RFID Receiver Antenna Project for 13.56 Mhz Band

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Abstract:

Radio Frequency Identification (RFID) is a promising technology that will be very useful in commercial areas in very near future. Enhancing the usefulness of barcodes, allowing product tracing and the effective usage in chip credit card technology is some of the current important usages of RFID in the world. The most significant advantages of RFID are its practical usage and cheap structure so that in near feature most of the new products will carry an RFID tag. However, the antenna dimensions of receivers is an obstacle for the practical usage because of the relatively high wavelength. In this project, an antenna with relatively small dimensions (30 x 60 mm), which is more appropriate for practical commercial usage, is designed and implemented to overcome this obstacle.

Introduction:

RFID technology is based on the wireless communication between small RFID tags on the product or card and the receiver in the possible usage area of these tags. Between various frequency bands that RFID works in, the most widely used frequency band is 13.56 Mhz in the high frequency (HF) band. Considering the wavelength in this frequency is 22.12 meters in the air and the wavelength is usually proportional with the antenna dimensions, designing small antennas for practical purposes is a challenging problem in the RFID technology. To overcome this problem, a practical and solid antenna is designed in this project with appropriate dimensions for the usage in commercial and manufacturing areas as a practical and cheap alternative. Therefore the antenna is implemented on a printed circuit board for the best solidity and performance.

The bandwidth requirement is very narrow in RFID such that only a band of ±7 kHz is required around the center frequency [1] so that there is not much concern for the bandwidth requirements of the antenna. Additionally there are some advantages of working in the HF band, the most significant ones are that it is easier to use lumped elements such as chip capacitors or resistors without facing with much deviation in their original values and that it is possible to use long transmission lines between the antenna and receiver without much signal loss which allows an easier implementation in shops and manufacturing plants.

<u>Design:</u>

The most effective antenna structure for such an antenna with small dimensions is a loop antenna on a PCB. Therefore the design of the antenna is based on a previously implemented loop antenna [2]. The printed board circuit is made of the dielectric material FR4 which has a thickness of 1.55 mm, a relative magnetic permeability of 1 and a relative electric permittivity of 4.55 . To design the antenna, the simulation tool Advanced Design System® (ADS) of Agilent Technologies is used. The designed antenna has a rectangular loop structure consisting of striped copper lines with curved corners and with three loops. The most outside loop has the dimensions 60 x 30 mm, the copper line of the loop has a width of 0.2 mm and the spacing between each loop is 2 mm. The designed antenna has the following mask in Figure 1:

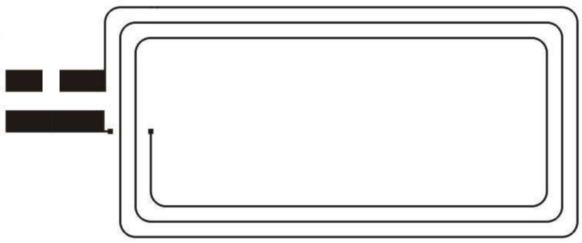
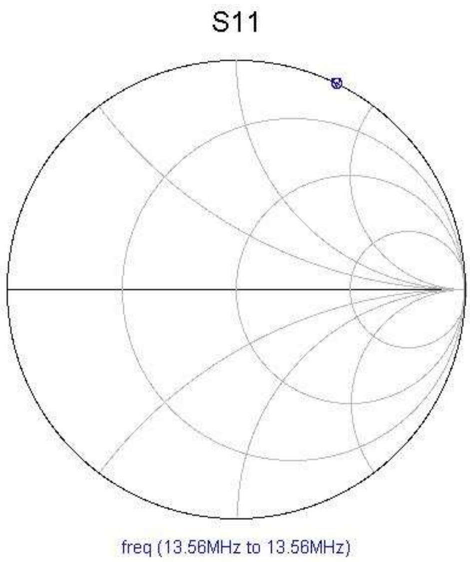


Figure 1: Antenna mask for PCB

The simulation results show that this loop has a pure inductivity of L = 939 nH with the result shown below in Figure 2.

Of course, this loop has to be matched to 50 Ohm and has to be tuned to radiate with a high Q value. Therefore a matching and resonator circuit is used which consists of a series capacitor, a parallel capacitor and a parallel resistor. The capacitances are used to match the inductive load and to build a resonator, the resistor is used to decrease the Q-value of the resonant circuit for a better antenna design. The designed circuit and the simulation results are shown in Figure 3.



freq	S(1,1)
13.56MHz	1.000 / 64.024

Figure 2: Simulation Results of the unmatched loop

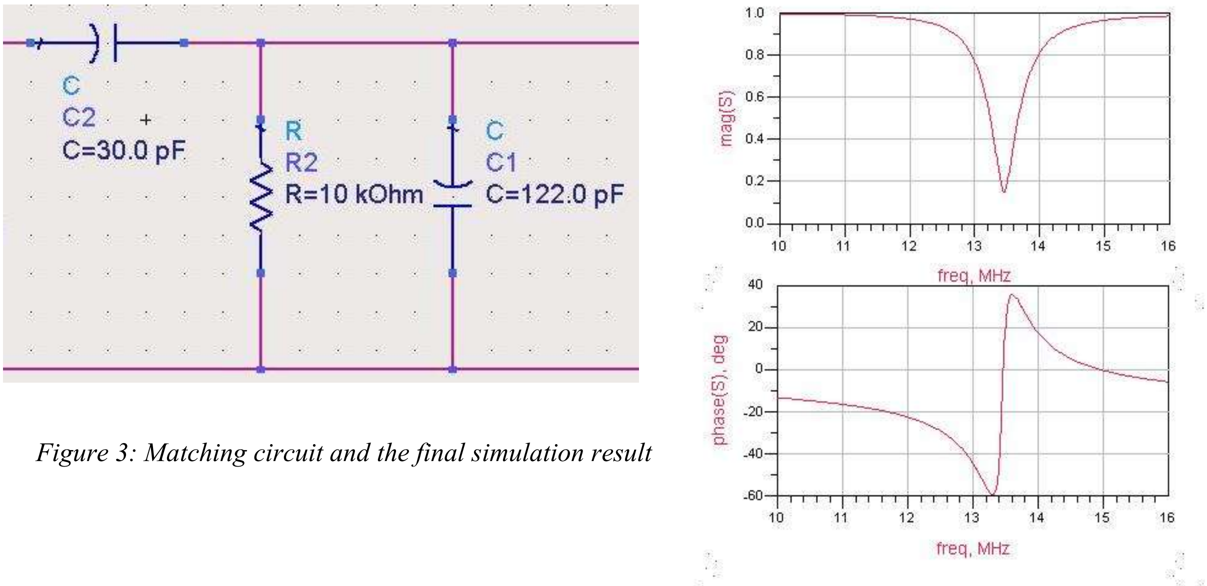


Figure 3: Matching circuit and the final simulation result

Implementation and Experimental Results:

The printed board circuit is prepared via PCB etching method. After the etching procedure, the following steps are done:

1) The inner loop is connected to the outer ground with a isolated wire of length 7 mm. After this step, the impedance of the loop showed that the circuit acts as a series L-R circuit with Ls = 924 nH and Rs = 2 Ohm. This shows that the simulation results are quite accurate.

2) The matching circuit is connected on the PCB board using chip capacitances and chip resistors and these are soldered to the PCB.

The complete circuit looks as in Figure 4.

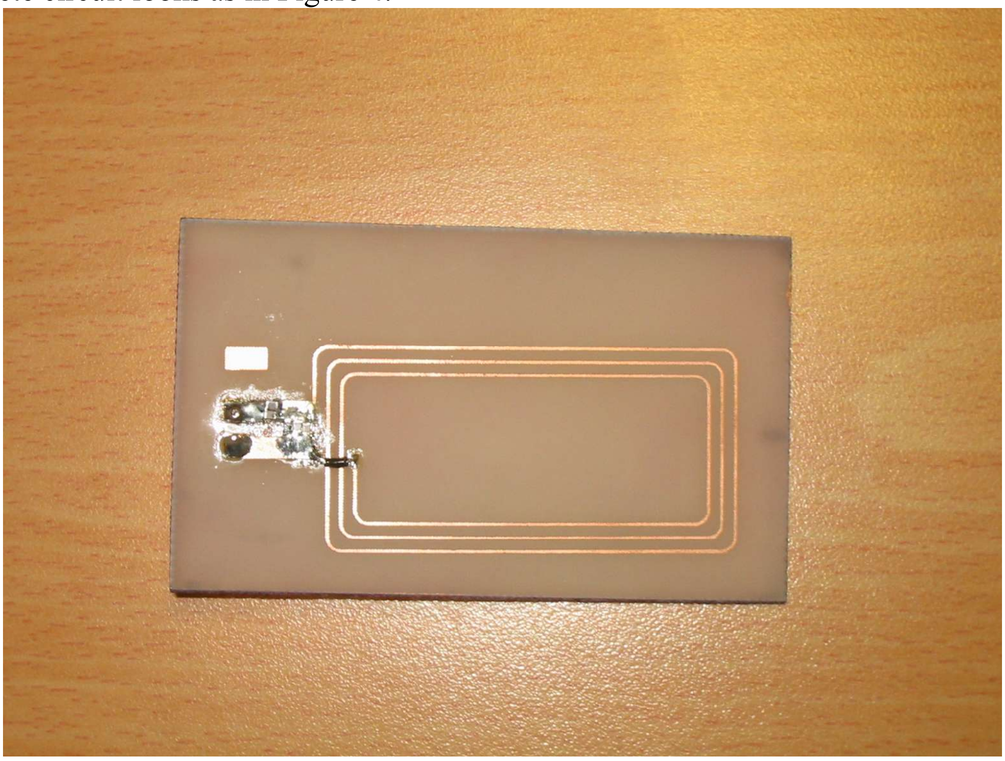


Figure 4: Complete Antenna

The resulting circuit has the measured impedance of Z = 38.85 – 26.11j Ohm with |Z| = 46.83 Ohm and θ = -33.8^{O}. This gives a S-parameter value of $|S_{11}|$ = 0.31 and a return loss value of RL =10.2dB. The circuit can also be modelled as series C-R circuit with values Cs = 451 pF and Rs = 38.85 Ohm. The experimental results are shown in Figure 5-7.

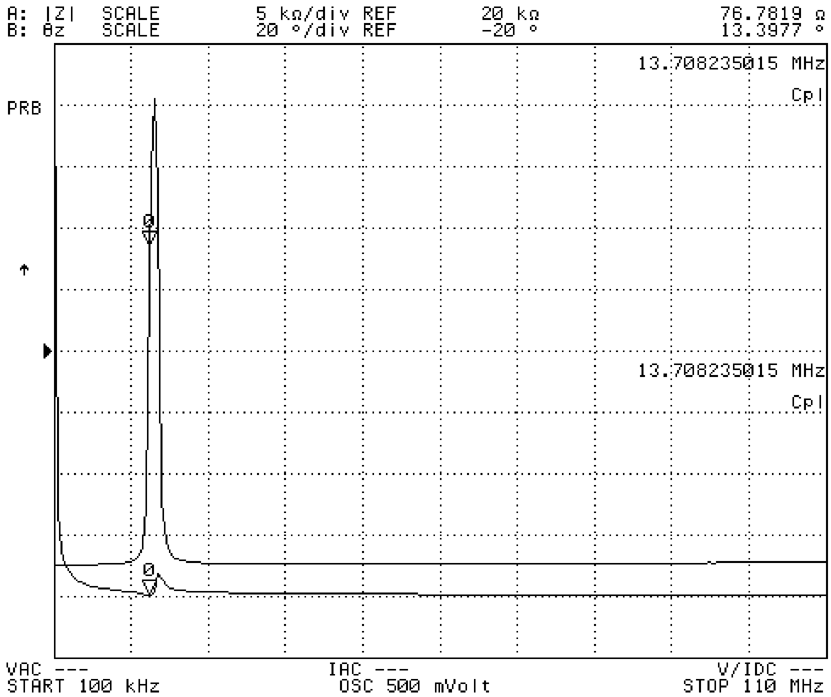


Figure 5: Wideband Impedance Curve

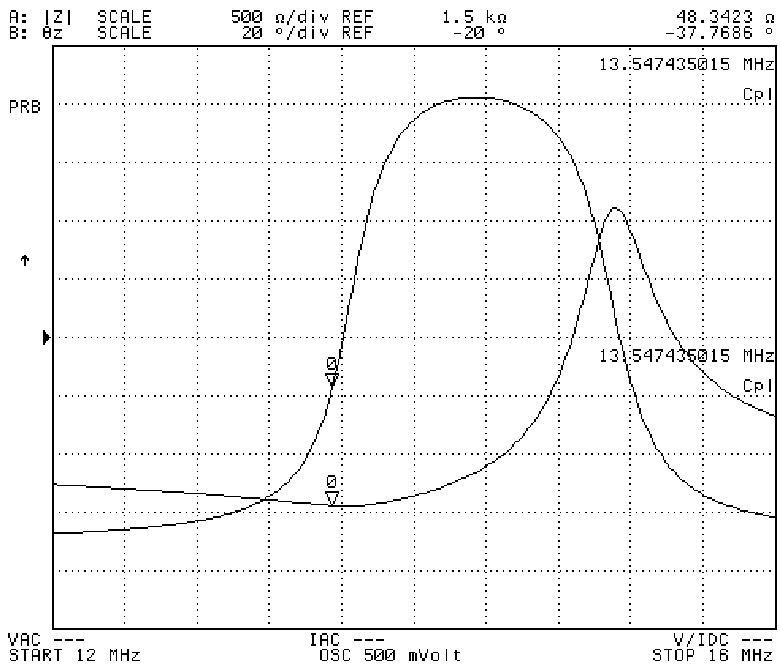


Figure 6: Impedance Curve Near f=13.56 Mhz

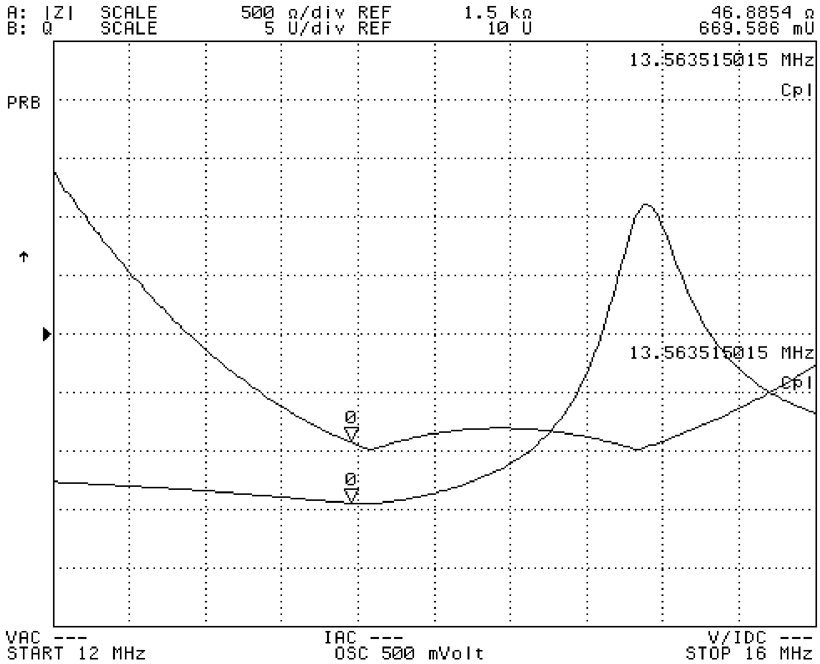


Figure 7: Q and |Z| curves near f=13.56 Mhz

Conclusion:

The resulting antenna has generally met our expectations at the beginning with a practical and solid structure and easy implementation. The sufficient return loss value shows that the design has been successful. The capacitive effect of the antenna in total shows that the matching is not very well adjusted; also the antenna radiation will only be effective in very short distances because the total antenna length is very short compared to the wavelength. However with finer tuning and enhancing the matching circuit, the antenna effectiveness can be improved dramatically. Another design improvement might be to change the one-sided design to a two sided PCB design to avoid the wire connection between the inner loop and ground connection for a more robust structure.

References:

[1] Youbok, Lee. "Antenna Circuit Design for RFID Applications" Microchip Technologies Inc. 2000.

[2] Goulbourne, J A. "HF Antenna Cookbook, Technical Application Report" Texas Instruments Inc. RFID Systems, Northampton. Jan, 2004.