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Design and Simulation of Planar Meander type Antenna for Passive UHF RFID

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Abstract: In this research work, passive radio frequency identification (RFID) for the European Telecommunications Standards Institute (ETSI) frequency band (865.7 MHz to 867.6 MHz) is discussed. In order to achieve desired band operation, the proposed antenna contains two rectangular sections, two chip pads and non-uniform meandered feed line section. The fundamental parameters such as return loss, radiation pattern and current distribution are obtained. A parametric study of proposed antenna has been carried out by varying some parameters. Simulation tool, based on method of moments has been used to analyze and optimize the antenna.

Keywords: Radio frequency identification (RFID), ETSI band, Ultra high frequency (UHF)

I. INTRODUCTION

Wireless technologies are now a part of modern life. Automatic identification (Auto ID) technology can identify a physical object automatically. Auto-ID technology is implemented in many ways such as voice identification, optical character recognition, barcodes and biometrics [1].Among these technologies, barcodes are the widely used. An ideal Auto ID technology should enable data transfer without human intervention. However, barcode technology has limitations in its data capability and requires line of sight. An Auto-ID technology which could overcome these limitations is RFID technology [2].

A radio frequency identification system is composed of three components: 1) an electronic data carrying device called RFID tag which is attached with an antenna. The tag is usually a microchip and contains the item data to be identified 2) a reader that communicates with the tag antenna by emitting electromagnetic waves 3) a host data processing system gives the information of the identified item and communicates with other remote data processing systems [2,3]. The RFID system [4] covers frequency bands of low-band range 100-500 KHz, high frequency 13.56 MHz, ultra high frequency (UHF) 860-960 MHz, and microwave band range 2.45 GHz and 5.8 GHz. The most highlighted applications that utilize the UHF and microwave band. A compact dual‐band tag antenna for RFID is presented in [5] that allow operation on both the HF (13.56MHz) and the UHF (919 MHz to 923MHz) band. In [6], a triple band printed dipole tag antenna is proposed for RFID. The triple‐ band printed dipole is designed to operate at 0.92GHz, 2.45 GHz and 5.8 GHz. A dual-band dipole antenna for RFID is presented in [7] that allow operation on both the UHF (860MHz to 960 MHz) and microwave (2.45GHz) band.

Various RFID antennas were reported in literature namely multi U-slot PIFA (Planar Inverted F-Antenna) structure [8], A loaded meander antenna design [9], shorted loop slot antenna and coil antenna [10], planar antennas for UHF [11] etc. At the same time, there exist many papers on practical analysis and design of particular classes of antennas used for other applications [12, 13].

In this paper, a planar antenna for passive UHF RFID is presented which covers ETSI frequency band (865.7MHz to 867.6MHz) which is the operating band of RFID application. The details of the proposed antenna design and the simulated results are presented and discussed next.

II. ANTENNA DESIGN

The structure of proposed Antenna is shown in Fig.1. Antenna consists of meandered line feed section and two rectangular sections. Two chip pads of size1.5mm × 2mm are included in the design for easy attachment of microchip. The separation gap between chip pads is 1 mm. In the proposed design, a meandered feed line section of width 1mm is used because meandering allow the antenna to be compact and to provide omnidirectional performance in the plane perpendicular to the axis. The proposed antenna is the most suitable antenna for use in the design because it possesses the advantages of a size reduction and a simple configuration. The total size of the proposed antenna is 63.9 mm x 62.8 mm. The size of rectangular section and meandered feed sections are adjusted to obtain optimum bandwidth. To obtain the optimal parameters of the proposed antenna for RFID application, IE3D, full-wave commercial EM software that can simulate a finite substrate and a finite ground structure, is used. By properly adjusting the dimension of antenna and feeding structure the characteristics of the proposed antenna is improved.

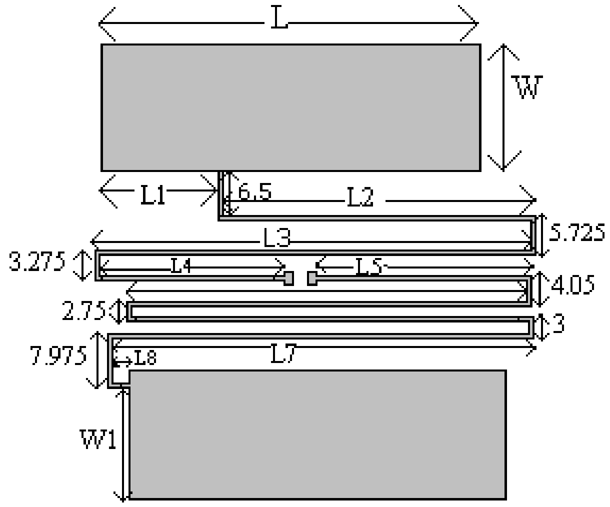

Figure. 1: Geometry of proposed ETSI band antenna

The optimized dimensions of antenna are set as follows:

Table 1: Parameters of the proposed ETSI frequency band antenna

Parameter	Dimensions (in mm)
L	55.90
W	18.725
L_1	17.225
L_2	46.175
L_3	64.3
L_4	28.3
L_5	31.7
L_6	59.2
L_7	62.225
L_8	3
W_1	16.775

With the aid of simulation by IE3D Simulator which is based on the method of moment (MOM), the antenna has been optimized. The details of simulated performance are described briefly in next section.

III. SIMULATION RESULTS AND DISCUSSIONS

The design evolution of the proposed antenna and its corresponding simulated return losses are presented in Fig. 2. It shows the simulated results of the proposed optimized antenna, which are in a good agreement. The band has a -10 dB impedance bandwidth of 3.6 MHz (865.3MHz - 868.9MHz) for the simulated results.

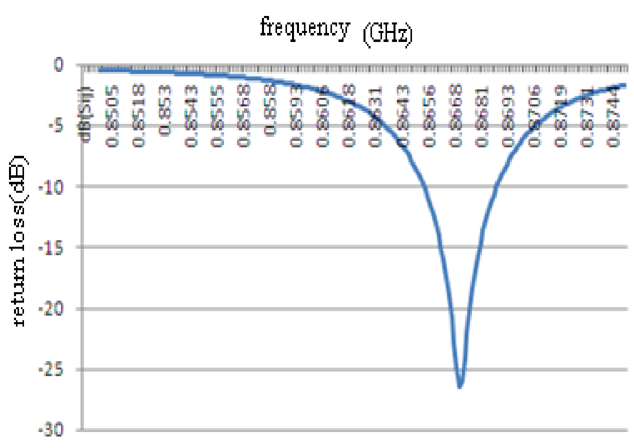

Figure. 2: Return loss of proposed ETSI band antenna

It has been examined that proposed design covers the ETSI frequency band from 865.7MHz -867.6MHz.

Fig. 3 shows the VSWR of proposed ETSI frequency band antenna. VSWR of 1.1 is obtained at 0.867 GHz.

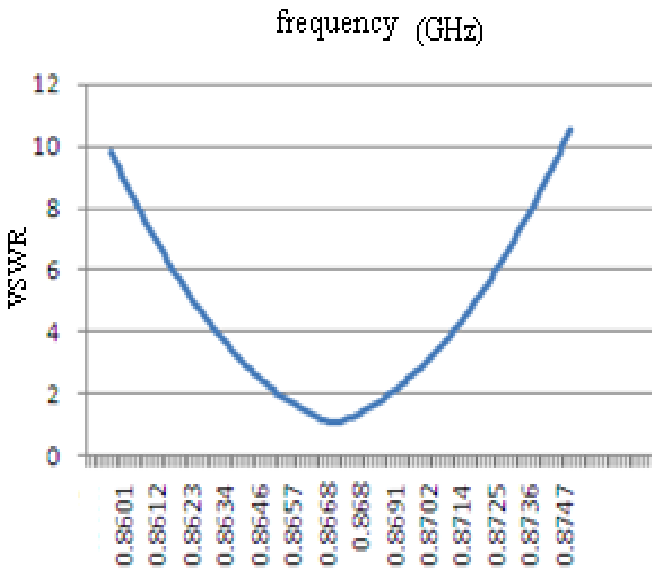

Figure. 3: VSWR of proposed antenna

Fig.4 shows the current distribution pattern of proposed antenna at 0.867 GHz frequency. Maximum current in the proposed antenna is 147.88(A/m) at this frequency. The 3D current distribution plot gives the relationship between the co-polarization (desired) and cross-polarization (undesired) components. It gives a clear picture as to the nature of polarization of the fields propagating through the patch antenna.

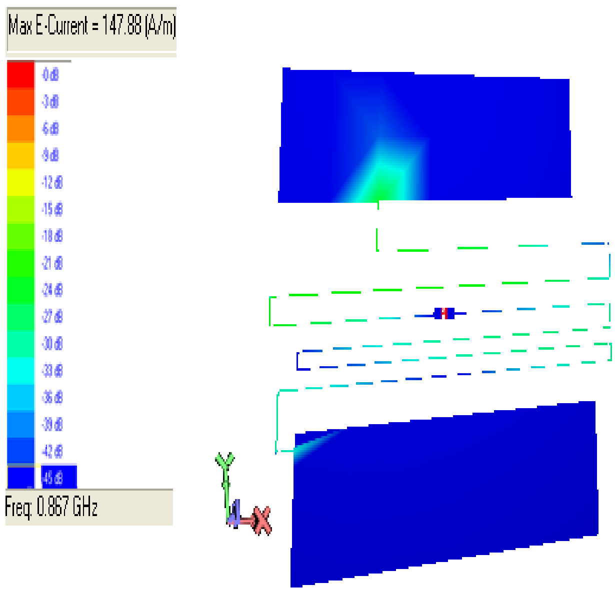

Figure 4: Current Distribution of proposed ETSI band antenna at 0.867 GHz

In fig. 5(a) and 5(b) simulated 2D radiation patterns for elevation and azimuthal plane at resonant frequency 0.867 GHz are shown. These patterns are desirable for RFID applications. Radiation pattern presents the graphical representation of radiation properties of antenna as a function of space co-ordinates. Three dimensional radiation pattern is obtained by combining elevation pattern and azimuth pattern. Fig. 6 shows three dimensional radiation pattern of proposed antenna.

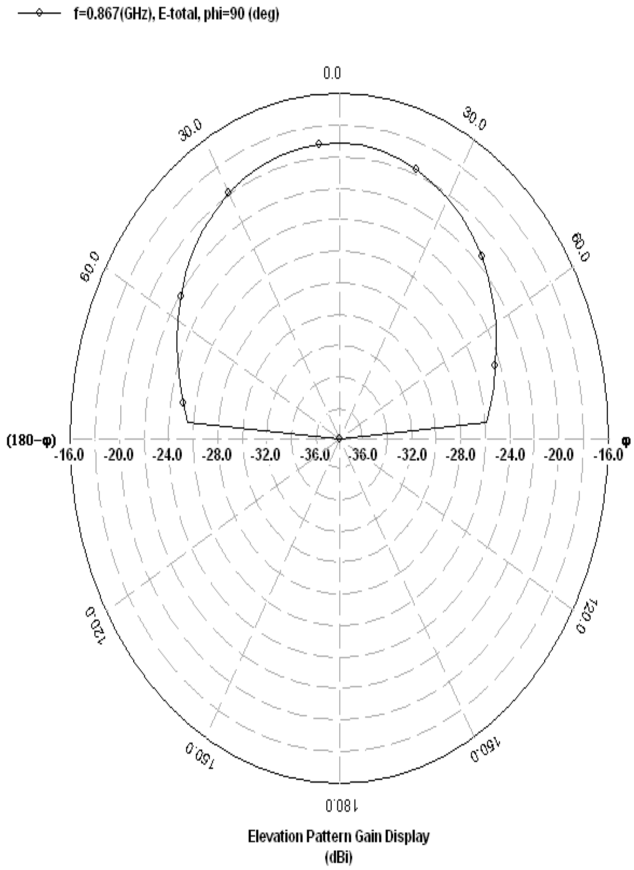

Figure. 5(a): Elevation pattern at 0.867 GHz

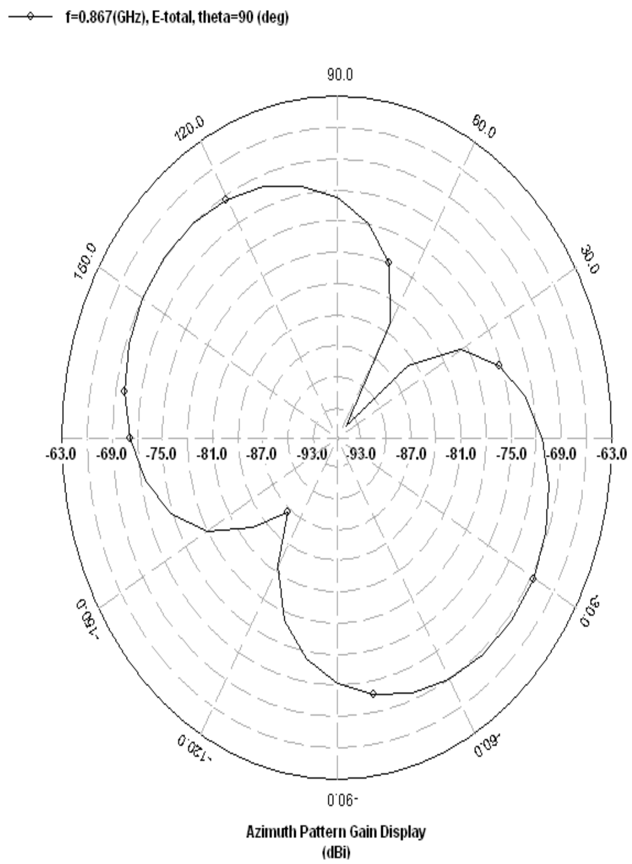

Figure. 5(b): Azimuth pattern at 0.867 GHz

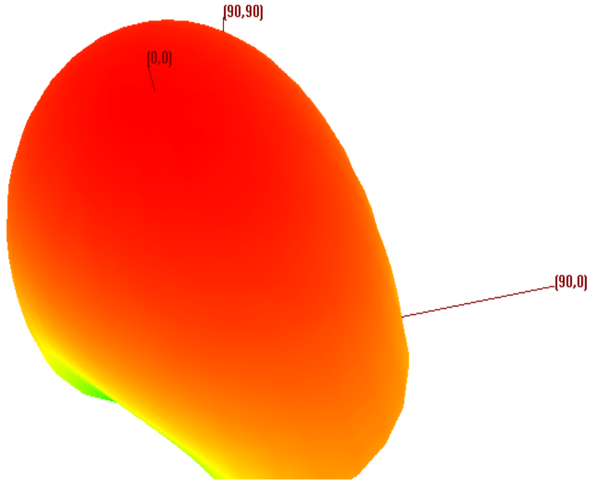

Figure.6: 3-Dimensional Pattern of Proposed Antenna

IV. PARAMETRIC STUDY

A parametric study has been carried out and it demonstrates that many parameters affect the performance of the proposed antenna. The parametric study is carried out by simulating the antenna with one geometry parameter slightly changed from the reference design while all the other parameters are fixed.

A. Effect of Variation of 'W' on Antenna Performance:

Fig.7 showing the case when width of patch changed, there was no impedance bandwidth in working bands. The variation of width has a greater effect on the antenna performance.

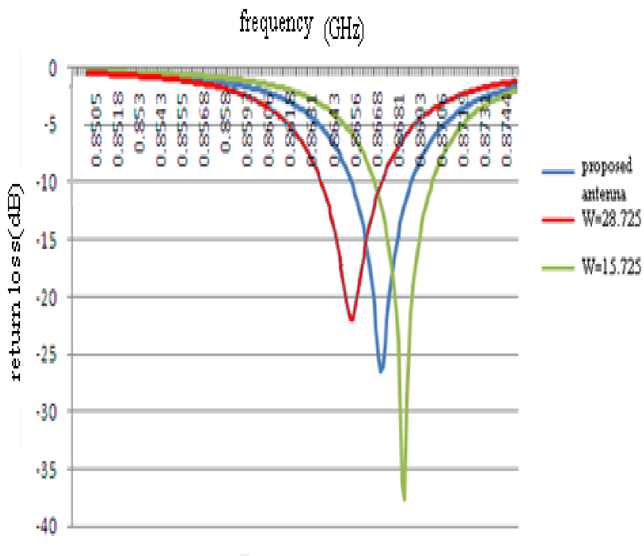

Figure 7**:** Return loss (S11) of the antenna for different values of W.

B. Effect of Variation of 'L_1' on Antenna Performance:

Fig.8 showing the case when L_1 slightly changed from the reference design, then there was no impedance bandwidth in working bands. It can be seen, as we increase L_1 from optimized value the return loss in dB (-ve) will increase and as we decrease L_1 from optimum value then value of return loss in dB (-ve) will decrease. Thus the variation of L_1 has a greater effect on the antenna performance.

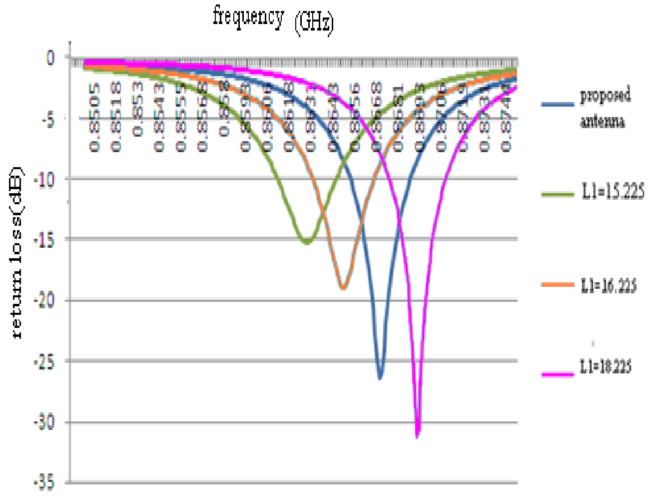

Figure **8:** Return loss (S11) of the antenna for different values of L_1

C. Effect of Variation of meander length on Antenna Performance:

Fig. 9 showing the case when meander length L_8 slightly changed from the reference design, then there was no impedance bandwidth in working bands.

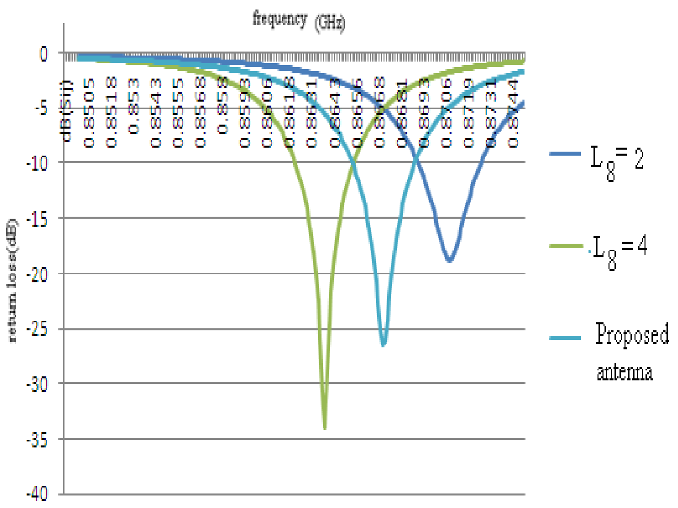

Figure 9**:** Return loss (S11) of the antenna for different values of L_8

V. CONCLUSION

A design of passive RFID tag antenna for ETSI UHF RFID frequency band is proposed and good radiation characteristics have been observed. The proposed antenna has been designed and simulated for resonant frequencies at 0.867 GHz. Effects of varying dimensions of key structure parameters on the antenna and various parameters like VSWR, current distribution, radiation pattern and their performance are also studied. These characteristics are very attractive for RFID tagging on cardboard and plastic boxes.

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