A TRI BAND-NOTCHED UWB ANTENNA

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ABSTRACT

A compact ultrawideband (UWB) monopole antenna with 3.5/5.5/7.5 GHz tri band-notched characteristics is presented. The antenna has Y-shape radiating patch and fed by a 50-Ω microstrip feed line. By removing two C-shaped slots in the radiating patch, and one U-shaped slot in the microstrip line, tri band-notched properties in the WiMAX/WLAN/X-band satellite bands are achieved. The proposed antenna is effectively simulated and shows stable radiation pattern characteristics.

Keywords: UWB, Tri Band Notch, C-shaped slot, U- shaped slot, WiMAX, WLAN, X-band satellite

I.INTRODUCTION

In the current era of communication, there is exponential growth in the wireless communications. This led to the development of various types of antennas. The Ultrawideband (UWB) is specified in the Federal Communication Commission (FCC) [1], as the frequency band that ranges from 3.1GHz to 10.6GHz, which is of 7.5GHz bandwidth. Several planar UWB monopole antennas, which have the potential to meet such requirements, were reported in [2–5].

But with the large operating bandwidth of the UWB (3.1-10.6 GHz), there are some narrowband wireless services, which occupy some of the frequency bands in the UWB bandwidth. The most well-known among them are WiMAX system at 3-4 GHz, WLAN at 5-6GHz and X-band satellite communication at 7-8 GHz. The main challenge in designing a UWB antenna to avoid potential interference with existing narrowband services.

Reviewing the literature shows that there are few ways for planar antennas to achieve band-notched characteristics. The most popular approach is cutting different shaped slots from the radiating patch, from the ground plane, or from the feed line, that is, U-shaped slot [5], a Hilbert-curve shaped slot [6],cutting a wide line [7], T-shaped slot [8], defected ground structure (DGS) [9], semi-circular slot [10], a bent slot or C-shaped slot [11–13], split ring in the ground plane [14],and slot line in the feed line [15]. Another way consists of loading diverse parasitic elements on the antenna, such as parasitic elements, CLL, near the radiating element [16], and near the feed line [17], to generate the band-notched characteristics.

In this paper, we propose a simple and compact microstrip line fed planar UWB antenna with tri band-notched characteristics in 3.5 GHz (3-4 GHz) ,5.5 GHz (5-6 GHz) and 7.5 GHz (7–8 GHz), The tri band-notched characteristic in the proposed antenna can be achieved by removing two C-shaped slots from radiator and U-shaped slot from microstrip line. The radiating patch is having a Y-shape structure. It has been observed that by adjusting the total length of the C- shaped and U-shaped slot to be approximately half wavelength (λ) of the required notch frequency, a destructive interference takes place making the antenna non-radiating at that notch frequency. The tuning of the central notch frequency can be done by adjusting. The total length of each slot can be calculated by (1), at which the slots resonate at the corresponding band notching frequency, and its total length is equal to a half wavelength as follows.

$$L_{total} = \frac{c}{2f_{notch}\sqrt{\varepsilon_{eff}}} \quad (1)$$

Where $$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} \quad (2)$$

L_{total} denotes the total length of the corresponding slot; ε_{eff} is the effective dielectric constant of the substrate; and C is the speed of light in free space.

The optimization of the design and the subsequent simulation is done by COMSOL Multiphysics software. The proposed antenna provides bandwidth of 3.1-10.6 GHz with $VSWR \leq 2$, except the bandwidths of 3-4 GHz for WiMAX system, 5-6 GHz for WLAN system and 7-8GHz for X-band satellite communication band.

II. ANTENNA DESIGN AND ANALYSIS

Antenna Geometry

The geometry of the proposed antenna is shown in Fig. 1 (a), (b). The antenna has a compact geometry of 30 x 32.5 mm^2 With FR4 substrate of thickness 1.6 mm and dielectric constant ε_r =4.4, The antenna is fed through a 50Ω microstrip line. The partial rectangular ground plane having a rectangular cut just beneath the microstrip feedline on the other side of the FR4 substrate ground plane to achieve wide impedance bandwidth.

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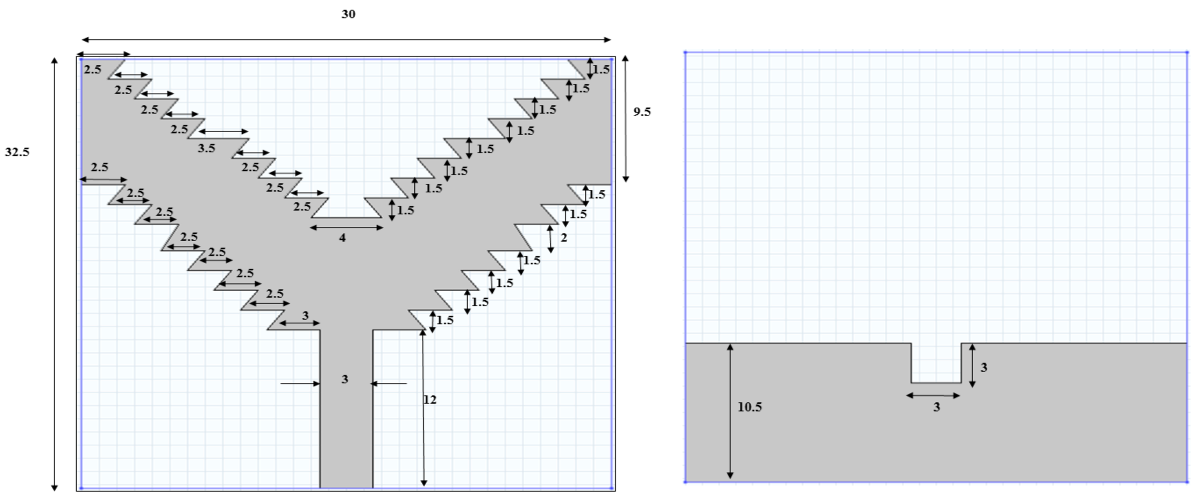
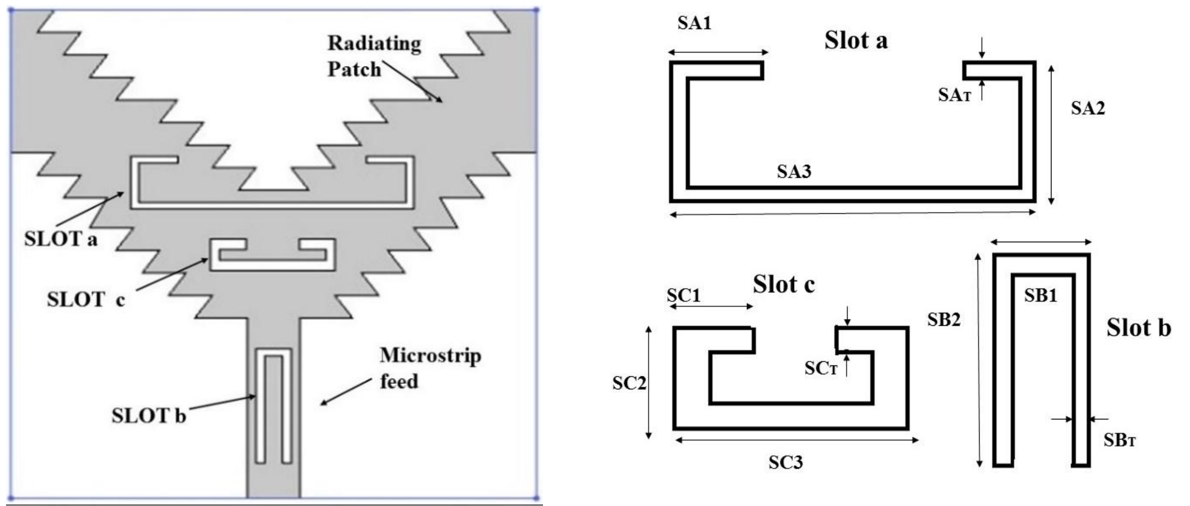


(a) (b)

Fig. 1. The design geometry of proposed initial monopole UWB antenna. (a) front view. (b) back view



(a) (b)

Fig.2(a) Layout of proposed UWB antenna with three band-notched (b) Layout of the slots with its parameters

Fig .2 shows layouts of proposed UWB antenna with three band-notched slots. The tri band-notched properties are observed with three band-notched elements such as slot a, slot b, slot c, at 3.5, 5.5, and 7.5, GHz, respectively. To ensure least mutual coupling, the dimension and position of tri band notched elements have been optimized in our proposed design. However, each band-notched element has been tuned independently.

Dimensions of the proposed UWB antenna with optimized parameters of antenna geometry in Fig.1 and slots shown in Fig.2. (b). are as follows SA1=2.7 mm, SA2=3.5mm, SA3=16.15mm, SA_T=0.4mm, SB1=2mm, SB2=7.6mm, SB_T=0.5mm, SC1=2mm, SC2=2.1mm, SC3=7.1mm, SC_T=0.7mm

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Fig. 3 shows the simulated VSWR of reference antenna without any slot. The simulated response indicates a wide impedance bandwidth from 3 GHz to 11 GHz for VSWR<2.The wide impedance bandwidth can be attributed to optimised value of gap between the radiator and the ground plane.

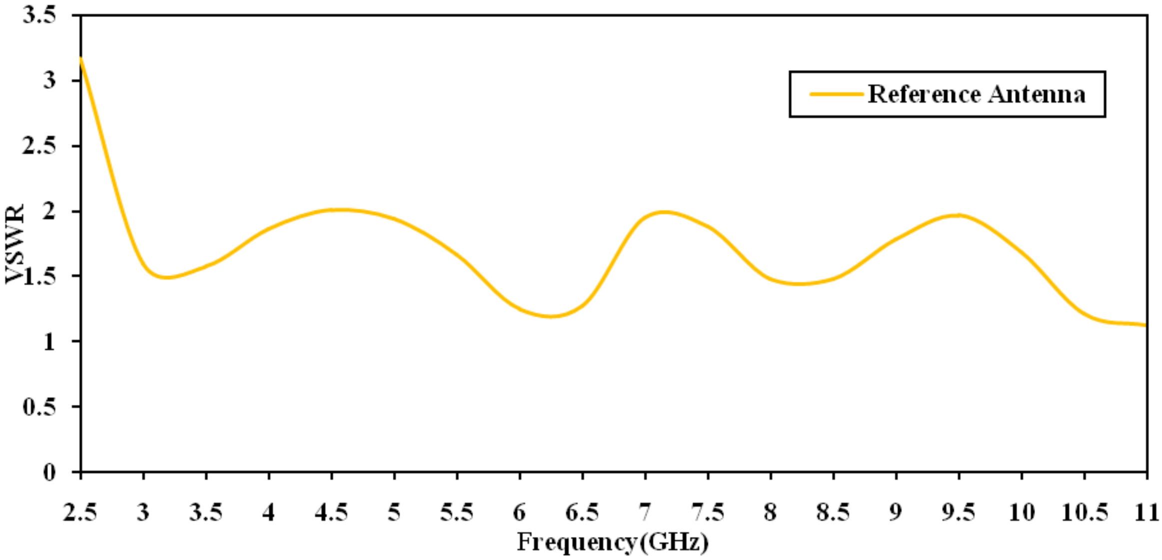
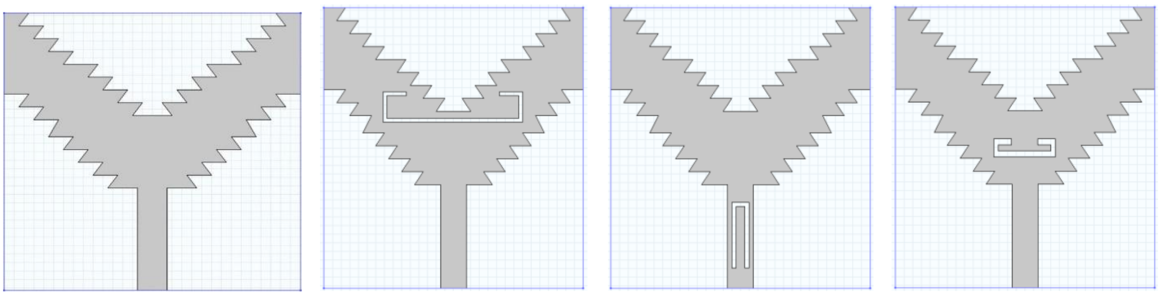


Fig. 3. VSWR of initial planner monopole UWB antenna without slot



Reference Antenna **Antenna a** **Antenna b** **Antenna c**

Fig.4. Geometry of UWB antenna having individual slots on radiating patch and microstrip line.

Fig. 4 shows the evolution of design of proposed UWB antenna from initial antenna. The slots for band notched characteristics are introduced individually and analysed in terms of VSWR for each slot. The antennas labelled as a, b and c have been designed to notch frequency bands centered at 3.5, 5.5 and 7.5 GHz.

The simulated VSWR of antenna having individual slots is shown in Fig. 5. It is noted that antennas a, b and c are able to notch frequency bands individually centered at 3.5 GHz, 5.5 GHz and 7.5 GHz, respectively. The location of each slot is different on the radiator patch so they do not interfere with notched bands created by other slots

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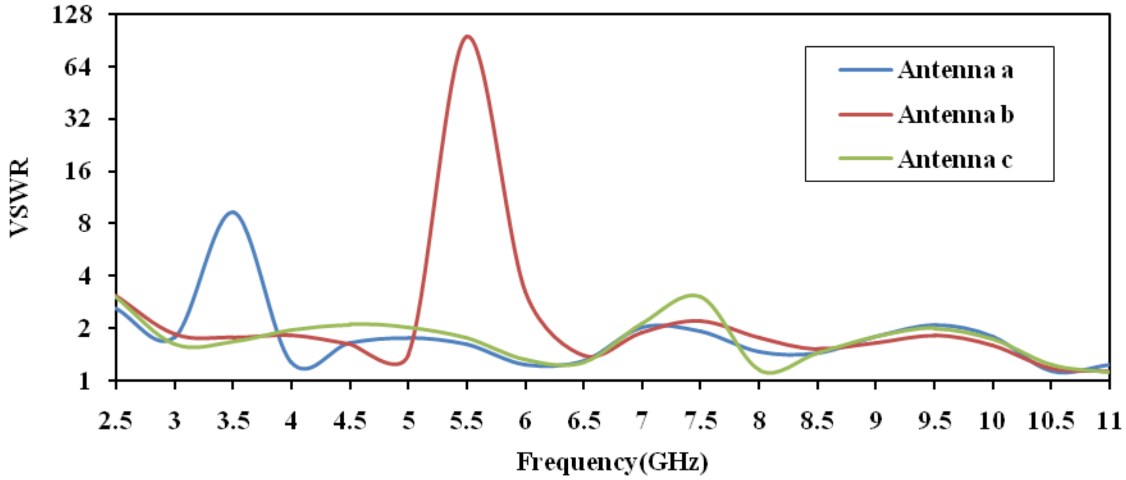


Fig.5. Simulated VSWR of UWB antennas a, b, and c.

UWB Antenna with Tri- Band Notched Characteristics

After simulating the individual band notched function, the three slots are then incorporated in a single antenna. The three stop bands have been generated by using two C-shaped slot in the radiator patch a U-shaped slot in the microstrip feedline. Each slot is able to notch the frequency band depends upon the length, width and gap of the slot.

Simulated VSWR of designed antenna is shown in Fig. 6. The acceptable VSWR should be <2 except three notch band**.** First notch band was created between frequencies of 3GHz to4 GHz by slot a with center frequency of 3.5GHz. Second notch band was created between frequencies of 5 GHz to 6 GHz by slot b with center frequency of 5.5 GHz. And third notch band is obtained between frequencies of 7 GHz to 8GHz by slot c with center frequency of 7.5 GHz, which can eliminate the interference with WiMAX, WLAN and X-band system.

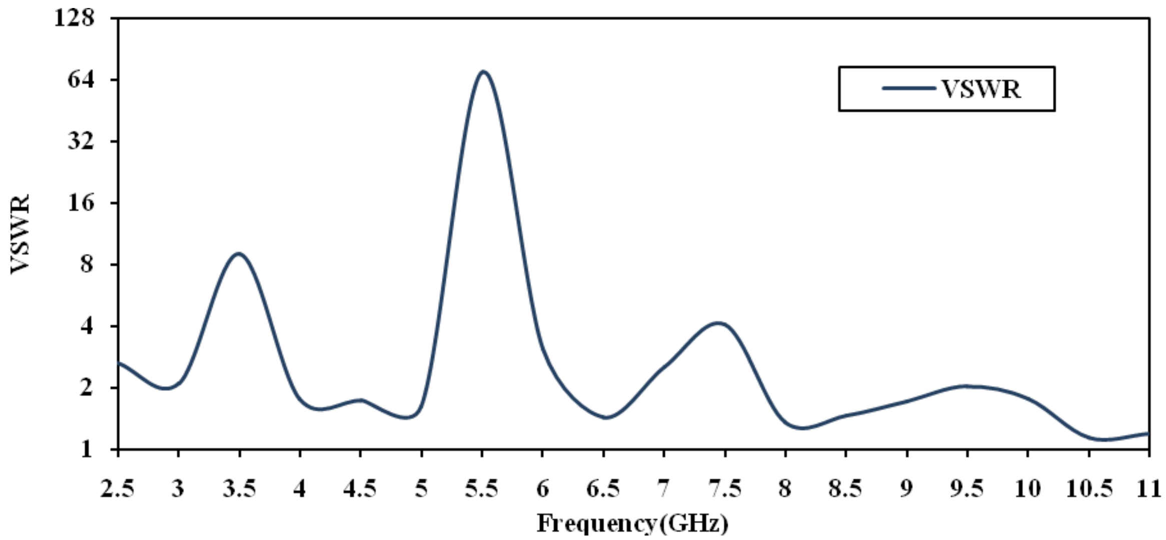
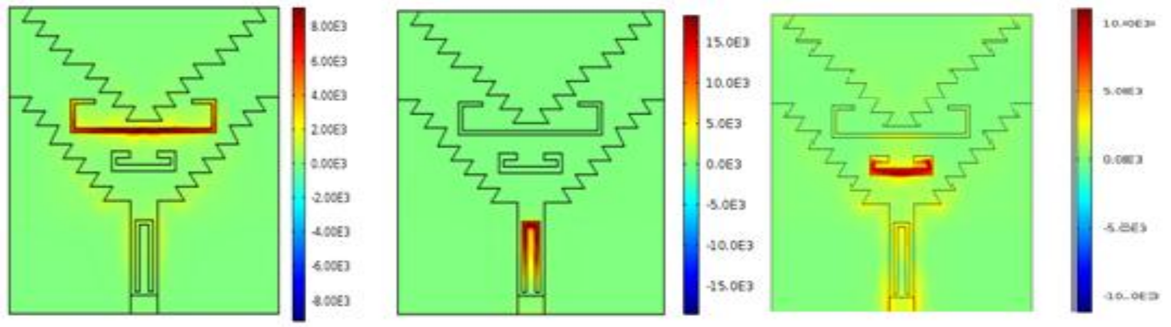


Fig. 6. Simulated VSWR of proposed UWB antenna.

Current Distribution

Fig.7. shows analysis of the band notched characteristics with surface current distribution at notched frequency of 3.5, 5.5 and 7.5 GHz, the three slots have considerable current concentration around the slots which acts as resonators. The current in radiator patch is quite small and hence, it does not radiate. At the same time, the ground plane has large surface current flowing through it which makes the antenna to be non-responsive at that frequency.

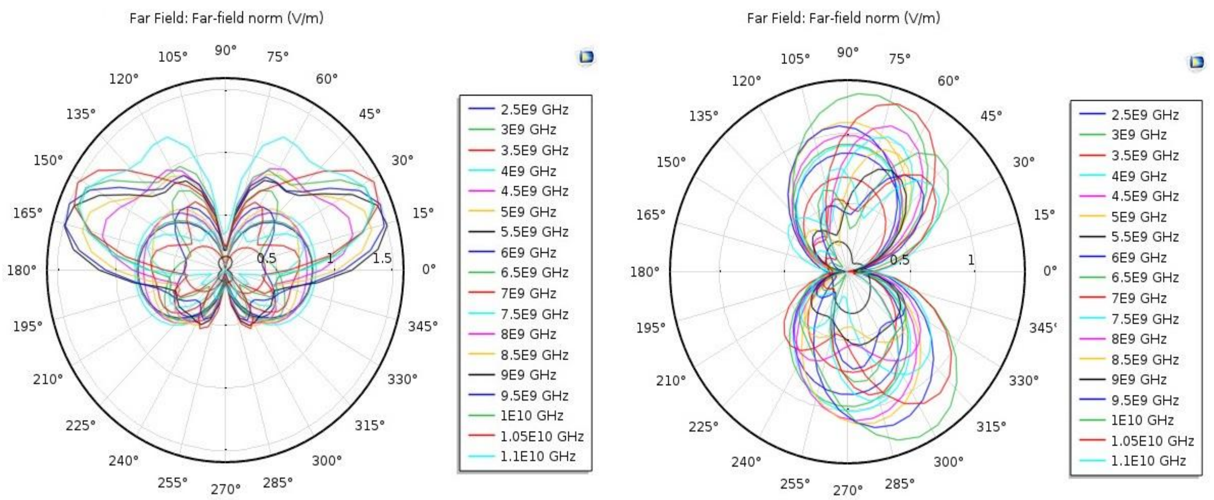


(a) **(b)** **(c)**

Fig.7. Simulated surface current distribution of proposed antenna at three notch frequencies (a) 3.5 (b) 5.5 and (c) 7.5GHz

Radiation Pattern

The simulated normalized far-field radiation patterns of antenna are shown in Fig 8. It is seen that the antenna shows a nearly omnidirectional radiation pattern in the xy-plane shows that the antenna is able to retain its omni-directional behaviour at lower frequencies while there is little variation at higher frequencies to simulated response. The yz-plane radiation pattern is bi-directional in nature at lower frequencies, the radiation pattern at higher frequencies deteriorates because the equivalent radiating area changes with frequency over UWB



(a) **(b)**

Fig .8 Simulated Radiation Pattern in (a) xy- plane (b) yz- plane

III.CONCLUSION

This paper presents a compact UWB antenna of size 30 x 32.5x1.6 mm^3 with tri band-notched features, using FR4 substrate, the proposed antenna is able to cover entire UWB spectrum from 3.1 to 10.6 GHz. The simulated results of three notched bands with center frequency at 3.5 GHz, 5.5 GHz and 7.5 GHz have been obtained by etching two C-shaped slot on radiating patch and a U-shaped slot on microstrip feedline. C-shaped slots are used for WLAN band and WiMAX band, U-shaped slot for X -band satellite communication. The length of the slots is taken to be one half of the guided wavelength of the center frequency of notched band. The measured results of fabricated antenna may have variation of 10% with simulated results.

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