IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 10, Issue 4 Ver. III (July – Aug. 2015), PP 52-56
www.iosrjournals.org

Band Notched Rectangular Patch Antenna with Polygon slot

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Abstract: *This paper presents design & simulation of ultra wide band microstrip patch antenna with notched characteristics. The antenna was designed using FR-4 substrate with dielectric constant of 4.4 and thickness of 1.6 mm. The proposed antenna was analysed & simulated on electromagnetic (EM) simulation software. The total size of antenna structure is 15×14.5 mm^2 and it is excited with 50 Ω microstrip feedline. With this design, the return loss is lower than -10 dB in frequency range of 3.3-12.8 GHz. It also shows the band-notch characteristic in the UWB band to avoid interference, caused by WLAN (5.15–5.825 GHz) and WiMAX (5.25–5.85 GHz) systems. The band-notched characteristics in the 5.147-5.855 GHz frequency band has been achieved by etching a polygon slot. The detail design & graphs are shown in the paper.*
Keywords: *Microstrip patch antenna, UWB antenna, partial ground plane*.

I. Introduction

An antenna is an electromagnetic radiator, a sensor and a transducer that converts guided electromagnetic energy in a transmission line to radiate electromagnetic energy [1]. Recently Ultra Wideband (UWB) antenna plays an important role in communication system because of its low cost, low power consumption, low interference, capability of high data rate of around 100 megha bits/second and easy fabrication [2]. As UWB have great potential in high speed short range wireless applications, such as medical imaging system, ground penetrating radars, high data rate wireless local area networks (WLAN), communication systems for military and short pulse radars for automotive even or robotics [3][4]; for designing of this antenna, miniaturization of its circuit design, low voltage standing wave ratio (VSWR<2), constant phase center and constant gain over entire operating frequency band are necessary [5].

In 2002, the Federal Communication Commission (FCC) assigned the frequency band of 3.1 to 10.6 GHz for UWB [6]. But unfortunately other signal spectrum WLAN (5.15–5.825 GHz) and WiMAX (5.25–5.85 GHz) are interfering in this range of UWB [7], which affecting the overall system performance of UWB system in terms of increasing pulse distortion and bit error rate [8]. To overcome this unwanted problem, UWB antennas are designed with band notched characteristics in the affected frequency bands.

For this, different types of slots are etched in the patch and ground plane. For example, U-shaped slot [9], V-shaped slot [10], E-shaped slot [11], S- shaped slot [12], C-shaped slot [13], Pie-shaped slot [14], square-shaped slot [15] etc.

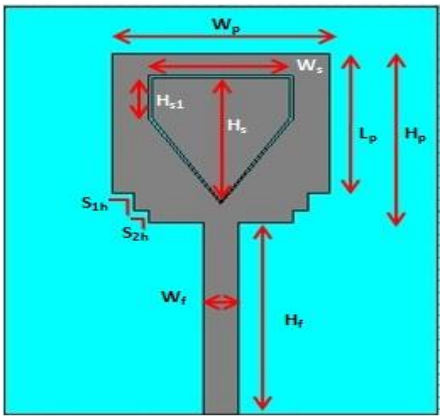
In this paper, an UWB microstrip patch antenna is proposed. The band notched characteristics of proposed antenna has been achieved by etching a polygon slot in rectangular patch with two steps. By simulating the antenna design on simulation software, optimized parameters of design have been obtained. The outline of this paper is as follows. In the section II, antenna design has been described. The simulation results & discussions are presented in section III. Finally, the paper is concluded in section IV.

II. Antenna Description

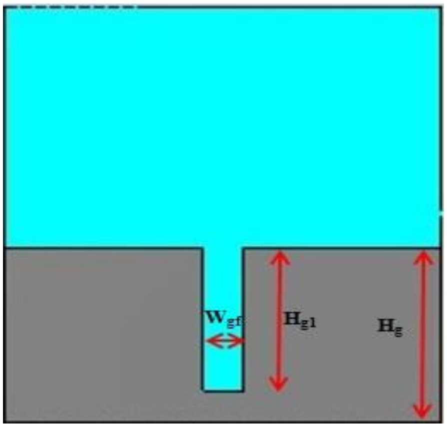
The proposed microstrip patch antenna is designed using FR-4 substrate with dielectric constant (ε_r) of 4.4 and thickness of 1.6 mm. The antenna design consists of a rectangular patch with two steps, a polygon slot, a partial ground plane and a feed-line. The antenna configuration is shown in Fig.1, which shows the whole geometry with detailed design parameters of the proposed UWB notched antenna. The designed antenna was simulated using electromagnetic simulation software.

Table 1: Optimized Parameters

Parameter	Optimized Value
W_p	15 mm
L_p	12 mm
H_p	14.5 mm
S_{1h}	1.5 mm
S_{2h}	1 mm
H_s	10.36 mm
H_{s1}	3.51 mm
W_s	10 mm
H_f	16.5 mm
W_f	2.4 mm
H_g	14.7 mm
H_{g1}	12 mm
W_{gf}	2.8 mm



(a)



(b)

Fig.1. Antenna configuration (a) front (b) back view

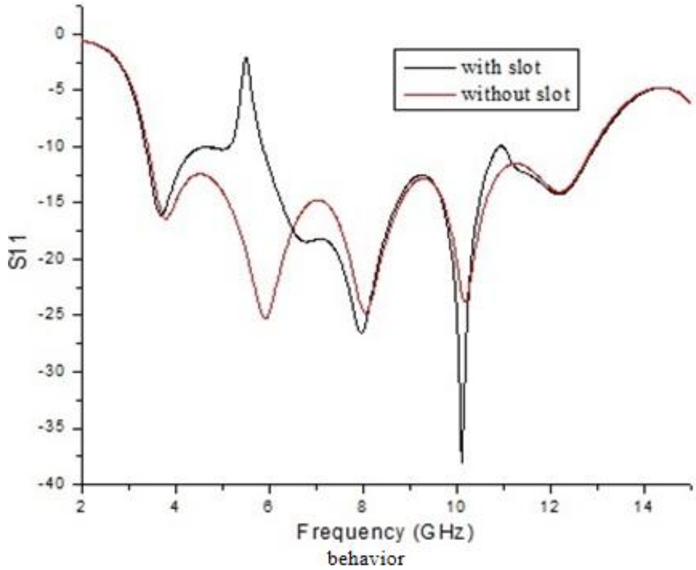
The substrate dimension is 30×35 mm^2. The gap for slot has been taken as 0.2mm. The antenna was excited using a 50Ω microstrip feedline whose width was calculated by using microstrip design equations. The polygon slot was etched in the rectangular patch as per given dimensions. Based on above design, the optimized parameters of proposed antenna are given in Table 1. The geometric parameters of rectangular patch with two steps, a partial ground plane, feed line and polygon slot were optimized with simulation software to get desired performance in terms of the return loss and bandwidth over wide frequency range.

III. Results And Discussion

The performance of proposed antenna was simulated & measured in this section by using electromagnetic (EM) simulation software. The simulated results of return loss for this antenna with and without slot are shown in Fig. 2. It represents that the antenna has a wide bandwidth ranging from 3.3 - 12.8GHz. The overall target of the proposed UWB antenna design is to achieve good output in terms of return loss below -10 dB. The polygon slot is rejecting the frequency band of 5.147 – 5.855 GHz, so frequency interference caused by

WLAN and WiMAX can be avoided. The simulated result of VSWR against frequency (GHz) is shown in Fig.3. This parameter of the antenna is also related to the return loss. As UWB characteristic requires the VSWR between 1 and 2, it can be observed that proposed antenna has a notched frequency band of 5.147 GHz to 5.855 GHz as expected with VSWR > 2. Desired VSWR values have been obtained throughout the frequency region except from 5.147 GHz to 5.855 GHz.

Fig.2. Simulated return loss of the antenna with & without notched band behavior



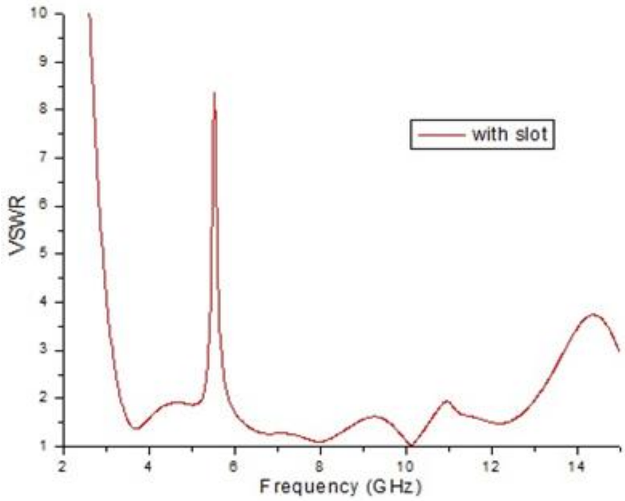
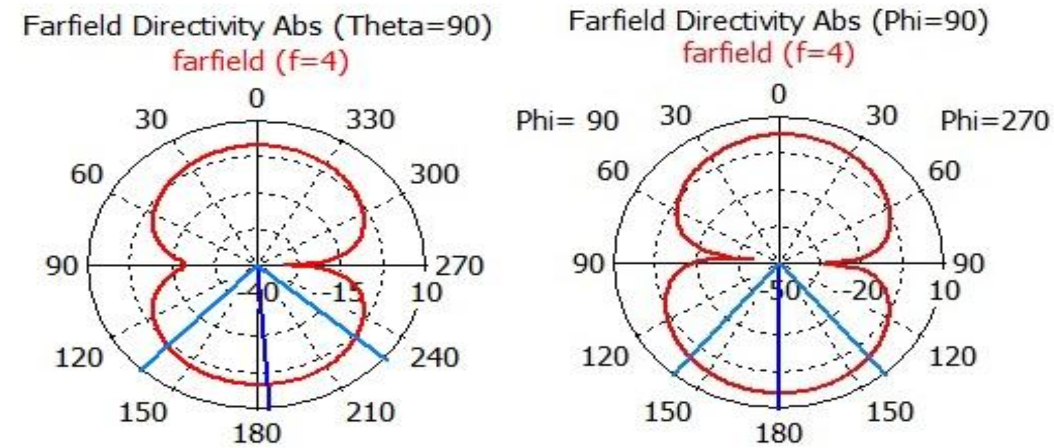


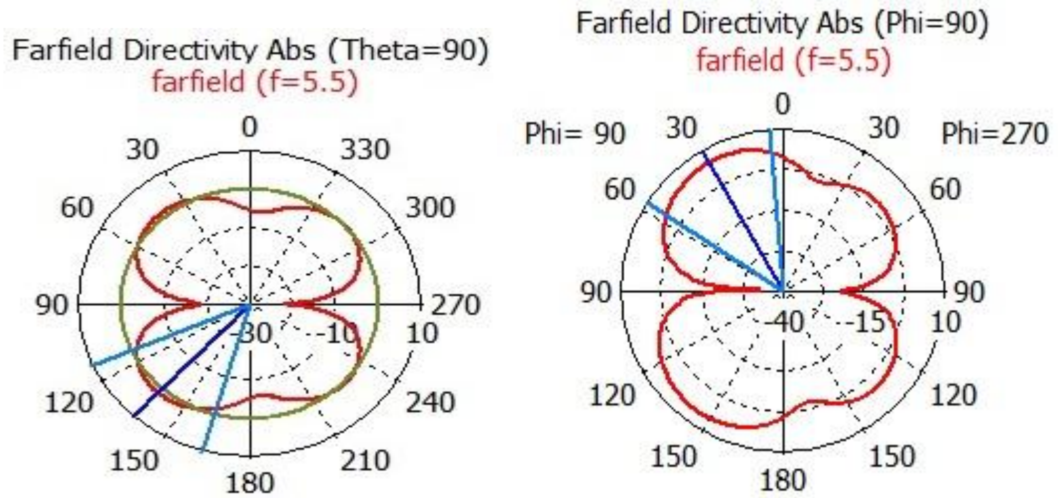
Fig.3 Simulated VSWR of the antenna with notched band behavior

The radiation patterns of the proposed antenna is simulated at 4, 5.5, 8 and 10 GHz frequencies along both E-plane and H- plane as shown in Fig. 4, Fig. 5, Fig. 6 and Fig. 7 respectively. In the view of UWB applications, radiation pattern of the antenna should be omnidirectional. The results of radiation pattern of the proposed antenna at various frequencies 4, 5.5, 8 and 10 GHz demonstrate that the radiation pattern is nearly omnidirectional with change in the frequency across its operating bandwidth.



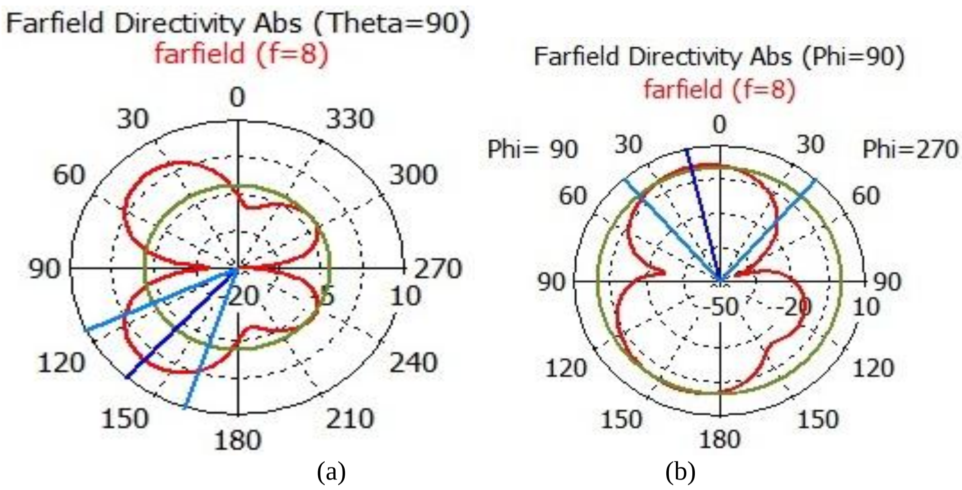
(a) (b)

Fig 4: Simulated radiation patterns of the antenna in (a) E-plane (b) H-plane at f = 4GHz



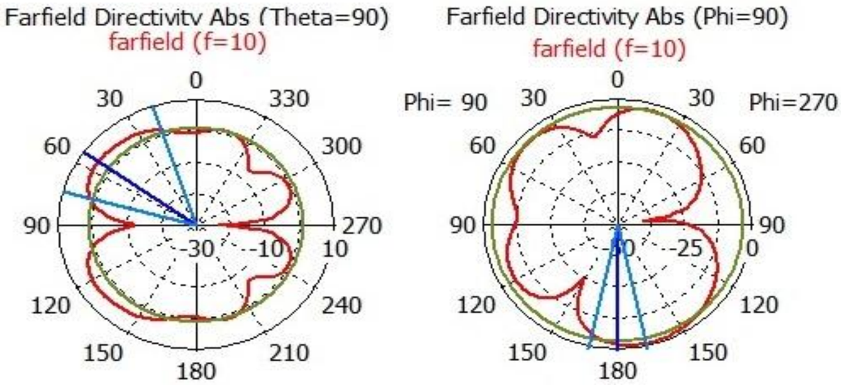
(a) (b)

Fig 5: Simulated radiation patterns of the antenna in (a) E-plane (b) H-plane at f=5.5GHz



(a) (b)

Fig 6: Simulated radiation patterns of the antenna in (a) E-plane (b) H-plane at f=8 GHz



(a) (b)

Fig 7: Simulated radiation patterns of the antenna in (a) E-plane (b) H-plane at f=10 GHz

Fig. 4, 5, 6 and 7 show the simulated radiation patterns at different frequencies at θ=90deg (E-plane) and ϕ=90deg (H-plane). It can be observed from all radiation pattern that, they received high power level except at the notched frequency.

IV. Conclusion

This paper represents a simple rectangular microstrip patch antenna with partial ground for UWB applications. The proposed UWB antenna can be operated from 3.3 to 12.8 GHz frequency range with return loss less than -10 dB and is rejecting the frequency band of about 5.147 to 5.855 GHz to avoid the frequency interference from WLAN and WIMAX. The good performance of proposed UWB antenna structure makes it suitable for future UWB communication applications.

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