# PIFA RFID Tag Antenna Design and Simulation using CST Microwave Studio

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**Abstract:** ***There has been an enormous upsurge in the popularity of RFID (Radio Frequency Identification) systems in recent years. The best example of this phenomenon is the contactless smart cards used as electronic tickets for public transport. Five years ago it was inconceivable that tens of millions of contactless tickets would now be in use. The possible fields of application for contactless identification systems have also multiplied recently. The passive RFID technology with no battery guarantees the lifelong functioning of the transponder and is also environmentally friendly. It works on the principle of Back-scattering and communication happens only when the Electromagnetic energy is being received from RFID reader to excite the tag [1]. RFID tag designed for UHF frequency working at 868 MHz is presented. This resonant frequency is chosen because it comes as Unlicensed European Frequency (Industrial Scientific Medical) band. A passive RFID tag is designed where adhesive copper is wrapped on both the sides (Front and Back side) of the PTFE (Polytetrafluoroethylene) substrate having relative permittivity εr = 2.08 like a PIFA (Planar inverted F antenna) structure.***

**Keywords:** Nested slot, PIFA, RFID, Tag

## 1. Introduction

The omnipresent barcode labels that triggered a revolution in identification systems some considerable time ago, are being found to be inadequate in an increasing number of cases. Barcodes are extremely cheap, but the problem with barcodes is their low storage capacity and that they cannot be reprogrammed. The technically optimal solution is the storage of data in a silicon chip. The most common form of electronic data-carrying devices is the smart card based upon a contact field (telephone smart card, bank cards etc). But, the mechanical contact used in the smart card is often impractical. A contactless transfer of data between the data-carrying device and its reader is more flexible. The power required to operate the electronic data-carrying device would also be transferred from the reader using contactless technology.

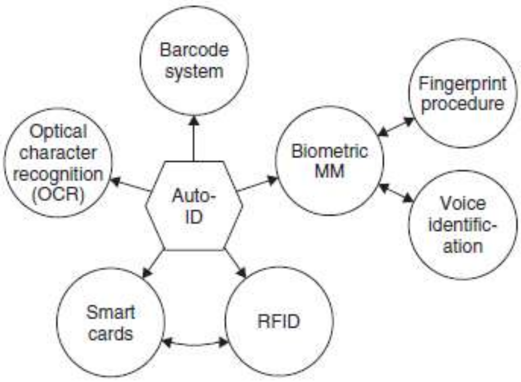


**Figure 1:** Mostly used Auto ID procedures [1]

Because of the procedures used for the transfer of power and data, contactless ID systems are called RFID systems (radio frequency identification). RFID systems can distinguish many different tags located in the same general area without human assistance. But still the research is required to reduce the cost of the system and design a simple system that is to handle. RFID technology is used for many applications such as collecting tolls without stopping on highways, managing traffic in crowded areas, gaining entrance to buildings and secured premises, automating parking system, controlling access of vehicles to gated communities, corporate campuses and airports, tracking library books. Due to these vast applications, many researchers are attracted towards doing the research in RFID technology and improvement in its new applications. The idea of passive tag as a sensor has been recently investigated for wireless observations of change of liquids and powders as well as some of human body pathologies [2,3].

## 2. Impedance Matching

Different methods have been proposed for antenna miniaturization. R. Shantha Selva Kumari proposed the Planar Inverted-F Antenna (PIFA) which is significantly miniaturized using slow wave structures obtained by periodically loading shunt capacitors. The effectiveness of circuit-based SWE for loaded and miniaturized antenna designs are verified by approximation. The experimental data shows that the electrical sizes of the loaded (with matching) and unloaded PIFA are reduced nearly about thirty times [4]. To improve the gain and bandwidth, a matching circuit designed from filter design techniques is employed. The gain and impedance bandwidth, however, degrade can be overcomed by the employment of filter type matching network.

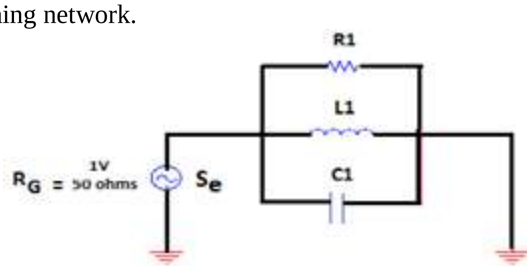


**Figure 2:** Equivalent electrical model of an antenna [5]


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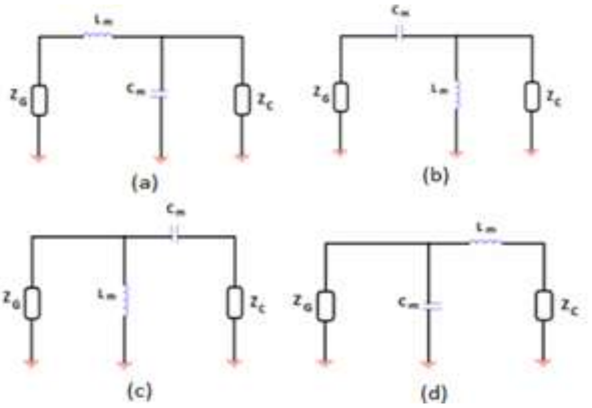


**Figure 3:** Configurations of L matching network [5]

In radio frequency domain, the impedance matching concept was related to match antenna with the aim to obtain desired characteristics such as the gain, the bandwidth and the resonance frequency without modifying the antenna geometry. In high frequency circuit design, impedance matching is about matching a part of the circuit to the other part and achieve maximum power transfer. The various techniques used for impedance matching are quarter wave impedance transformer, transmission line, L matching network in fig. 3.etc.

## 3. PIFA Antenna Configuration

Mustapha El Halaoui et. al. presents simulation of a compact planar inverted-F antenna (PIFA) with a radiating plate to the associated ground plane by a shorting plate and a FR-4 substrate between the ground plane and the radiating plate. The PIFA antenna is fed by a coaxial cable through a SMA connector. The geometry of the PIFA antenna designed is as shown in fig. 4.

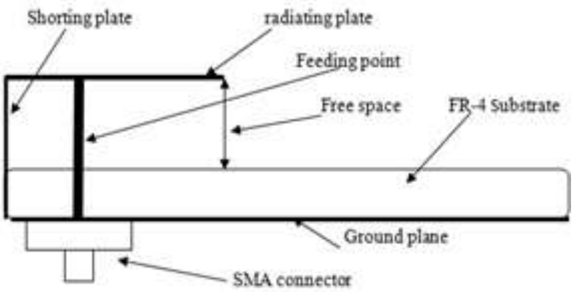


**Figure 4:** Geometry of PIFA antenna [6]

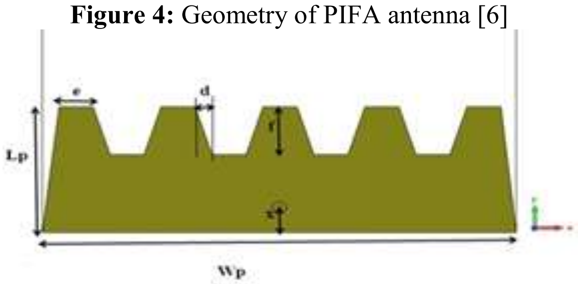


**Figure 5:** Top radiating plate geometry [6]

In practice, a substrate is generally just underneath the top plate, but this makes the top plate too heavy to be supported by the shorting and feeding plates. So, the shorting plate is placed under the top corner of the top plate.

## 4. Simulation Results For The Proposed Tag

A RFID tag prototype was designed and fabricated. The tag is matched to the microchip with impedance Zchip = 15-j170 ohms. The parameter size in mm for the designed tag is as shown in the table 1.

**Table 1:** Designed tag dimensions in mm

| Sr. No. | Parameter | Value (mm) |
|---|---|---|
| 1 | Lg | 60 |
| 2 | Wg | 60 |
| 3 | W | 53 |
| 4 | L | 52.5 |
| 5 | t | 0.05 |
| 6 | S | 10 |
| 7 | Ld | 7.5 |
| 8 | hs | 4 |
| 9 | g | 1.5 |
| 10 | p | 14 |
| 11 | a1 | 9 |
| 12 | a2 | 3 |
| 13 | b | 5 |

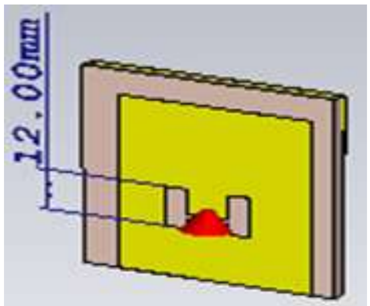
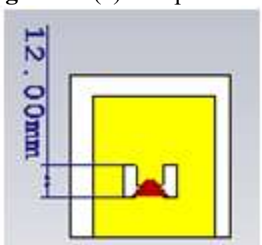


**Figure 6:** (a) Perspective view of the simulated RFID tag



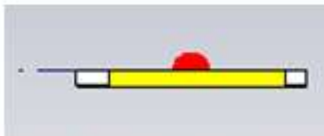


**Figure 6:** (b) Front view of the view of the simulated tag

**Figure 6:** (c) Bottom simulated tag

The figure 6 above shows the simulated results. Figure (a) shows the perspective view of the RFID tag antenna whereas figures (b) and (c) shows the front and bottom view of the antenna. The PIFA structure can be seen in the bottom view where the adhesive copper sheet is folded back. The impedance of the antenna can be varied by varying the values of parameters ‘p’ and ‘b’.

After simulation of the structure, fxing the dimensions and knowing the tag antenna impedance, the tag is fabricated (shown in fig. 7) manually at the hardware lab. The Teflon with εr = 2.08, tan δ = 0.0004 and thickness = 4 mm is used as the substrate for the tag. Adhesive Copper is used as the conductor.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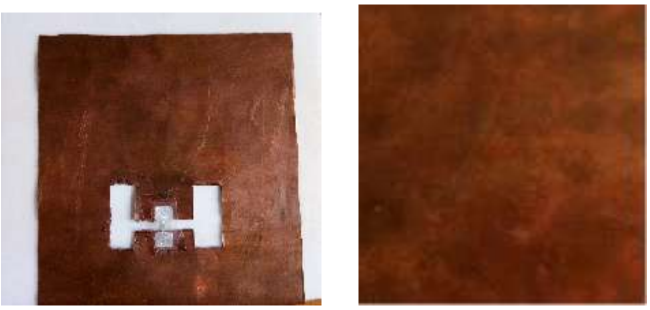

**Figure 7:** Front view and bottom view of fabricated tag

The tag is designed so as to resonate at 868 MHz which comes under ISM (Industrial – Scientific – Medical ) band. The Figures above shows the real and imaginary part of the designed tag which should be complex conjugate of the impedance of microchip.

The length L controlsthe antenna resonances and is about a quarter of wavelength, while the shape factor of the slots can be properly designed to achieve the required input inductive reactance to match the capacitive impedance of the RFID microchip[8].

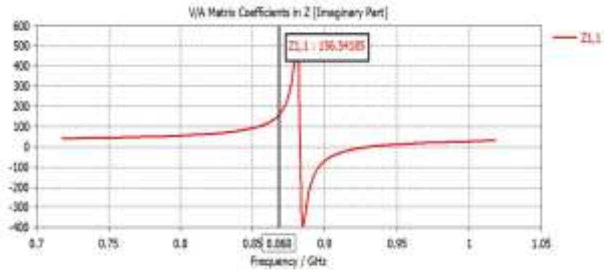


**Figure 8:** (a) Imaginary part of impedance

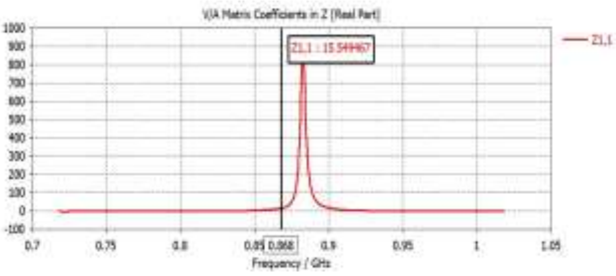


**Figure 8:** (b) Real part of impedance

**Table 2:** Variations in parameter ‘p’

| Parameter ‘p’ | Impedance (Z) | |
|---|---|---|
| | Real | Imaginary |
| 12 | 26.56 | 209.95 |
| 13 | 18.48 | 179.57 |
| 14 | 15.54 | 156.54 |
| 15 | 11.67 | 138.93 |
| 16 | 10.22 | 125.44 |

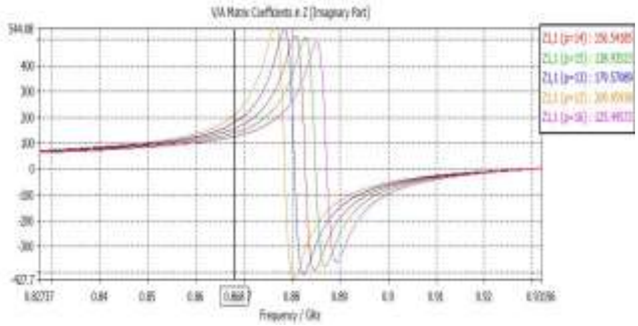


**Figure 8:** (c) Variations with parameter ‘p’ in Z imaginary for the designed tag

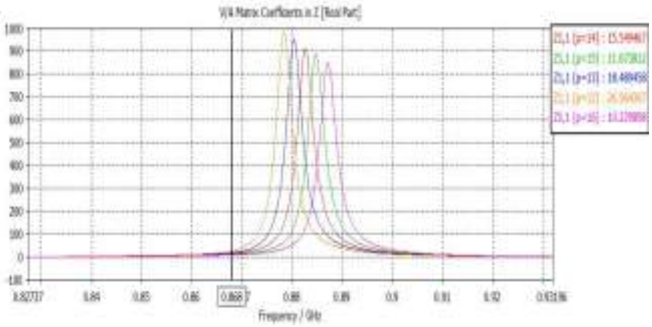


**Figure 8:** (d) Variations with parameter ‘p’ in Z real for the designed tag

The table 2 and results 8 (c) and (d) shows that as the parameter ‘p’ is increases i.e. distance between PIFA fold and the centre of centre slot or centre of microchip is increased then both the real and imaginary part of the impedance decreases. The results shown above are observed at 868 MHz.

**Table 3:** Variations in parameter ‘b’

| Parameter ‘b’ | Impedance (Z) | |
|---|---|---|
| | Real | Imaginary |
| 3 | 1.108 | 63.54 |
| 4 | 5.80 | 90.99 |
| 4.5 | 8.59 | 113.80 |
| 5 | 15.54 | 156.54 |

The figures 8 (e) and (f) shows that as the parameter ‘b’ is decreased i.e. distance between PIFA fold and the centre of centre slot or centre of microchip is decreased then both the real and imaginary part of the impedance decreases. Other parameters as ‘p’, ‘a1’ and ‘a2’ are kept constant and the observed frequency is 868 MHz.

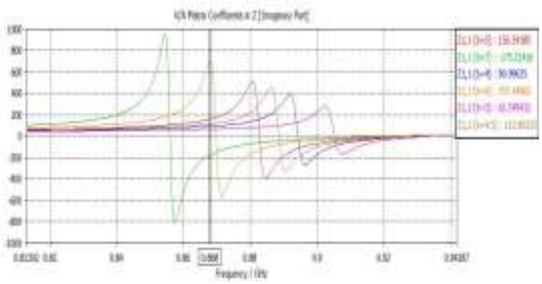

**Figure 8:** (e) Variations with parameter ‘b’ in Z imaginary for the designed tag


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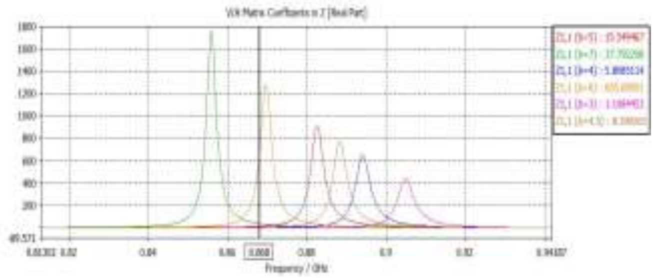

**Figure 8:** (f) Variations with parameter 'b' in Z real for the designed tag

## 5. Conclusion

The design considerations for RFID tag, Impedance matching and PIFA structures are discussed in this paper. Before fabricating the actual tag, the simulation of antenna is done to achieve the required impedance to be matched with the microchip. Finally the fabricated antenna with the same dimensions is presented. The presence of the ground plane, which separates the antenna from its location, this kind of tag is moreover suitable to environmental and body-centric applications.

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