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Multipolarized Near Field RFID Antenna for Mobile Devices

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Abstract: Line alignment problem is usually faced by radio frequency identification (RFID) users, which is one of the limitations of RFID. This paper provides the solution by a multipolarized antenna of size 56mm×56mm×1.6mm having an impedance bandwidth of 110MHz. The return loss at 900MHz is found to be-20.54dB which ensures 98 percent power transmission to the atmospheric load. Axial ratio less than 3dB is found over the range of 110°. The antenna is fabricated using FR-4 as a substrate of ϵ_r 4.4. Antenna with this size can be easily implemented on the mobile devices. The proposed antenna is tested and read range is found to be 430mm.

Keywords: RFID, Multi polarization, Axial Ratio, Return Loss, Impedance Bandwidth, Read Range.

1 INTRODUCTION

The use of RFID now days has become a common technology used in hospitals, industries and the shopping malls for the detection of various things [1]. The use of RFID is dependent on the range because RFID works in two fields namely near and far field. Therefore, depending upon the reading distance the field of operation is decided. For near field application, it is desired to have high read rate for the defined small region. The design of such a reliable antenna is an engineering challenge [2]-[6]. For far field, gain, directivity and radiation pattern are of much concern. Tag antenna and reader antenna communicate by means of two type of coupling namely magnetic and capacitive coupling.

For near field application the mismatch in the line alignment causes a great loss in the communication and hence it is difficult to identify the tag [7]. The antenna with large gain are found to be linearly polarized in general and having a problem of alignment. For such cases multi polarized antenna can be fabricated at the cost of directive gain [8]. It overcome the problem of orientation, in order to serve the purpose, number of design already has been presented, in addition folded dipole and open ended micro strip lines have been manufactured for far field as well as near field application[9].

Antenna designed for near field may detect unwanted tags if the gain beyond a certain limit is not kept controlled and hence mislead the identification. Greater the size of the antenna higher will be its gain [10]. Therefore, small size antenna design is required to control the gain and to enhance the incredibility of the mobile devices. In this paper we have presented a UHF RFID multi polarized antenna for mobile devices working in the near field application. The proposed antenna is low cost, easy to design and fabricate. The simulated return loss below -10dB ranges from 932MHz to 942MHz providing an impedance bandwidth of 110 MHz which is covering maximum of UHF RFID standard moreover the antenna has axial ratio less than 3dB for a range of 110° which reflect the capability of the antenna to identify arbitrarily oriented antenna within the range of 430mm.

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II RFID Antenna Design

Fig.1 shows the configuration of the proposed antenna which is fabricated on FR-4 substrate with electrical permittivity of 4.4 having overall dimension of 56mm×56mm×1.6mm. An IC Alien Higgs-4 is used to excite the antenna. Antenna design includes ground of dimension 56mm×56mm, patch having dimension of 52mm×52mm. Chip is placed in rectangular portion 'T' on horizontal slot 'L' as shown by Fig.1 having dimension of 1mm×0.5mm along x and y direction respectively. Slot having dimension of w1×w3 has been cut at a distance of 'a' from the centre point of intersection of horizontal and vertical slot.

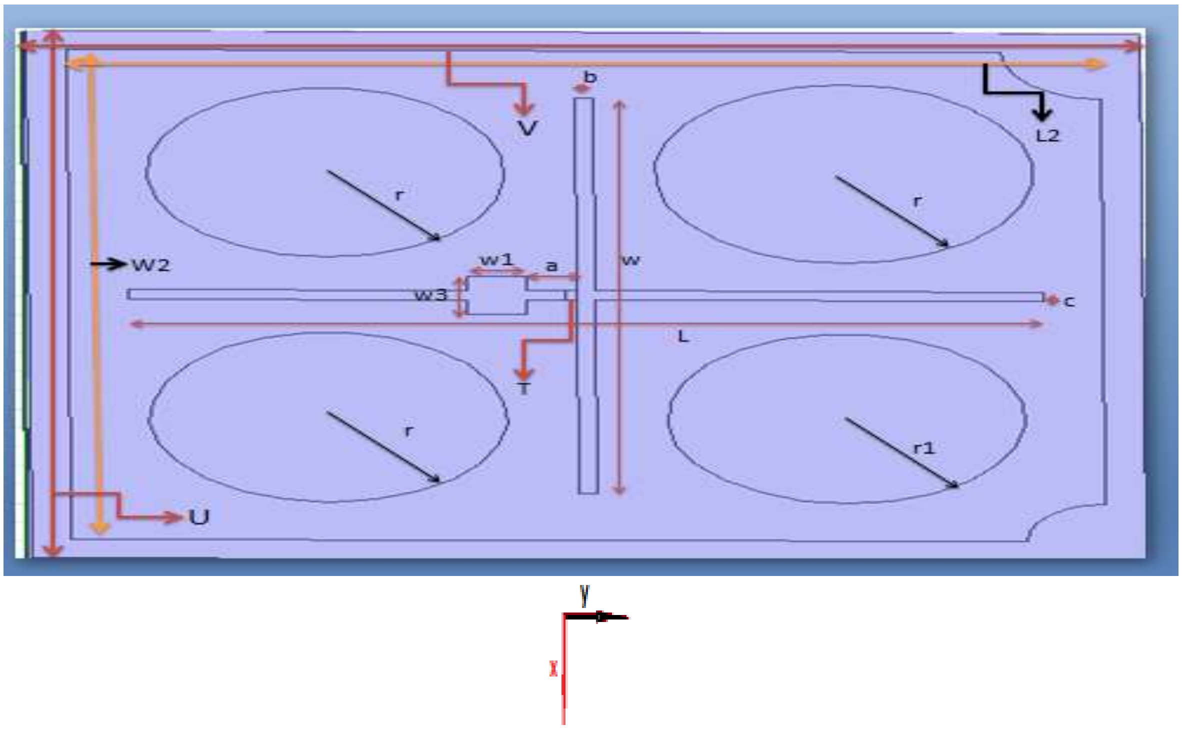

Fig. 1. Proposed Antenna Configuration.

Table 1contains the optimized dimensions of the proposed antenna. Dimensions of circular slot with radius 'r','r1', vertical and horizontal slots with length 'L' and width 'w', chip with rectangular slot 'T', substrate length 'V' and width 'U' is mentioned in the table shown below. The effect of the various dimensions is explained in the following sections.

Table 1 Proposed Antenna Dimensions

Parameter	Value(mm)	Parameter	Value(mm)
r1	9.5	w3	4
r	9	a	1.5
L	42	b	1
w	46	c	1
w1	3	L2	52
w2	52	T(Y axis X axis)	0.5
U	56		1
V	56		

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III Principle of Size Reduction and Circular Polarisation

The approximated size of the antenna can be found by the various relations between width or length and permittivity. Depending upon the frequency of operation and permittivity the width of the antenna can be calculated. Length is generally taken to be half of the wavelength of operation. The length can be reduced by cutting different slots, short placements at appropriate locations and by increasing the permittivity but it causes a decrease in bandwidth and the radiation efficiency. As per literature, for circular polarization, the antenna is provided with two excitations having phase difference of 90 degree or by providing 90 degree shift in the design itself by means some phase shifter. Another important method that is implemented in the proposed design is to provide asymmetry.

IV Parametric study

Different dimension of the antenna are varied to optimize the proposed antenna. At a time one parameter is considered and rest are kept constant and corresponding effect is seen on S11 and axial ratio with respect to frequency. S11 and axial ratio of proposed antenna is shown below.

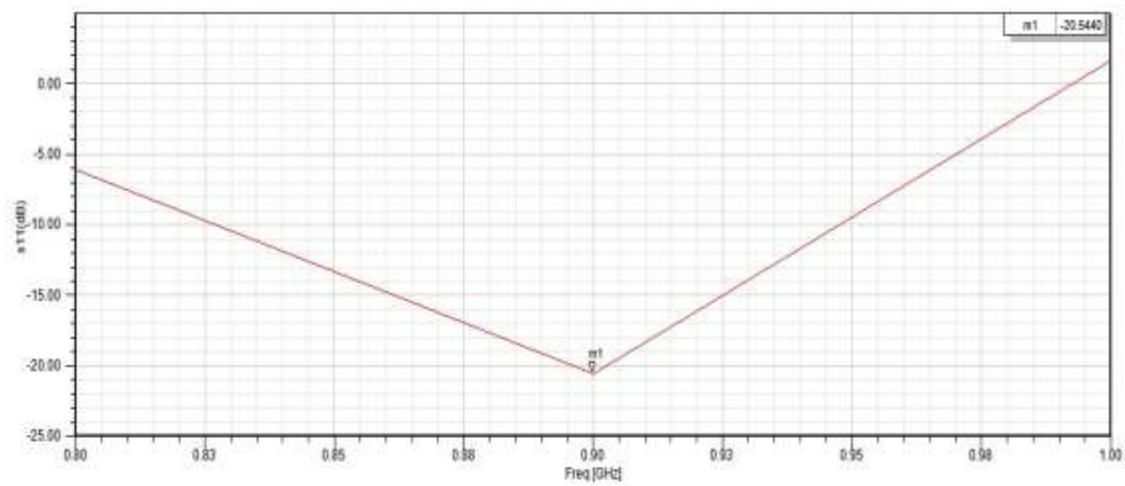

Fig. 2. Simulated S11 of Proposed Antenna.

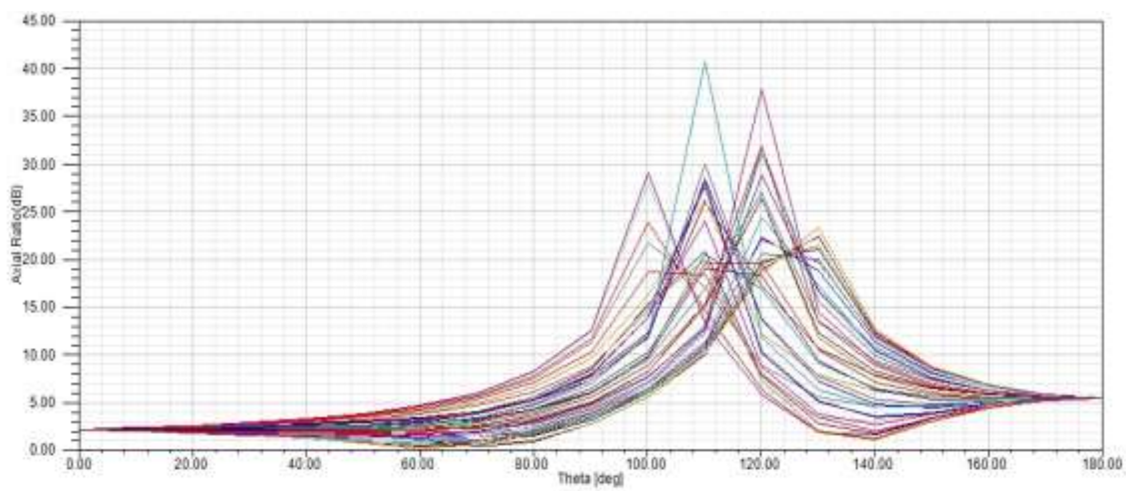

Fig. 3. Simulated Axial Ratio of Proposed Antenna.

Fig. 2 and Fig. 3 shows the S11 vs. frequency and the axial ratio vs. theta respectively of proposed antenna. Results show that the proposed antenna is resonating at 900MHz and having an impedance bandwidth of about 110MHz ranging from 832MHz to 942MHz and Axial ratio less than 3dB is found over the range of 110°.

a) Effect of parameter 'r1'

Three circular slots with radius r equals to 9mm and one circular slot with radius r1 has been cut as shown in Fig. 1.Circles with radius 'r' are kept constant and circle with radius 'r1' is varied from 8.5mm to 10mm as shown in Fig. 4 which is generated by optimetric analysis.

It shows that impedance bandwidth varies from 832MHz to 942 MHz and is found to be maximum for r1 equals to 9.5mm.The minimum value of S11 shown in Fig. 4 is -20.05dB with an impedance bandwidth of about 110MHz. Simulated results shows that the proposed antenna is covering almost entire UHF band (840 MHz to 960MHz).

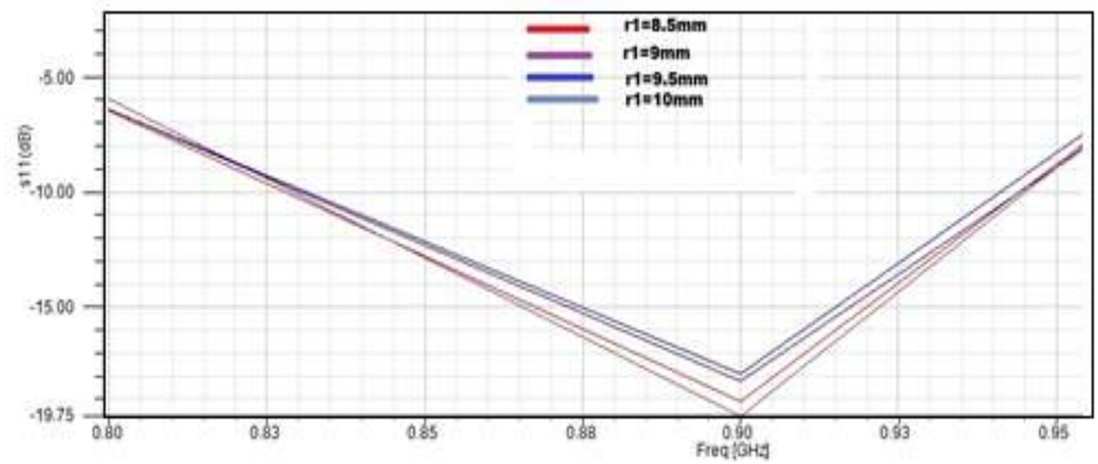

Fig. 4. Simulated S11 by Varying 'r1'.

b) Effect of parameter 'w'

A vertical slot with dimension 'w' equals to 42mm and b equals to 1mm has been cut along the 'x' direction.

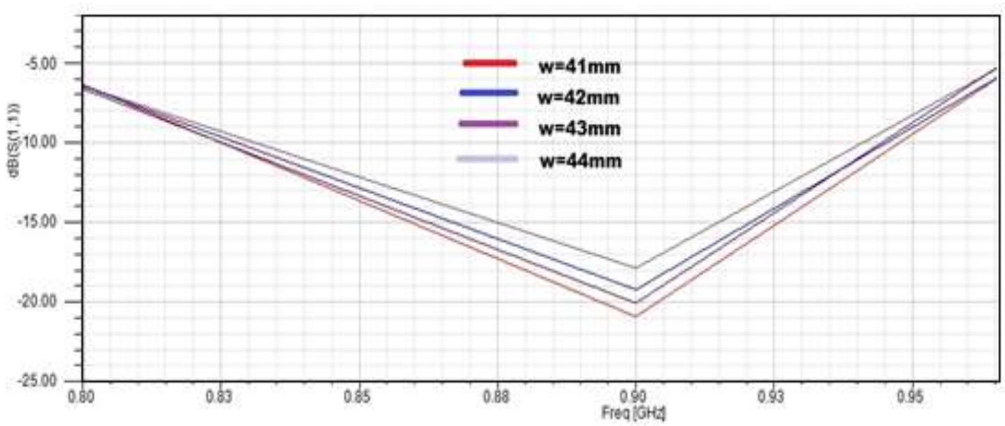

Fig. 5. Simulated S11 by Varying 'w'.

The width 'w' is varied from 41mm to 44mm. Fig. 5 shows that the resonant frequency does not change by varying 'w'. For 'w' equals to 41mm, S11 is minimum, so it is considered as optimal value of 'w' for vertical slot but from Fig. 6 it is found that for w equals to 42mm, beam width is maximum. To fulfil the objective of multi polarization, it is required to have desired level of circular polarization. Therefore, by considering both S11 and axial ratio, w equals to 42mm is considered as optimal value.

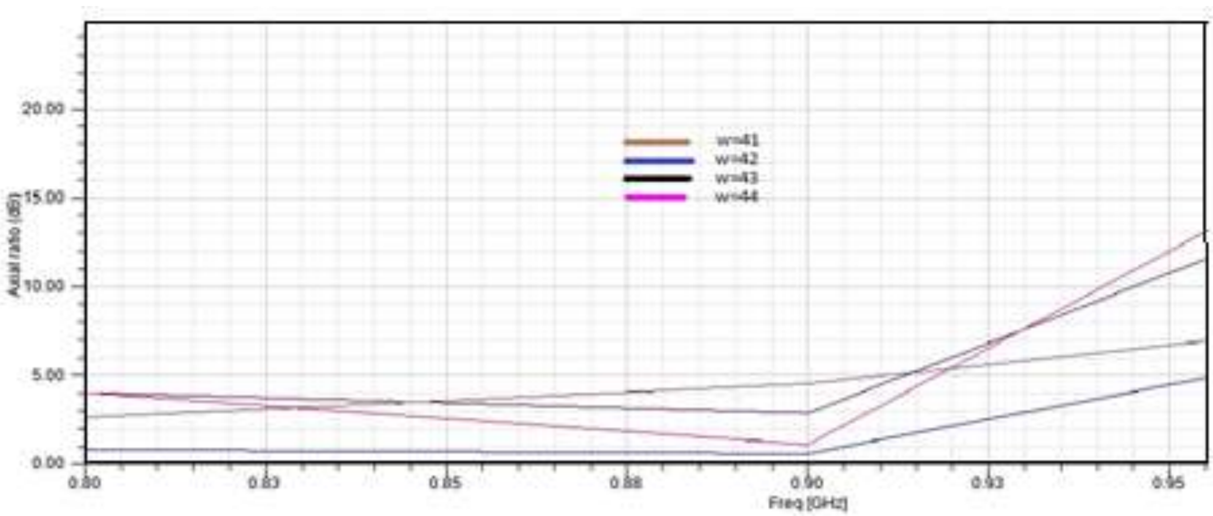

Fig. 6. Simulated Axial Ratio by Varying 'w'.

c) Effect of parameter 'L'

A horizontal slot with dimension 'L' equals to 46mm and 'a' equals to 1mm has been cut along 'y' direction. The length 'L' is varied from 44mm to 47mm. Fig. 7 shows large variation in impedance bandwidth when 'L' is varied from 44mm to 47mm.

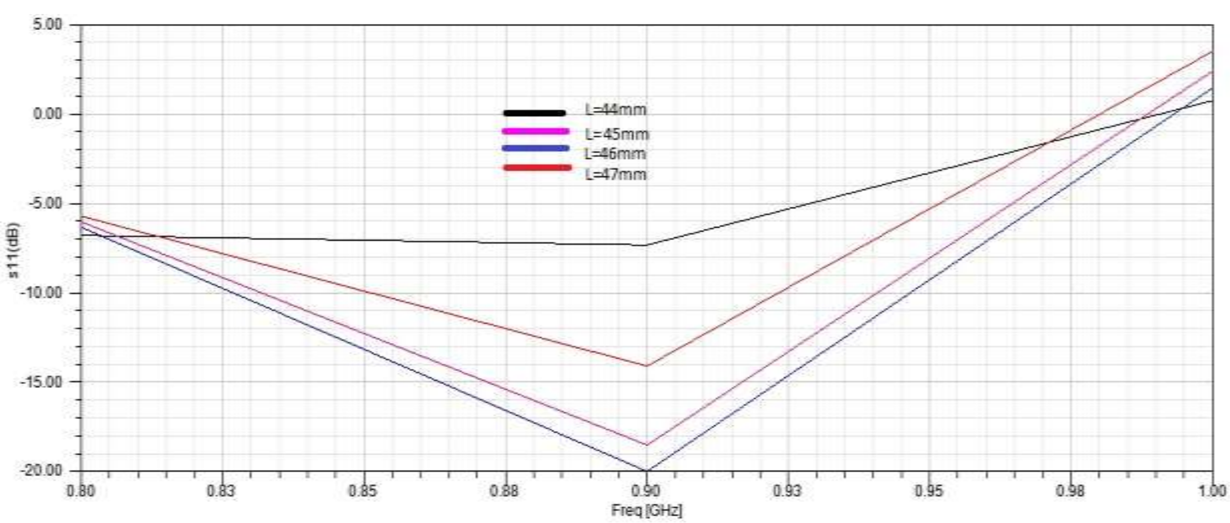

Fig. 7. Simulated S11 by Varying 'L'.

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For L equals to 46mm and 44mm, S11 is best (-20.05dB) and worst (-6 dB) respectively among all other values of L. Fig. 8 shows that, for L equals to 46mm and 47 mm, axial ratio is found to be less than 3dB over wide range. Therefore, shows the large bandwidth nearly equals to 75 MHz from 840 to 915MHz. The simulated analysis shows that 'L' equals to 46mm gives optimal results.

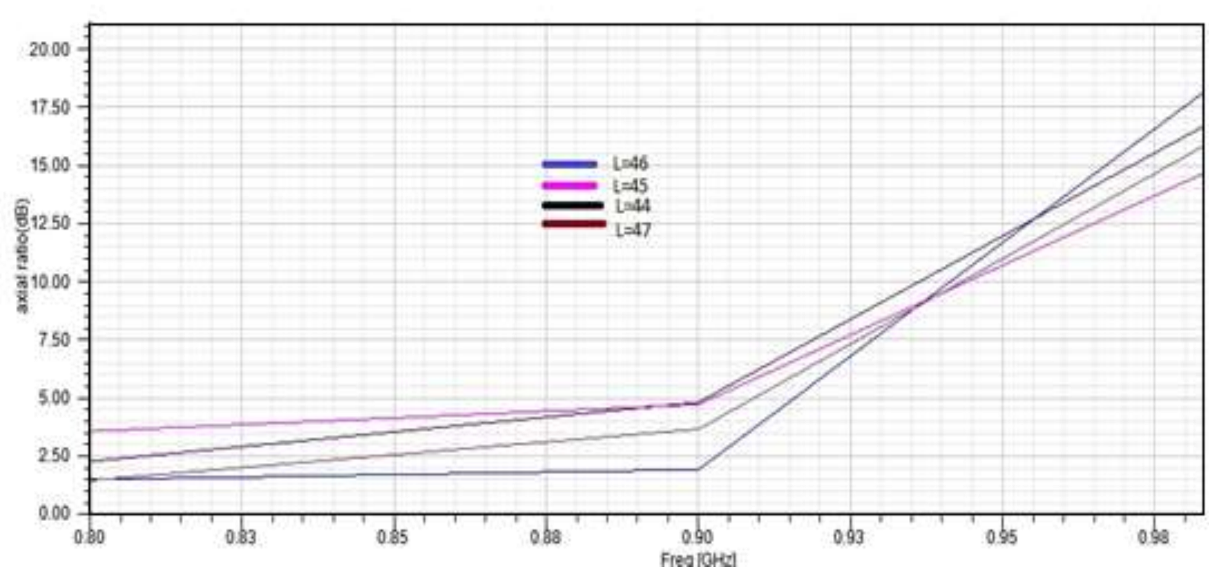

Fig. 8. Simulated Axial Ratio by Varying 'L'.

d) Effect of parameter 'w1'

Slot on the horizontal slot 'L' with dimension w1 along y axis is varied from 1mm to 4mm while w2 is kept at 4mm. Fig. 9 depicts that S11 is minimum for w1 equals to 4mm but for w1 equals to 3mm, axial ratio is less than 3 dB. From simulated analysis w1 equals to 3mm is considered as optimal value.

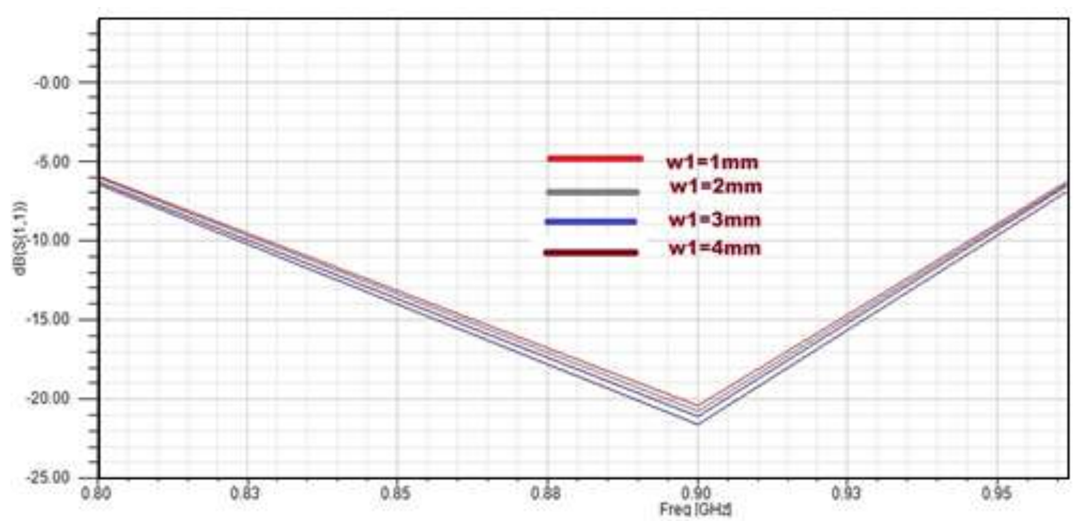

Fig. 9. Simulated S11 by Varying 'w1'.

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V Read Range Measurement

To verify the read range of proposed antenna, experimental set up is shown below. In the set up, Super Nova Skytech Reader with maximum output power 0.5 Watt is connected with a reader of gain 9dB through co-axial cable. The tag is having Alien Higgs-4 chip with -20dBm chip sensitivity and has power level of micron watt which is used to excite the antenna.

Fig. 10. Set Up for Antenna Testing.

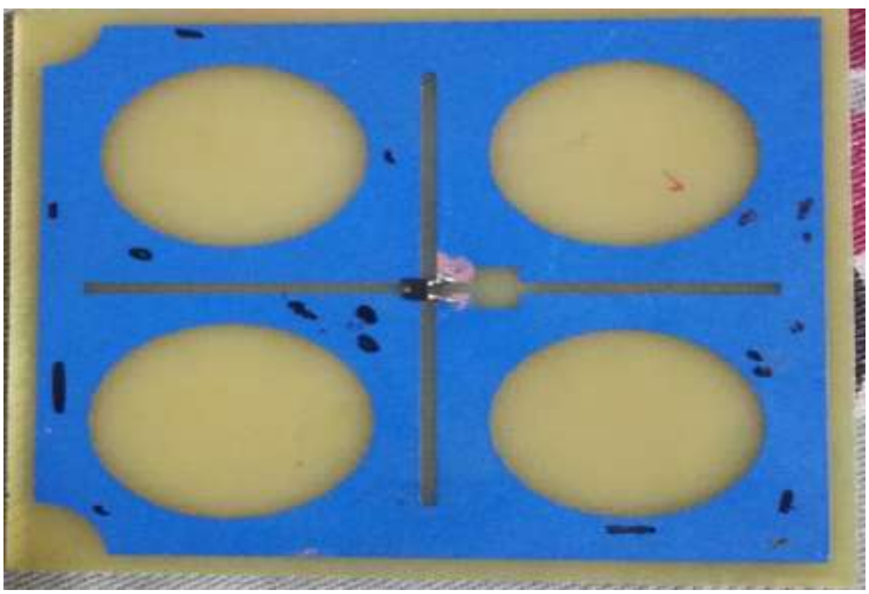

Fig. 11. Fabricated Antenna with Alien Higgs-3 chip.

Fig. 11 represents the fabricated proposed antenna resonating at 900 MHz with overall dimension of 56mm×56mm×1.6mm.

paper reference	Electrical Specification	Mechanical specification	
	Frequency range(MHz)	3dB Beamwidth (degree)	Dimension(L×W×H) (mm3)
[16]	825-965	---	450×450×350
[13]	860-960	66	54×54×5.2
[12]	901-930	75	150×150×34
[17]	918-920	100	90×90×4.8
proposed	832-942	110	56×56×1.6

Table 2 Comparison of Proposed Antenna Design

The proposed measured antenna has 3dB beam width of 110 degree and overall size is 56×56×1.6mm^3 which is found to be better when compared with the design proposed in [12], [13], [16], [17]. The antenna size compared to conventional antennas is reduced by approximately half of their size. The beam width is improved by 10 degree. Other parameters such as impedance bandwidth is also improved. The measured read range is 430mm.

VI Conclusion

The impedance bandwidth can be increased to desired level. The antennas designed so far either have larger dimension with circular polarization or small dimension with linear polarization for the near field applications. Best techniques and procedures reviewed for the designing of antenna, so as to reduce the antenna dimension. Multi polarized near field RFID antenna is successfully performed and tested. By providing asymmetry in the design and optimization, desired level of impedance bandwidth and axial ratio is obtained. Since the size of antenna is small and hence easy to implement in the mobile devices.

VII ACKNOWLEDGEMENT

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