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A Compact Triple-Band Rectangular Microstrip Patch Antenna by Using Circular Slits for Wireless Communication

Saddam Hussain[1], Vamsi Krishna Regalla[2], Sandeep Kumar Singh[3], Sabyasachi Mukherjee[4]
[1, 2] B. Tech. Students, Department of ECE, SET, Sharda University, Greater Noida, India-201306
[3, 4] Assistant Professor, Department of ECE, SET, Sharda University, Greater Noida, India-201306
[1] sddmhussain72@gmail.com, [3] sandeepsingh.ec@sharda.ac.in

ABSTRACT

This paper presents the design and characteristics of rectangular microstrip patch antenna, printed on FR-4 epoxy substrate. In this paper the concept of design technique of the triple-band small antenna, which covers IMT (3.84 – 4.00 GHz)/ WLAN (5.06 – 5.25 GHz) and (5.75 – 5.89 GHz) bands respectively. The two circular slits are etched on the radiating patch, and the broadband characteristic are obtained by optimizing the dimensions of antenna [4] [5]. The triple resonant frequencies are obtained by optimizing the slit diameter at various locations. The proposed antenna is simulated using CST V.12 microwave studio, and the performance of the antenna parameters are measured and characterized in the terms of return loss, gain, bandwidth, radiation pattern and surface current distribution at the resonant frequencies respectively. The simulated results confirmed by the successful design, using 50Ω inset strip feed line of microstrip antenna for IMT and WLAN applications.

Key words: Microstrip Antenna (MSA), Circular Slit, Triple-Band, International Mobile Telecommunication (IMT), Wireless Local Area Network (WLAN).

1. INTRODUCTION

The recent development in communication system such as different application works over different frequency bands like GSM/UMTS/DCS/PCS/IMT, Bluetooth, GPS, Wi-MAX, and WLAN etc. Gain enhancement and size reduction are the major considerations for practical applications of microstrip antennas. Satellite and wireless communication often require antenna with compact size, low cost, ease of construction and capable of operating more than one band of frequency [1]. This technique is focused much into the design of microstrip patch antenna. The patch antennas have advantages like low profile, light weight, simple and inexpensive to fabricate [2].

The disadvantages of microstrip patch antenna are narrow frequency, low bandwidth and low efficiency. In order to overcome the disadvantage of narrow bandwidth, several techniques are employed. By incorporating a slit, the bandwidth can be increased. In this work, two circular slits are etched on the radiating patch, and the broadband characteristic are obtained by optimizing the dimensions of antenna. Multiple frequencies operation is necessary to wireless communication for application such as IMT, WLAN etc. The triple resonant frequencies are obtained by optimizing the slit diameter at various locations. The substrate used for the design of rectangular microstrip patch antenna is FR-4 epoxy with dielectric constant (ε_r) 4.3. The proposed antenna is fed by 50Ω inset strip feed line [3].
Antenna design and structure is presented in Section 2. The simulation and characterization results are described in section 3. Conclusion is given at section 4.

2. ANTENNA DESIGN AND STRUCTURE

The geometry of the proposed triple band microstrip patch antenna for operating which in IMT/WLAN bands is shown in figure 1. The radiating patch is made of copper and is in rectangular shape with circular slits, which adjust to the surface current paths. Its size is (61.80 x 31.12 x 1.684) mm^3 volume.

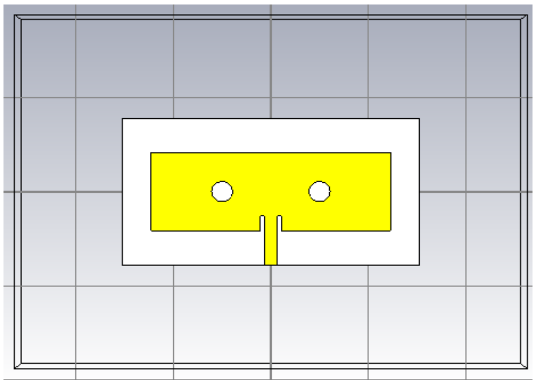


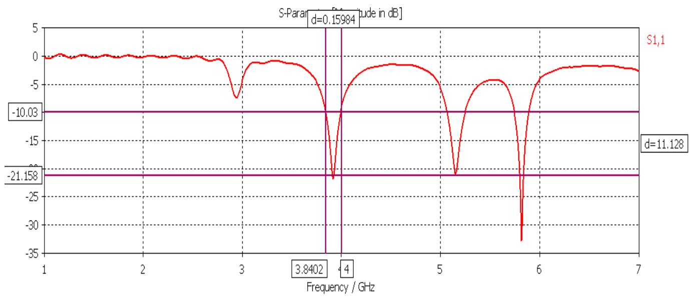
Figure 1: Structure view of circular slits antenna

Ground/Substrate size = (61.80 x 31.12) mm^2
Radiating Patch size = (49.14 x 16.80) mm^2

The built-in antenna mounted on the printed circuit board (PCB) is shown in figure 1. Main PCB layer has a FR-4 epoxy substrate with thickness of 1.524mm, and relative permittivity (ε_r) of 4.3. A 50Ω inset strip feed line is used to feeding this proposed antenna, and etched on the FR-4 substrate [6].
As the thickness and dimension of radiating patch is increased, the impedance bandwidth is broadened. However, the gain decreases. The resonant frequencies and impedance matching are mainly determined by the dimension and thickness of metal, substrate, and the location of circular slits. In order to obtain the triple bands, the design parameters of antenna are tuned and optimized [7].

3. SIMULATION AND CHARACTRIZATION

The simulation result is performed with Computer Simulation Technology (CST) V.12 microwave studio. There is a good agreement with each other, the simulated return losses of the proposed antenna are shown in figure 2, the wide impedence bandwidth can be obtained. The proposed antenna operates from 3.84 to 4.0 GHz within -10dB return loss. The center frequency is resonanted at 3.92GHz with the bandwidth about 20%. This operating bandwidth can cover IMT (3.4 - 4.2GHz) along with another two bands operated from 5.06 to 5.25GHz, the center frequency is resonanted at 5.15GHz with the bandwidth about 94.5%. This operating bandwidth can cover WLAN band-1 (5.15 - 5.35GHz) and third band operated from 5.746 - 5.893GHz, the center frequency is resonanted at 5.85GHz with a bandwidth of about 79%. This operating bandwidth can cover WLAN band-2.



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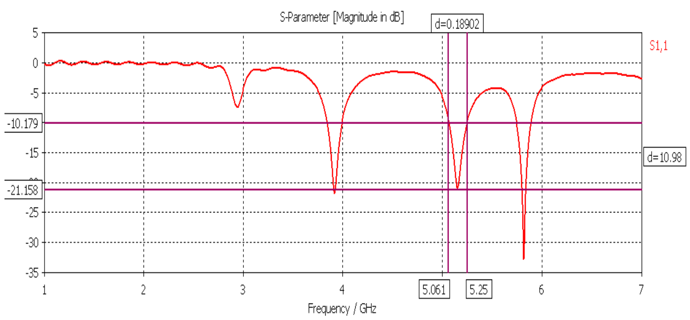

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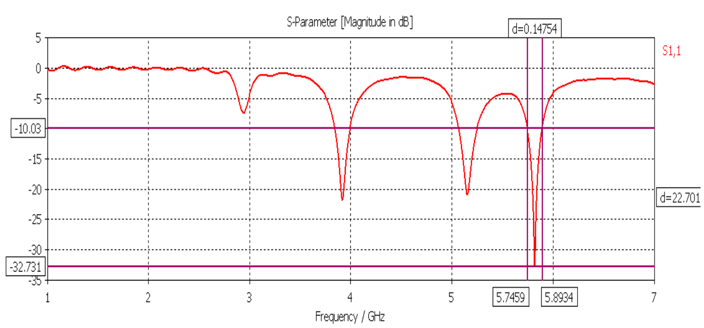

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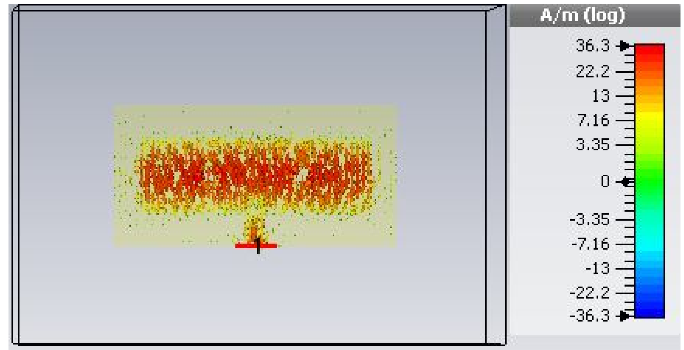
Figure 2: Return loss of proposed antenna at (a) 3.92 GHz (b) 5.15 GHz (c) 5.85 GHz



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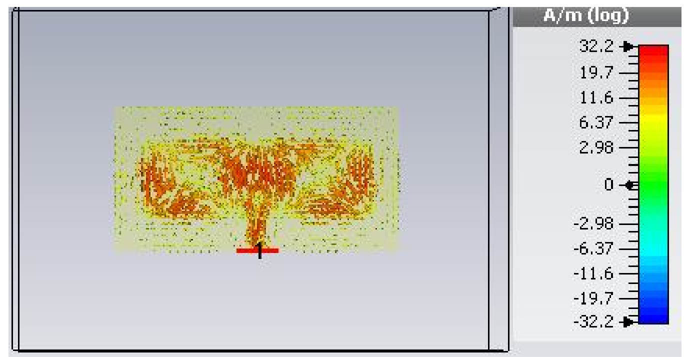

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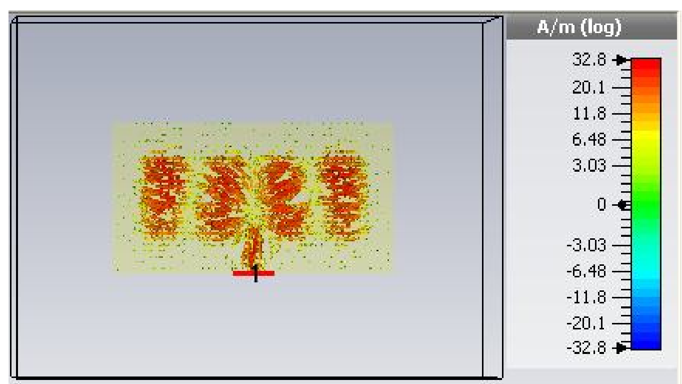

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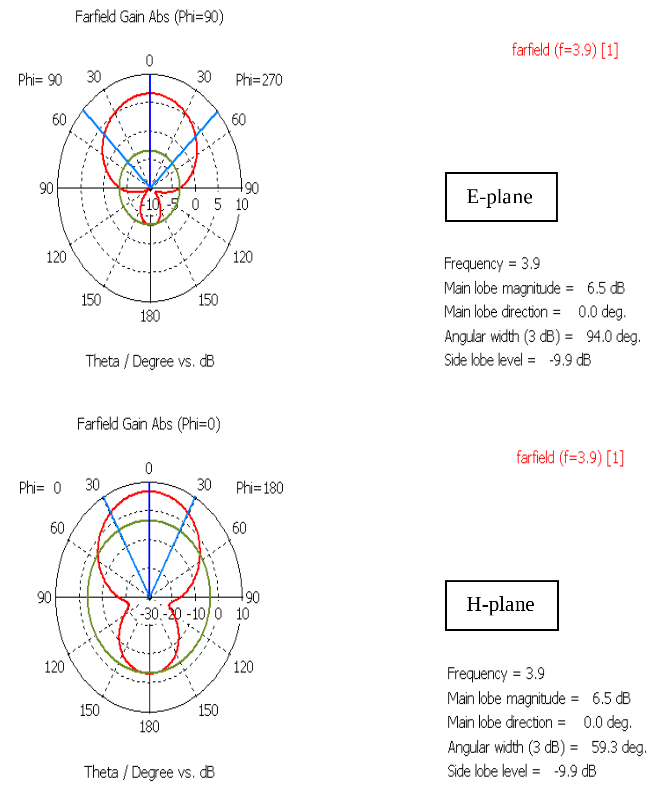
Figure 3**:** Surface current density of proposed antenna at (a) 3.92 GHz, (b) 5.15 GHz, and (c) 5.85 GHz.

In order to check the current flow density at the resonant frequencies, the simulation results of the excited patch surface currents at 3.92GHz, 5.15GHz and 5.85GHz, which obtaibned from the CST software,are presented in figure 3 [8].

The radiation patterns at the resonant frequencuies of 3.92GHz, 5.15Ghz and 5.85Ghz are shown in figure 4 respectively. This slight difference can be attributed to the fact that the feed influences the radiation patterns [9] [10].



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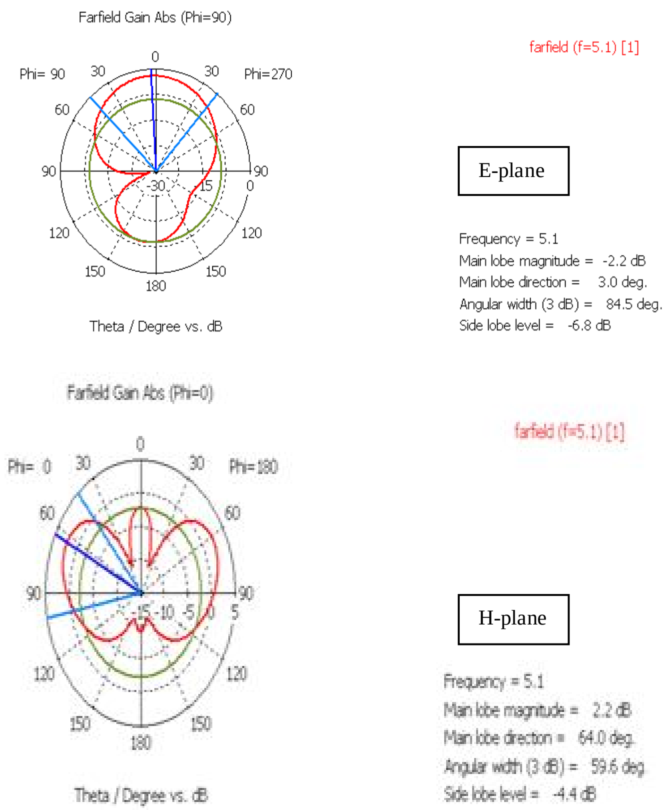

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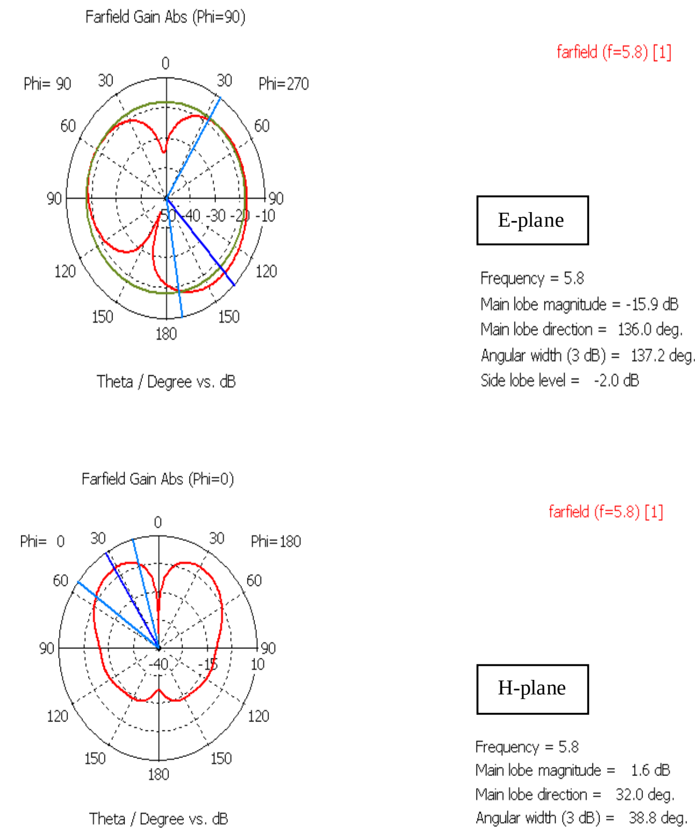

(c)

Figure 4: Far field radiation pattern of proposed antenna at (a) 3.92 GHz (b) 5.8 GHz (c) 7.5 GHz

Table 1: Characteristics of proposed Antenna

Antenna Parameters	**3.92GHz (IMT)**	**5.15GHz (WLAN-1)**	**5.85GHz (WLAN-2)**
Return loss	-21.56dB	-21.158dB	-32.731dB
Gain	6.497dB	2.171dB	1.903dB
Bandwidth	160MHz	189MHz	147MHz

4. CONCLUSION

A triple-band rectangular microstrip patch antenna with circular slits suitable for IMT and WLAN bands. The characteristics of proposed antenna are shown in table1, and met the better requirement specifications of WLAN bands but not so efficient in case of IMT band. These features are attractive for WLAN internal antenna applications.

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