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Miniaturized L- Slotted Rectangular Patch Antenna for LTE and RFID Applications

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Abstract: The article presents a very compact dual band microstrip patch antenna for Long Term Evolution (1.7-1.8 GHz) and Radio Frequency Identification (2.45 GHz) applications. The proposed antenna has been designed using Fire Resistant FR4 Epoxy substrate. The patch antenna dimensions are 44.2 x 25.8 x 1.6 mm and have a 50 ohm Microstrip Line feed. The antenna has a low return loss of about -23.2 dB with VSWR of almost 1.14 and a good directivity of 2.52 dBi at 1.82 GHz and it has return loss of -32.13 dB, VSWR of 1.05 and directivity of 4.36 dBi at 2.459 GHz. The proposed antenna operates between 1.65-1.86 GHz and 2.38-2.54 GHz with resonating frequencies 1.82 GHz and 2.46 GHz. The performance of the proposed antenna is analyzed using CST Microwave Studio software.

Keywords: Microstrip patch antenna, Long Term Evolution (LTE), Dual Band, RFID, CST Microwave Studio.

1. INTRODUCTION

Antennas play a very important role in the field of wireless communications. During the recent years, microstrip antennas have attracted an important interest in modern communication systems because of their significant characteristics of small size, light weight, low cost on mass production and thin profile [1]. They are also compatible with wireless communication integrated circuitry due to their simple feed methods, especially microstrip-line and coplanar waveguide feeds. However, their capability to operate at a single frequency, narrow bandwidth and low gain when comparing it with other microwave antennas restrict their practical applications [2]. Because of the low profile and compact size of the planar and printed antennas, there is a strong preference to this type of antennas for applications such as WLAN, UWB, LTE and RFID. Modern mobile and wireless communication systems require compact size, broadband and dual/multi frequency antennas, thus the possibility to apply these antennas for modern communication systems is reinvestigated by applying modifications in their patch geometries [3]. Wireless technology advancements have given birth to Radio Frequency Identification (RFID) systems, which have generated significant interest and hype among scientists, researchers and industry [4]. RFID technology enables identification, location and information exchange of distant objects via radio waves. It has been commercialized in areas of logistics, manufacturing, transportation, health care, and mobile communications [5].

Basically RFID system is a tag or transponder and a transceiver or reader. The tag consists of an antenna combined with an application-specific integrated circuit (ASIC) chip. In order to activate and detect a tag, a base station (reader) transmits a modulated signal with periods of unmodulated carrier [5, 6, and 7]. Most of the RFID applications work with a bandwidth of around 180 to 300 MHz for different bands such as Low Frequency (LF) band of 120-150KHz, High Frequency (HF) band for 13.56 MHz, Ultra High Frequency (UHF) for 860 MHz to 960MHz and Microwave (MW) band for 2.45 GHz or 5.8 GHz [8]. The microwave bands are popular than other RFID bands in many areas because of its high readable range, fast reading speed, large information storage capability [9]. Many attempts have been made in recent times to reduce the antenna size. A Patch antenna with a large dimension working in ISM band was proposed in [10]. A low power slotted patch antenna for RFID tag reader applications was proposed in [11] which has an operating frequency band of 2.3-2.4 GHz. A tag antenna mountable on objects was proposed in [12] which have a bandwidth of 37 MHz and Power transmission coefficient of 0.86. In [13], a novel circularly polarized asymmetric circular shaped slotted patch antenna was proposed for the UHF RFID handheld reader applications. A new type of compact slotted microstrip patch antenna was proposed in [14], which consists of a slot cut in the ground plane of the antenna and produces gain of 2.5 dB. A compact printed antenna with multiple rectangular slots in patch is also proposed for RFID applications [15] .

In this paper, a miniaturized dual band microstrip patch antenna resonating at 1.82GHz and 2.45 GHz for LTE and RFID applications is presented. For the purpose of miniaturization and multiband operation printed antenna has been modified with respect to the actual calculated value by etching slots in patch as well as ground plane. For purpose of impedance matching strip line is also modified. The proposed antenna is compact, light weight and slim. The theoretical simulations are performed using CST software.

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2. ANTENNA DESIGN

Microstrip patch antenna is designed at 1.82 and 2.45Hz operating frequencies and is fed with a microstrip feed line. The design of the proposed microstrip patch antenna is modeled using the classical equations [1].

2.1 Model and Geometry of the proposed antenna

The design of the proposed antenna is shown in Figure (1). This figure shows the microstrip rectangular patch antenna and microstrip feed line is used to excite the antenna. The antenna is fabricated on FR4 substrate with a thickness of 1.6 mm, permittivity of 4.4 and tangential loss of 0.025. It is necessary to introduce slots in the patch and ground to get the desired output. First of all basic antenna design is optimized. After this a L shaped slot was etched in the patch of proposed antenna for getting return loss less than -10 dB at 2.45 GHz. But after etching L slot return loss was still greater than -10 dB at 2.45 GHz. Then after applying technique of etching slot in ground plane of length half of substrate we get desired results with reduced return loss in

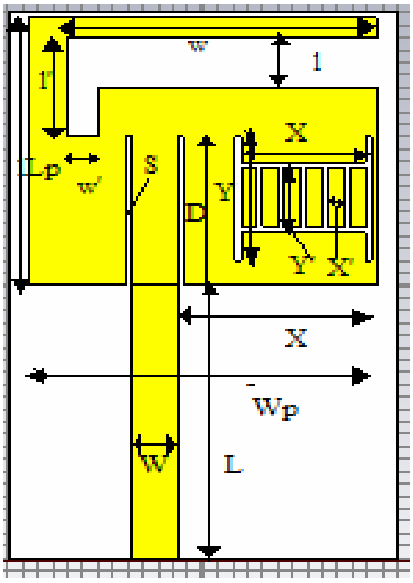

Fig-1: Top view of antenna

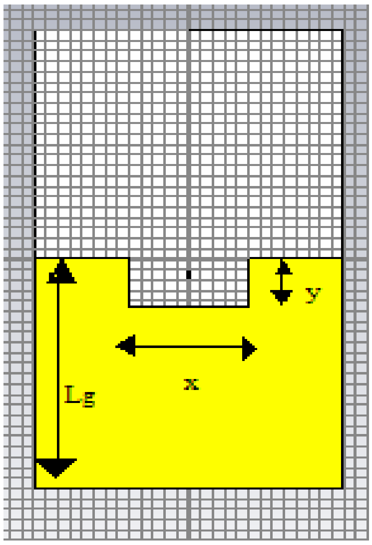

Fig-2: Bottom view of antenna

TABLE-1 Antenna Specifications

Parameter	Basic Antenna Dimensions (mm)	Proposed antenna dimensions (mm)
Lp	27	21.6
Wp	29	23.2
Lg	54	22.1
Wg	31	25.8
L	27	22.1
W	2.6	3
S	0.4	0.4
D	12	12
X	8.48	8.3
X’	1.48	1.05
Y	10	10
Y’	5.2	4.8
l	-------	4
w	-------	20.6
l’	-------	4
w’	-------	2
X	16.2	10.3
x	-------	10
y	-------	4.5

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two desired frequency bands LTE and RFID. For the purpose of matching the antenna to 50 Ω impedance of the feed line, the width of the feed line is varied. The detail dimensions of the designed antenna are listed in table1.

3. SIMULATIONS AND RESULTS

From the data calculated and optimized, the proposed antenna has miniaturized structure. The antenna dimensions are pretty compact as compared to the design in [15]. The proposed antenna has 20% reduction in size and new LTE band is integrated in the antenna with the technique of slotting. Observed return loss by applying different techniques is shown in fig.3

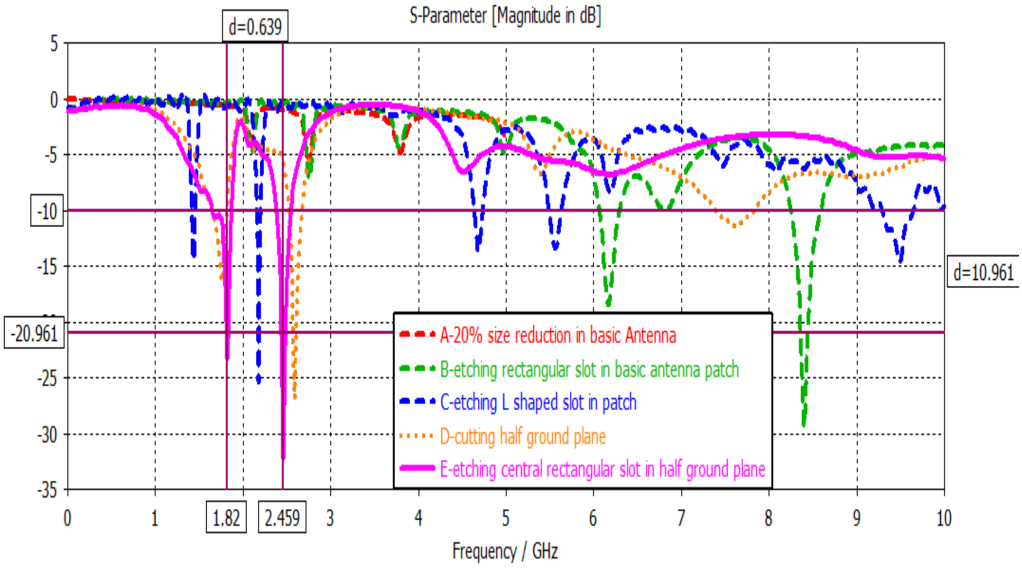

Fig-3: Simulated return loss of the proposed antenna

The simulation of the proposed antenna is done using CST software. From Fig-3, it can be seen that the minimum return loss value of the proposed antenna is about -32.13dB at 2.459 GHz RFID band. It has a -10 dB bandwidth of 162.54 MHz at 2.459 GHz resonant frequency which reveals that the designed antenna is suitable for the RFID applications and it is also observed that increase in bandwidth as compared to basic antenna is 88.54 MHz. At 1.82 GHz resonant frequency, the return loss is found to be -23.02 dB having a -10 dB bandwidth of 214.43 MHz. When we reduced dimensions of antenna up to 20% antenna was not resonating at both the desired frequency bands. Then we use the techniques of slotting and introduced rectangular slot in patch but after etching slot return loss of proposed antenna become less but still it is not operating at desired frequency bands. Then L-shaped slot is etched and with etching this slot return loss considerably reduced in 1-2 GHz and 2-3 GHz but still antenna is not operating in LTE and RFID bands. Then we use the technique of cutting ground pane and inserting slots in it. With use of half ground plane -10dB return loss curve start shifting towards desired frequency range. After inserting central rectangular slot in ground plane of proposed antenna it started operating well in LTE and RFID frequency band. Some of parameters of proposed antenna are varied to get desired results. Parametric study conducted to obtain desired results is shown in fig.4.

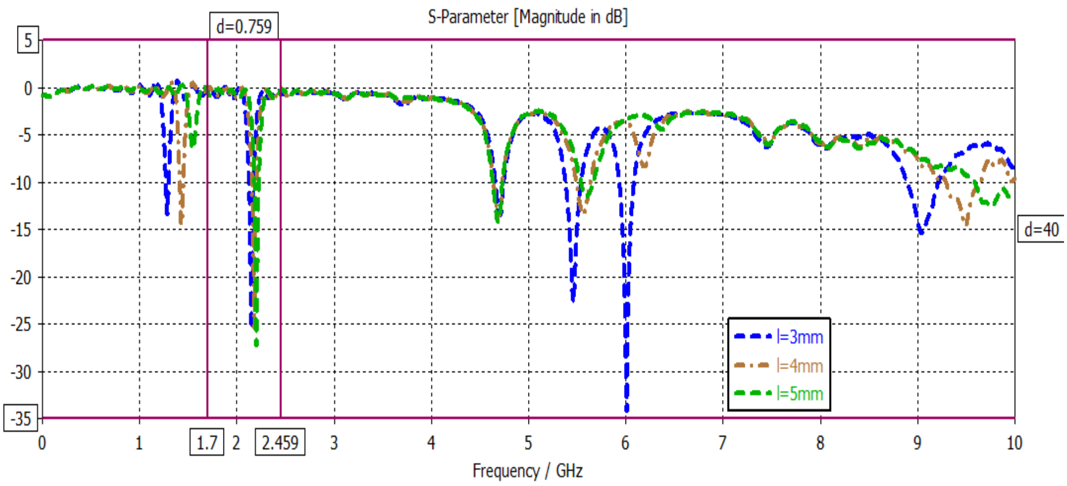

Fig-4: Effect of L- slot width on return loss of the proposed antenna

As we can observe from the graph that when l=4mm -10dB return loss curve is nearer to LTE required frequency band (1.7-1.8 GHz) and has minimum return loss as compared to l=3mm and 5mm. But results near RFID frequency band are almost similar for l= 3mm. 4mm and 5mm.

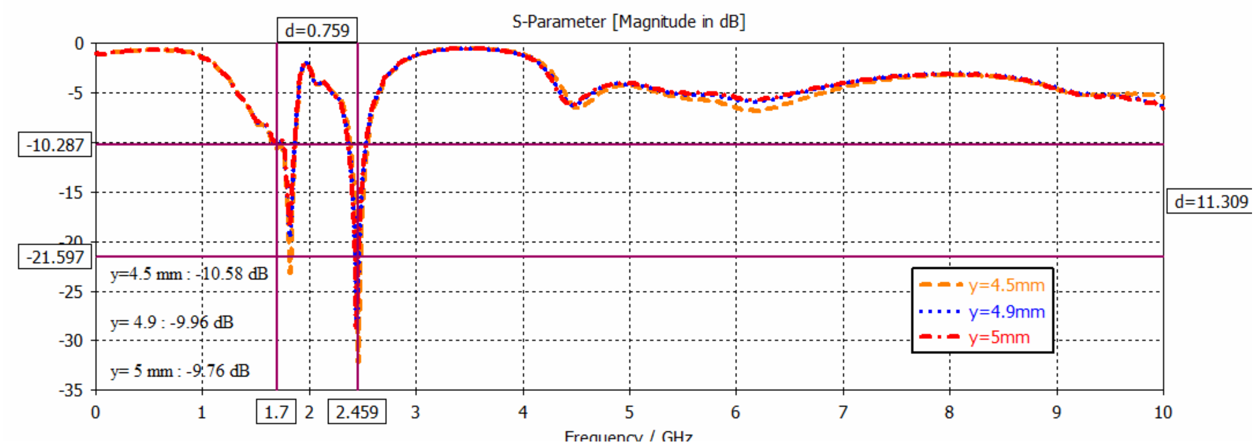

Fig-5: Effect of length of central rectangular ground slot on return loss of the proposed antenna

It is observed from fig.5 to operate well in LTE band (1.7-1.8 GHz) y=4.5 mm is better choice than y=4.9 mm and 5mm. Also for y= 4.5 mm return loss is minimum at 2.459 GHz.

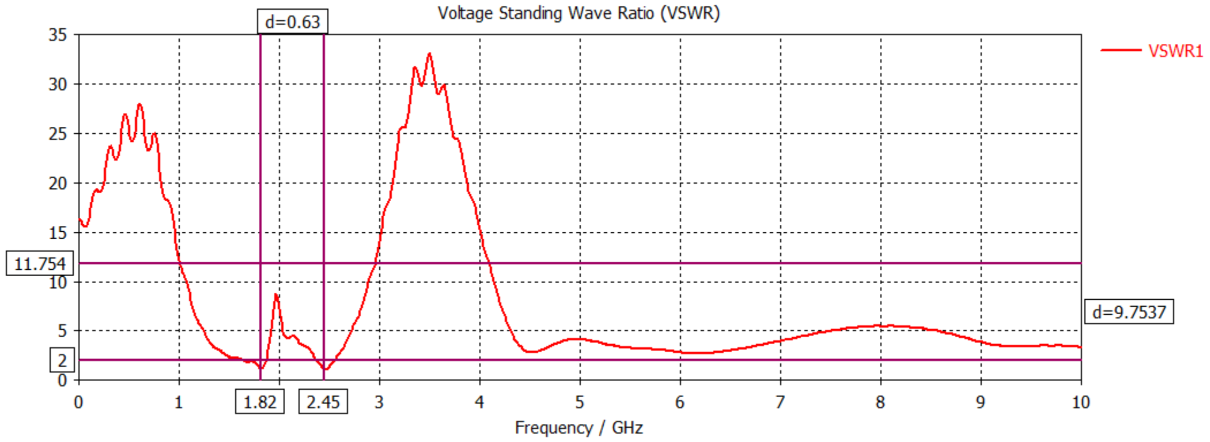

Fig:6 VSWR of proposed antenna

From the VSWR plot for the proposed antenna as shown in fig.6, it is observed that VSWR is less than 2 in LTE and RFID frequency bands. The optimized values of VSWR at 1.82GHz and 2.459 GHZ are 1.14 and 1.05 respectively.

Far field simulations

Polar radiation plots for proposed antenna are shown in fig.7 and fig.8 at 1.82 and 2.459 GHz respectively and observed gain at 1.82GHz and 2.459 GHz is 0.99 dB and 2.27 dB.

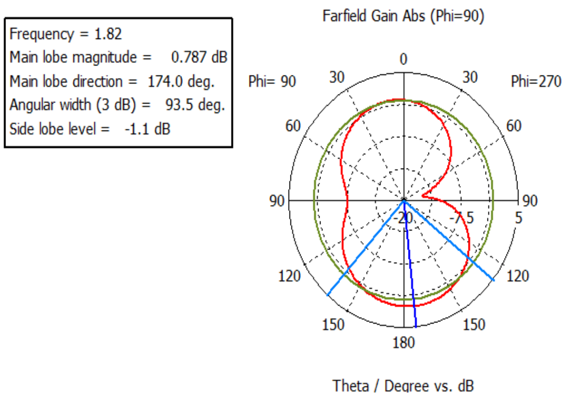

Fig:7 Polar plot at 1.82GHz

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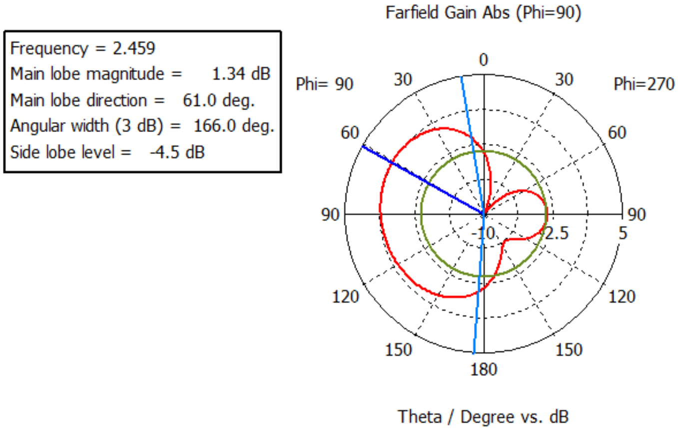

Fig: 8 Polar plot at 2.4599

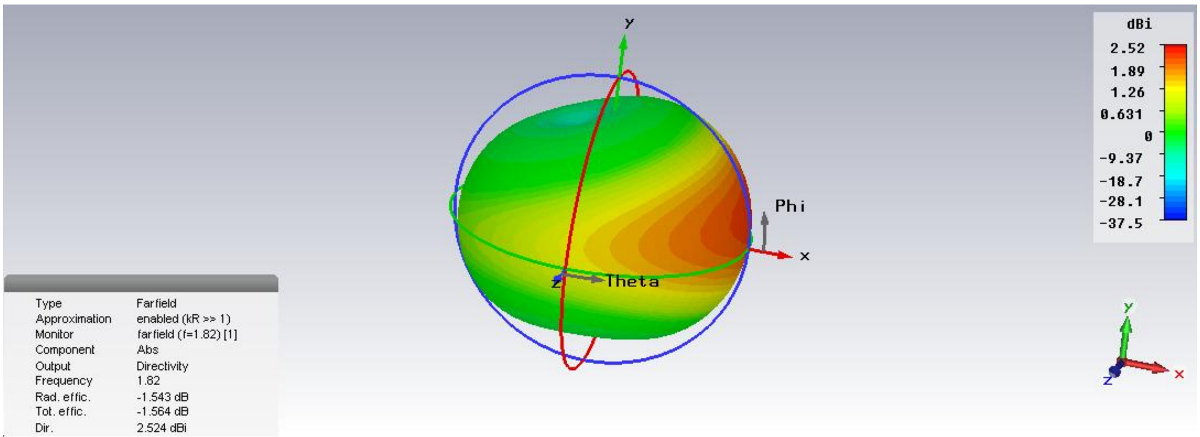

Fig-9: Radiation pattern at 1.82 GHz with directivity 2.52 dBi

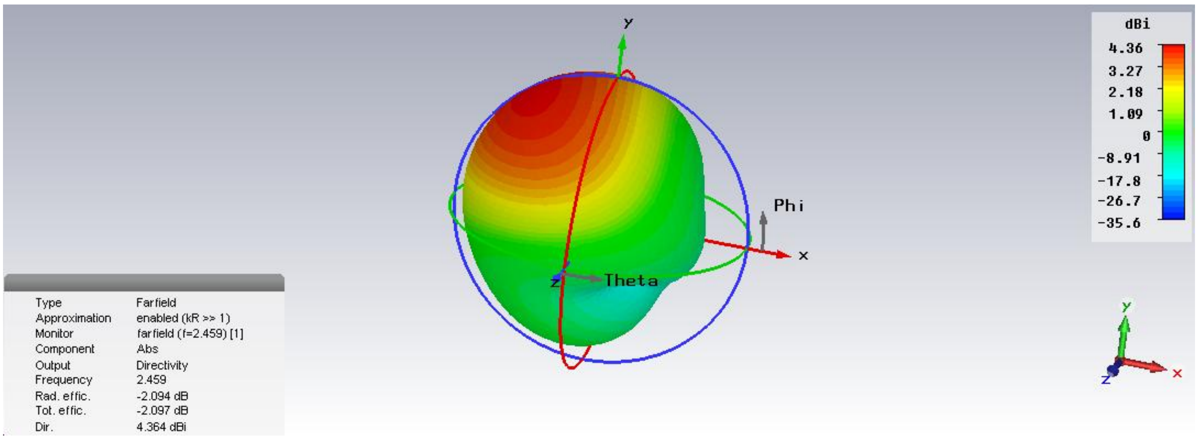

Fig-10: Radiation pattern at 2.459 GHz with directivity 4.36 dBi

From the 3D radiation plots(fig.9 and fig.10) of proposed antenna the observed values of directivity are 2.52 db and 4.35 dB at resonant frequencies 1.82GHz and 2.45 GHz respectively.

4. CONCLUSION

A L-slotted rectangular dual band microstrip patch antenna with slits and slotted half ground plane has been presented for the LTE and radio frequency identification applications. It has been shown that by changing the dimensions of the L-slot and central rectangular slot in the half ground plane, the return loss of the antenna varies. The proposed dual band integrated antenna has enough bandwidth to operate well in LTE and RFID band. The antenna is thin and compact with the use of low dielectric constant substrate material. These features are very useful for worldwide portability of RFID and wireless LTE equipment.

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