2.4 GHz Inverted F Antenna

By Audun Andersen

Keywords

- *CC2400*
- *CC2420*
- *CC2430*
- *CC2431*
- *CC2500*
- *CC2510*

- *CC2511*
- *CC2550*
- *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 is 25.7 x 7.5 mm. Thus, this is a compact, low cost and high performance antenna.

**Chipcon Products
from Texas Instruments**

Table of Contents

2   Abbreviations

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.
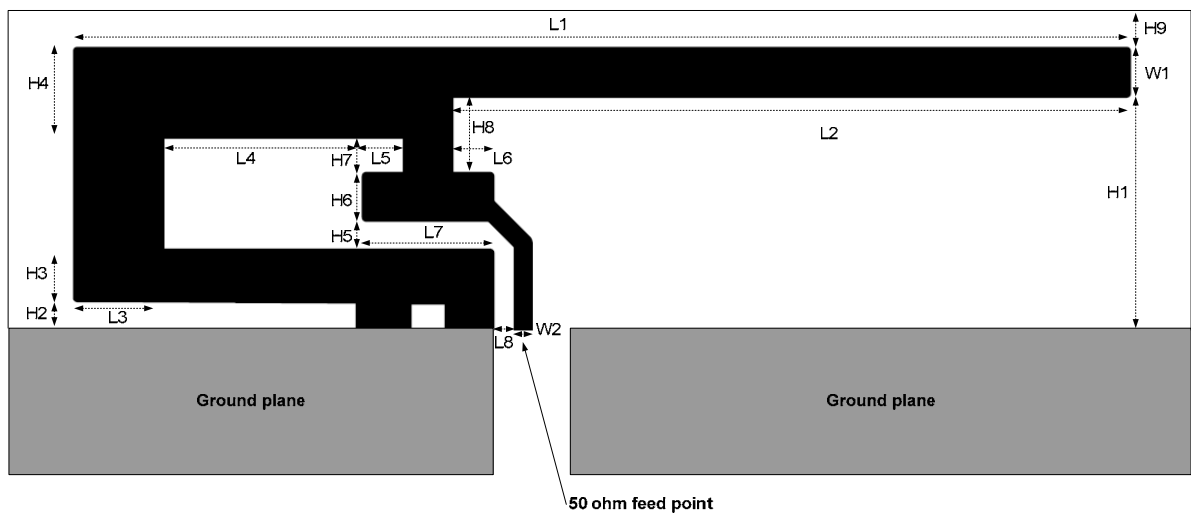

Figure 1. IFA Dimensions

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.
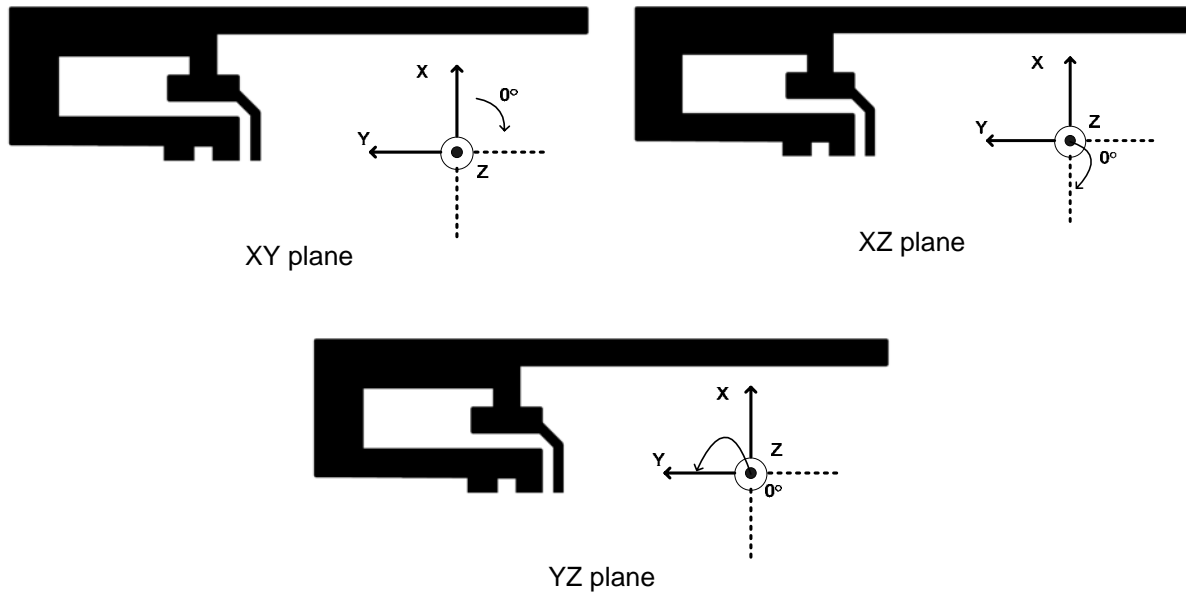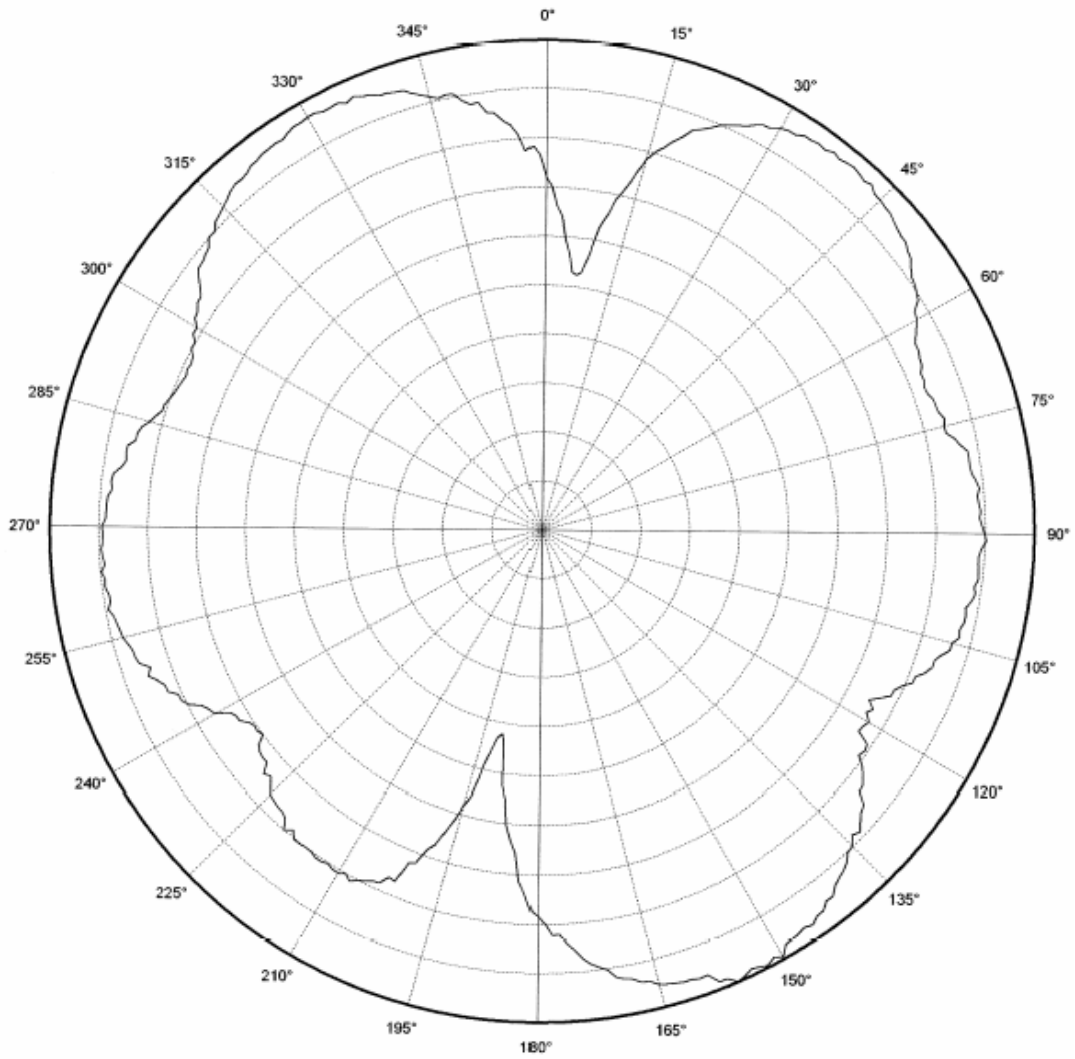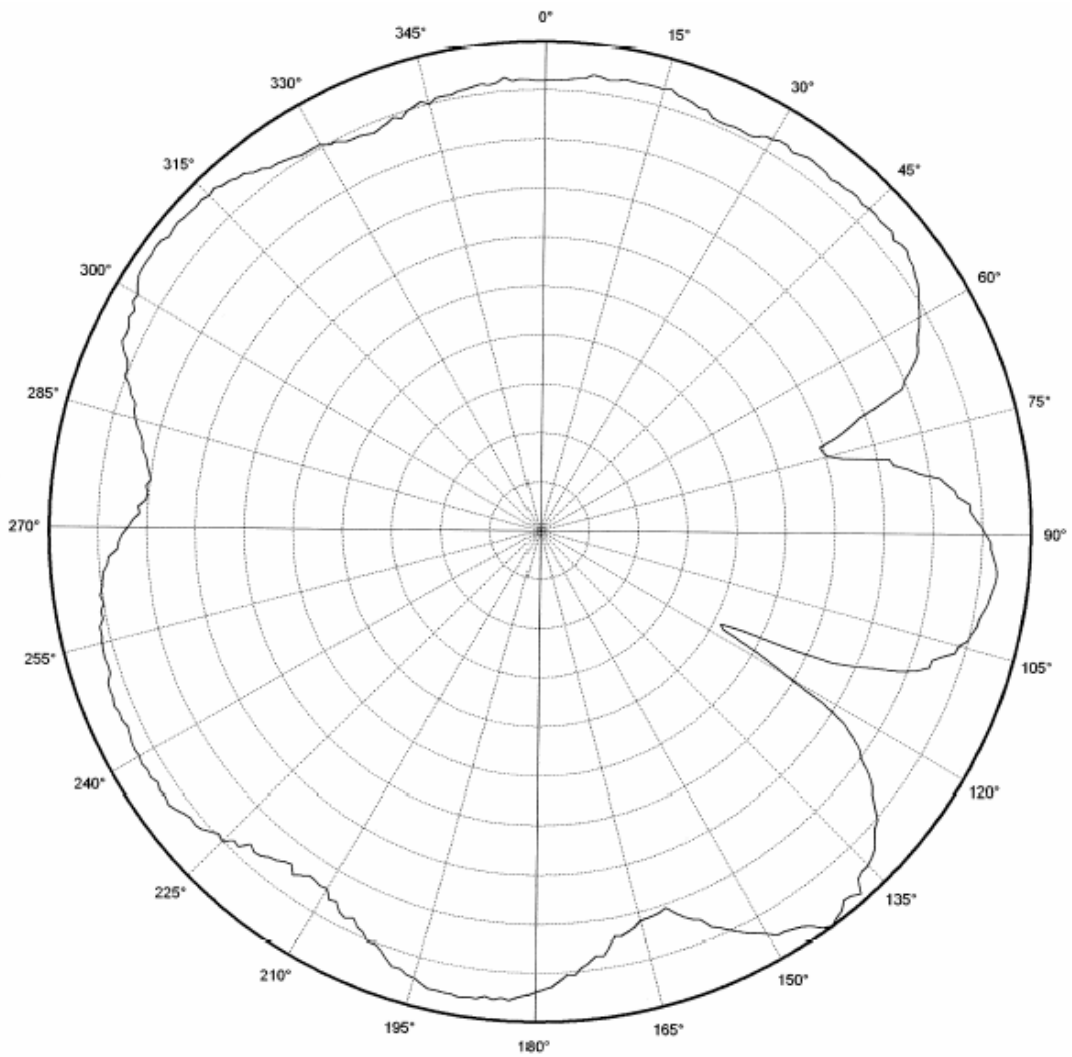

XY plane

XZ plane

YZ plane

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

Vertical Polarization
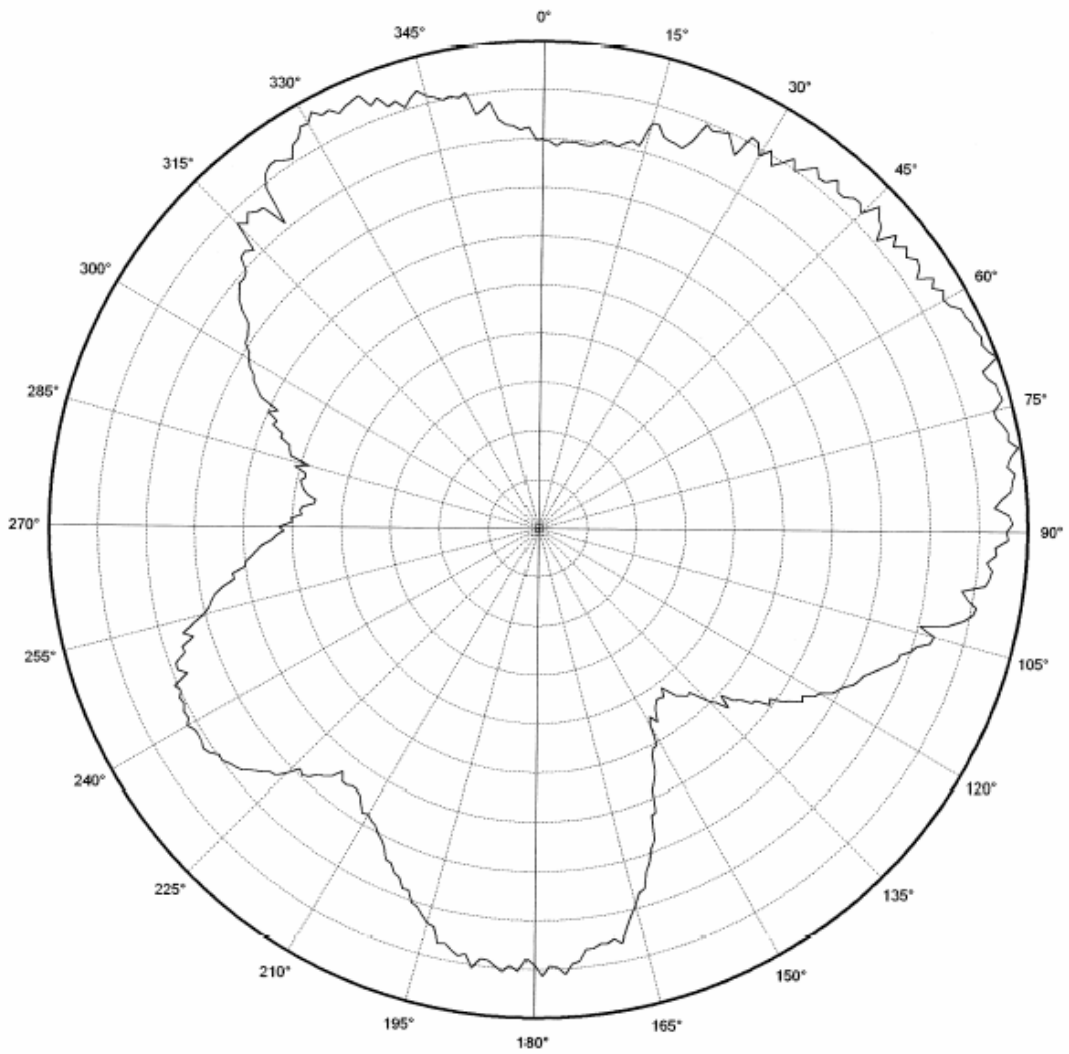
cc2430db xy

CF 2450.000 MHz
4 dB/ div

Ref Lev: .+.).O.... dBm

Figure 3. XY Plane Vertical Polarization

Horisontal Polarization

cc2430db xy

CF 2450.000 MHz
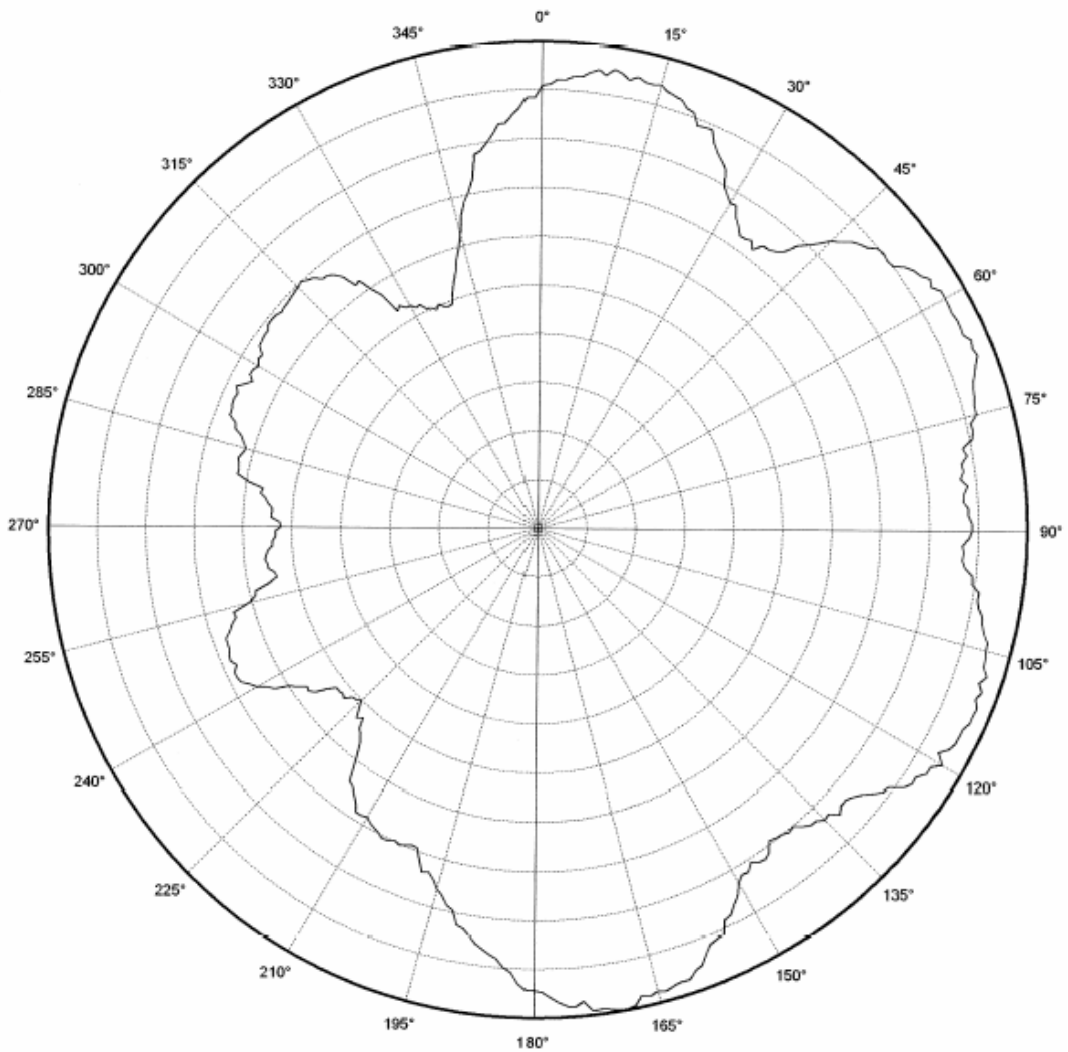4 dB/ div

Ref Lev: +.4./....... dBm

Figure 4. XY Plane Horizontal Polarization

Vertical Polarization

cc2430db xz
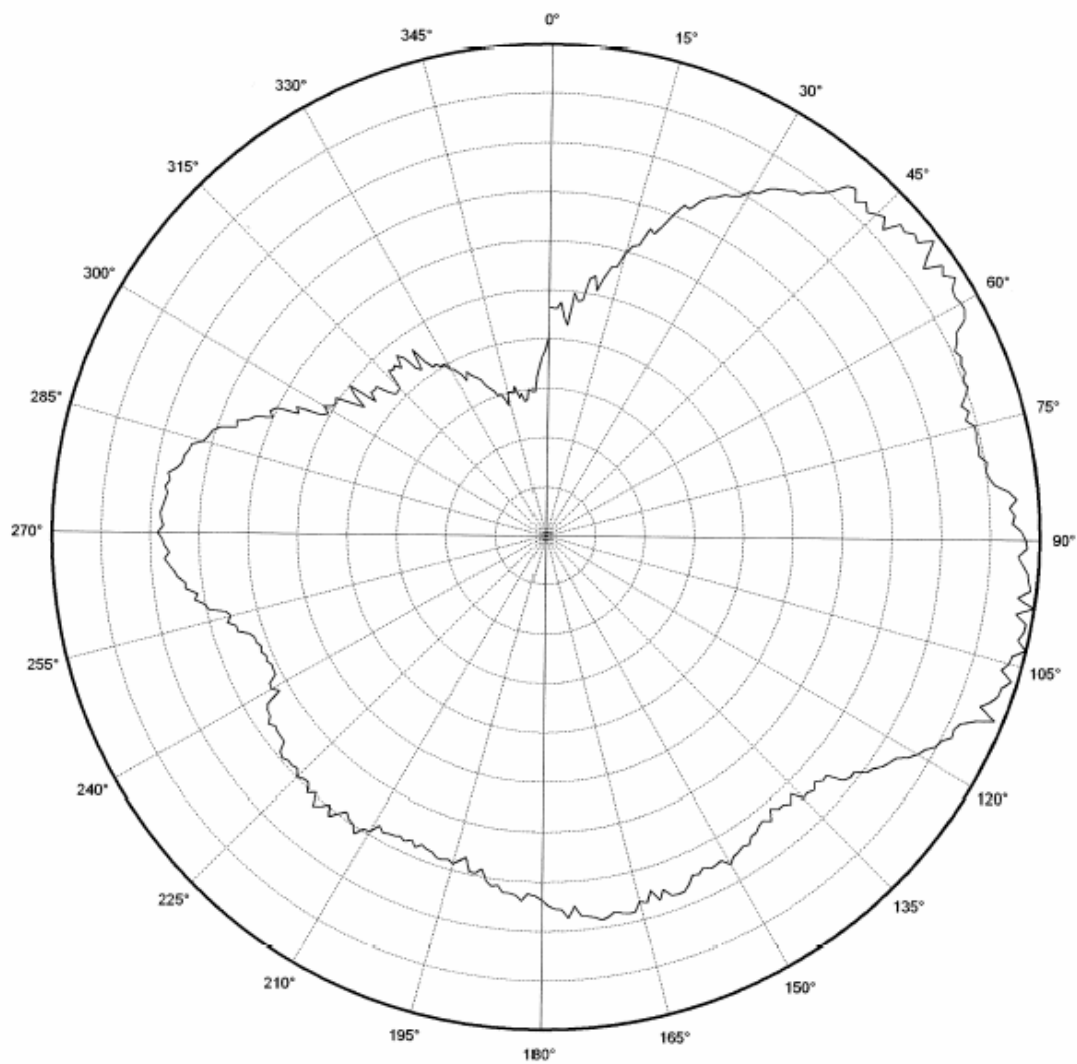
CF 2450.000 MHz
2 dB/ div
Ref Lev: +33 dBm

Figure 5. XZ Plane Vertical Polarization

Horisontal Polarization

cc2430db xz

CF 2450.000 MHz
3 dB/ div
Ref Lev: ‾1.5‾ dBm

Figure 6. XZ Plane Horizontal Polarization

Vertical Polarization

cc2430db yz
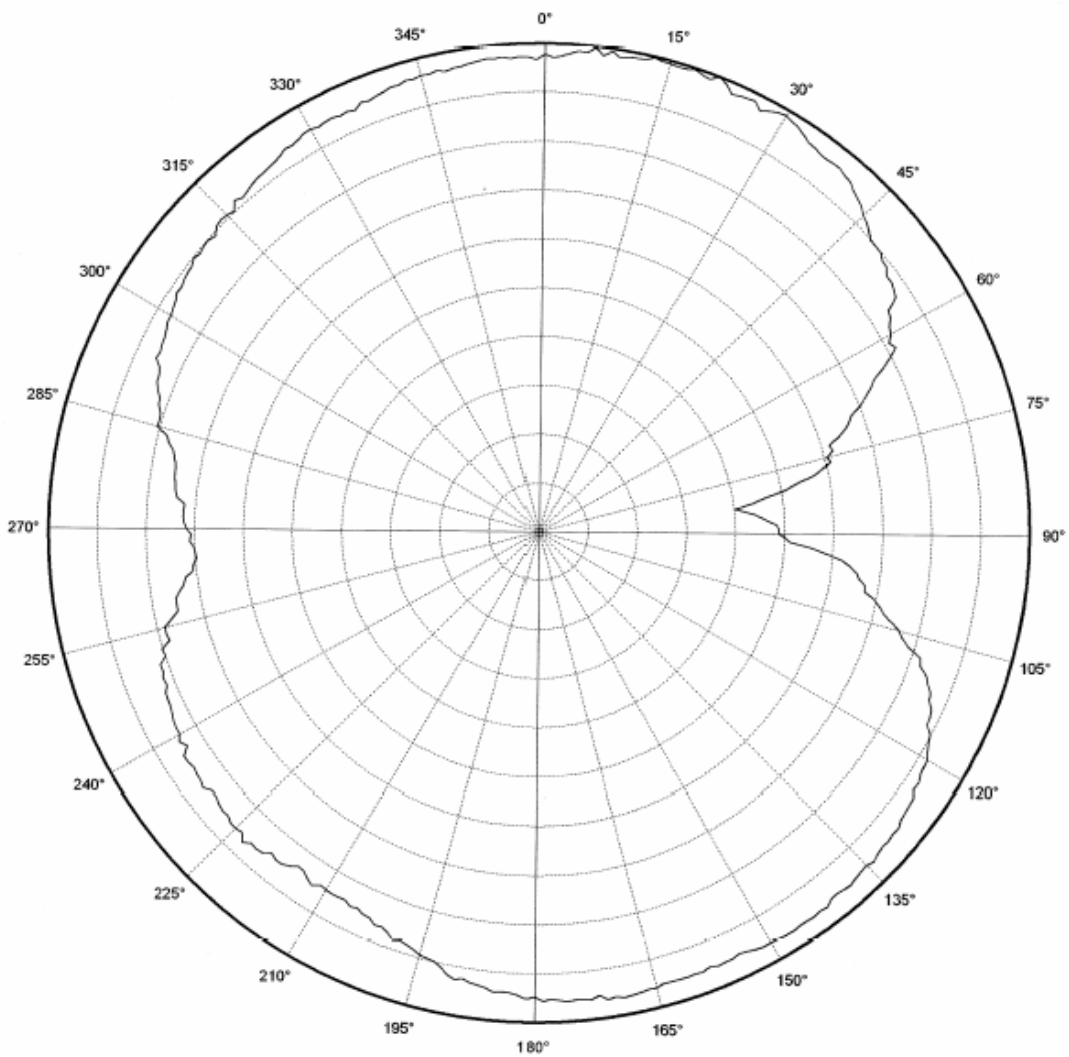
CF 2450.000 MHz
2 dB/ div

Ref Lev: ...±11.6.... dBm

Figure 7. YZ Plane Vertical Polarization

Horisontal Polarization

cc2430db yz

CF 2450.000 MHz
5 dB/ div

Ref Lev: +.4.1.... dBm

Figure 8. YZ Plane Horizontal Polarization
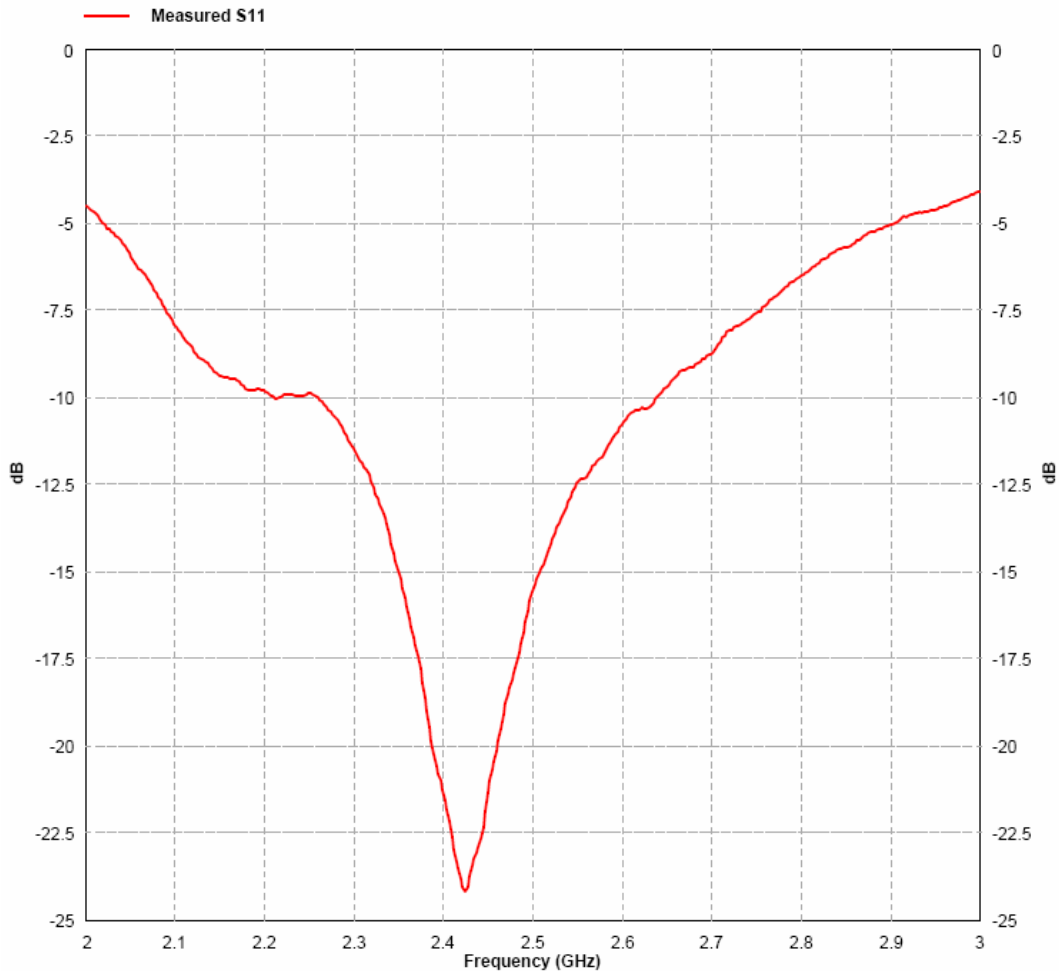
4.2   Reflection

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.
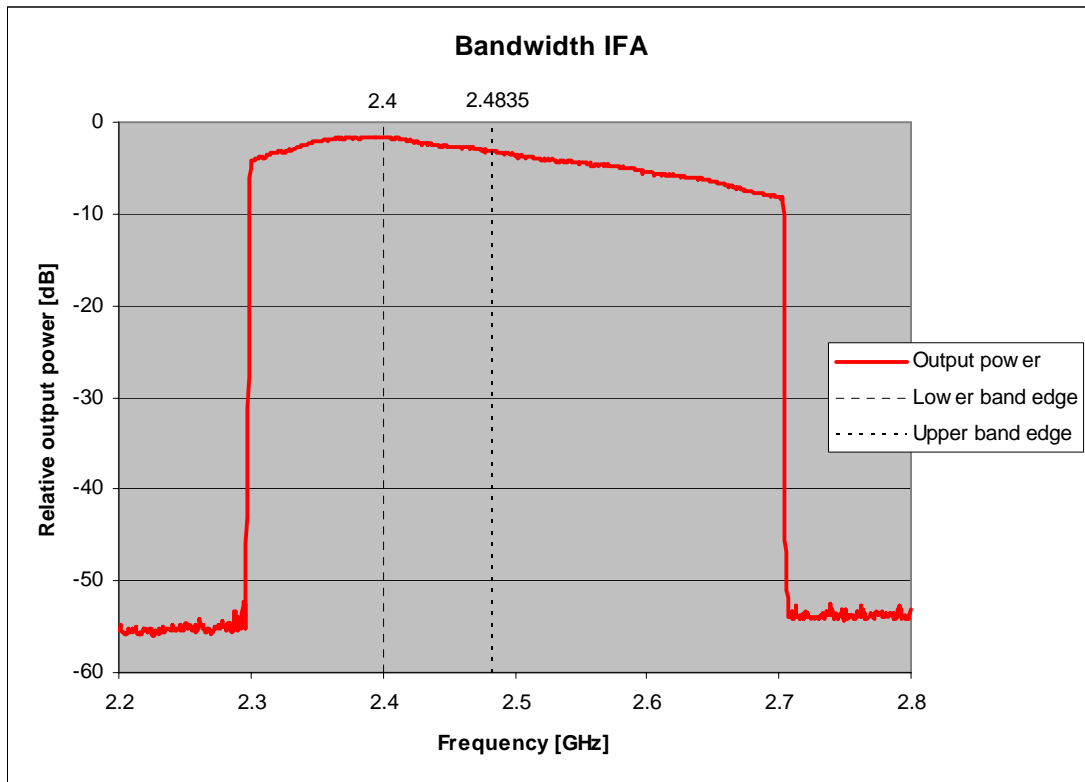
Bandwidth IFA

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. Summery 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
SWRU120	2007.04.16	Initial release.

8 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 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.

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.

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

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
Low Power Wireless	www.ti.com/lpw	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