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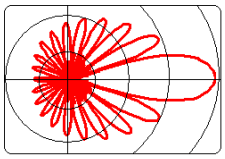


RF Design Studios
206 Hemingford Circle, Simpsonville, SC, 29681
864.676.1905 http://www.rfdesignstudios.com

EM4325 Reference Tag Design Documentation

Customer: **EM Microelectronic**
5475 Mark Dabling Blvd, Suite 200
Colorado Springs, CO, 78746

1.0 Introduction

This report outlines the physical and electrical characteristics of the EM Microelectronic EM4325 Reference RFID Tag Design. The tag was fabricated using standard FR4 PCB assembly processes using the TSSOP8 IC package. Section 2.0 describes aspects of the design for the antenna and supporting circuitry. Section 2.1 describes the theoretical RF performance based on EM (Moment Method) modeling. Section 2.2 displays the measured RF performance with a comparison between theoretical and actual performance outlined in Section 2.3. Fabrication details are contained in Section 3.0 with supporting information (Bill of Materials, Gerber file references, schematic diagram) in the Appendix.

2.0 Antenna Design

The EM4325 RFID IC has an RF sensitivity of -28 dBm (BAP mode sensitivity = 01) with an input impedance of 7.6 – j114 ohms (1717Ω // 1.52 pF) at 915 MHz. A folded dipole design was chosen for providing global performance from 865 to 928 MHz. An RF choke (parallel LC combination) with a resonant frequency of 900 MHz was implemented to isolate the negative terminal of the battery from the antenna connected to pin 8 of the IC. A quarter wavelength transmission line with a series 10 nH inductor was used to isolate the positive terminal of battery. The optimized antenna design is shown in Figure 1.0.

This design provides the capability for continuous “Tamper” and “Temp” monitoring with LED visual alarm indicators and is a real-world implementation of the circuit on page 6 of the EM4325 datasheet. The header (J1) is optional and was implemented for monitoring battery current consumption. The SPST switch (S1) simulates a low or high impedance path for demonstrating the “Tamper” detection feature.

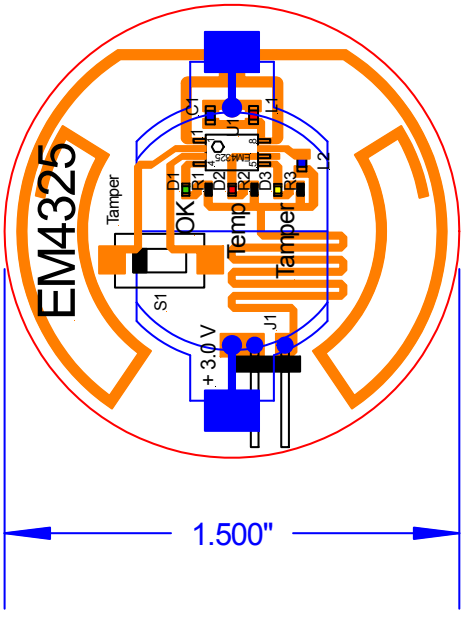


Figure 1.0, “EM4325 Antenna Geometry.”

2.1 Theoretical Performance

The antenna design in Figure 1.0 was initially modeled and optimized using Mentor Graphics HyperLynx 3D Electromagnetics modeling software, formerly IE3D from Zeland software. The mismatch loss between the IC and antenna is shown in Figure 2.0, the

antenna impedance, both real and imaginary is shown in Figure 3.0. The radiation efficiency, shown is Figure 4.0 is 11% to 14% from 867 to 930 MHz.
The theoretical antenna impedance, directivity, and radiation efficiency data was collected for estimating the inlay sensitivity and read range. The results are displayed in Table 1.0. The estimated RF sensitivity is -18.6 to -17.7 dBm at 867 and 915 MHz respectively. The resulting read range using an FCC (NA) approved reader system (1 W, 6 dBi gain, CP reader antenna, 36 dBm EIRP) is 29.3' (8.9 m). The EU read range using a similar reader system with 0.5W of conducted power is 24.3' (7.4 m).

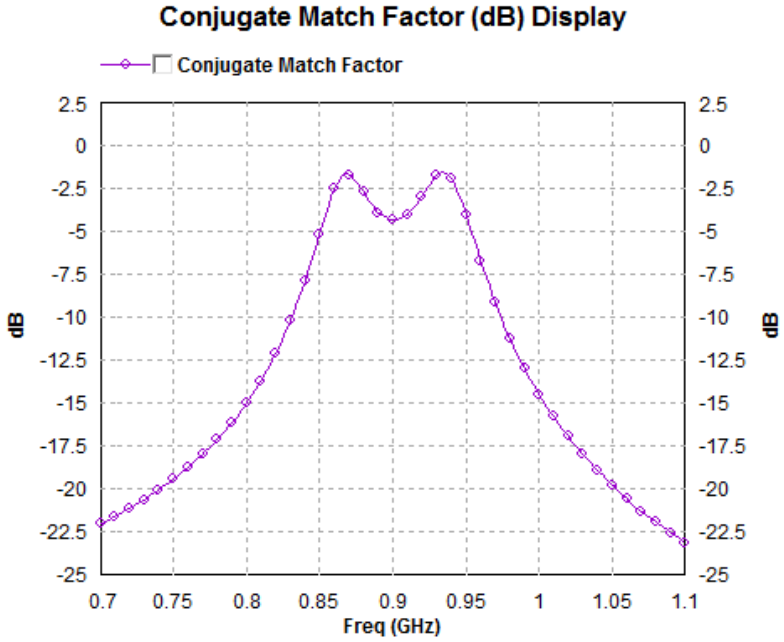


Figure 2.0, "Theoretical Impedance Mismatch Loss between EM4325 & Antenna."

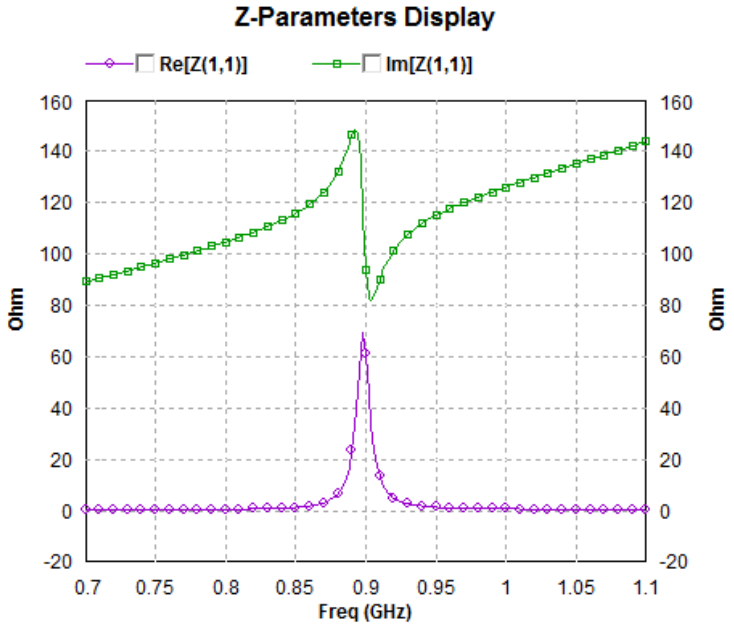


Figure 3.0, "Theoretical Antenna Impedance – Real and Imaginary."

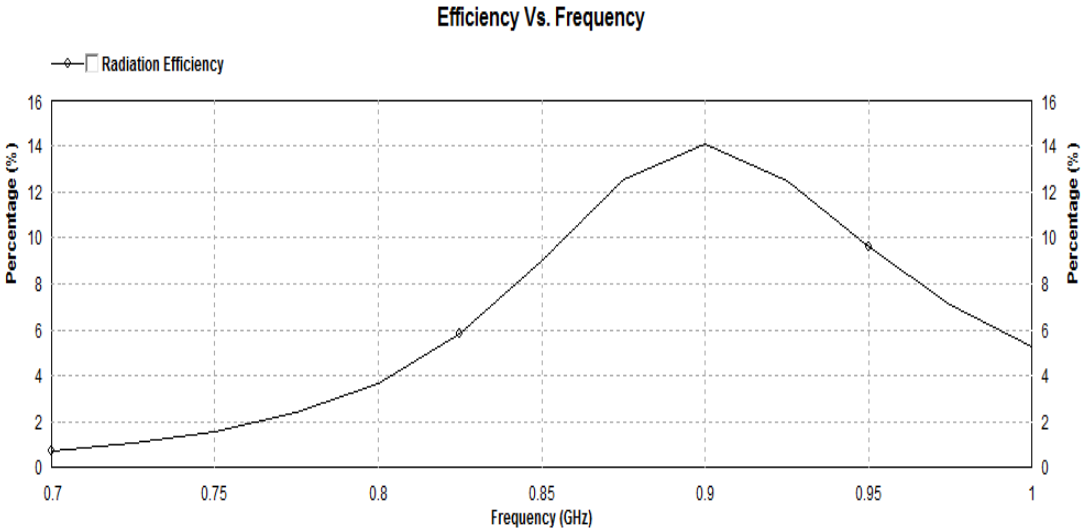


Figure 4.0, "Theoretical Antenna Efficiency."

Parameter	Frequency (MHz)	
	867	**915**
IC Sensitivity (dBm)	-28.0	-28.0
Mismatch Loss – CMF (dB)	1.75	3.5
Radiation Efficiency (%)	11.4	13.7
Radiation Efficiency Loss (dB)	9.4	8.6
Antenna Directivity (dBi)	1.7	1.8
Inlay Sensitivity (dBm)	-18.55	-17.7
Read Range (EU / NA)	24.3' (7.4 m)	29.3' (8.9 m)

Table 1.0, "Theoretical RF Sensitivity and Read Range."

2.2 Measured Performance

The RFID antenna was fabricated using the materials and assembly processes outlined in Section 3.0. The assembled inlays were characterized inside RF Design Studios LLC anechoic chamber, located in the RF laboratory. The measured RF sensitivity is shown in Figure 5.0.

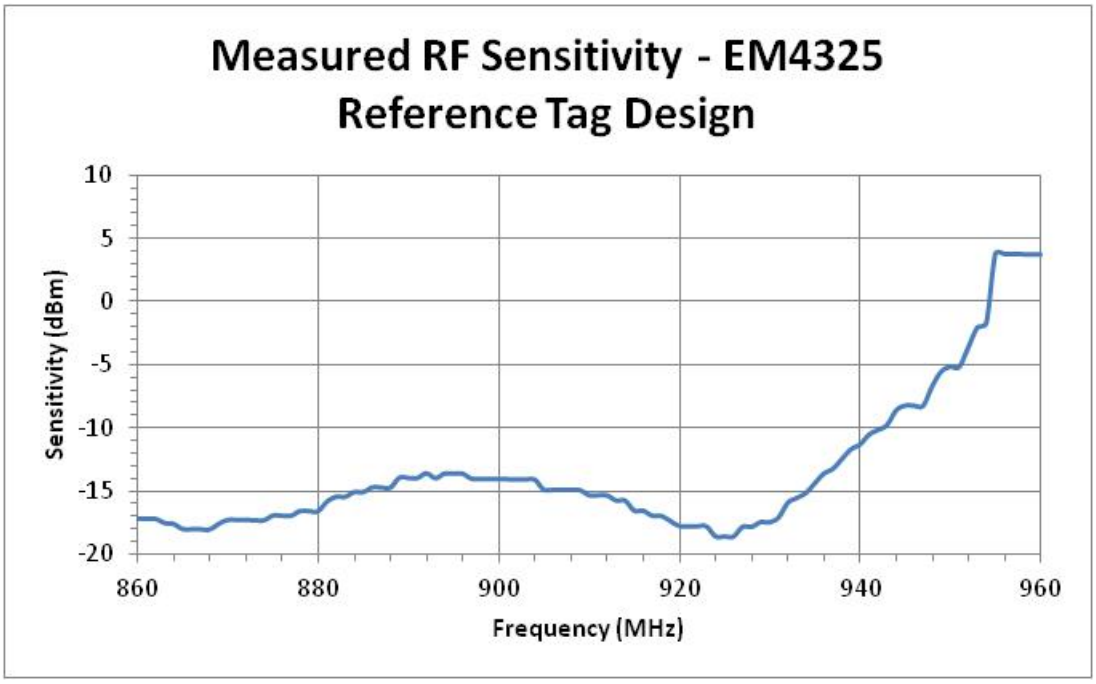


Figure 5.0, "Measured RF Sensitivity."

2.3 Comparison – Theory and Practice

The chart below displays the theoretical and measured RF sensitivity for the EM4325 Reference Tag.

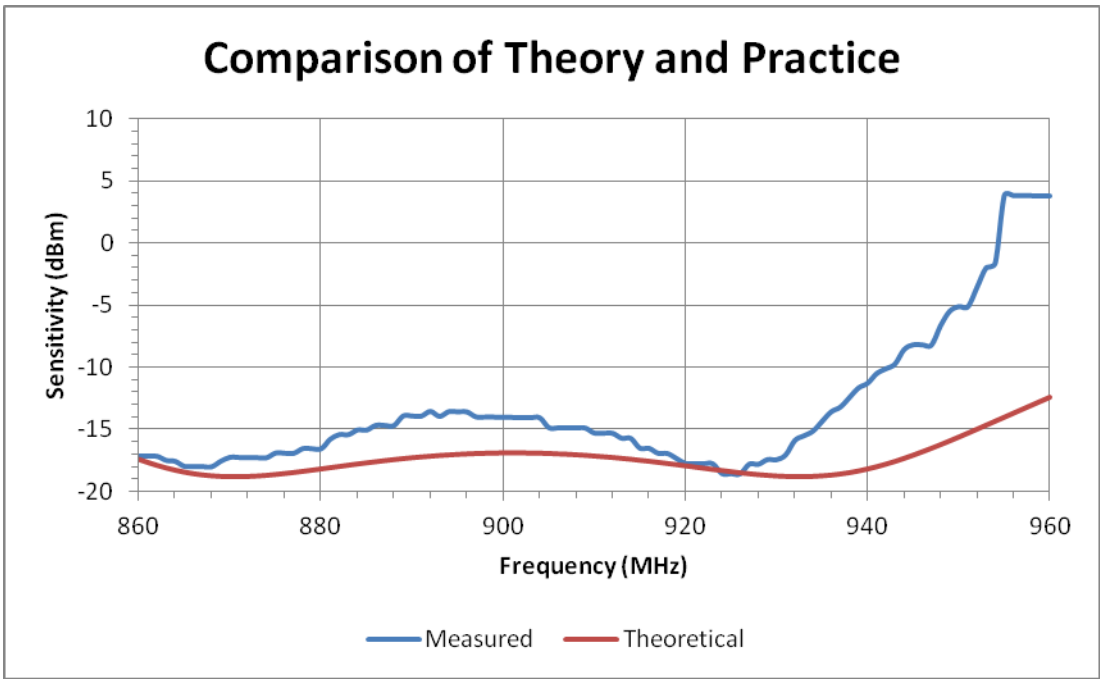


Figure 6.0, "Comparison of the Measured and Theoretical Tag Sensitivity."

3.0 Inlay Fabrication

The sections below contain the fabrication specifications for the EM4325 Reference RFID tag.

3.1 Antenna Fabrication

The antenna was fabricated using standard FR4 PCB processes. The files used for fabrication are referenced in Section 4.2 of the Appendix. The PCB fabrication specifications are shown in the Table below.

Parameter	Specification
PCB Material	PCB, er = 4.5, 0.010” thick
Soldermask Color	Green
Copper Thickness	½ oz (0.0007”)
PCB Size	1.500” (38.1 mm) Circular
Silkscreen Color	White
PCB Finish	Immersion Gold
Number of Layers	2
Number of Holes	4 x 0.034” plated through
Hole Tenting	Yes

Table 2.0, PCB Specifications.

4.0 Appendix

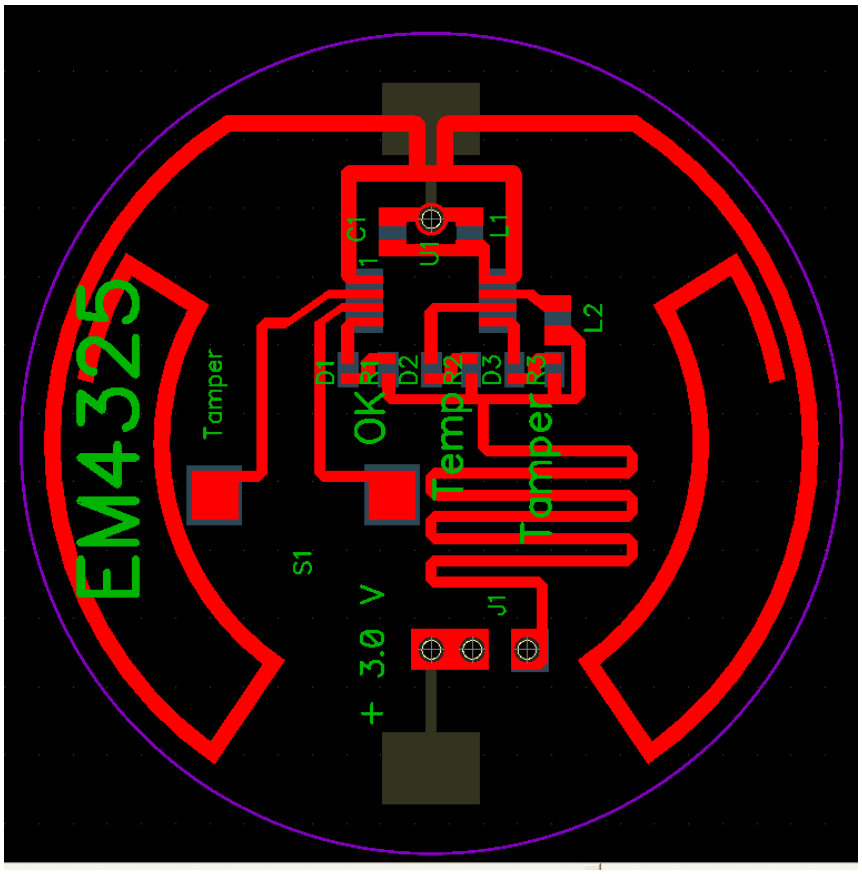
4.1 Bill of Materials

UHF38C-4325-002 Bill of Materials					
			Manufacturer		PCB
No	Description	Manufacturer	P/N	Quantity	Designator
1	RFID IC	EM Marin	EM4325V1TP8B+	1	U1
2	PCB	Cirexx Intl	UHF38C-4325-001	1	-
3	SPST SIP Switch	C&K Components	SDA01H1SBD	1	S1
4	SMT Inductor (10 nH +/- 2%) 0603	Murata	LQW18AN10NG00D	2	L1, L2
5	SMT Capacitor (3.0 pF +/- 0.1 pF) 0603	Johanson Technology	251R14S3R0BV4T	1	C1
6	SMT Resistor 1.2k 0402	Vishay Dale	CRCW04021K20FKED	1	R2
7	SMT Resistor 1.1k 0402	Vishay Dale	CRCW04021K10FKED	2	R1, R3
8	SMD Green Yellow LED 0402	Rohm	SML-P11MTT86	1	D1
9	SMD Red LED 0402	Rohm	SML-P11VTT86	1	D2
10	SMD Yellow LED 0402	Rohm	SML-P11YTT86	1	D3
11	Rt Angle Header Conn, 0.1" spacing, 2 Pin	FCI	68015-402HLF	1	J1
12	Shorting Jumper	Multicomp	SPC19806	1	-
13	Battery Holder	renata	SMTU2032-LF	1	-
14	Coin Cell Battery	renata	CR2032 MFR.TS	1	-

4.2 Gerber Files

The table below displays the Gerber file names and designated PCB layers.

Filename	Layer Designation
outline.gbr	pcb outline
topckt.gbr	top circuit artwork
topmask.gbr	top mask artwork
topsilk.gbr	top silkscreen/graphics artwork
botmask.gbr	bottom mask artwork
botckt.gbr	bottom circuit artwork
drill.drl	N/C drill file



4.3 Schematic Diagram

The figure below displays the schematic diagram for the EM4325 Reference Tag design.