A Planar UWB Antenna with Triple Notched Bands

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Abstract-This paper presents a rectangular planar monopole antenna with triple stop bands for ultra-wide band Applications. The antenna is compact size (24mm x 24mm x 1.6mm) and is covering the entire UWB band with VSWR < 2 except the band of WiMAX range from 3.07 — 4.73 GHz, the WLAN band range from 5.14 — 5.97 GHz and the ITU frequency band range from of 7.92 — 8.61 GHz. The three slots are added to this antenna to stop various bands. Different shaped slots i.e. inverted Z, C and U are introduced in radiating element to stop WiMAX, WLAN and ITU respectively. The antenna is simulated using High Frequency Structure Simulator (HFSS) using FR4 as a substrate.

Keywords-ITU band, WLAN, VSWR, WiMAX, HFSS, Ultra-wide band

I. INTRODUCTION

These days wireless communication is under consideration for researcher all over the world and advancing at a very rapid pace. Antenna is an important part of any communication system which is used as a filter/radiator; it can transmit/receive signals at certain frequencies. There is also a need of high gain antennas on both transmitter and receiver sides; in addition, multi-path environment emphasizes the use of multiple antennas. Due to continuous development in wireless communication system and the need of high data rate transmission, the use of microstrip fed printed monopole antennas (PMAs) has become popular in wireless communication systems.

Today's wireless communication is a need of human life. Mostly the electronic devices around are using wireless communication systems. Antenna is an essential part of such kind of systems, example include radars, television, spacecraft, wireless computer networks, satellite communications, and wireless phones etc. The demand of compact and low profile antennas are increasing day by day. The use of multiple antennas in wireless system like MIMO has also increased the demand of small size antennas.

The authorization of UWB band (3.1-106GHz) was given by Federal Communication Commission (FCC) USA in 2002, for commercial applications [i]. The implementation of UWB with low profile antennas has been under consideration by researchers since last decade. UWB is larger bandwidth as compared with narrowband and wideband, but UWB communication systems have interference problem with existing narrowband communication systems, the existing narrow bands are WiMAX, WLAN and ITU frequency band. These bands are stopped with the help of band-stop filter in order to reduce electromagnetic interference. However, the complexity and limitations are increased due to these filters. Therefore, the PMA with notched characteristics is required to reduce the interference, which is very simple, low profile, compact in size, easy in installation and fabrication.

The aim of the research is, to design microsrip fed rectangular planar monopole antenna which is used for UWB applications and will stop various bands such as WLAN (5.15—5.82 GHz), WiMAX (3.3—3.7 GHz) and ITU 8 GHz (8.025—8.4 GHz). Various methods and techniques are used to reduce the electromagnetic interference, these techniques are split ring resonator (SRR), electromagnetic-band gap (EBG) and complementary split ring resonator (CSSR), pair of open loop resonator, embedding T-shaped stub and pair of U-shaped parasitic strips [ii-v]. The stop bands are also achieved by etching slots in planar monopole antenna such as semi-elliptical slot, E-shaped slot, U-shaped slot, symmetrical elliptical slots, L-shaped slot, fractal shaped slot, circular slot, C-shaped slots, rectangular slot and inverted C-shaped slots [vi-xiii].

Recently various planar monopole antennas with stop bands are reported. Zhen hong et al. presented a circular shaped printed antenna with dimensions of 34mm x 35mm x 1.6mm, and stopped only two bands with the help of U shaped and C shaped slots [xiv]. Aiting Wu and Boran Guan proposed an UWB antenna with size of 32mm x 32mm x 0.508 mm and stopped dual bands [xv]. A. Chaabane et al. developed UWB printed antenna with size of 31mm x 31mm x 1.6mm and rejected two bands with the help of slots, which are etched in radiating patch and feed line [xvi]. Ronghua Shi et al. designed a UWB Antenna with size of 35.5mm x 30mm x 1.6mm, etched H shaped slot in the radiator and narrow slots in the ground to stop the bands of WLAN and WiMAX [xvii]. Guoping Gao et al. fabricated U shaped UWB antenna with CSRR and T shaped slot to stop the bands of WiMAX and WLAN, the size of antenna is 24.6mm x 38.1mm x 1.5mm [xviii]. Manas Sarkar et al. propounded a printed antenna with size of 24mm x 34.6mm x 0.8mm, and with triple notched bands, the stop bands are achieved with the help of pair of slots and CSRR [xix]. The antennas discussed in literature have larger sizes and maximum antennas have dual notched bands.

In this paper rectangular UWB planar monopole antenna with three stop bands is presented. The stop bands are due to various slots, these slots are inverted Z, inverted C and inverted U. The inverted Z slot is used to stop the band of WiMAX, the inverted C slot is used to stop the band of WLAN and the inverted U slot is used to stop the ITU frequency band. The simulations were carried out in HFSS using FR4 as a substrate.

II. ANTENNA DESIGN

The rectangular planar monopole antenna with triple stop bands is designed by using a microstrip fed technique. The presented design is printed on a FR4 low cost dielectric substrate, with thickness of 1.6mm, loss tangent of .02 and permittivity of 4.6. The slots are added to stop various bands. The inverted Z shaped slot is used to stop the band of 3.07 — 4.73 GHz used for WiMAX applications. The inverted C shaped slot is used to stop the band of 5.14 —5.97 GHz used for WLAN applications. The inverted U shaped slot is used to stop the band of 7.92 — 8.61 GHz (ITU frequency band). After the optimization of the design and slot position, the final design is obtained which is shown in Fig. 1. Simulated VSWR is depicted in Fig. 2 and simulated S_{11} (dB) is also shown in Fig. 3. The dimensions of slots depend on notch frequency and substrate permittivity εr. The length of slots are half wavelength or quarter wavelength at notch frequency. The length of slots are determined from the equations (1) and (2) [xx].

$$Ls = c/(4f_n\ \varepsilon_c) \tag{1}$$

or

$$Ls = c/(2f_n\ \varepsilon_c) \tag{2}$$

Where L_{s1} is the inverted Z slot length (mm), L_{s2} is the inverted C slot length (mm), L_{s3} is the inverted U slot length (mm), c is the light speed (3×10^8 m/s) and f_n is the notch frequency (GHz) and ε_r is a unit-less constant known as relative dielectric constant of the material.

The dimensions of design are 24mm x 24mm x 1.6mm. The dimension of inverted Z shaped slot is 14.8mm x 0.4mm. The dimension of inverted C shaped slot is 19.6mm x 0.3mm. The dimension of inverted U shaped slot is 10.8mm x 0.2mm. The crucial part of the design is the gap between radiator and ground, which is 0.4mm. Various Table I summarizes various design parameters.

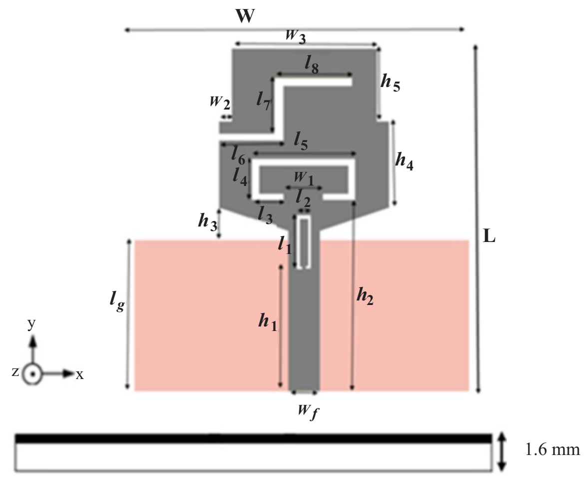


Fig. 1. Design of the proposed triple stop bands Antenna

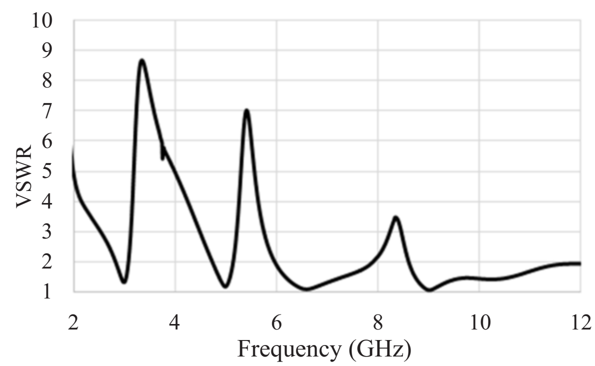


Fig. 2. Simulated VSWR of the proposed antenna with triple stop bands.

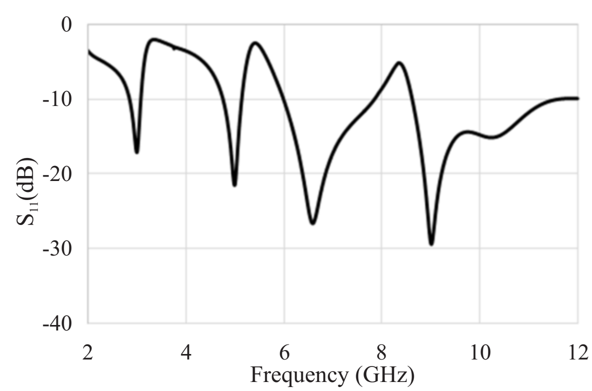


Fig. 3. Simulated S11(dB) of the proposed antenna with triple stop bands

TABLE I
DESIGN PARAMETERS OF THE ANTENNA

Parameter	Value (mm)	Parameter	Value (mm)
L	24	l_g	10.7
W	24	h_1	7.8
l_1	4.6	h_2	13.2
l_2	1.2	h_3	2.1
l_3	3.1	h_4	6.1
l_4	2.7	h_5	5.1
l_5	8	w_1	1.8
l_6	4.4	w_2	0.9
l_7	4.5	w_{13}	10.2
l_8	5.9	w_f	2.2

III. RESULTS AND DISCUSSION

The antenna is resonating in the entire range of UWB band with VSWR < 2 except the band of WiMAX range from 3.07 — 4.73 GHz, the WLAN band range from 5.14 — 5.97 GHz and the ITU frequency band range from of 7.92 — 8.61 GHz, which is justified from Fig. 2. Fig. 4 shows the gain of the antenna. The gain at stop frequencies are -12 dBi, -5 dBi and -5 dBi respectively, which is very poor as compared with other frequencies. Similarly, the radiation efficiency is poor at notched frequencies which is shown in Fig. 5. The radiation patterns at various frequencies are illustrated in Fig. 6. The solid line represents E-plane (phi = 00) and dash line represents H-plane (phi = 900) radiation pattern, which is nearly omnidirectional.

The front and back view of the fabricated design is shown in Fig. 7. The measured and simulated VSWR are given in Fig. 8. & Fig. 9 shows simulated vs measured coefficient. From the result, a slight shift in notched frequencies is noted, it may be due to fabrication errors or due to connector losses. In the measured results antenna is resonate from 2.90 GHz to 11 GHz, the stop band of 7.92 — 8.61 GHz (ITU frequency band) is shifted to 7.92 — 9 GHz, the stop band of 5.14 — 5.97 GHz is shifted to 5.15 — 6.05 GHz, the stop band of 3.07 — 4.73 GHz is not shifted.

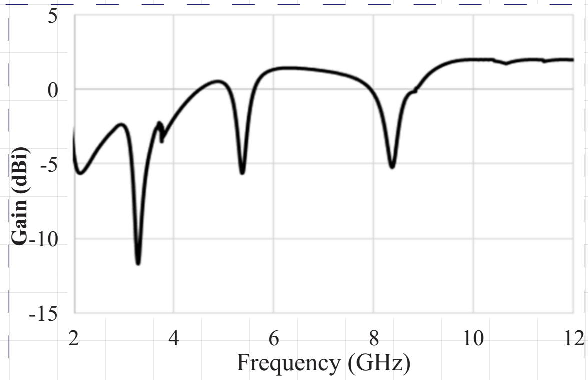


Fig. 4. Gain Distribution of the proposed antenna

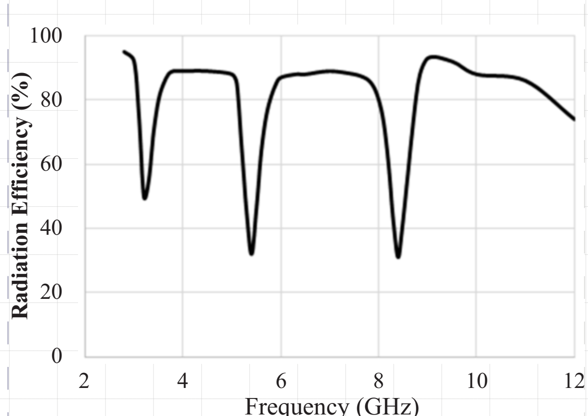
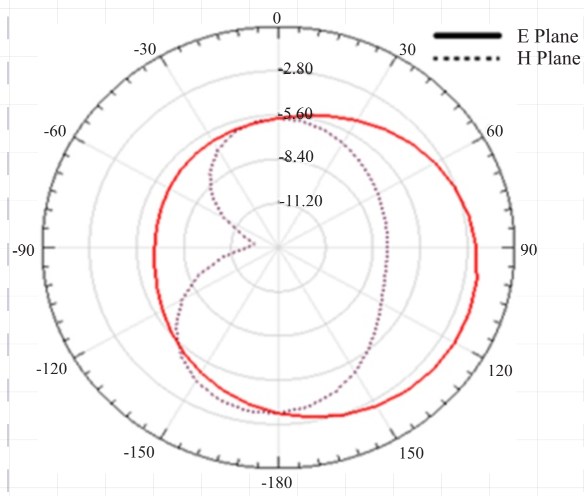
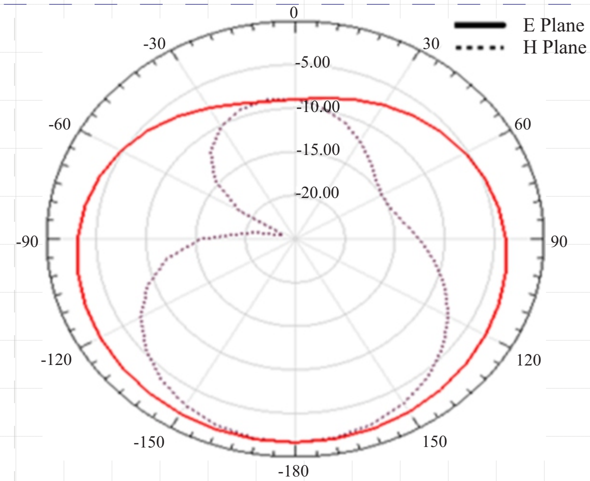


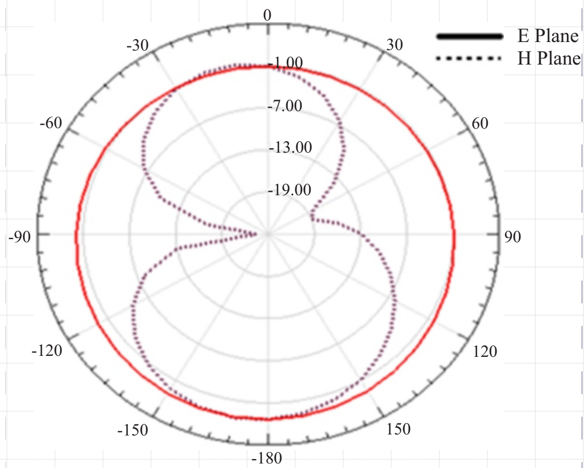
Fig. 5. Radiation efficiency plot



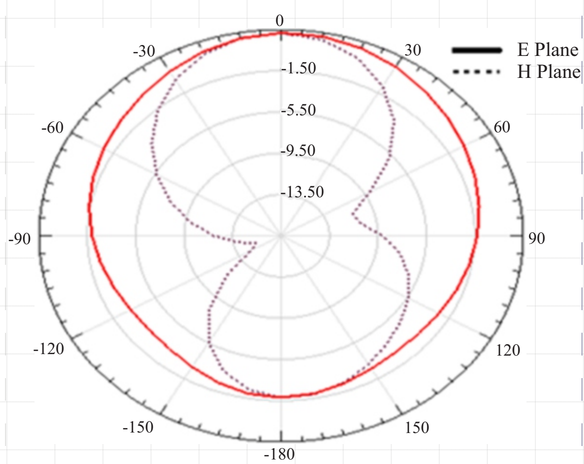
(a)



(b)



(c)



(d)

Fig. 6. Radiation patterns of proposed antenna with triple stop bands (a) 3.2 GHz (b) 5.5 GHz (c) 6 GHz (d) 8.2 Ghz

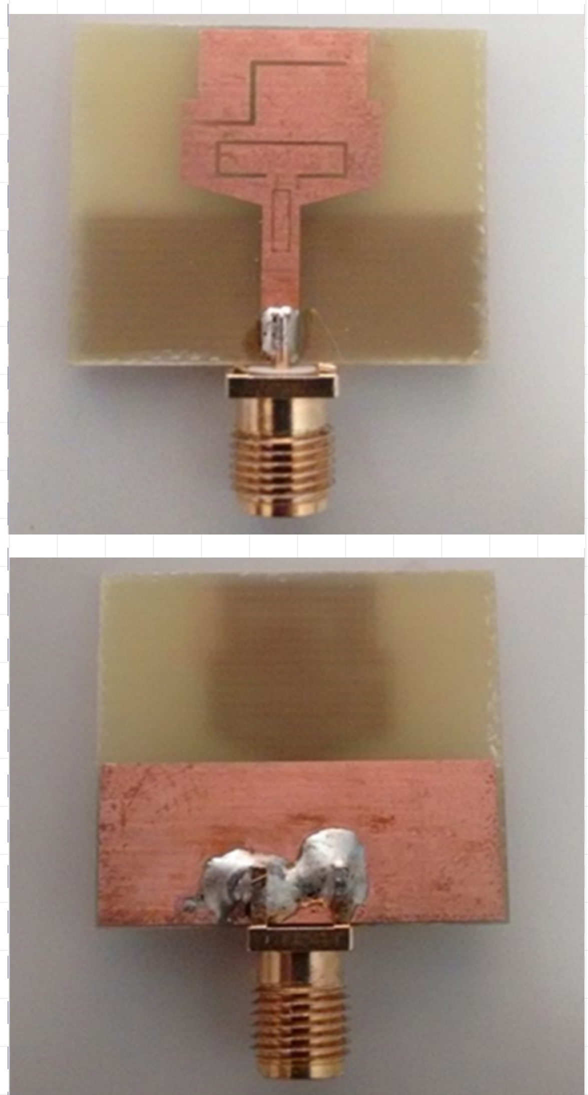


Fig. 7. Fabricated image of proposed antenna with triple stop bands: Front View and Back View

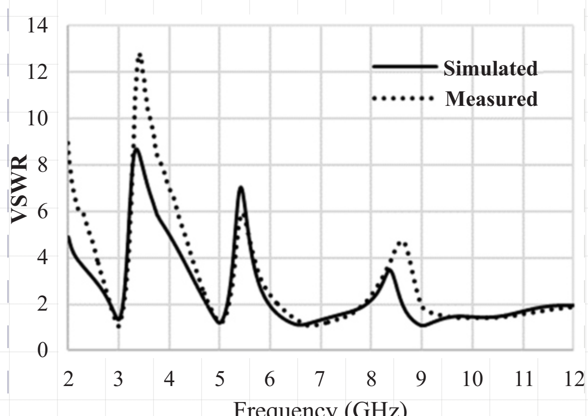


Fig. 8. Comparison between measured and simulated VSWR of proposed antenna with triple stop bands

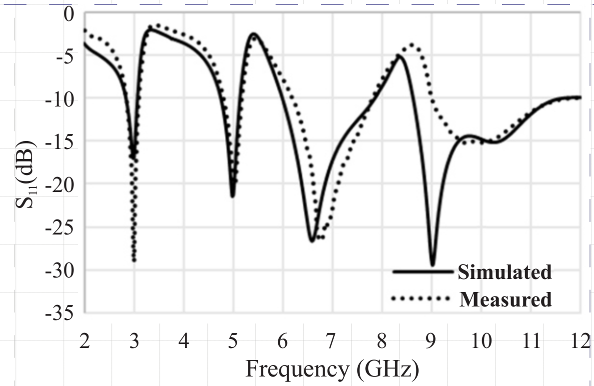


Fig. 9. Comparison between measured vs simulated S_{11} (dB) of proposed antenna with triple stop bands

IV. Conclusion

In this paper, rectangular planar monopole antenna with triple stop bands is presented for UWB applications. Antenna is resonating from 2.90 GHz to 12 GHz. Inverted Z, inverted C and inverted U shaped slots are used to stop the bands of WiMAX, WLAN and ITU 8 GHz. The proposed design is simulated and tested in ANSYS HFSS, the design is also fabricated and measured. The small size, simple structure and easy integration and fabrication, are some of the key characteristics of this antenna.

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