Chipcon Products from Texas Instruments

Design Note DN004

Folded Dipole Antenna for CC25xx

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Keywords

- *CC2500*
- *CC2550*
- *CC2510*
- *CC2511*
- *Folded Dipole*
- *PCB Antenna*
- *2.4 GHz*

1 Introduction

This document describes a folded dipole PCB antenna design that can be used with the following products from Texas Instruments, CC2500, CC2550, CC2510 and CC2511. Maximum gain is measured to be 7.4 dB and overall size requirements for this antenna is 46 x 9 mm. Thus this is a compact, low cost and high performance antenna.

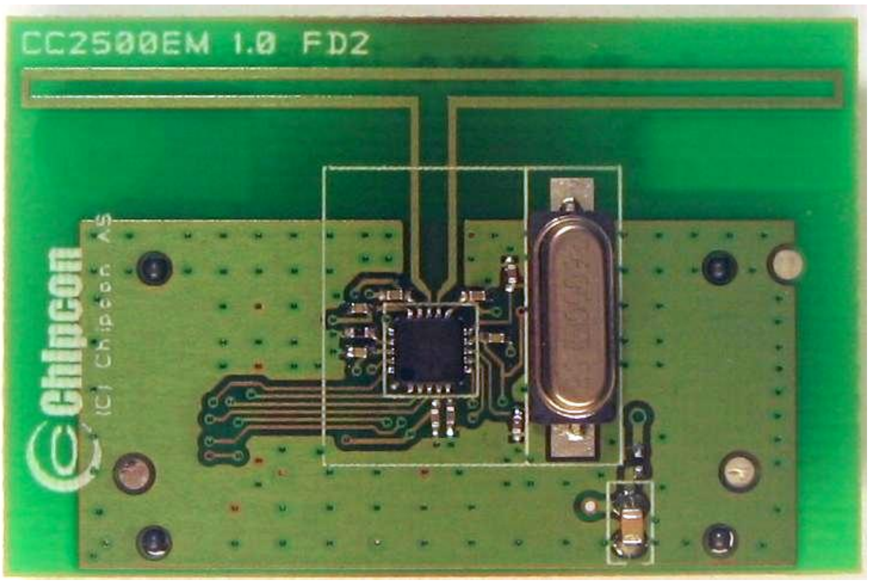


Figure 1: CC2500 Folded Dipole EM.

Table of Contents

2 Abbreviations

CC25xx	CC2500, CC2550, CC2510, CC2511
CAD	Computer Aided Design
DXF	Data eXchange Format
EM	Evaluation Module
LOS	Line Of Sight
PCB	Printed Circuit Board

3 Description of the folded dipole design

Since the impedance of the folded dipole is matched directly to the impedance of the radio no external matching components are needed. Dependent on which regulatory limits the application should comply with, two filtering capacitors might however be needed. To ensure compliance with ETSI requirements for receiver spurious emission, C121 and C131 in Figure 3 must be included. The optimum value of C121 and C131 depends on which ETSI standard to comply with. For EN 300 440, 2.2 pF is recommended and 1.5 pF is recommended for EN 300 328. The required filtering for compliance with FCC is dependent on which regulatory part to meet, part 15.247 or 15.249, and the duty cycle of the transmitted signal. Including C121 and C131 reduces the output power but ensures lower harmonic emission in TX and reduced VCO leakage in RX. Typically a board with two 1.5 pF capacitors will have 2 dB less output power than a board without C121 and C131.

3.1 Implementation of the folded dipole

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 the reference design, “CC2500EM_FD_Reference_Design_1_1.zip” available at www.ti.com/lpw. The gerber file is called “CC25xx_Folded_Dipole.spl” and the DXF file is called “CC25xx_Folded_Dipole.dxf”. If the antenna is implemented on a PCB that is wider than the antenna it is important to avoid placing component 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 2 and Table 1 can be used. Since the pinout of CC251x differs from CC2500 it might be necessary to make a slight modification on the routing of the antenna feed lines. If this is done it is important to keep the same distance between the chip and the antenna.

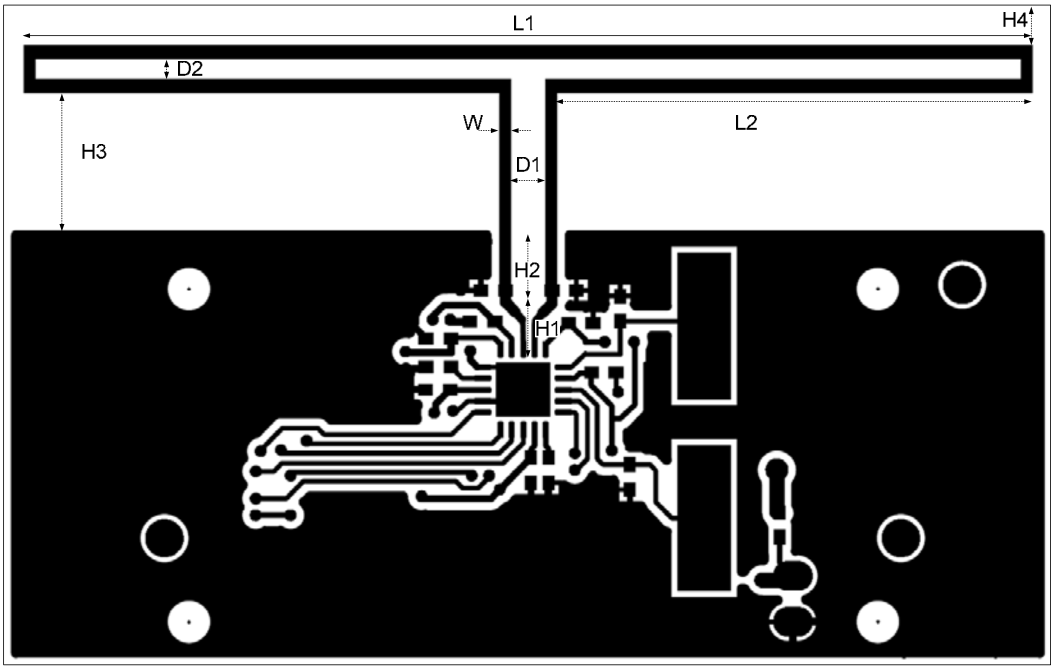


Figure 2: Antenna dimension.

L1	44.7 mm	H1	2.4 mm
L2	21.0 mm	H2	3.1 mm
D1	1.5 mm	H3	6.0 mm
D2	0.9 mm	H4	2.8 mm

Table 1: Antenna dimension.

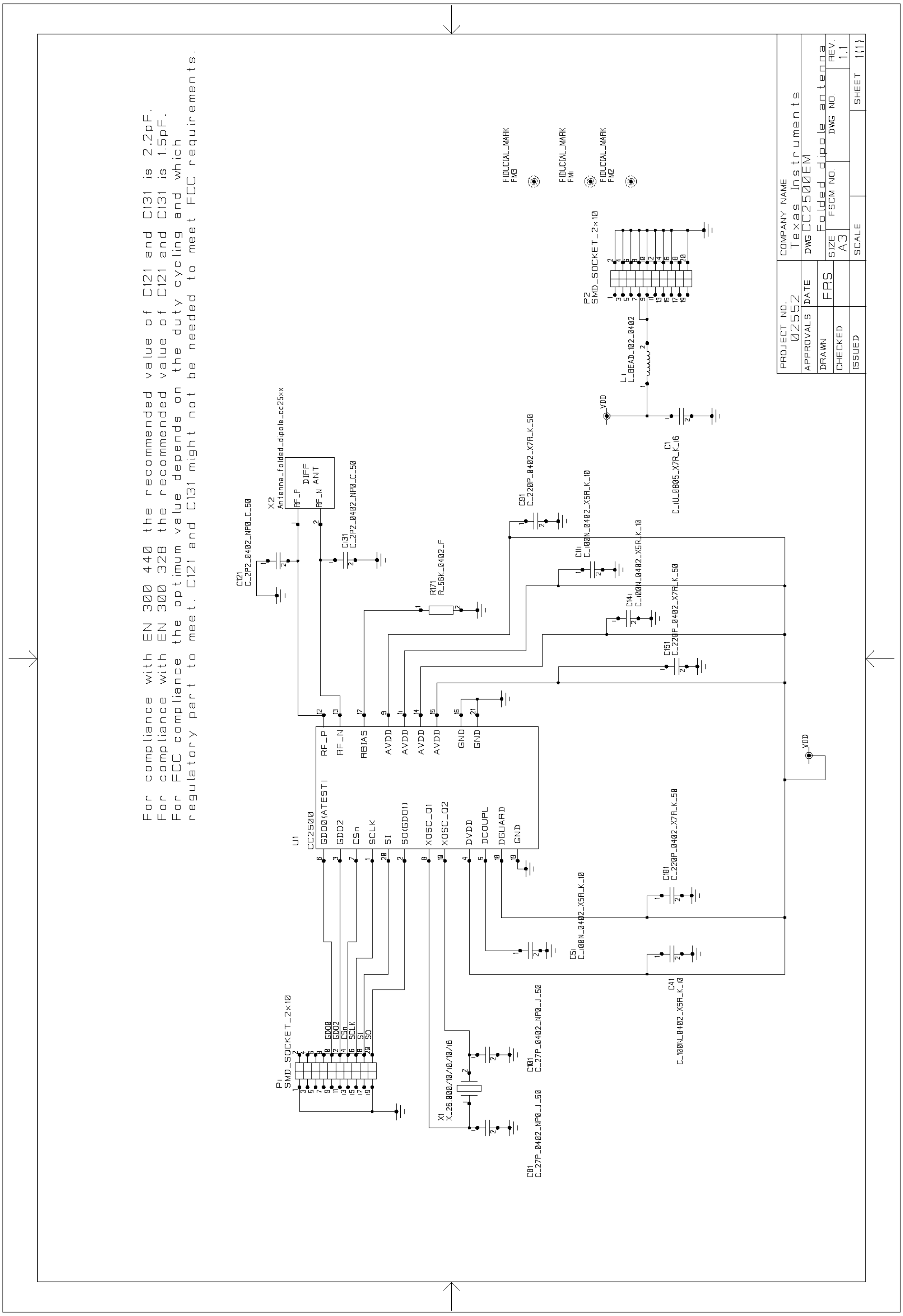


Figure 3: Schematic for CC2500 folded dipole reference design.

4 Results

All results presented in this chapter are based on measurements performed with the CC2500 Folded Dipole EM placed on SmartRF04EB.

4.1 Radiation pattern

Figure 4 shows how to relate all the radiation patterns in this section to the orientation of the antenna. The radiation patterns were measured with 0 dBm output power.

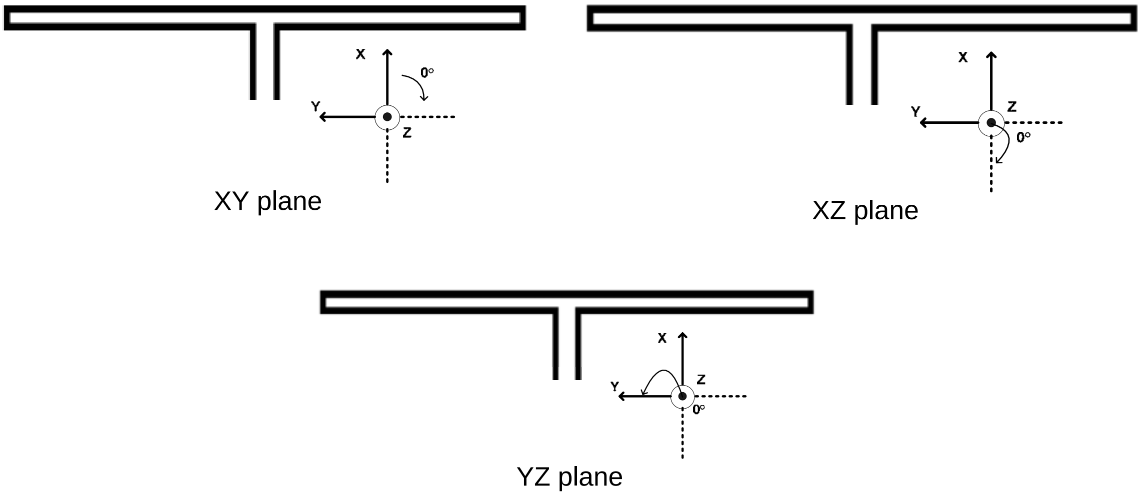


Figure 4: How to relate the antenna to the radiation patterns.

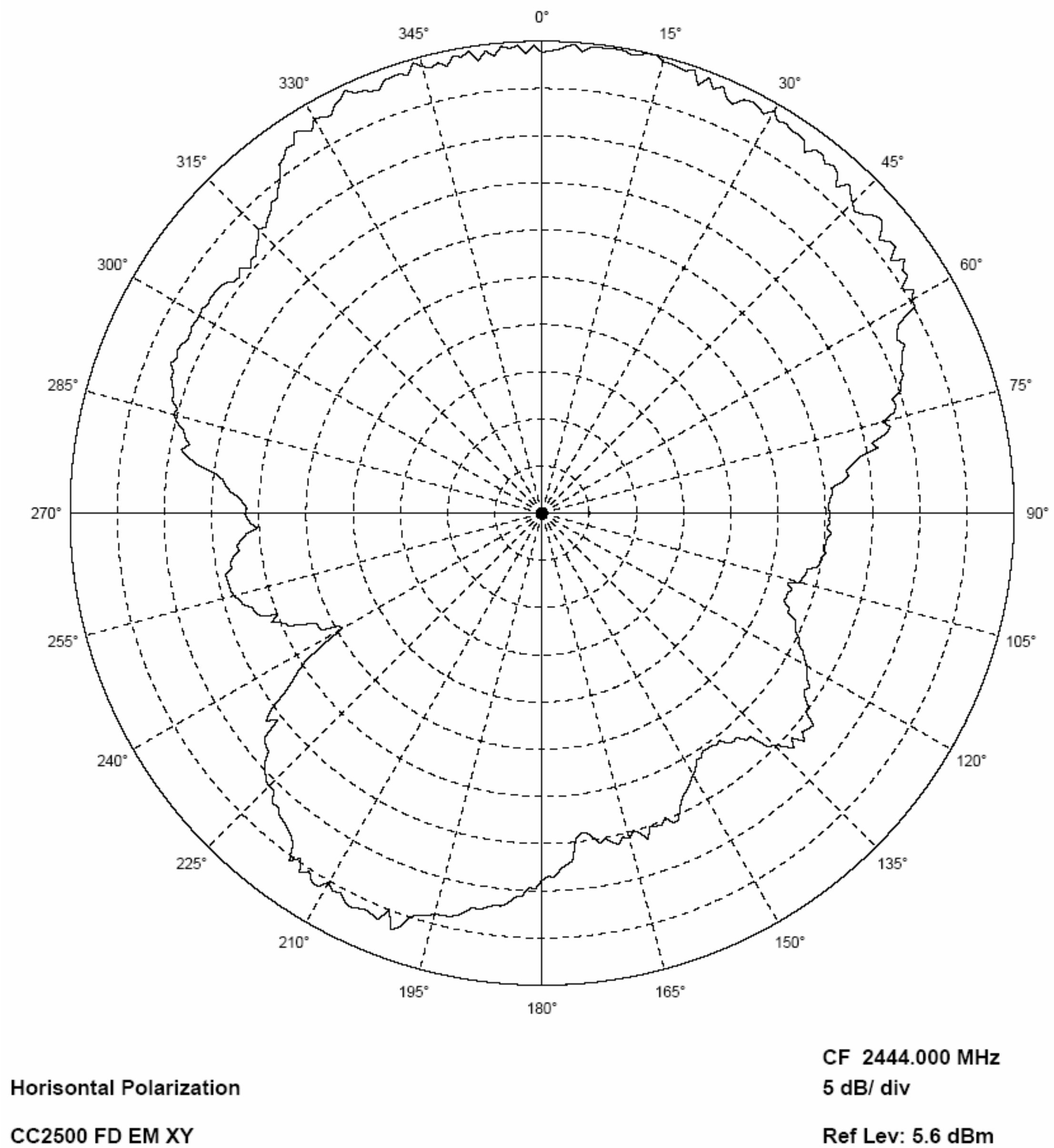


Figure 5: XY plane horizontal polarization.

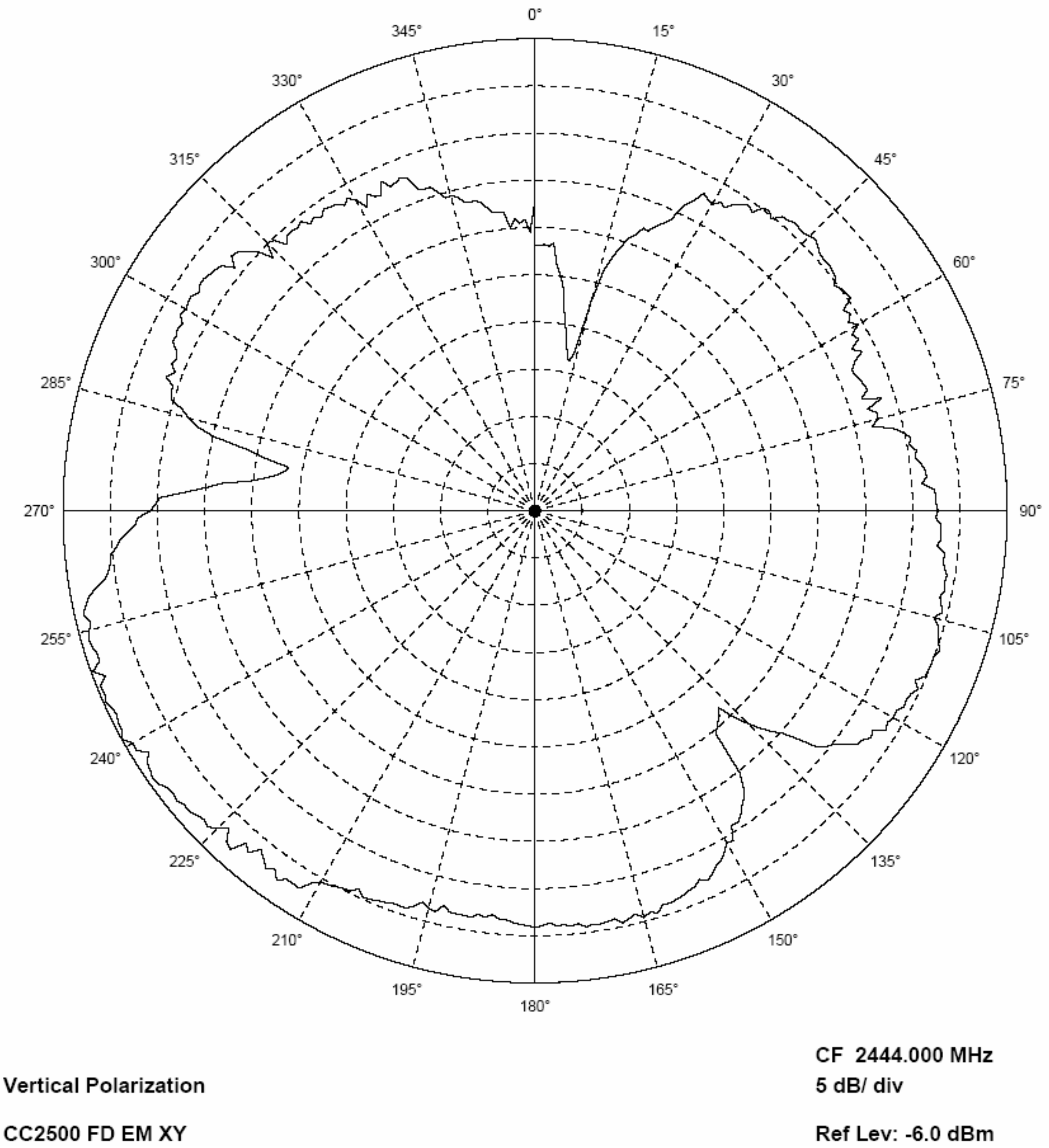
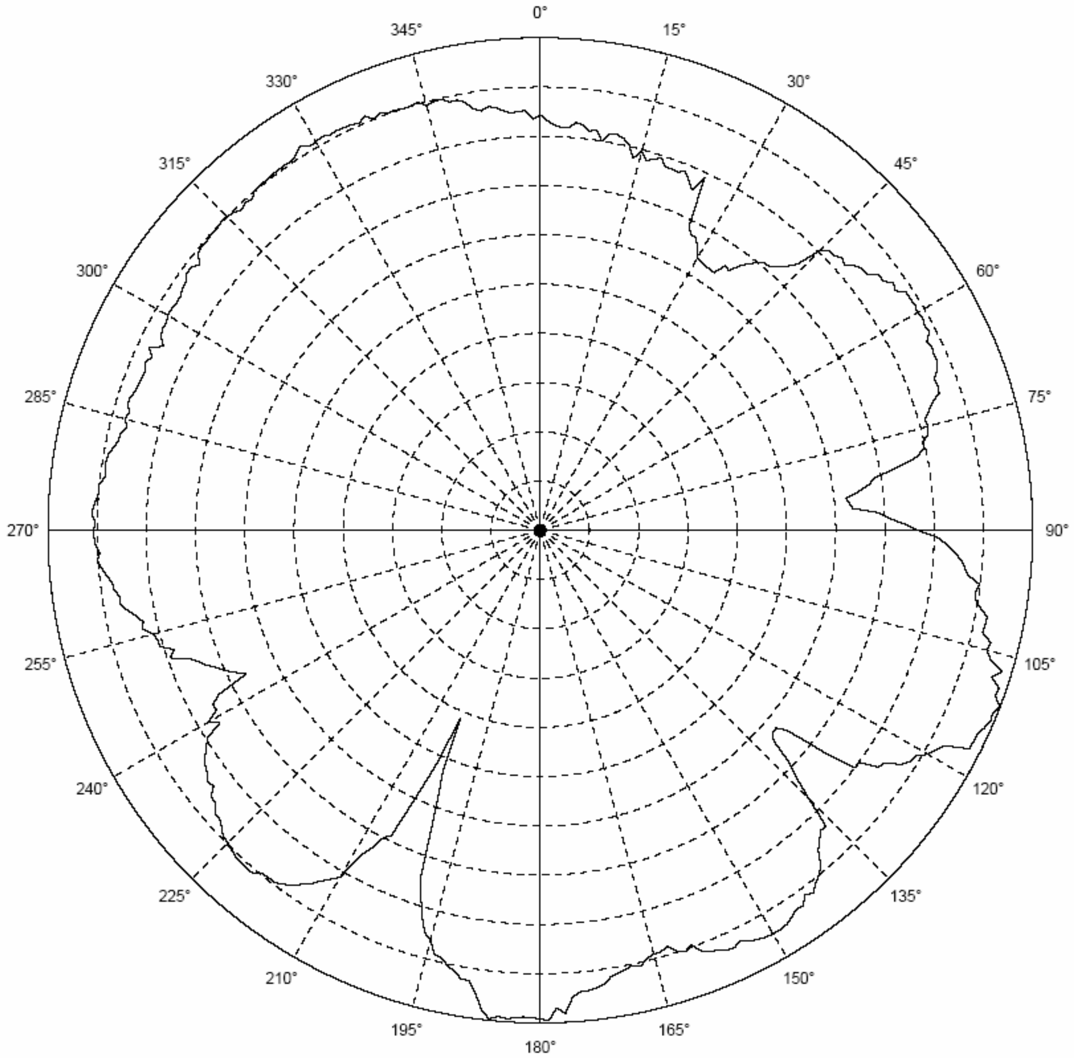


Figure 6: XY plane vertical polarization.



Horisontal Polarization

CC2500 FD EM XZ

CF 2444.000 MHz
5 dB/ div

Ref Lev: -7.4 dBm

Figure 7: XZ plane horizontal polarization.

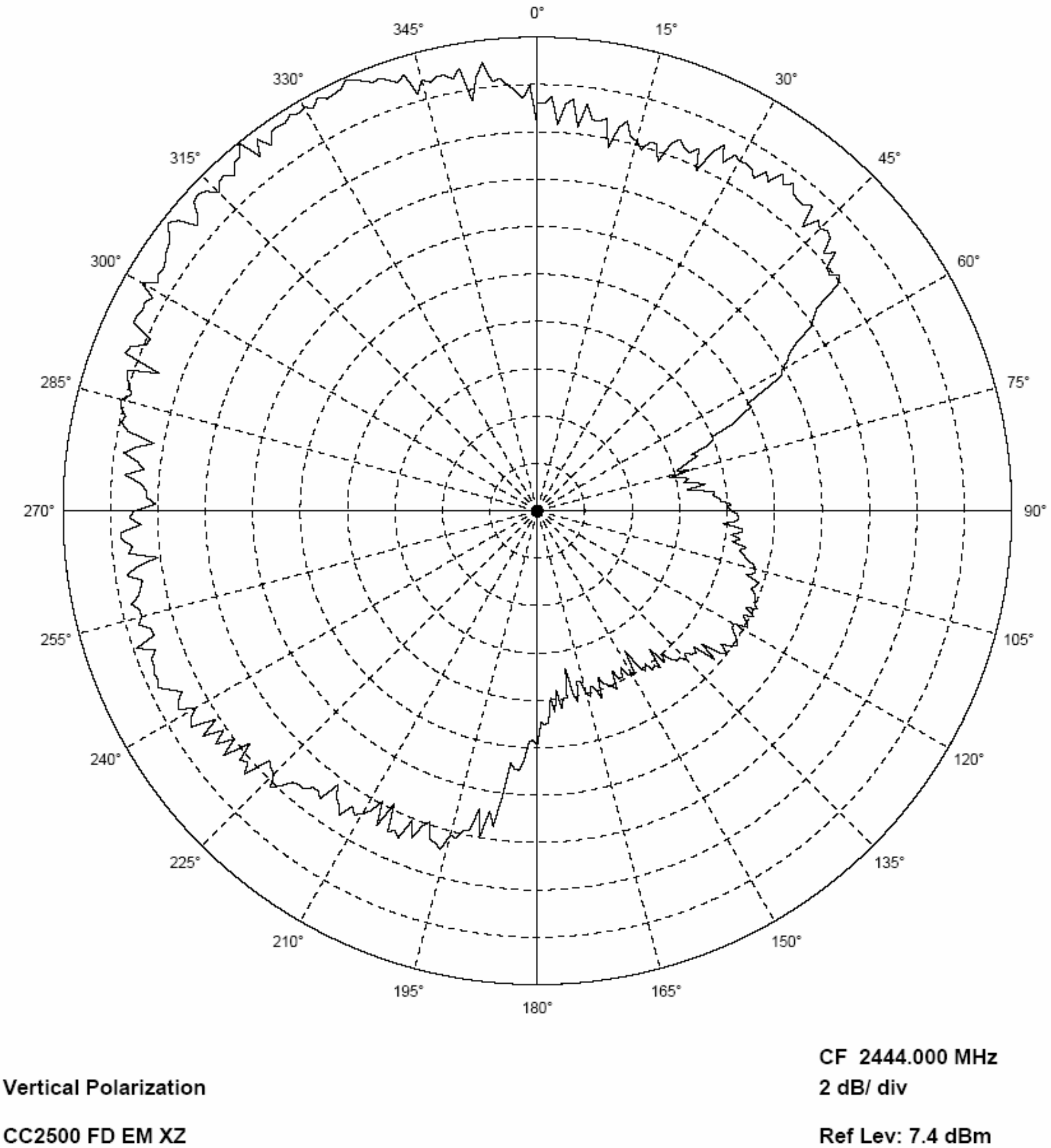


Figure 8: XZ plane vertical polarization.

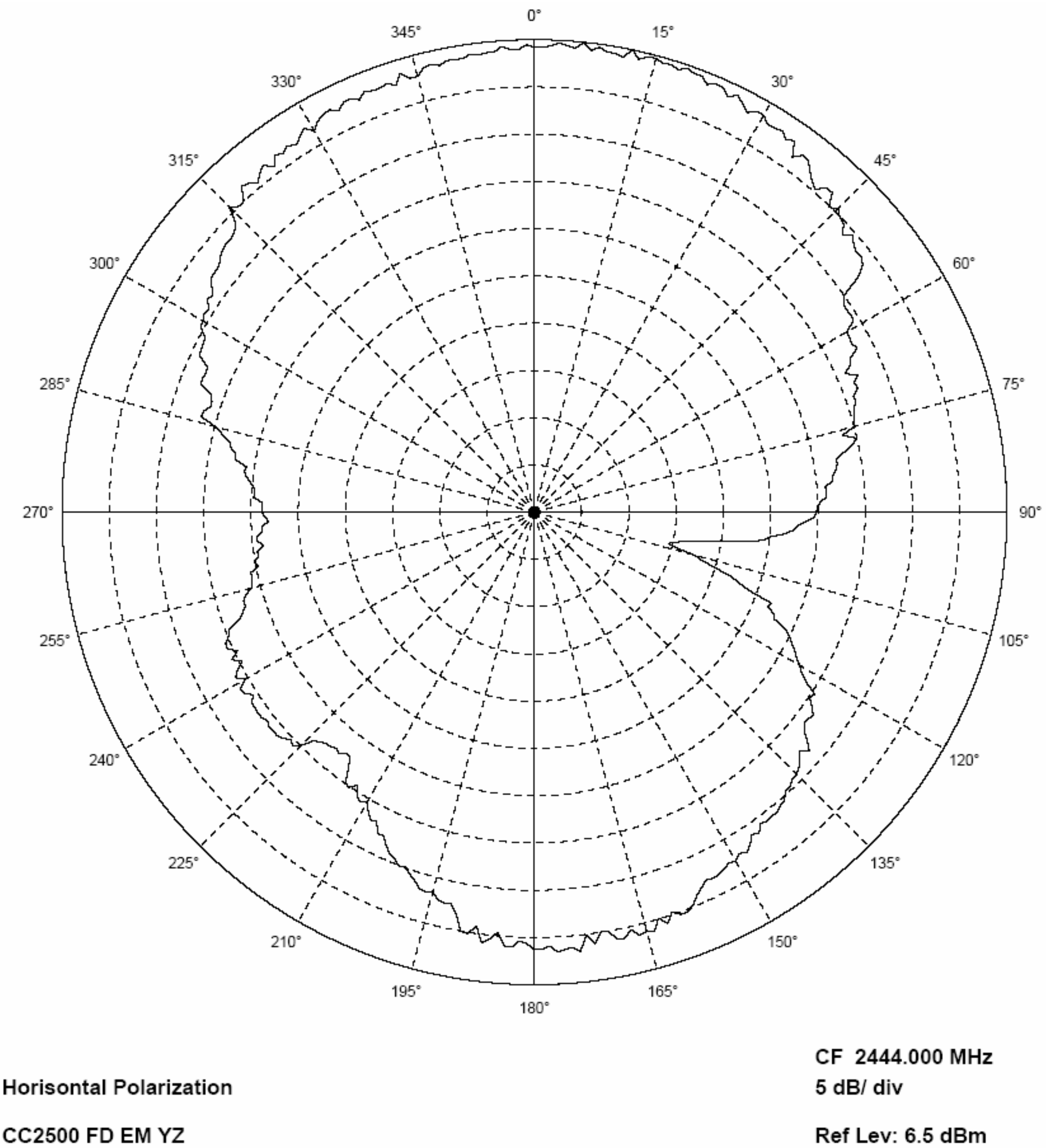


Figure 9: YZ plane horizontal polarization.

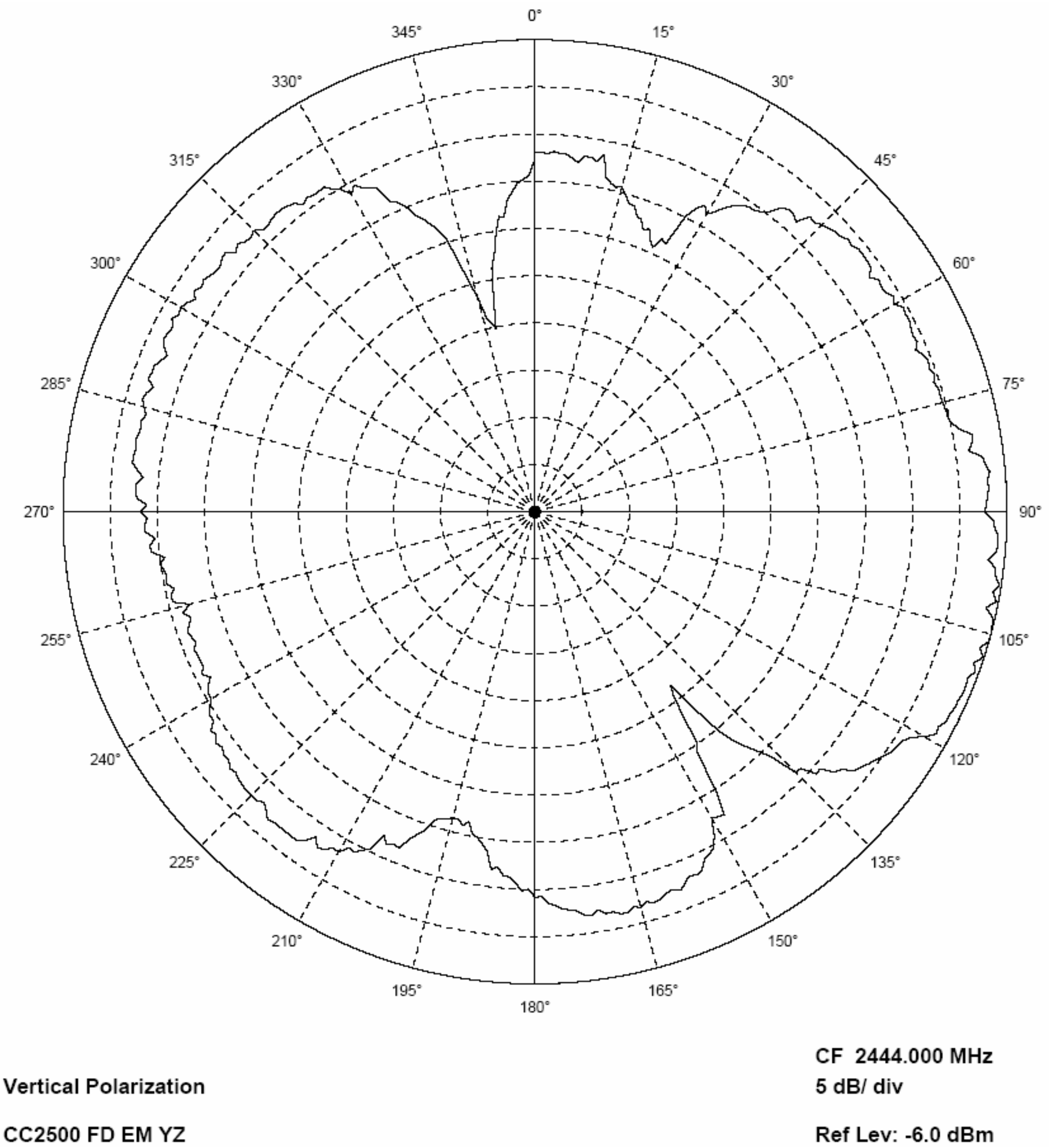


Figure 10: YZ plane vertical polarization.

4.2 Bandwidth

The bandwidth of the antenna was measured by using a simple test program. This program steps a carrier programmed for 0 dBm output power in 1 MHz step, from 2.3 GHz to 2.8 GHz. The measurement is performed with 0° in Figure 5 directed towards a horizontal polarized receiving antenna. Figure 11 shows that the folded dipole ensures more than 0 dBm output power across the whole 2.4 GHz ISM band at 0° in the XY plane.

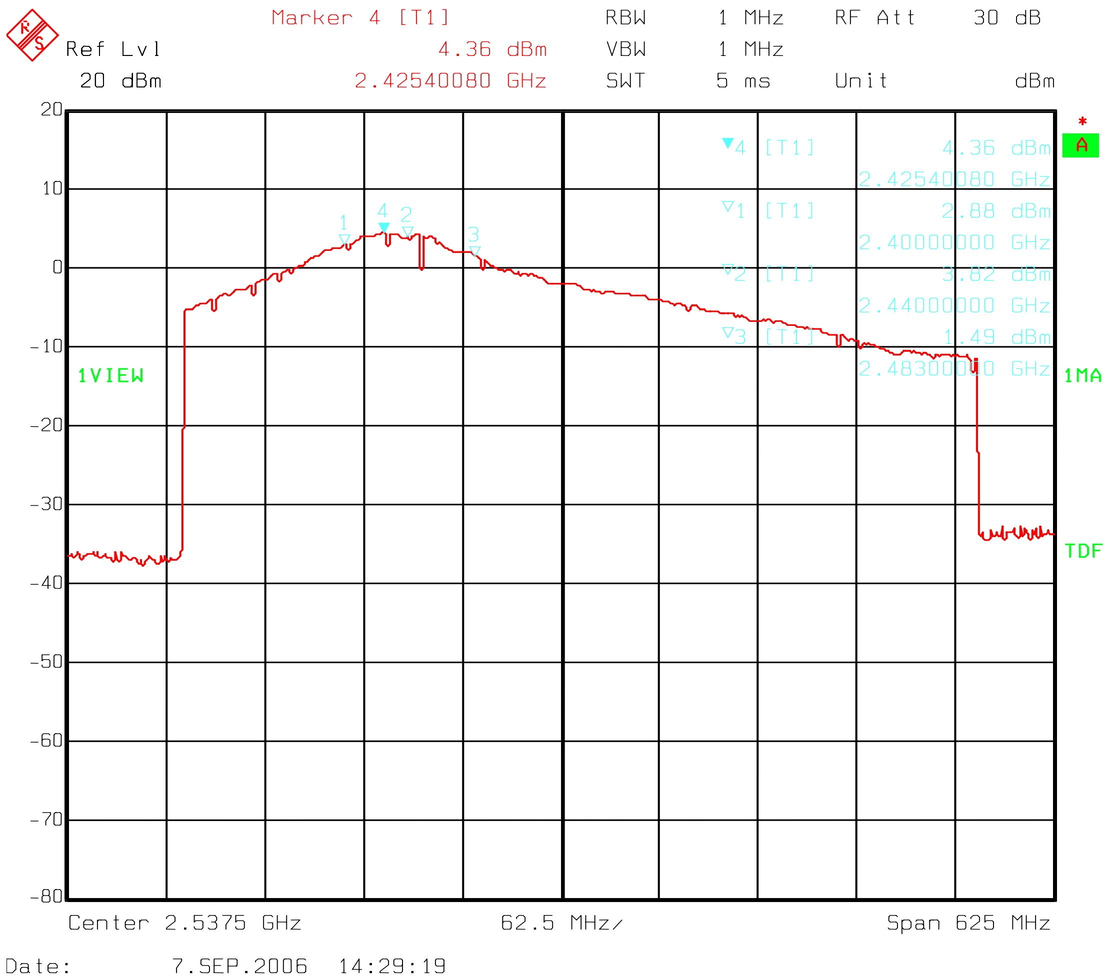


Figure 11: Bandwidth of folded dipole antenna.

4.3 Spurious and harmonic emission

Table 2 shows measured output power and harmonic emission for different power settings between +1 dBm and -6 dBm. These measurements were performed with C121 and C131 as 1.5 pF.

Programmed output power		Measured output power and harmonic emission			
		2.44 GHz	4.88 GHz	7.32 GHz	9.76 GHz
+1 dBm	FF	100.0 dBμV/m	48.3 dBμV/m	49.3 dBμV/m	37 dBμV/m
0 dBm	FE	98.4 dBμV/m	44.4 dBμV/m	47.3 dBμV/m	Below noise floor
-1 dBm	F9	97.4 dBμV/m	43.7 dBμV/m	Below noise floor	Below noise floor
-2 dBm	BB	96.4 dBμV/m	48.3 dBμV/m	Below noise floor	Below noise floor
-4 dBm	A9	94.1 dBμV/m	44.1 dBμV/m	Below noise floor	Below noise floor
-6 dBm	7F	92.0 dBμV/m	46.8 dBμV/m	Below noise floor	Below noise floor

Table 2: Measured output power and harmonic emission.

The field strength values from Table 2 can be converted into an Effective Isotropic Radiated Power (EIRP) using the following formula:

$$P_{EIRP} = 10\log\left(1000\frac{E^2 r^2}{30}\right)[dBm]$$

Where E is the field strength in V/m and r is the distance in m between the transmitter and receiving antenna. The results in Table 2 are based on measurements with 3 meters between the CC2500 Folded Dipole EM and the receiving antenna.

5 Conclusion

Table 2 shows that the folded dipole antenna described in this document can meet both ETSI and FCC regulations. When using +1 dBm output power, either duty cycling or frequency hopping must be used to ensure compliance with FCC limits. For more information about SRD regulations for license free transceiver operation in the 2.4 GHz ISM band please download Application Note AN032 from:
http://focus.ti.com/analog/docs/techdocsabstract.tsp?familyId=368&abstractName=swra060

Table 3 lists the properties of the folded dipole antenna. The range test was performed outdoors with free line of sight (LOS). The range was measured with 250 kbps and 1% PER without C121 and C131 mounted.

Gain in XY plane	5.6 dB
Gain in XZ plane	7.4 dB
Gain in YZ plane	6.5 dB
LOS Range	300 m
Antenna size	46 x 9 mm

Table 3: Folded dipole properties.

6 General Information

6.1 Document History

Revision	Date	Description/Changes
SWRA118	2006.12.06	Initial release.

7 Important Notice

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