

2.4 GHz Inverted F Antenna

By Audun Andersen

Keywords

- CC2400
- CC2420
- CC2430
- CC2431
- CC2500
- CC2510
- CC2511
- CC2550
- CC2520
- CC2480
- PCB Antenna
- 2.4 GHz
- Inverted F Antenna

1 Introduction

This document describes a PCB antenna design that can be used with all 2.4 GHz transceivers and transmitters from Texas Instruments. Maximum gain is measured

to be +3.3 dB and overall size requirements for this antenna are 25.7 x 7.5 mm. Thus, this is a compact, low cost and high performance antenna.



Table of Contents

| | |
|---|-----------|
| KEYWORDS..... | 1 |
| 1 INTRODUCTION..... | 1 |
| 2 ABBREVIATIONS..... | 2 |
| 3 DESCRIPTION OF THE INVERTED F ANTENNA DESIGN | 3 |
| 3.1 IMPLEMENTATION OF THE INVERTED F ANTENNA | 3 |
| 4 RESULTS..... | 4 |
| 4.1 RADIATION PATTERN | 4 |
| 4.2 REFLECTION | 11 |
| 4.3 BANDWIDTH | 11 |
| 5 CONCLUSION | 12 |
| 6 REFERENCES..... | 13 |
| 7 GENERAL INFORMATION | 14 |
| 7.1 DOCUMENT HISTORY..... | 14 |

2 Abbreviations

| | |
|--------|---------------------------------|
| CC2480 | Z-Accel ZigBee Processor |
| EM | Evaluation Module |
| IFA | Inverted F Antenna |
| ISM | Industrial, Scientific, Medical |
| PCB | Printed Circuit Board |

3 Description of the Inverted F Antenna Design

Since the impedance of the Inverted F Antenna is matched directly to 50 ohm no external matching components are needed.

3.1 Implementation of the 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 either a gerber or 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 it is important to avoid placing components or having a ground plane close to the end points of the antenna. If the CAD tool being used doesn't support import of gerber or DXF files, Figure 1 and Table 1 can be used.

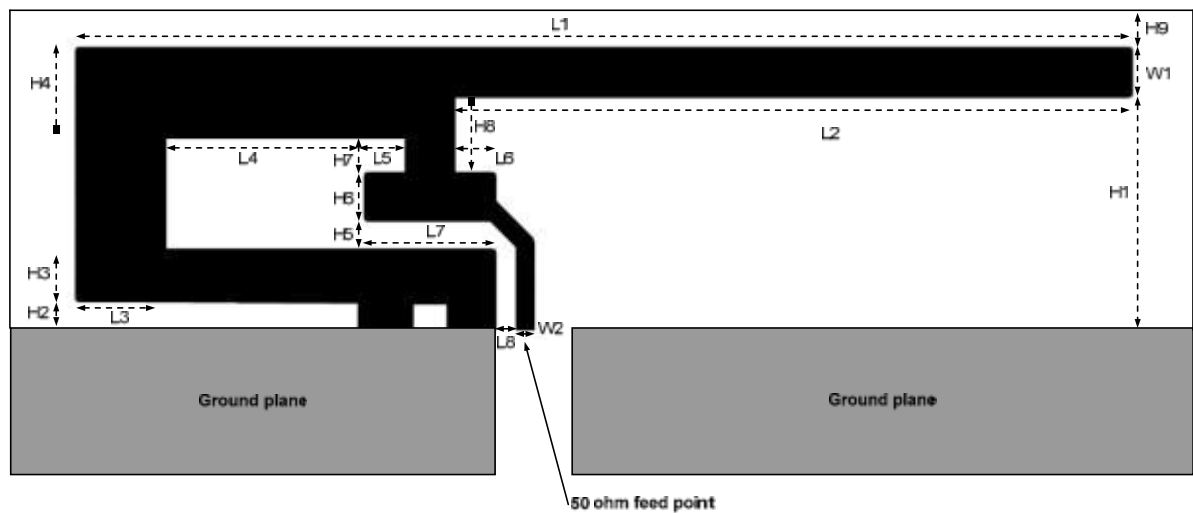


Figure 1. IFA Dimensions

| | | | |
|----|---------|----|----------|
| 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 | | |

Table 1. IFA Dimensions

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

4 Results

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

4.1 Radiation Pattern

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

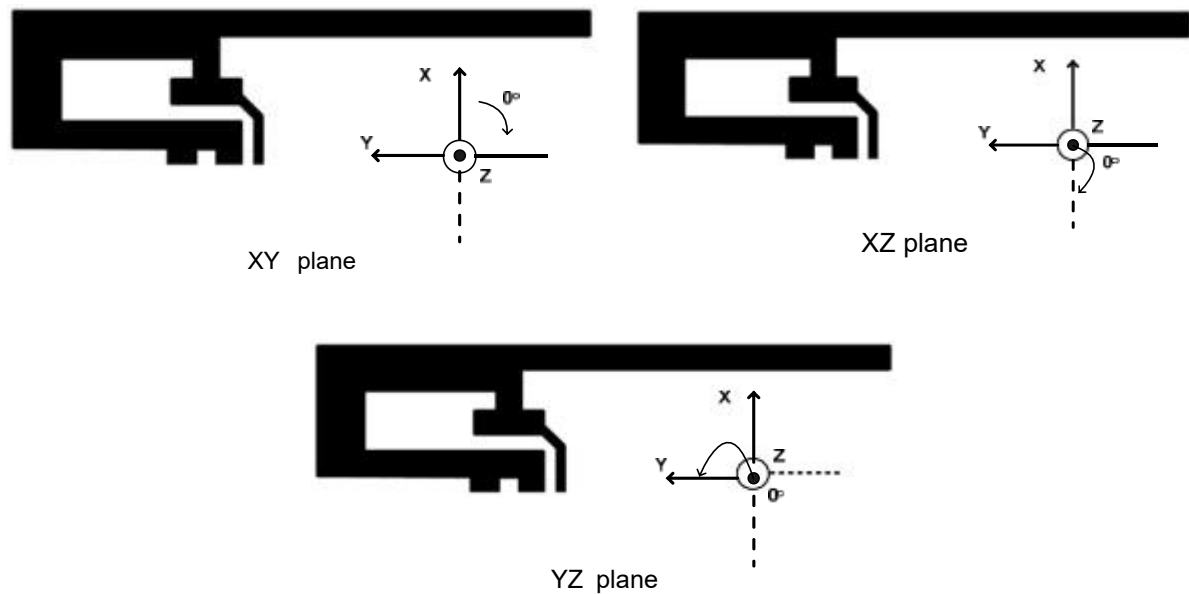


Figure 2. How to Relate the Antenna to the Radiation Patterns

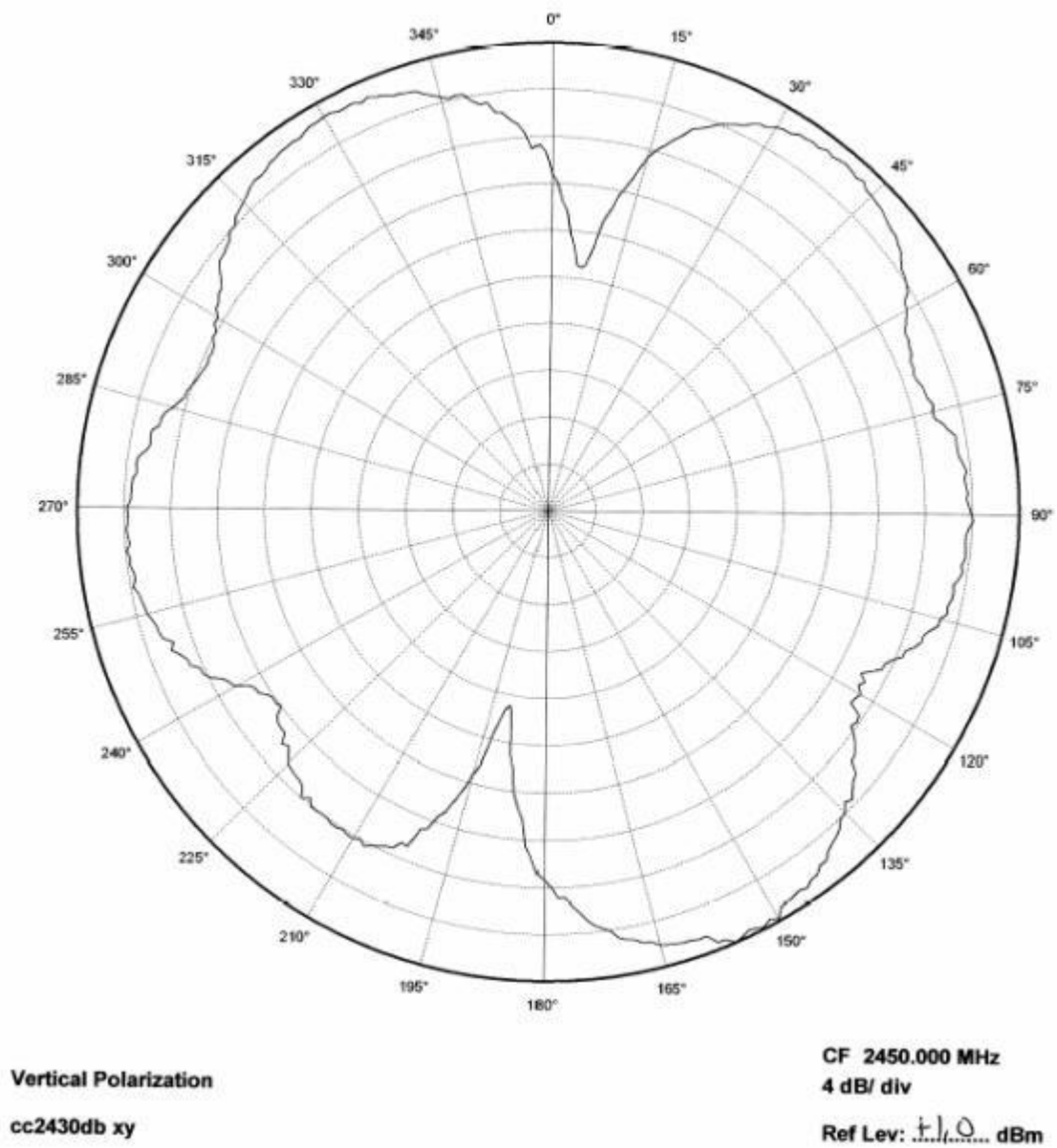


Figure 3. XY Plane Vertical Polarization

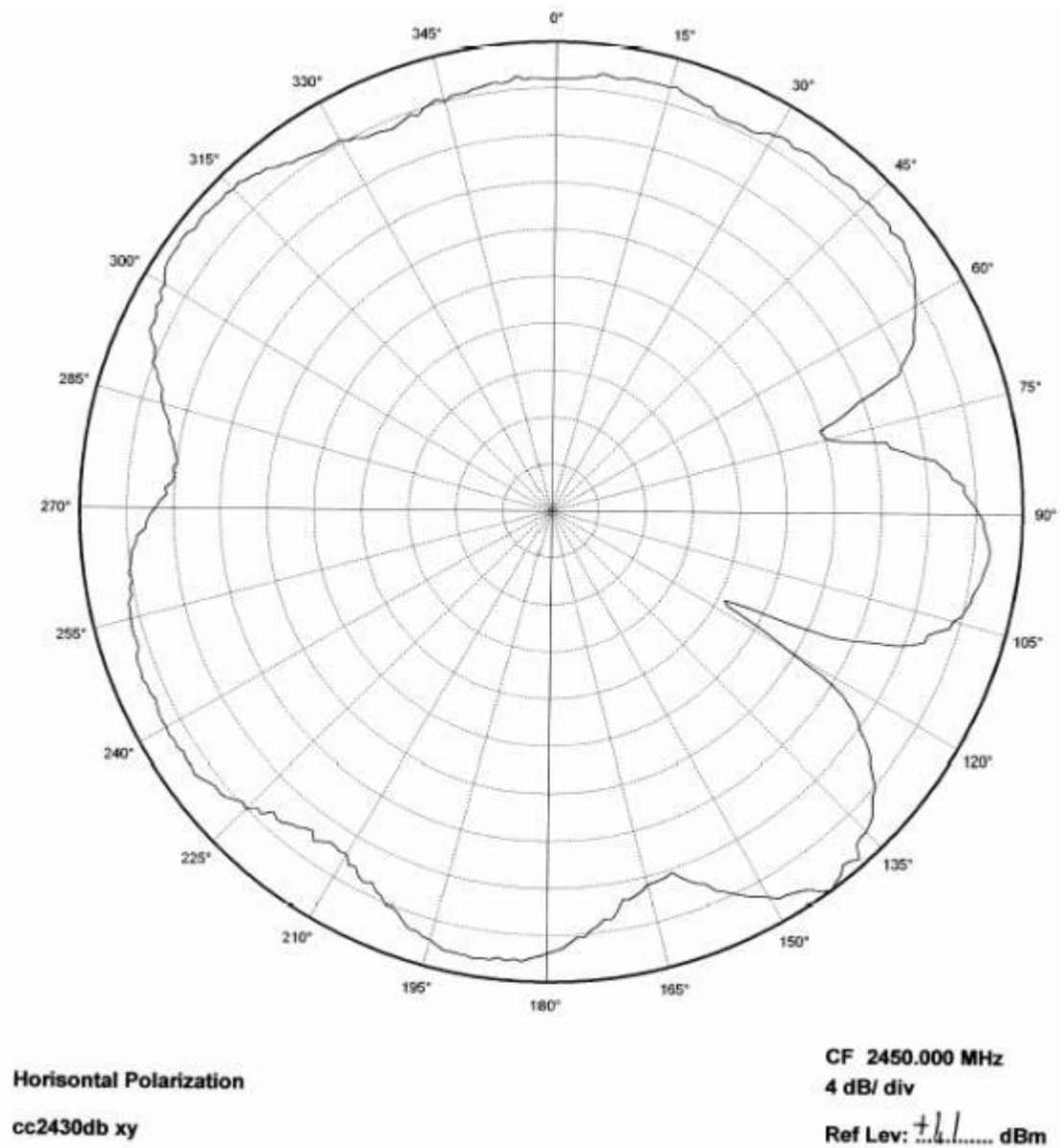


Figure 4. XY Plane Horizontal Polarization

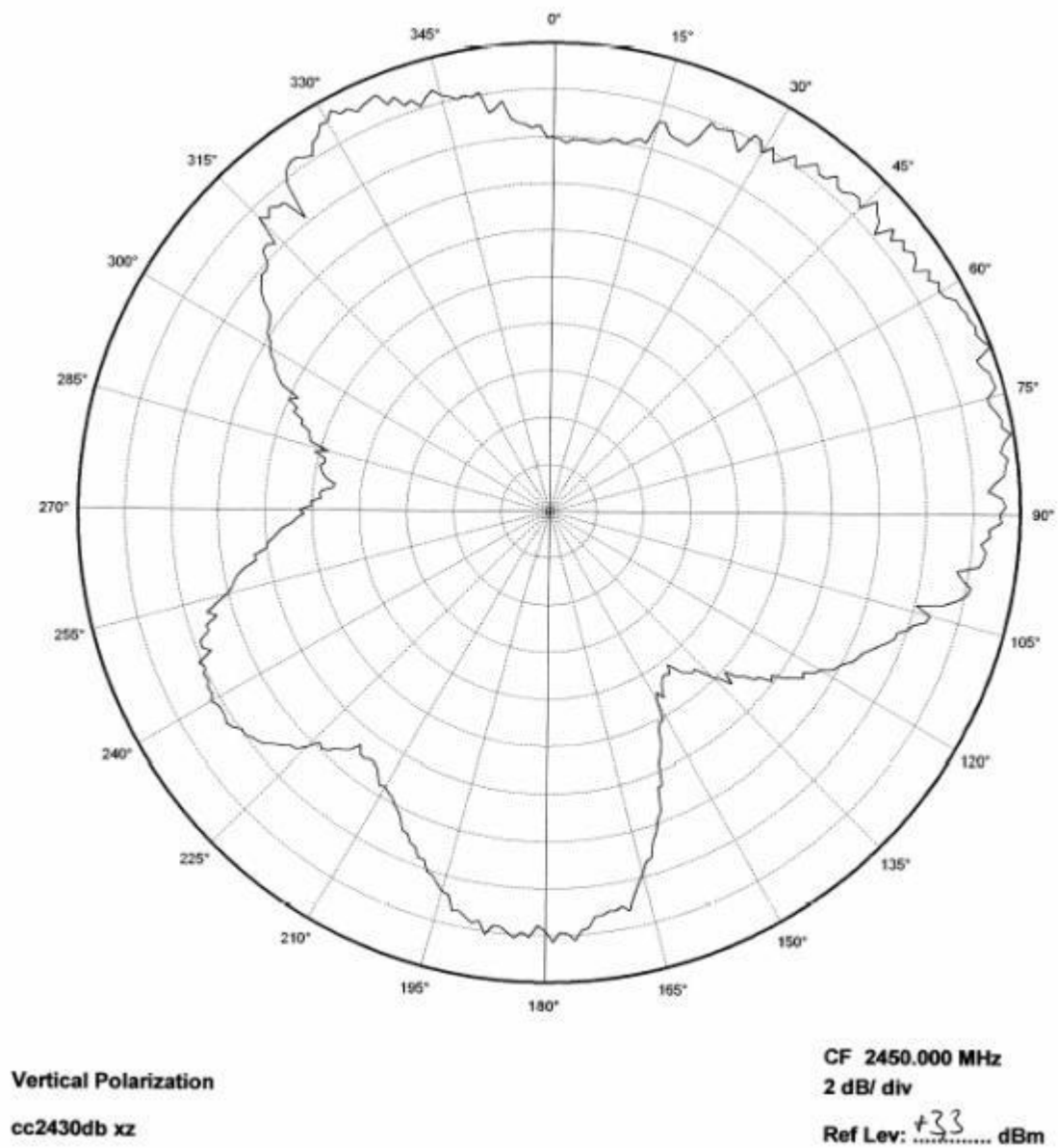


Figure 5. XZ Plane Vertical Polarization

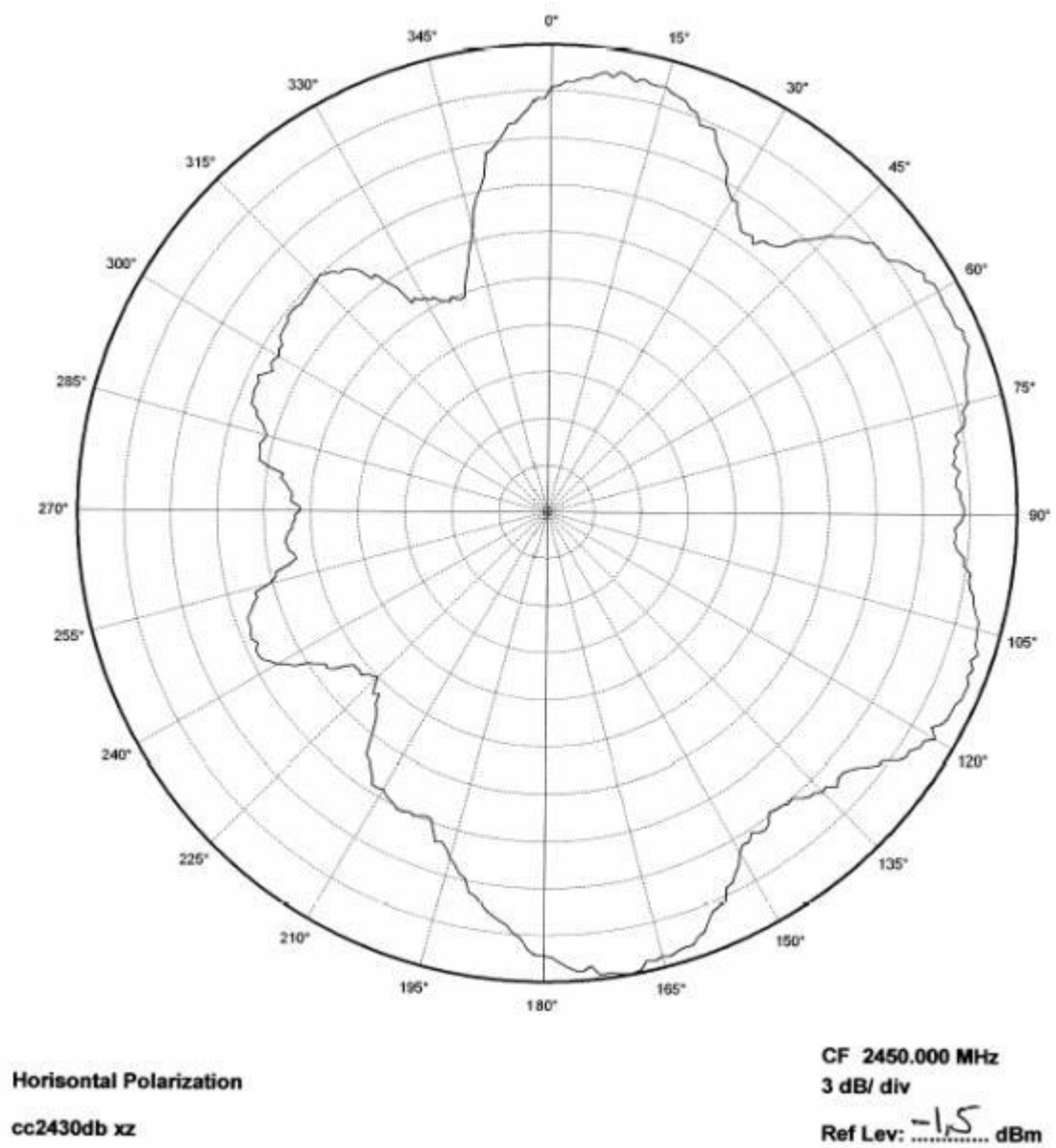


Figure 6. XZ Plane Horizontal Polarization

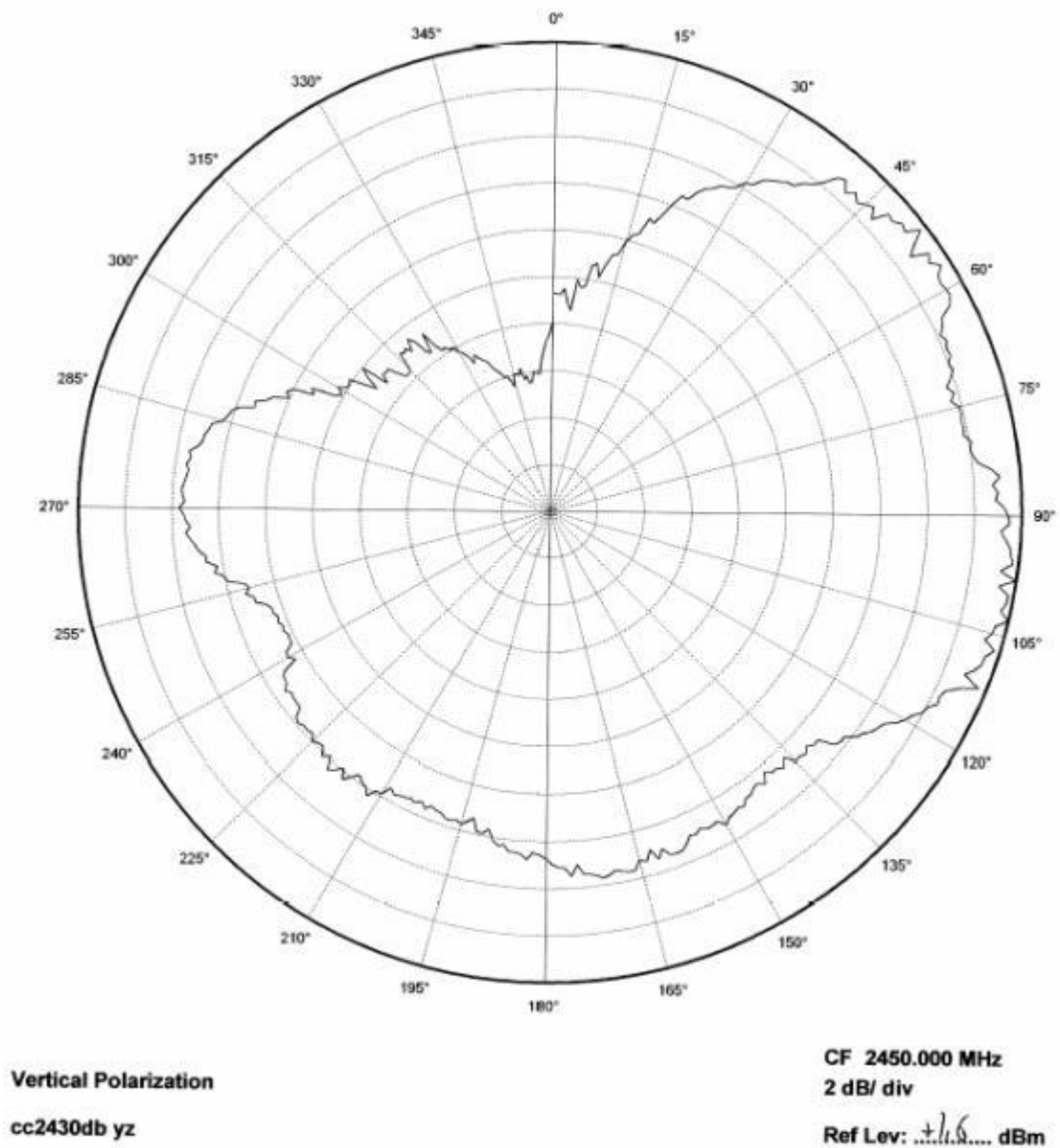


Figure 7. YZ Plane Vertical Polarization

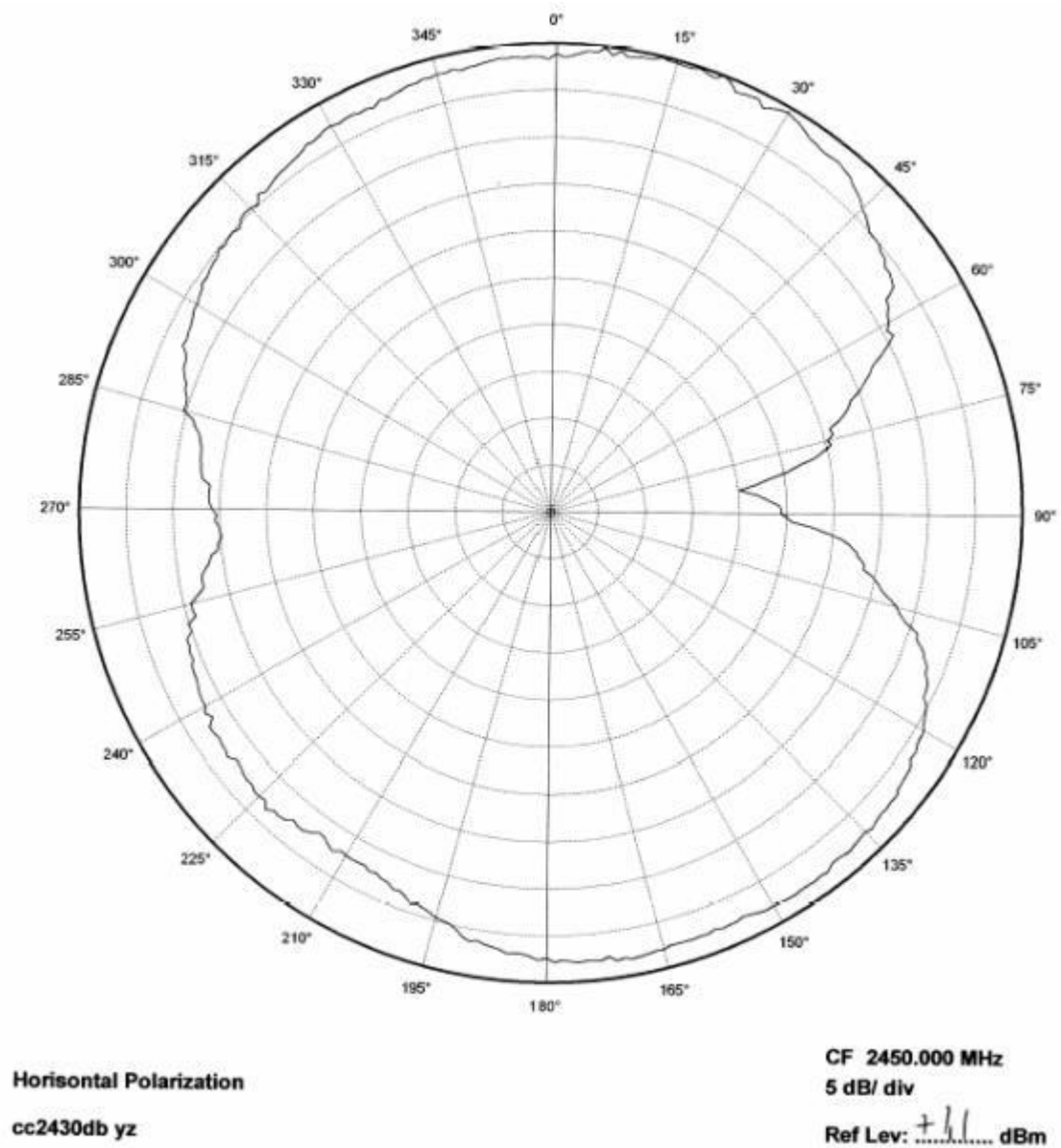


Figure 8. YZ Plane Horizontal Polarization

4.2 Reflection

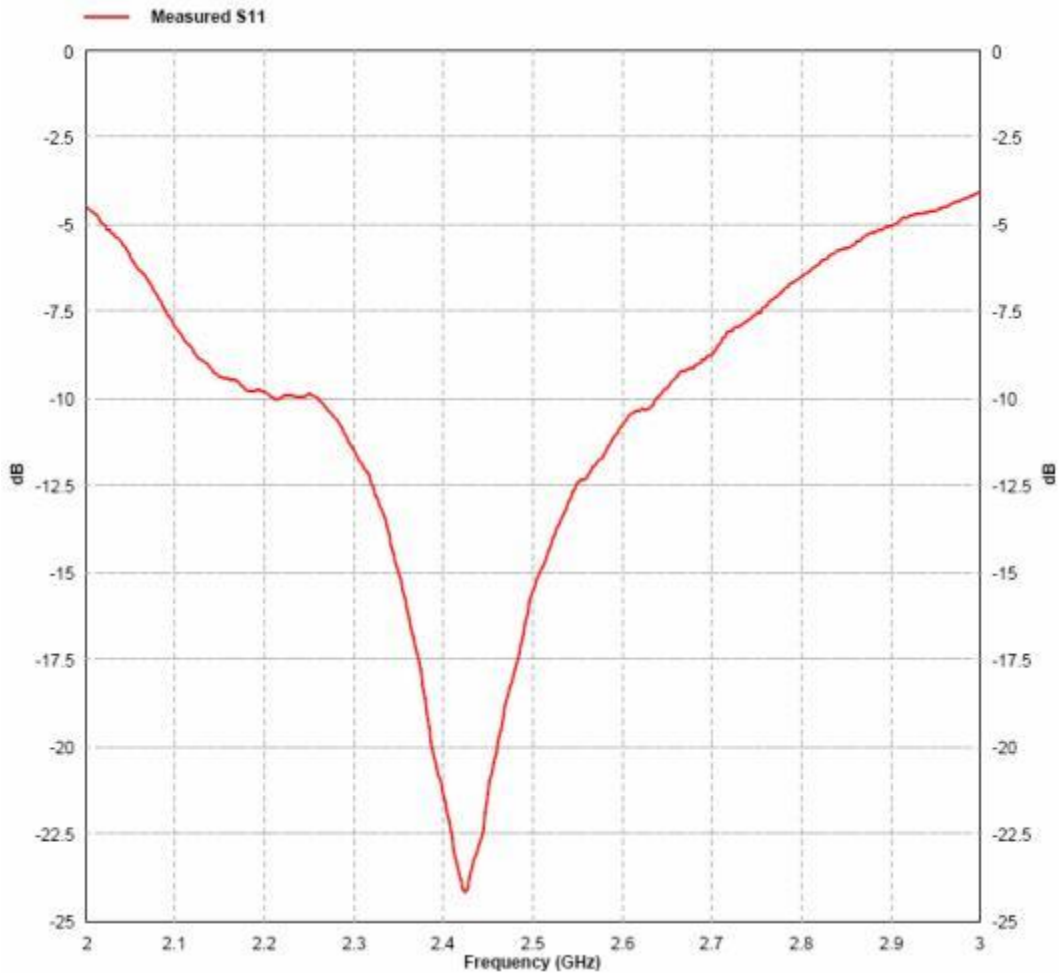


Figure 9. Measured Reflection at the Feed Point of the Antenna

Figure 9 show 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 due to plastic encapsulation or other objects in the vicinity of the antenna.

4.3 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 “Max 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.

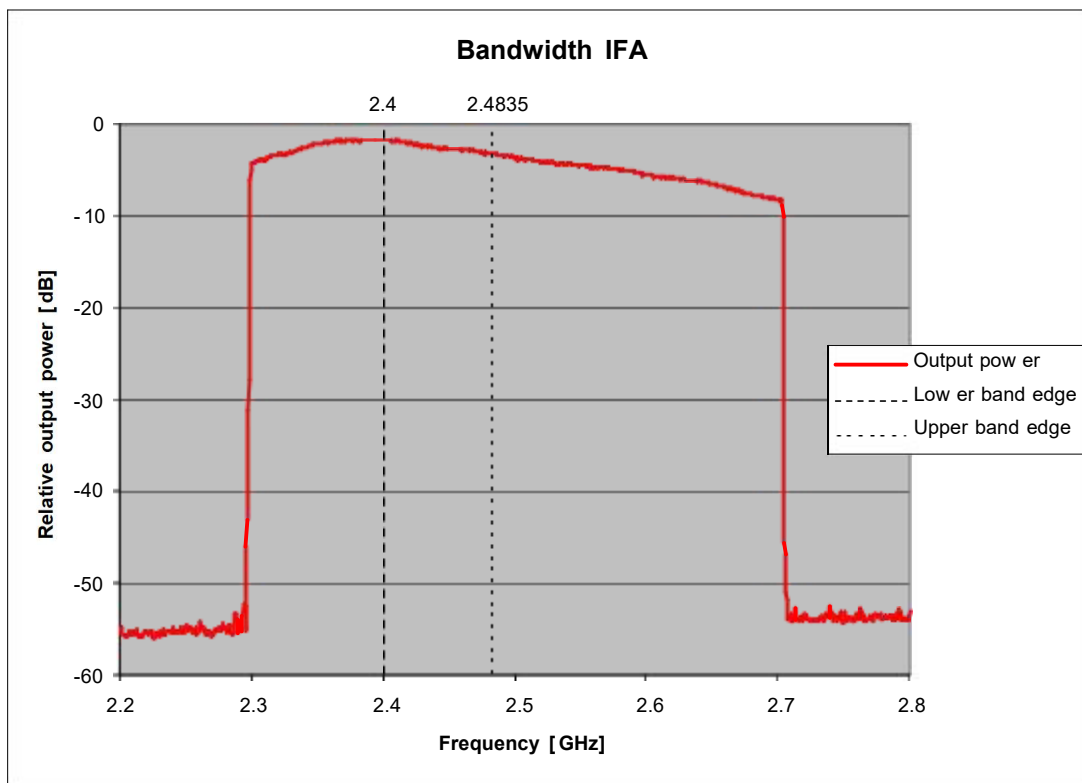


Figure 10. Bandwidth of IFA

5 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 inverted F antenna.

| | |
|------------------|---------------|
| Gain in XY Plane | 1.1 dB |
| Gain in XZ Plane | 3.3 dB |
| Gain in YZ Plane | 1.6 dB |
| Reflection | < - 15 dB |
| Antenna Size | 25.7 x 7.5 mm |

Table 2. Summary of the Properties of the IFA

6 References

- [1] CC2430DB Reference Design ([swrr034.zip](#))

7 General Information

7.1 Document History

| Revision | Date | Description/ Changes |
|----------|------------|--|
| SWRU120B | 2008-04-04 | Renamed CCZACC06 to CC2480 |
| SWRU120A | 2008-02-28 | Added reference to CCZACC06 and CC2520 |
| SWRU120 | 2007-04-16 | Initial release |

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information 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.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

| | |
|-----------------------------|--|
| Amplifiers | amplifier.ti.com |
| Data Converters | dataconverter.ti.com |
| DSP | dsp.ti.com |
| Clocks and Timers | www.ti.com/clocks |
| Interface | interface.ti.com |
| Logic | logic.ti.com |
| Power Mgmt | power.ti.com |
| Microcontrollers | microcontroller.ti.com |
| RFID | www.ti-rfid.com |
| RF/IF and ZigBee® Solutions | www.ti.com/lprf |

Applications

| | |
|--------------------|--|
| Audio | www.ti.com/audio |
| Automotive | www.ti.com/automotive |
| Broadband | www.ti.com/broadband |
| Digital Control | www.ti.com/digitalcontrol |
| Medical | www.ti.com/medical |
| Military | www.ti.com/military |
| Optical Networking | www.ti.com/opticalnetwork |
| Security | www.ti.com/security |
| Telephony | www.ti.com/telephony |
| Video & Imaging | www.ti.com/video |
| Wireless | www.ti.com/wireless |

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2008, Texas Instruments Incorporated