ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 7, March 2017

Miniaturized Loaded Circularly Polarized RFID Reader Antenna

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***Abstract*—A simple circularly polarized (CP) RFID (radio frequency identification) antenna that operates in the ISM band (902–928 MHz) is investigated. Here, the technique of placing a corner truncated square patch antenna over an L-shaped ground plane is initially studied to achieve good impedance matching with broad CP bandwidth. To further miniaturize the antenna and to enhance both the impedance bandwidth and CP bandwidth, a dielectric material is placed in between the antenna and the ground plane. From the simulated results, it is observed that besides achieving a high gain of about 6.7 dBi, the proposed antenna also shows an impedance bandwidth of 42.6%, with good CP bandwidth from 885 to 935 MHz in a miniaturized dimension. Thus the proposed antenna can be utilized for low profile RFID reader applications because of its miniaturized size and high gain properties.**

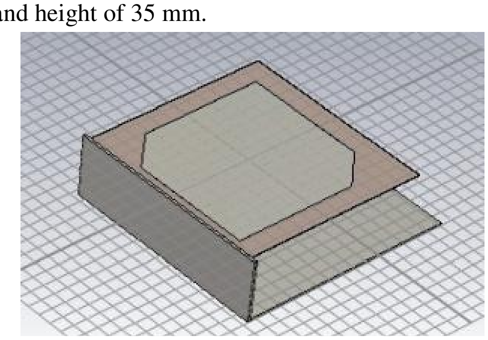
Keywords—Axial ratio, circular polarization, corner truncated square patch, RFID, ISM.

I.INTRODUCTION

Circularly polarized (CP) antennas are attractive for wireless communication applications, because no strict orientation and polarization between the base station and the mobile unit are required. To achieve CP operations, many designs of patch antennas have been reported. The three narrow slits are meticulously loaded into the corner truncated square patch [1] in a certain manner to generate an additional upper CP frequency can excite a single CP frequency with CP bandwidth of 16%, which is used for universal UHF RFID band. The available two types of RFID antenna which is designed with CP radiation are single layer planar type [2],[3] and multi-layer stacked type[4],[5]. The characteristics of single layer planer type are gain less than or equal to 4 dBic and its narrow CP bandwidth should be less than 1%, and advantages of this planar type are low cost in manufacturing ,light weight and low profile. The multilayer stacked type has CP bandwidth ranges between 902MHz-920MHz of UHF RFID band. By increasing the gap between the antenna and the ground plane its bandwidth increases to 3.2%, its range will be 902MHz-928MHz was achieved by using a simple L-shaped probe feed. To further miniaturize the antenna and to enhance both the CP bandwidth, with the range 885MHz–935 MHz, the method of placing a dielectric material between the antenna and the ground plane was proposed. Hence, multilayer stacked antennas with broad CP bandwidth of up to 16.4% for universal UHF RFID applications have been studied recently [5]–[6]. Here, the three layers of stacked patches are the main structure of [5] and [7], while two layers of stacked square patched (with a foam sandwiched between them) are composed, thus, these designs may lead to higher manufacturing cost. [6] discussed about E-plane and H-plane patterns which forms the basis of Microwave Engineering principles. Here, an L-shaped ground plane with a simple direct fed single layer corner truncated square patch antenna was initially studied [8]. Therefore, a novel technique of loading a dielectric material between a corner truncated square patch and the L-shaped ground plane is done. The dimensions of the antenna are reduced with an impedance bandwidth of the antenna is retained and the CP bandwidth ranges from 885 to 935 MHz.

II.ANTENNA DESIGN

The design of the proposed antenna is described and it is composed of two simple elements, namely, the corner truncated square patch (main radiating patch) and L-shaped ground plane (made by thin copper sheet of thickness 0.2mm). Here, the square patch is printed on an inexpensive 0.8 mm thick FR4 substrate (and loss tangent 0.02), and it is fed by a SMA connector soldered to strip fed line. The L-shaped ground plane is comprised of two major sections, namely, the horizontal section and vertical section. The main radiating patch is supported above the horizontal section of the L-shaped ground plane with a gap of 35mm were the dielectric material is placed in between filling the gap. Fig.1 (a) and (b) shows the design evolution of the proposed antenna by subsequently loading the dielectric material between the corner truncated square patch and L-shaped ground plane. The simulations are performed by CST Microwave Studio. The loaded dielectric material is FR4 with dielectric constant of 4.4 and height of 35 mm.



(a)

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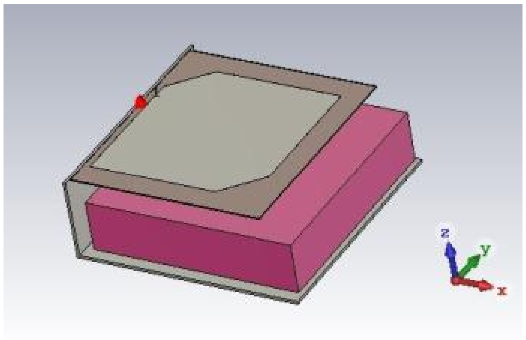


(b)

Fig. 1 Proposed antenna (a) Before inserting the dielectric material (b) After inserting the dielectric material

III. RESULT AND ANALYSIS

The return loss plot of the antenna is shown in Fig. 2. The return loss plot shows that the antenna has a wide impedance bandwidth of about 380 MHz from 702 MHz to 1083 MHz. The percentage bandwidth is 42.6%.

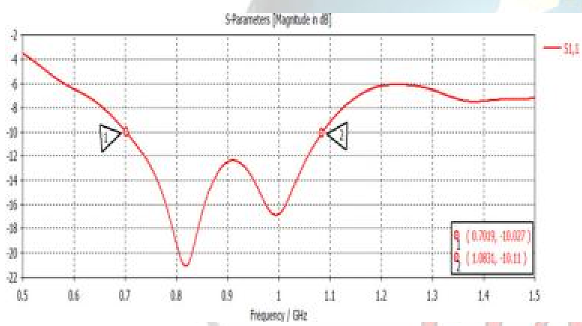
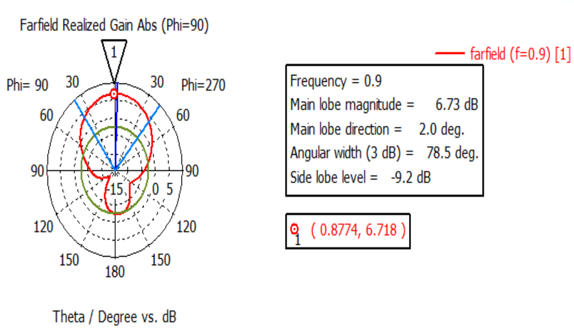
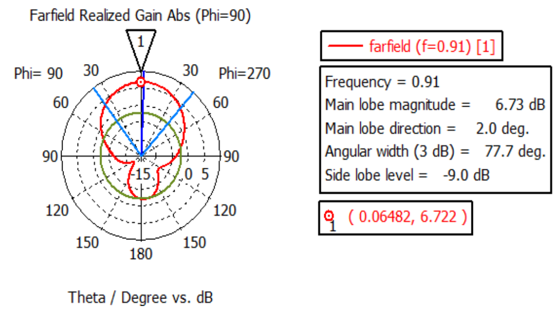


Fig. 2 Simulated S-Parameter

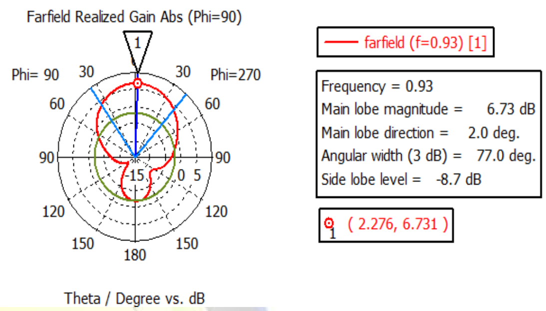
The radiation patterns of the simulated antenna are analysed. The antenna shows positive gain over the entire impedance bandwidth. The gains requssired ISM band in which the antenna is intended to operate for RFID application is presented in Fig. 3. The gain vs frequency plot is shown in



(a)



(b)



(c)

Fig. 3 Simulated radiation patterns with gain (a) at 900MHz (b) at 910MHz (c) at 930MHz

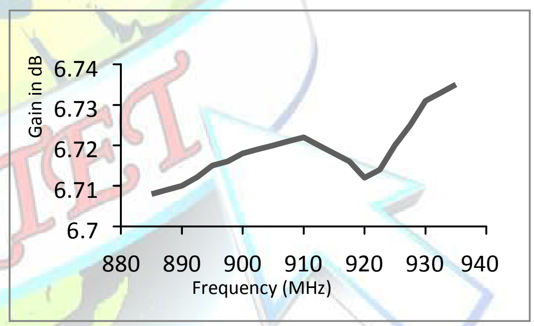
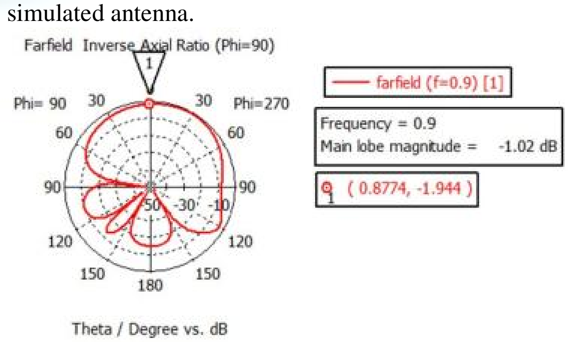


Fig. 4. Simulated Gain vs Frequency

Fig. 4. The axial ratio bandwidth of the antenna is 50 MHz. i.e., from 885 MHz to 935 MHz. The percentage AR bandwidth is 5.6 MHz. Fig. 5 shows 2D the axial ratio cut of the simulated antenna.



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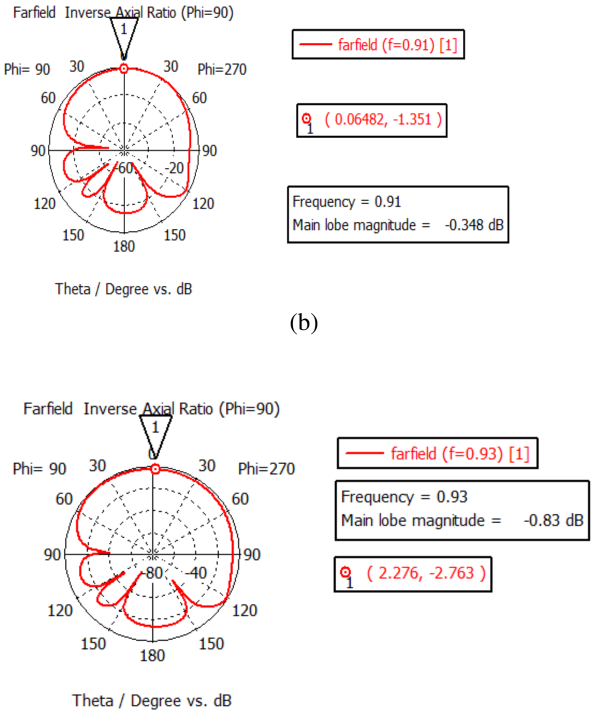

(b)

(c)

Fig. 5 Simulated radiation patterns with Axial Ratio (a) at 900MHz (b) at 910MHz (c) at 930MHz

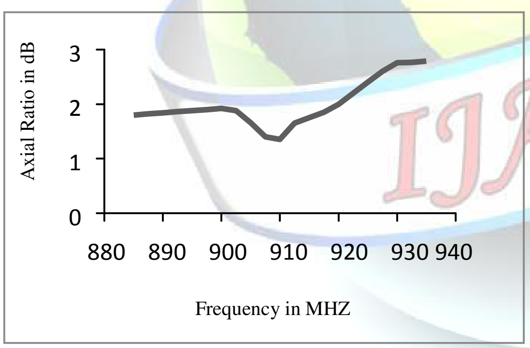

Fig. 6 Simulated Axial Ratio vs Frequency

IV. CONCLUSION

A novel technique of loading a dielectric material between a corner truncated square patch and the L-shaped ground plane with CP radiation has been successfully investigated. By loading a dielectric material between the antenna and the ground plane, good CP bandwidth of 5.6% (885–935 MHz) and wide impedance bandwidth of 42.6% (702-1083 MHz) can be attained. Normally, the previous technique of loading three narrow slits of different size has a CP bandwidth of 16.5 % (836-936 MHz) and wide impedance bandwidth of 48.6% (685-1125 MHz) was obtained. Also provides, high antenna gain of more than 6.5 dBi respectively, while the previous technique [1] provides gain more than 8dBi. The size of the antenna (150*150*35) gets reduced by 40% in the proposed system when compared to the previous technique [1] (250*250*60). As the structure is simple and easy to fabricate, the proposed antenna is a potential candidate for fixed ISM RFID reader applications applied to both indoor and outdoor environment that operates in the universal RFID ISM band 902–928 MHz Notably, this dielectric material loading technique to improve the CP bandwidth of a corner truncated square patch is novel, and it has never been reported elsewhere.

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