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Microstrip Patch Antenna Design for UWB Communication with Notch band Characteristics

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ABSTRACT: A Multi Frequency wide Band Rectangular Microstrip patch Antenna with T Shaped Slot rotated with an angle is designed on FR-4 substrate. The performance of this antenna is compared with that of a simple rectangular patch antenna containing a centre T slot with patch dimension 60 mm×50 mm. The simulated results for this antenna are optimized by varying position, and angle of T shaped slot on patch with dimension 15 mm×12 mm and also by introducing one T slot in the ground plane. The results indicate that the designed structure resonate at various closely spaced frequencies which are use full for Ultra wide band (UWB) communication systems, which has been allocated IEEE 802.15.3a standard for specifies the frequency range 3.1GHz to 10.6GHz. The Modified antenna offers bandwidth 89.6 % and at central resonance frequency 6.62GHz in comparison to a rectangular patch antenna having band width 76% but with 83.5 % lesser dimension and in this era size and bandwidth matters in designing compact devices. The directivity of antenna also improves significantly at some of the resonance frequencies.

KEYWORDS: FR-4, UWB, WLAN, WiMAX, Radiation pattern, Return loss.

I. INTRODUCTION

Microstrip antennas consist of a very thin metallic patch on a substrate found extensive applications in communication fields due to their attractive features [1, 2].These antennas are low profile, light weight, compact and easy to fabricate [2]. These antennas have drawn attentions of scientific community over the past decades. These antennas may easily be put on any surface and may be easily coupled with MIC components. However their low bandwidth and gain values restrict their commercial applications. Now a day, the scientific community is putting miraculous effort in improving their performance so that they may overcome the low bandwidth and low gain problem and can be used in comparable with other antenna structures in modern communication systems. The commercial utilization of UWB which had been approved by FCC, the interest of UWB systems has aroused among many due to it has feasible design and implementation [9, 19, 23, 26, 28, 30]. The UWB technology in wireless system consumes very low pulse energy. This is being proposed for short range and high bandwidth communication systems since UWB is a low power system, it does not provide any interference with any other system. The interferences present in the working ultra wideband frequency can be overcome the help of notch band characteristics [3, 12, 16, 17, 22, 29, 31, 33]. Those characteristics can be achieved with different method like defected ground plane [4, 10, 11, 14], with using different materials, with slot of different shape on the patch L,T,C and U etc. These miniaturized designs with working in UWB band can be highly desirable in bio technological field [18]. Some of these designs also include wireless communication system which comes under UWB band to provide multi utility devices [22].

In the present structure of patch antenna we have presented a rectangular patch antenna with tilted T shaped slot at the corner of the patch with a rotation angle of 30̊. The two T slots of different dimensions are designed one on the front and other at the ground of patch antenna with monopole design as shown in the figure-1.1. This design also provides notch band characteristics to suppress some of the interference band. The simulation analysis of these antennas is carried out by applying Zeland IE3D simulation software.

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II. ANTENNA DESIGN

The end fed microstrip patch antenna has been designed with no slots on it and the considering patch has been calculated with the formula of designing microstrip patch antenna. The rectangular patch antenna geometry is shown in figure-1.1. The antenna is designed on FR4 substrate having substrate thickness taken as 1.6 mm, and relative dielectric constant $\in_r$= 4.4 with copper as its patch and ground plane. The patch size of 15mm x 12mm is considered for the present work. Theoretical analysis of rectangular patch antenna without slot is carried out by applying cavity model based model expansion technique. The proposed antenna without slot mainly resonates at 5.37 GHz, 9.31 GHz, and 11.16 GHz and Since we designed it on a high permittivity substrate antenna efficiencies is found low whereas bandwidth is around 23.58 %, 5.523 %, and 3.88 % corresponding to those resonating frequencies respectively.

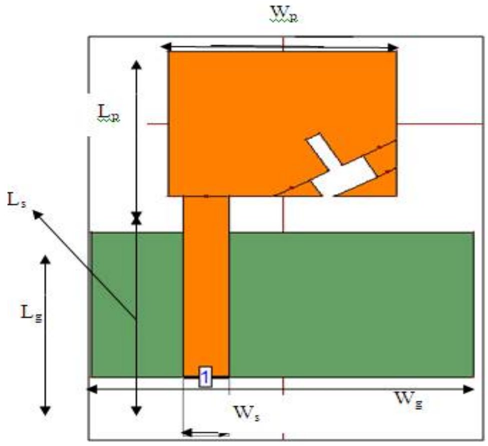

Fig. 1 Final design of the proposed antenna

The dimensions of different slots and strips are being mentioned in table 1. With all those design bandwidth of antenna has increased up to 89.5 % whereas the return loss of the antenna is also considerable for entire band except for notch bands.

Table 1.Parameter's values of the Design

Parameters	Dimension
W_p	15 mm
L_p	12 mm
L_g	12 mm
W_g	25 mm
W_s	3 mm
L_s	15 mm
1st slot(4,-4.5)	4 mm × 2 mm
2nd slot	1 mm × 3 mm
1st Slot on the ground	1mm × 4 mm
2nd Slot on the ground	3 mm ×11 mm
End feed location	(-5.5,21)

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III. RESULT AND DISCUSSION

When T shaped slots as shown in the figure, having dimensions 4 mm x2 mm and 1 mm x3 mm are introduced at the position of (4, -4.5) on the patch geometry, the antenna now resonates at different frequencies such as 3.648GHz, 5.904GHz, 7.536GHz, 9.696GHz, and 11.016 GHz respectively. The simulated results for this modified antenna are optimized by varying position and angle of T shaped slot. The results indicate that the designed structure resonate a band of frequencies which lying between three different frequency bands allocation which are S band, C band and X band and offers much improved bandwidth 48% at central resonance frequency 3.648GHz and 20.33% at central resonance frequency 9.696 GHz in comparison to an rectangular patch antenna**.** To improve the result a 2nd T slot is introduced in the ground plane with dimension 1mm ×4mm and 3mm× 11mm. Then the simulated results is as shown in the figure 1.5 and figure 1.6. After observing those obtained return loss pattern we can say that the performance of the antenna has improved for the ultra wide band with another resonant frequency at 2.5 GHz with return loss about to **-**15 dB. The return loss provided by the design is either less than or equal to -10 dB in entire operating band except on notch bands.

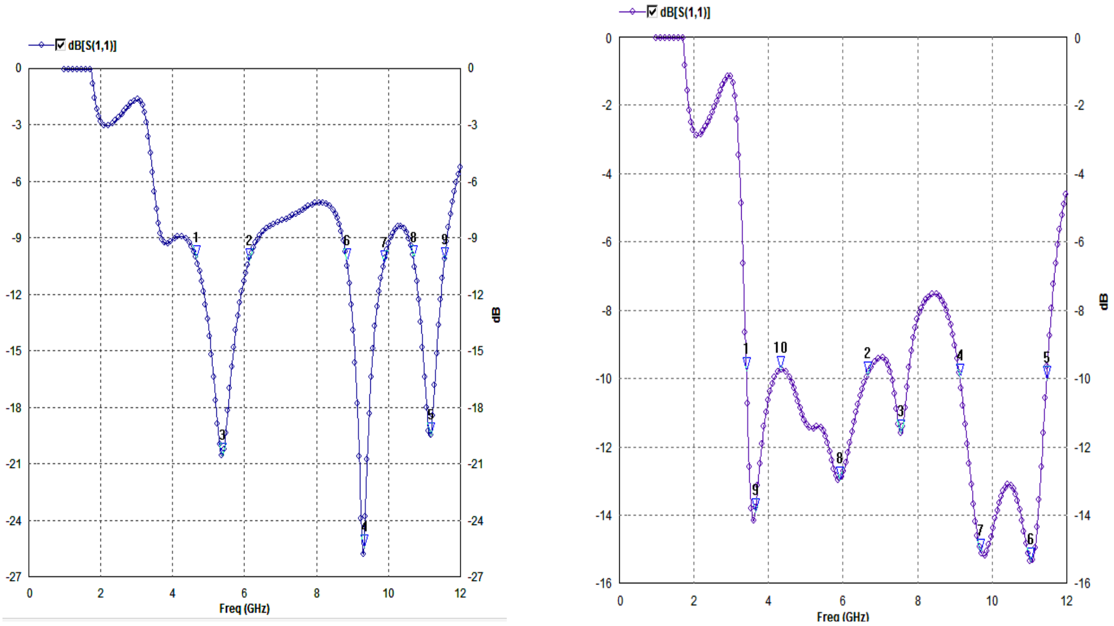

Fig. 2 Plot of return loss with respect to frequency for without slot on patch and with slots on patch

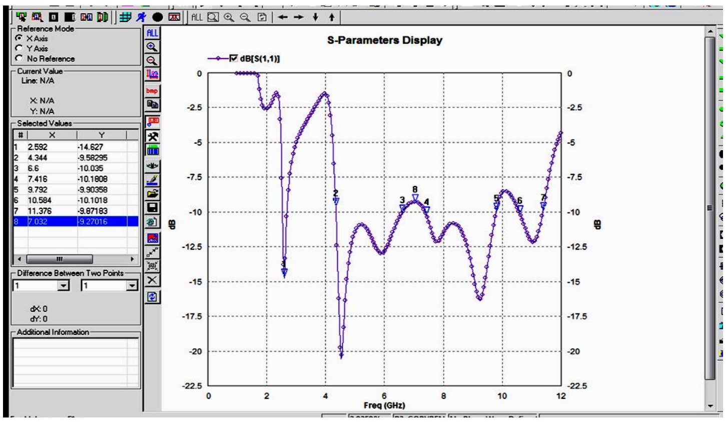

Fig. 3 Plot of return loss with respect to frequency with final design

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The radiation pattern of the proposed antenna for different frequency is in the shape of eight. In H plane radiation pattern is broader than E plane.

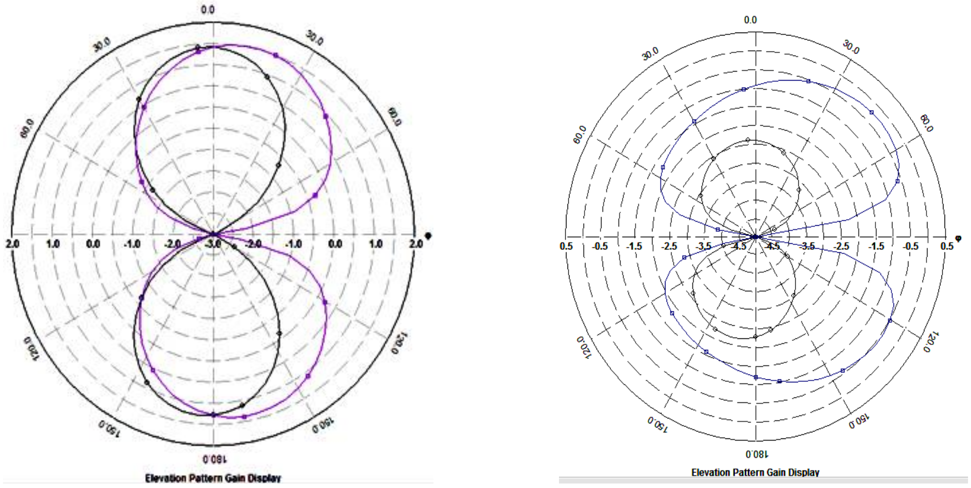

Fig. 4 Radiation pattern of proposed antenna for 2.66 GHz in E plane and H plane

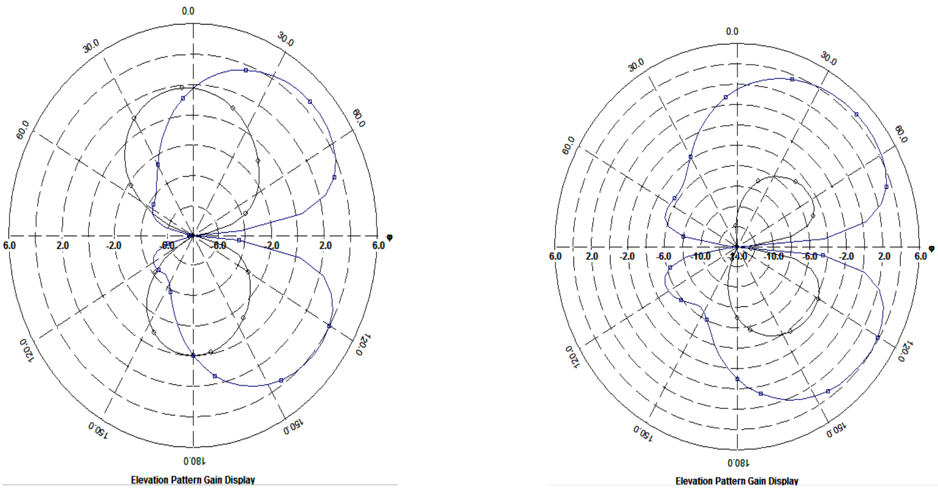

Fig. 5 Radiation pattern of proposed antenna for 4.43 GHz in E plane and H plane

IV. CONCLUSION

The total miniaturization of the design can be calculated with respect to the minimum resonant frequency of the design. The minimum resonant frequency of this design is 2.5 GHz and from the design formula we can calculate the required dimension for the cutoff frequency. According to those calculations miniaturization of the design is 83.5%. The return loss in the entire working band is less than or equal to -10 dB. The bandwidth of the design is about 89.5% around the centre frequency 6.62 GHz with respect to the reference design [14]. The gain of the design is around 6 dB but the maximum directivity ranges up to 7 dB for higher frequencies.

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