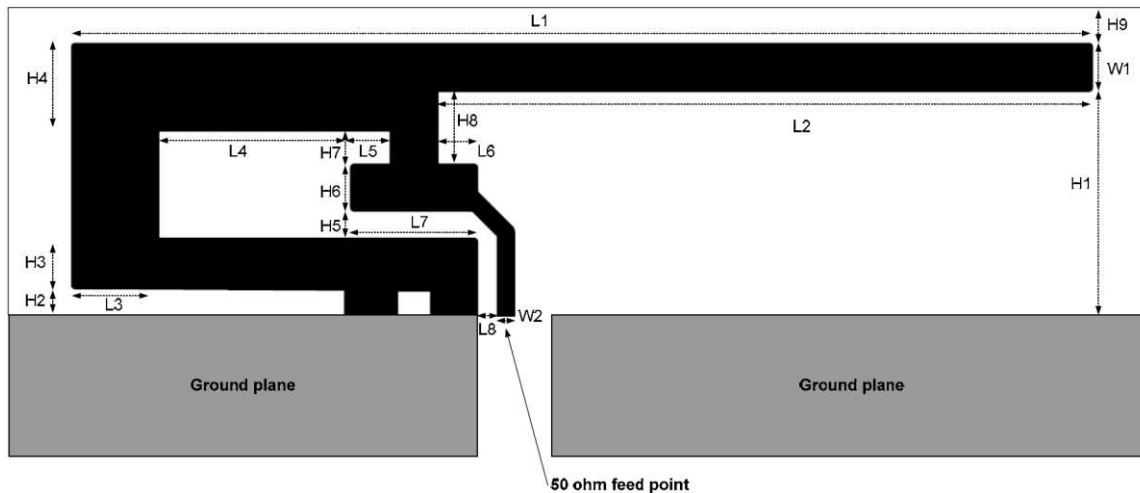


Figure 1. IFA Dimensions

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		

Because there is no ground plane beneath the antenna, the PCB thickness will have little effect on the performance. The results presented in this document are based on an antenna implemented on a PCB with a 1-mm thickness.

2 Results

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

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.

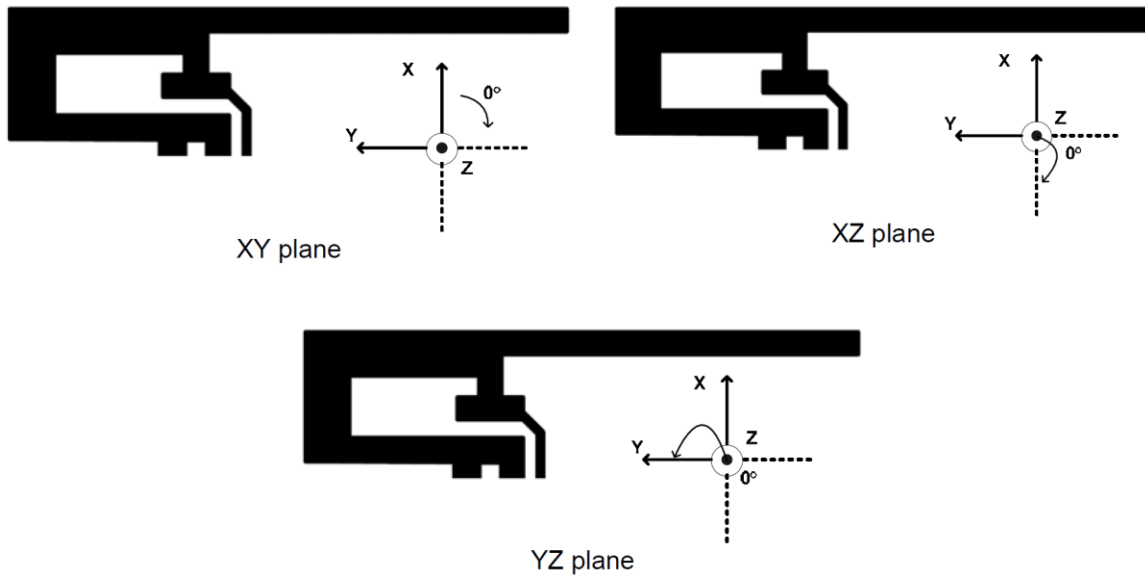


Figure 2. Relating Antenna to Radiation Patterns

Figure 3 shows the XY plane vertical polarization.

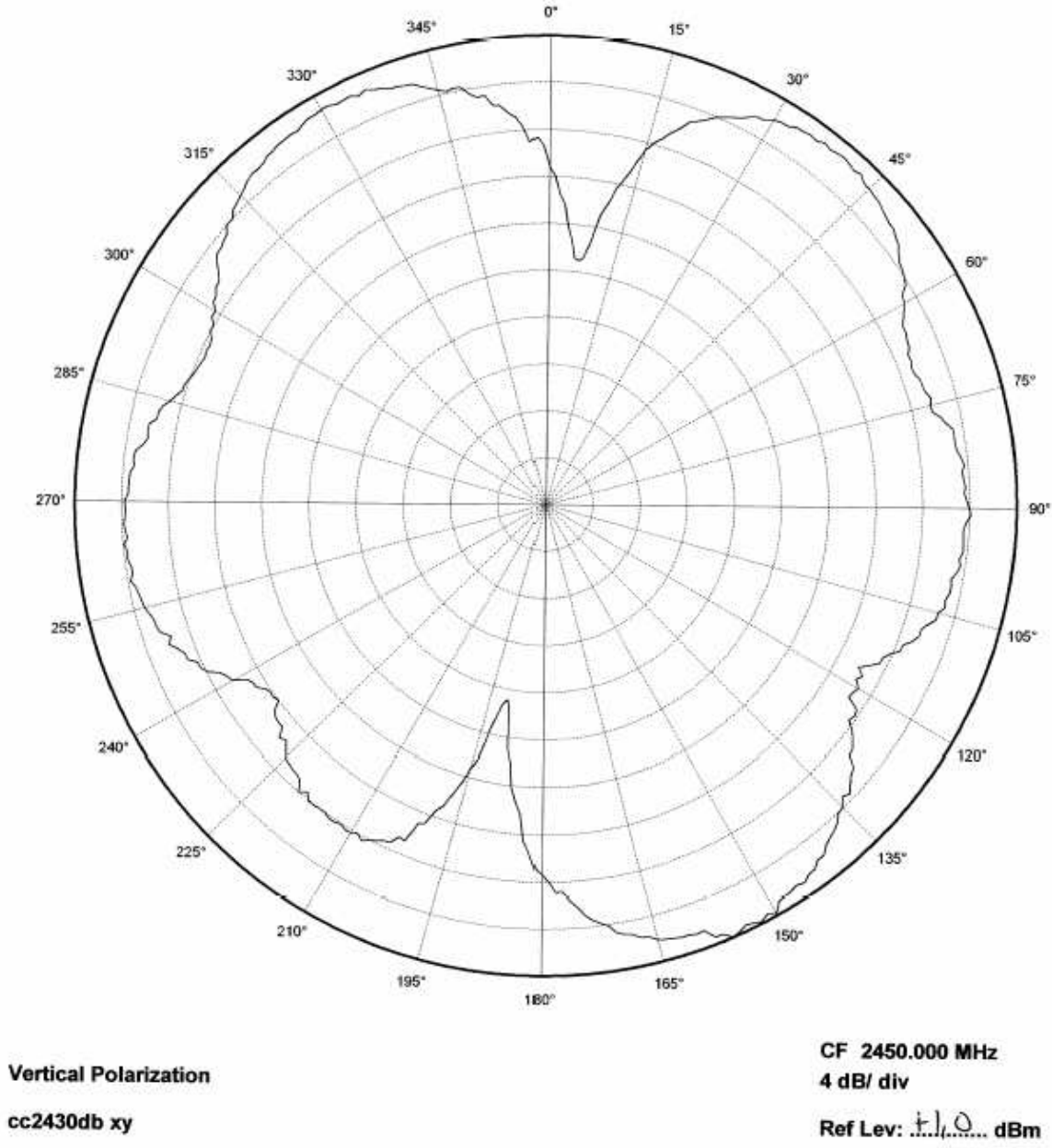


Figure 3. XY Plane–Vertical Polarization

Figure 4 shows the XY plane horizontal polarization.

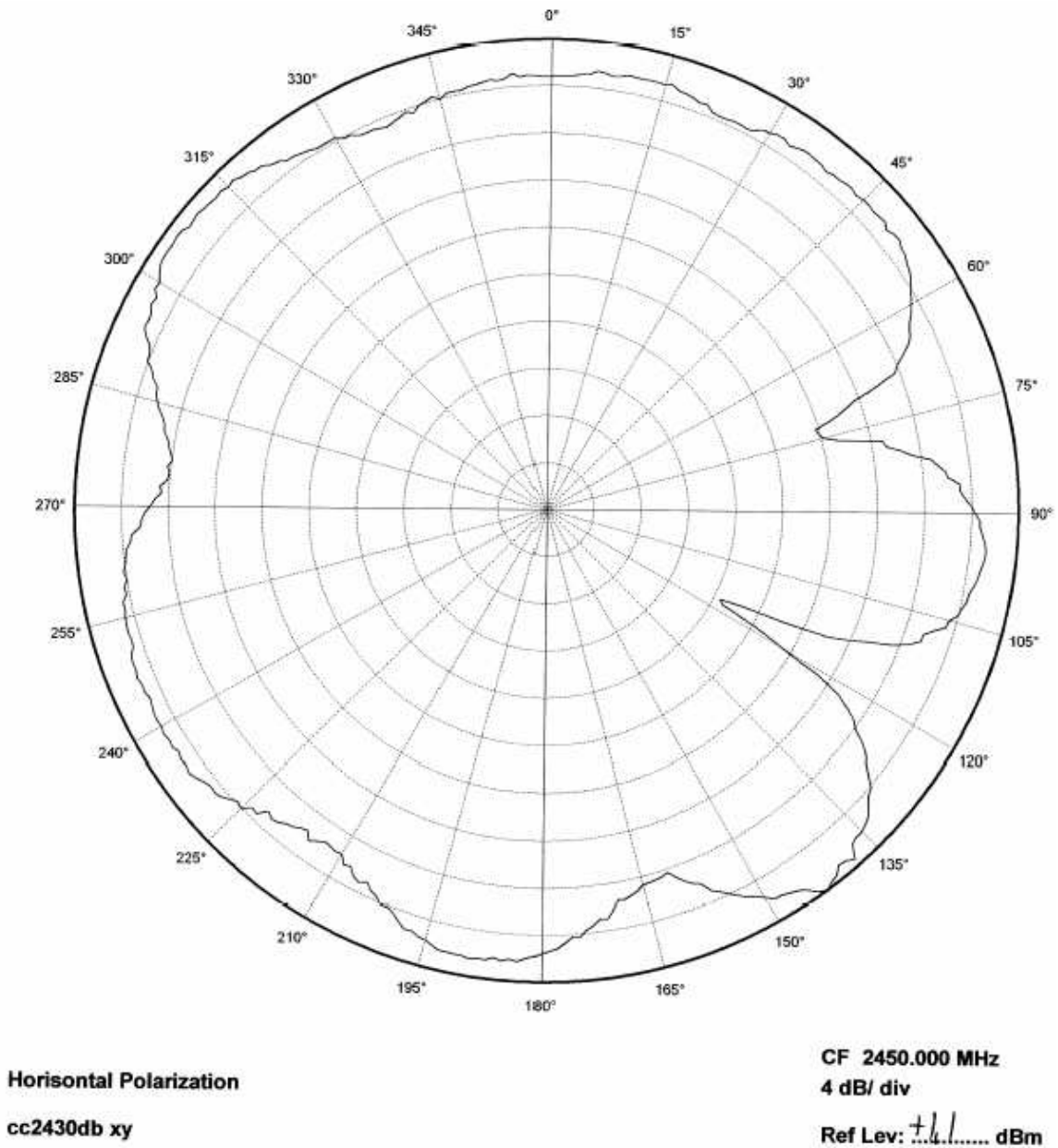


Figure 4. XY Plane–Horizontal Polarization

Figure 5 shows the XZ plane vertical polarization.

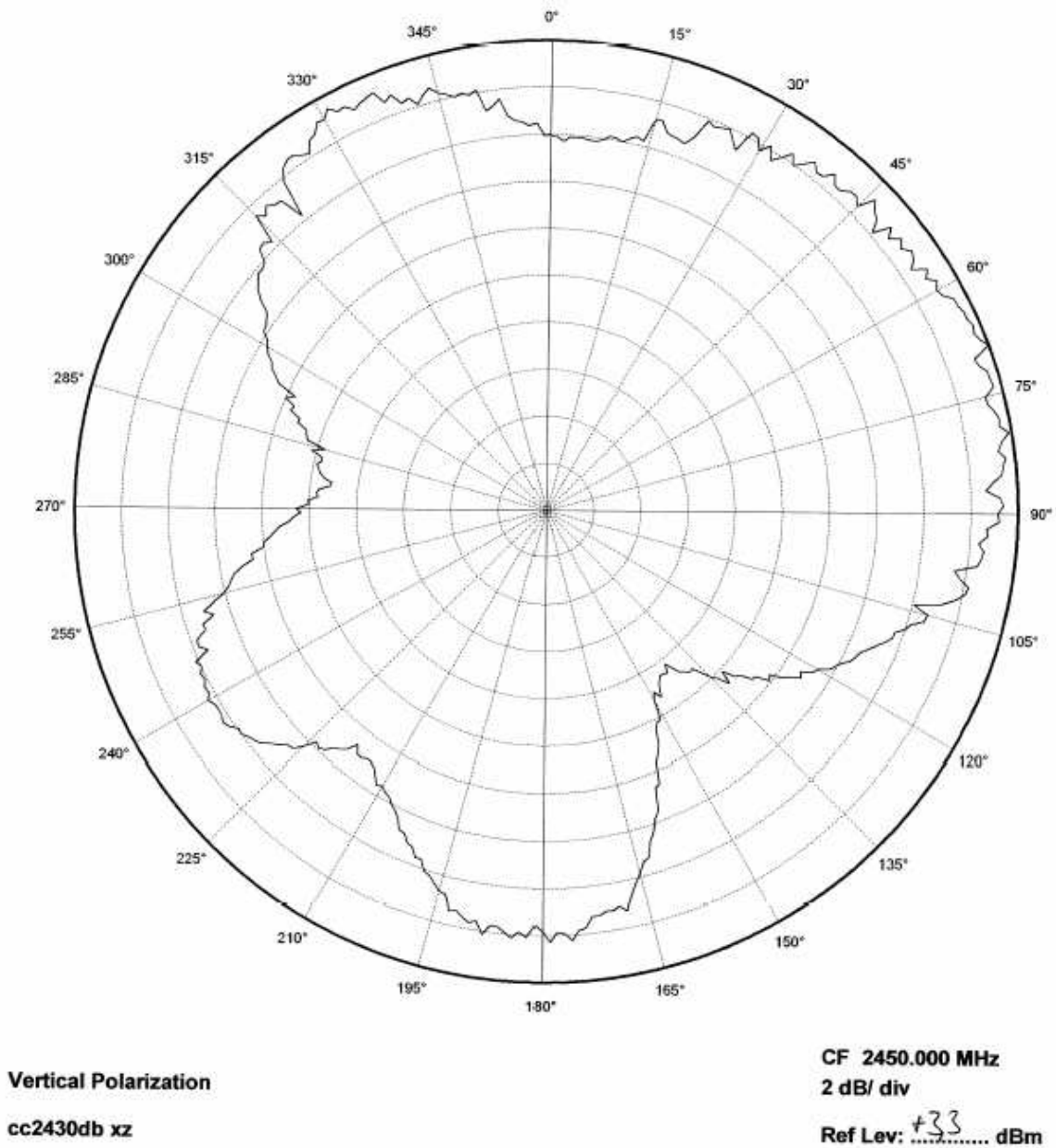


Figure 5. XZ Plane–Vertical Polarization

Figure 6 shows the XZ plane horizontal polarization.

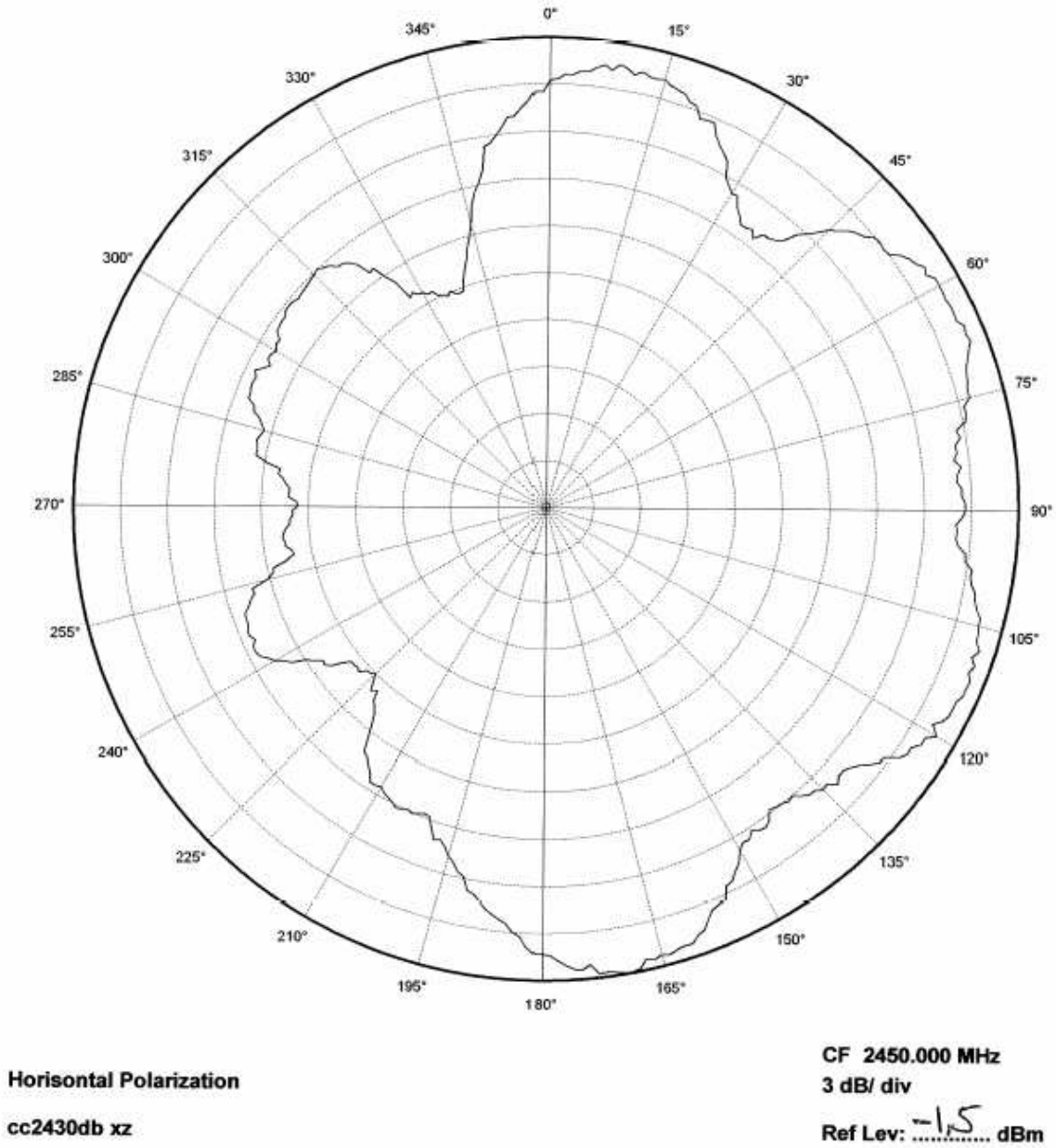


Figure 6. XZ Plane–Horizontal Polarization

Figure 7 shows the YZ plane vertical polarization.

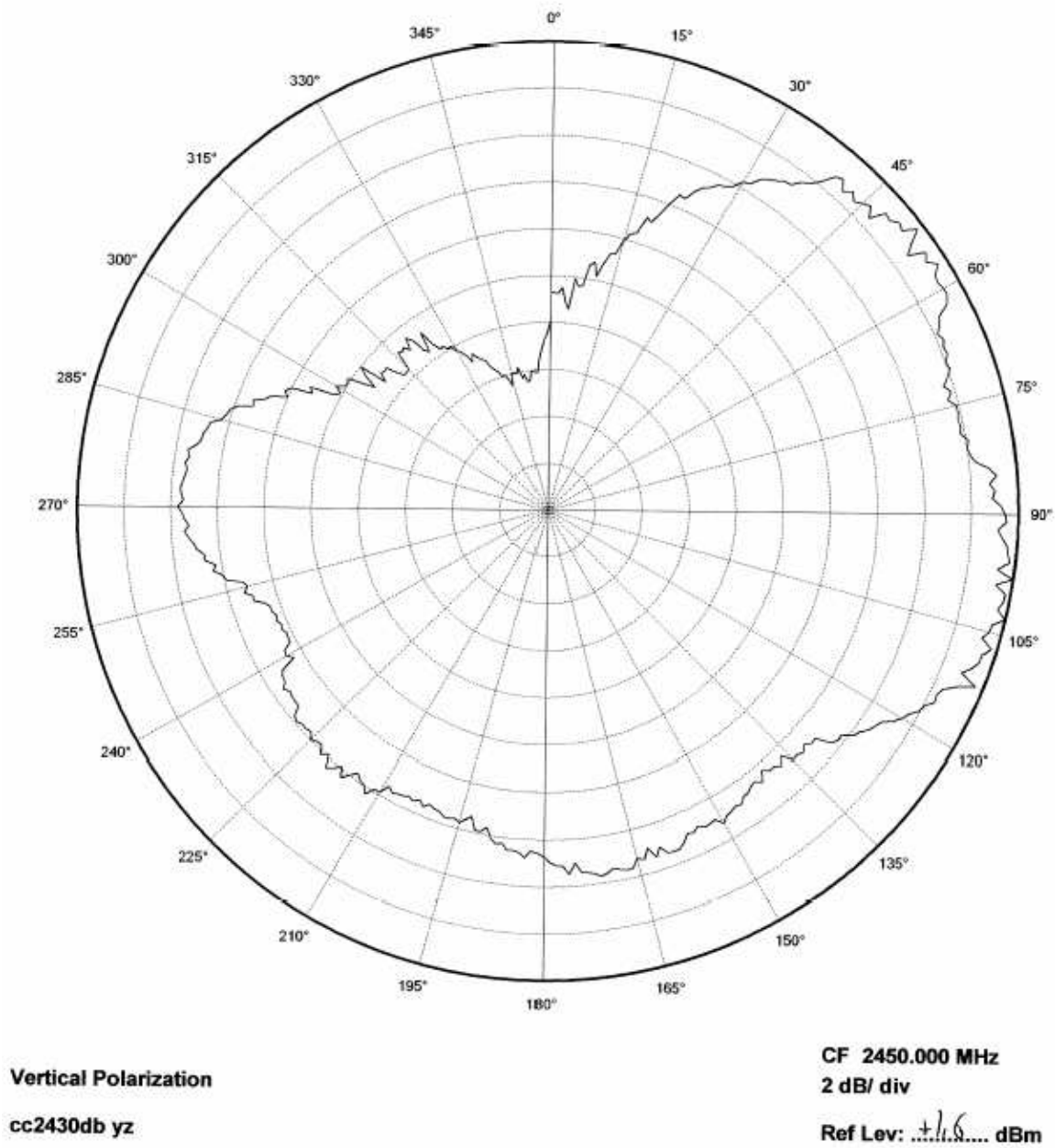


Figure 7. YZ Plane–Vertical Polarization

Figure 8 shows the YZ plane horizontal polarization.

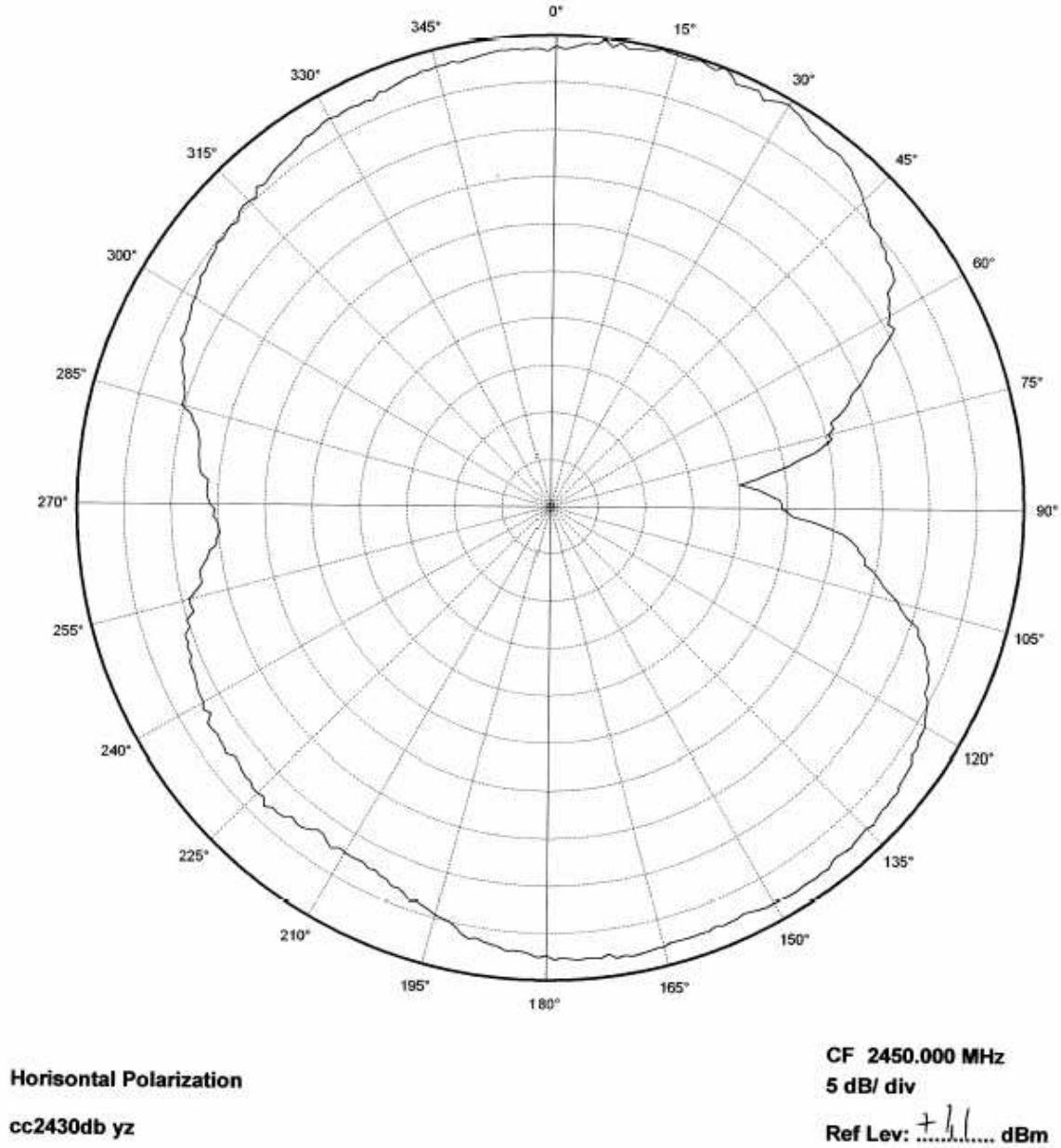


Figure 8. YZ Plane–Horizontal Polarization

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.

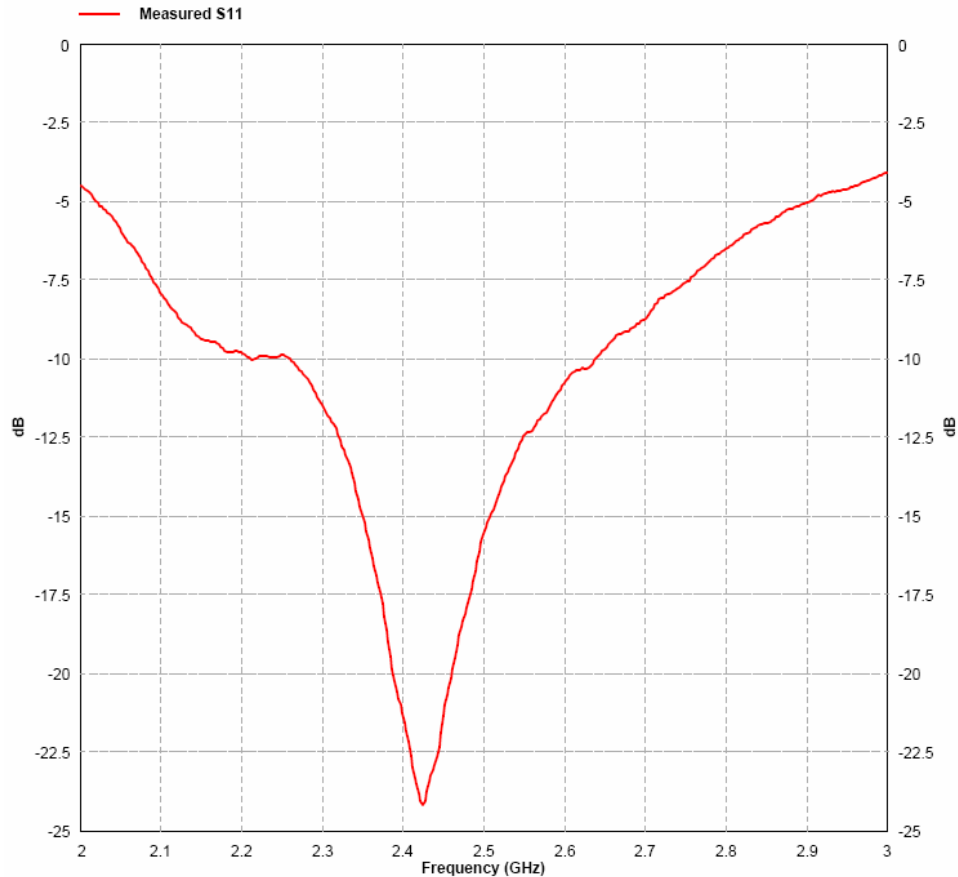


Figure 9. Measured Reflection at Feed Point of Antenna

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.

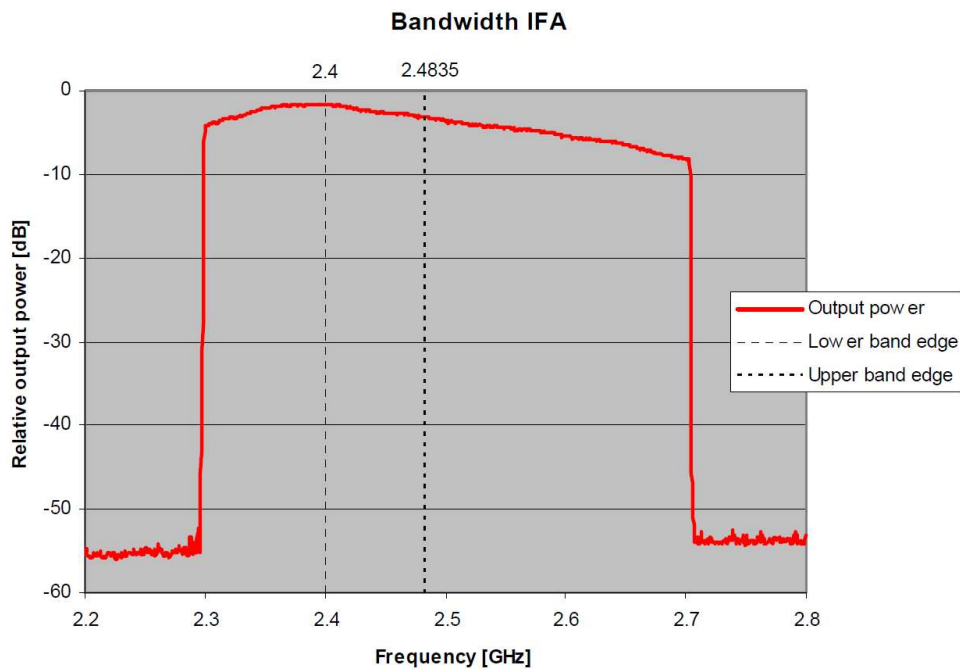


Figure 10. Bandwidth of IFA

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](#)

Revision History

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

Changes from B Revision (April 2008) to C Revision	Page
• Changed +3.3 dB to be +3.3 dBi.....	1
• Changed dB in Table 2 to dBi.....	11

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), [evaluation modules](#), and [samples](http://www.ti.com/sc/docs/sampterm.htm) (<http://www.ti.com/sc/docs/sampterm.htm>).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2018, Texas Instruments Incorporated