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A COMPACT ULTRAWIDEBANDANTENNA WITH BAND-NOTCHES AT WIMAX AND WLAN BANDS

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ABSTRACT

A circular disk-shaped monopole ultra-wideband (UWB) antenna having a small area of 26 x 31 x 1.6 mm^3 was proposed in this paper. The antenna printed on FR4 material of permittivity 4.4 and height of 1.6mm. Microstrip line having a width of 3mm is used to excite antenna. The band-notch from 3.2 to 3.7 GHz is achieved by incorporating C-shape slot having a length of 28 mm on the radiating patch. Two symmetrical C-shaped strips are placed near to the feeding line edges to achieve another notch at 5 to 6 GHz. The proposed antenna is operating in the whole ultra-wideband from 2.4 to 11.8 GHz while rejecting electromagnetic interference from WiMax and WLAN systems. The simulated results such as S-parameters, VSWR, radiation patterns, current distributions, and gain shows that the antenna is well appropriate for wireless portable devices.

Keywords: *Band-Notched Characteristics, Monopole Antenna, Ultra-wideband (UWB)*

1. INTRODUCTION

The current wireless system demands for high data rate, more capacity, less power consumption, and less interference with other systems. The Ultrawideband (UWB) is the prominent technology which provides the possible solution to satisfy the requirements of current as well as future wireless communication systems like 4G and 5G [1]. The antenna design for ultrawideband systems is a challenging job. The inherent advantages of monopole antenna such as small size, simple fabrication, simple structure, and less cost make more suitable for ultrawideband systems. Several UWB monopole antenna shapes are proposed in the literature such as elliptical [2], planar U-shape [3], semi-circle [4], and compact printed antennas [5-7]. Federal Communication Commission officially authorized band of frequencies from 3.1-10.6 GHz for ultrawideband systems in 2002, which also includes WiMAX (3.3-3.7 GHz) and WLAN (5.15-5.825 GHz) band. Hence, the ultrawideband system may interfere with existing WiMax and WLAN systems which results in loss of information. Various UWB antenna designs have been presented with single and multiple notched functions to reject the interference [8-20].

A new compact antenna for UWB systems having dual notched properties is presented in this paper. The dual band notches are obtained by the use of C-shape slot cut on the radiating patch and symmetrical C-shaped strips near the feed line. The proposed antenna is working from 2.4 - 11.8 GHz except at 3.2 - 3.7 GHz and 5 - 6 GHz notched bands. Antenna performance in terms of s-parameters, VSWR, and gain is studied by performing the parametric analysis. The 2-D radiation patterns and surface current distributions are also investigated. Ansoft's HFSS EM simulator is used to simulate the antenna.

The paper is organized into five sections. UWB antenna design is given in Section 2. Section 3 presents parameter analysis. Section 4 provides discussion on results. Conclusions of the proposed work are mentioned in Section 5.

2. PROPOSED UWB ANTENNA DESIGN

The design of proposed circular disk-shaped monopole ultrawideband antenna is shown in Figure 1. The proposed antenna size is 26mm x 31mm and is etched on an FR4 dielectric substrate with a permittivity of 4.4 and thickness of 1.6mm. The proposed antenna contains a disk-shaped

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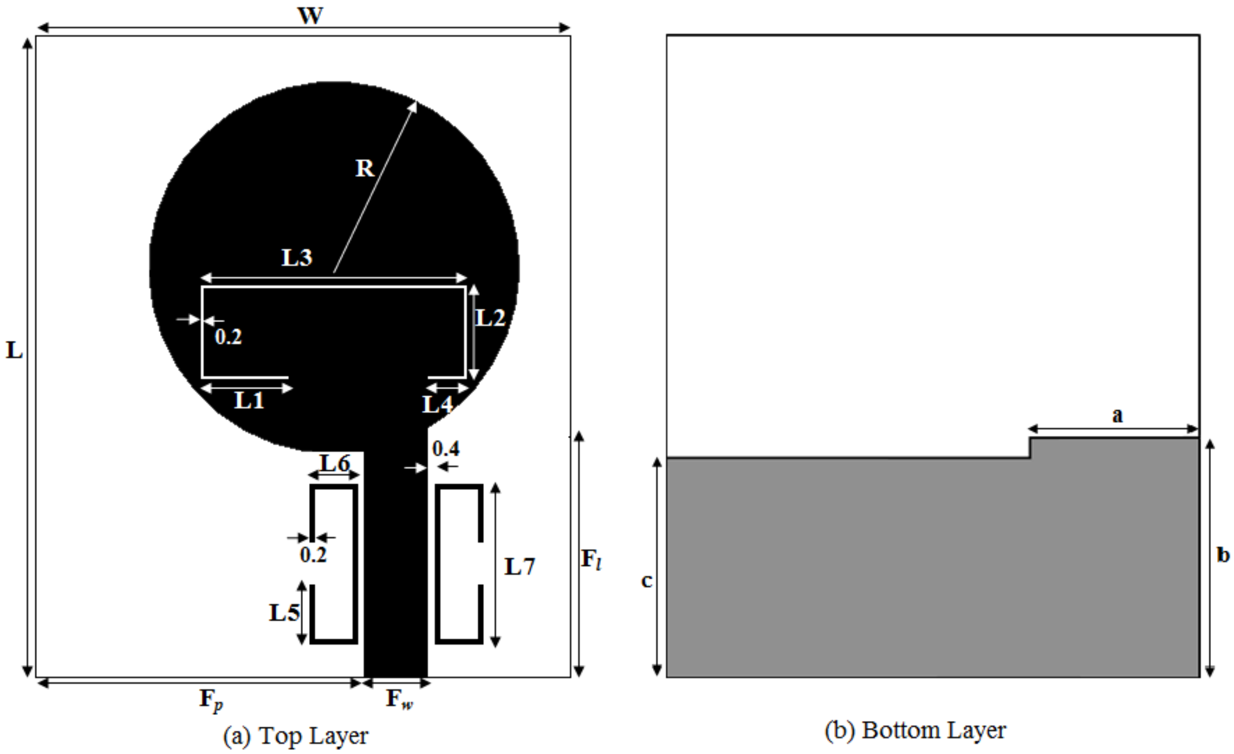

Figure 1: The Design Of The Proposed Antenna.

monopole radiating element (patch) of radius 9mm with defected ground plane structure. The first band-notch function from 3.2 to 3.7 GHz which corresponds to WiMax service (IEEE 802.16) is achieved with a C-shape slot on radiating element. Two symmetrical C-shaped resonators are added at the edges of the feeding line to get second notch at 5 to 6 GHz which corresponds to Wi-Fi communication service (IEEE 802.11). The optimized dimensions of the proposed antenna are a=8mm, b=11.6mm, c=10.6mm, F_l=12.8mm, F_p=16mm, F_w=3mm, L=31mm, L1=4.2mm, L2=4.6mm, L3=12.8mm, L4=1.8mm, L5=2.8mm, L6=2.2mm, L7=7.6mm, R=9mm, W=26mm. Band-notch functions are controlled by changing the slot, resonators and ground plane lengths, which are discussed in following sections.

3. PARAMETRIC ANALYSIS

The proposed dual notched-band antenna parametric analysis is presented in this section. The Figure 2 illustrates the simulated S-parameters (return loss S11) of proposed UWB antenna with and without band-notch filters. Antenna-1 represents basic UWB antenna which is operating at 2.8 to 11.8 GHz without giving any notch function. A C-shaped slot is incorporated in antenna-1 to form an Antenna-2. By addition of a C-shaped slot on radiating patch single notch is achieved at 3.2 to 3.7 GHz. Two C-shaped strips (resonators) are added to the microstrip line of Antenna-1 to make Antenna-3. Another notch 5-6 GHz is obtained with the two strips. Finally, proposed antenna is produced by using slot cut on the radiating patch and addition of two strips to the feed line of basic UWB antenna (i.e., Antenna-1). The proposed antenna is having good impedance matching (S11<-10dB) from 2.4-11.8 GHz except at 3.2-3.7 GHz and 5-6 GHz.

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11.6mm to 12.6mm, return loss is decreasing drastically as observed from Figure 4 (b). It is observed the better band-notched characteristics are obtained for a=8mm and b=11.6mm.

3.2. Effect of C-Shaped Slot

In this paper, a C-shape slot is used on the radiating patch to produce band-notching function at 3.3-3.7 GHz band. The slot length denoted by L_{n1} is calculated using equation (1) at first notch center frequency (i.e., 3.5 GHz). The theoretical value of

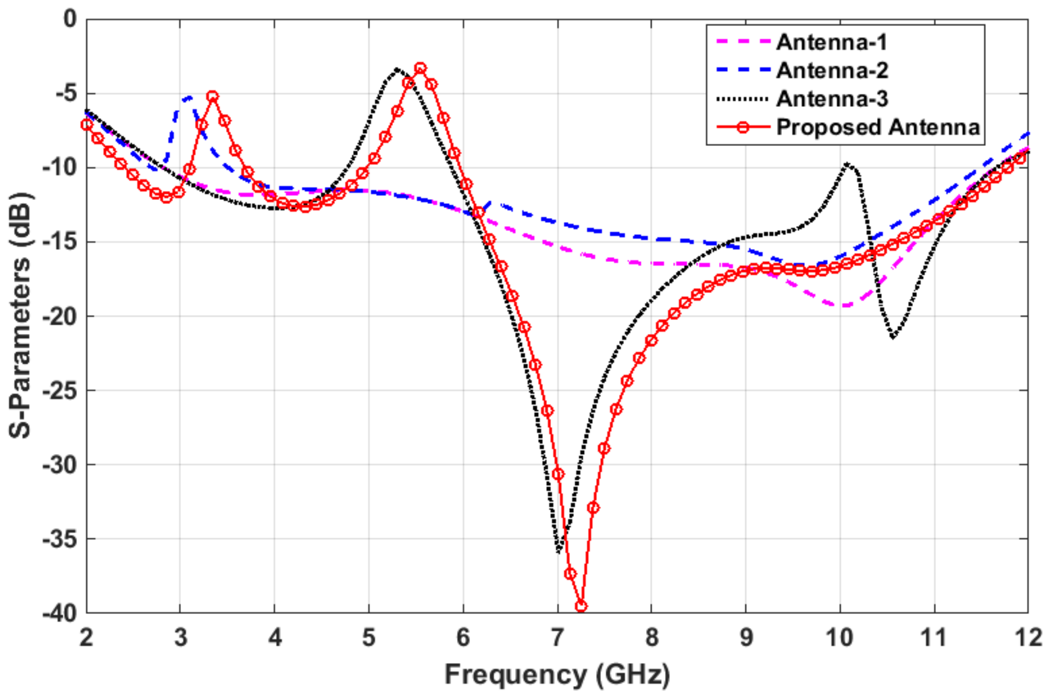

Figure 2: S-Parameters Of Four Antenna Configurations.

The VSWR of four antenna configurations is illustrated in Figure 3. The proposed antenna is giving considerably good VSWR less than 2 from 2.4 to 11.8 GHz excluding at notched-bands. The behavior of proposed antenna is studied in the following sub-sections by changing the parameters of the ground plane, C-shaped slot, and two symmetrical strips.

3.1. Effect of Ground Plane Dimensions

The Figure 4 (a) shows that the notch frequencies are moving to the right by varying the ground plane dimension ‘a’ from 6mm to 10mm. Similarly, with varying the ground plane dimension ‘b’ from

L_{n1} is 26.5mm, whereas the practical value of L_{n1} is approximated as 28mm (L1+2L2+L3+L4=28mm). As observed from the Figure 5, it is clear that antenna is efficiently rejecting the signals from 3.2-3.7 GHz. The antenna performance is also studied for various slot lengths L1. The notch frequency is shifting to the left side when the L1 length is decreasing from 4.2mm to 4.1mm.

$$L_{ni} = \frac{C}{2 f_{ni} \sqrt{\frac{1+\varepsilon_r}{2}}} \qquad (1)$$

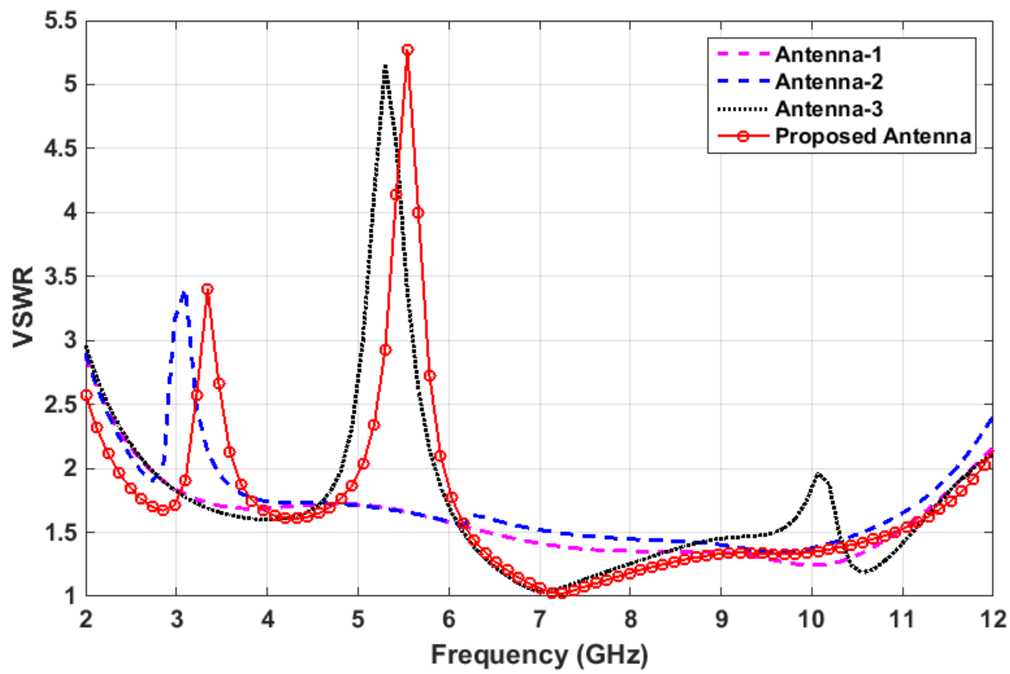

Figure 3: S-Parameters Of Four Antenna Configurations.

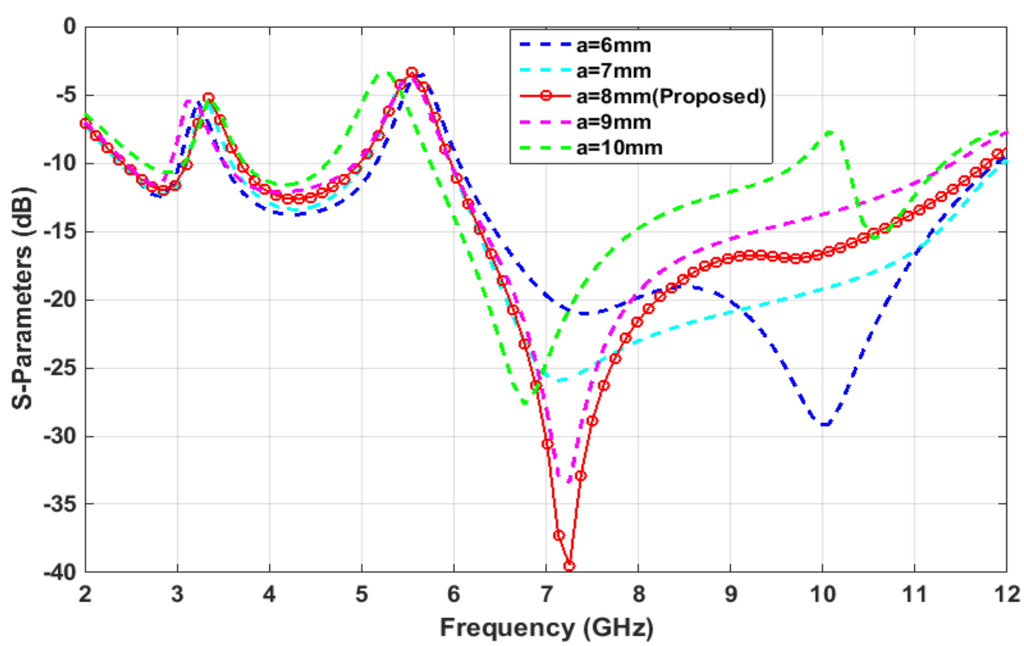

Figure.4 (A): S-Parameters Of The Proposed Antenna As A Function Of 'A'.

Where C denotes the speed of light, f_{ni} is the corresponding notch center frequency, and ε_r is substrate permittivity.

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3.3. Effects of Two C-Shaped Strips

To get second notch band at 5.15 to 5.825 GHz, two symmetrical strips (or resonators) are placed near the edges of the feed line. The theoretical value of strip length L_{n2} is determined from equation (1) and is 16.7mm at notch center frequency (i.e., 5.5 GHz). The practical strip length is approximated as 17.6mm (L_{n2}=2L5+2L6+L7). The simulated results in Figure 6 demonstrate that the proposed antenna producing notched function from 5 to 6 GHz. It is also observed that as strip length L5 decreased from 2.8mm to 2.2mm, notch frequency is moving to the right side which leads to undesired notch band.

Finally, it is concluded that the better notched-bands such as 3.2 to 3.7 GHz and 5 to 6 GHz are achieved when the antenna is optimized with L1=4.2mm and L5=2.8mm.

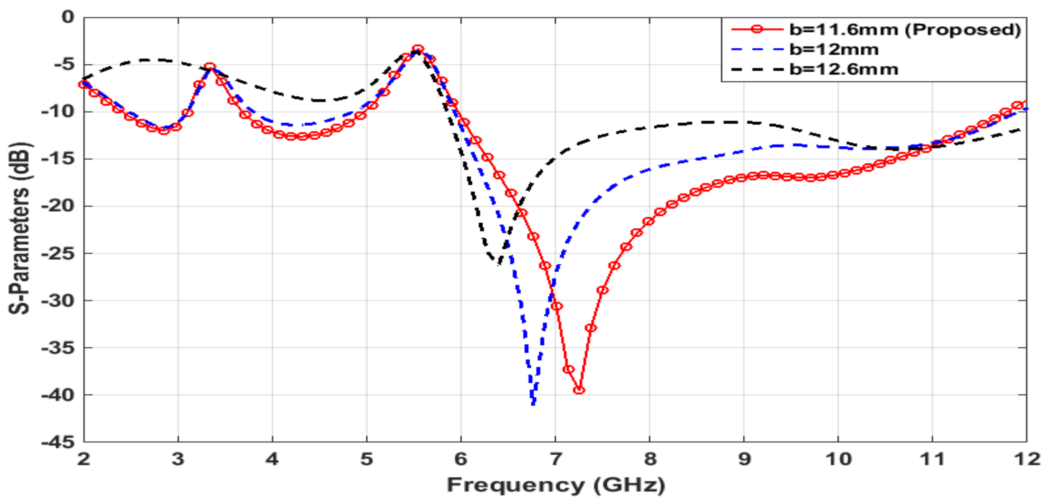


Figure 4 (B): S-Parameters Of The Proposed Antenna As A Function Of 'B'.

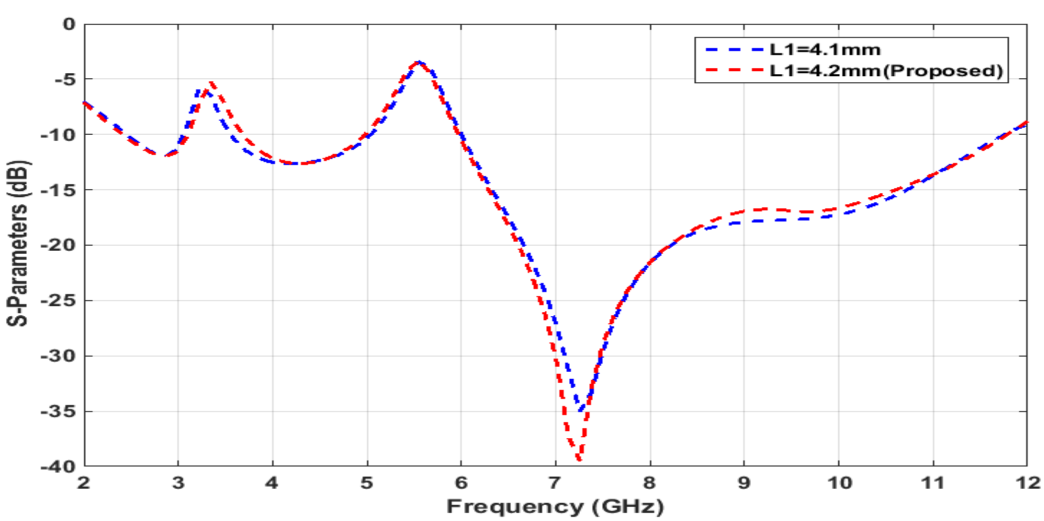


Figure 5: S-Parameters Of Antenna For Various Slot Lengths.

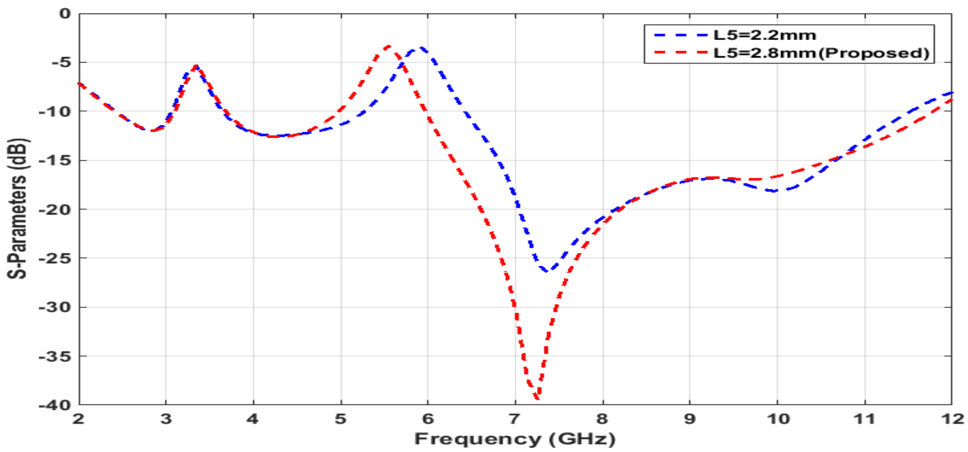
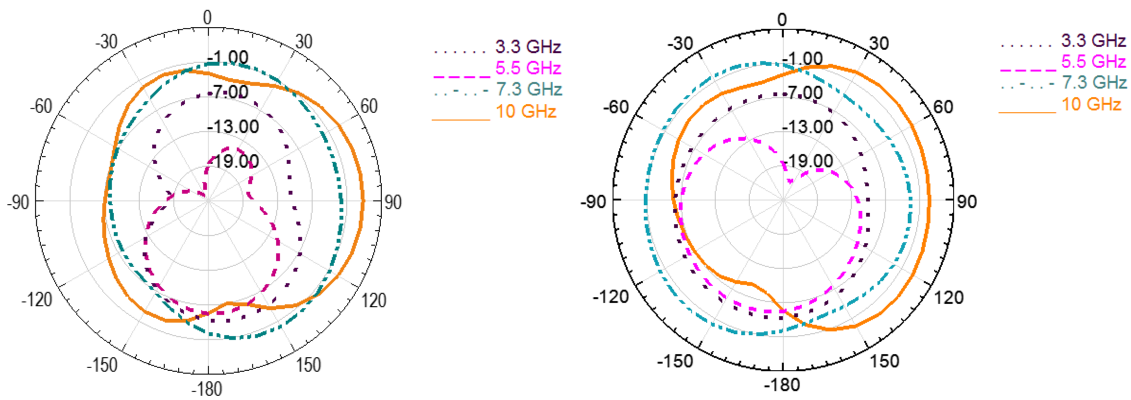


Figure 6: S-Parameters Of Antenna For Various Strip Lengths.



(a) *(b)*

Figure 7: Simulated 2-D Radiation Patterns At 3.3, 5.5, 7.3, And 10 Ghz (A) E-Plane (B) H-Plane.

4. RESULTS AND DISCUSSIONS

The simulated 2-D radiation patterns of the antenna with dual notched properties on E-plane and H-plane at 3.3, 5.5, 7.3, and 10 GHz are given in Figure 7. The results illustrate that proposed antenna exhibiting bi-directional properties on E-plane and almost omnidirectional properties on H-plane.

The distribution of surface currents on antenna at 3.3, 5.5, and 7.3 GHz are given in Figure 8. The current is heavily surrounded near the slot on the radiating patch at 3.3 GHz as depicted in Figure 8 (a). So, the slot behaves as band notch filter which gives off radiation and hence no current is coming out at 3.3 GHz. Similarly, at 5.5 GHz the two strips near the feed edges act as band stop filters and stop total current and nullify it as described in Figure 8 (b). Therefore, proposed antenna will not work at those two notched frequency band. In the remaining spectrum, the antenna radiates well as illustrated in Figure 8(c).

The simulated gain plot of the antenna is described in Figure 9. The antenna is providing a maximum gain of 5dBi at 7.4 GHz and also well above 3dBi from 2.4 to 11.8 GHz except at notches such as 3.2 to 3.7 GHz 5 to 6 GHz.

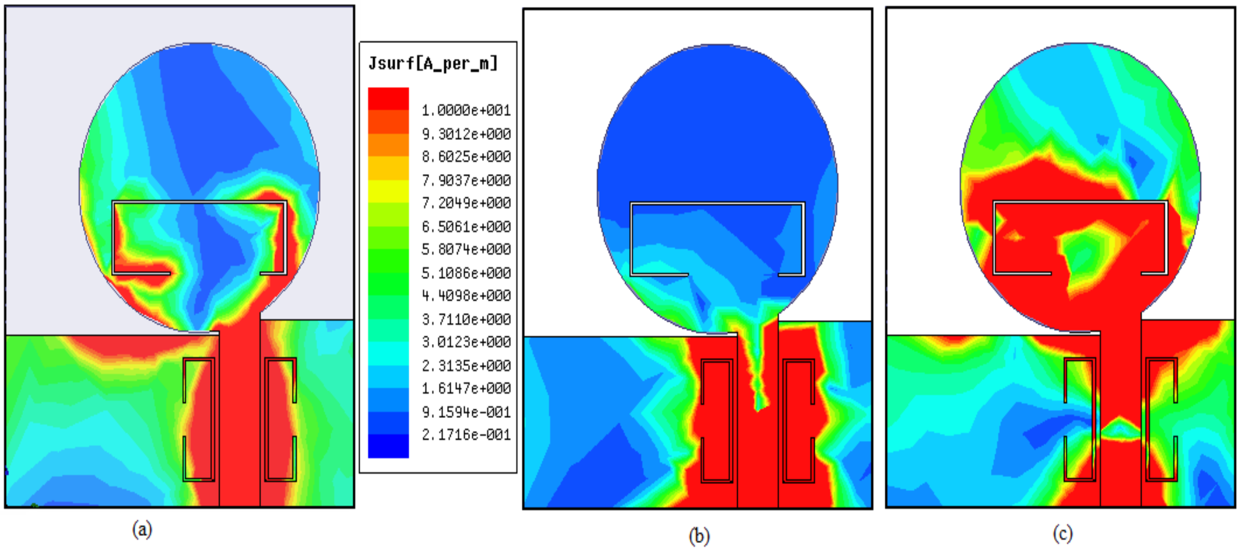


Figure 8: Current Distribution Of Antenna At (A) 3.3 Ghz, (B) 5.5 Ghz, And (C) 7.3 Ghz.

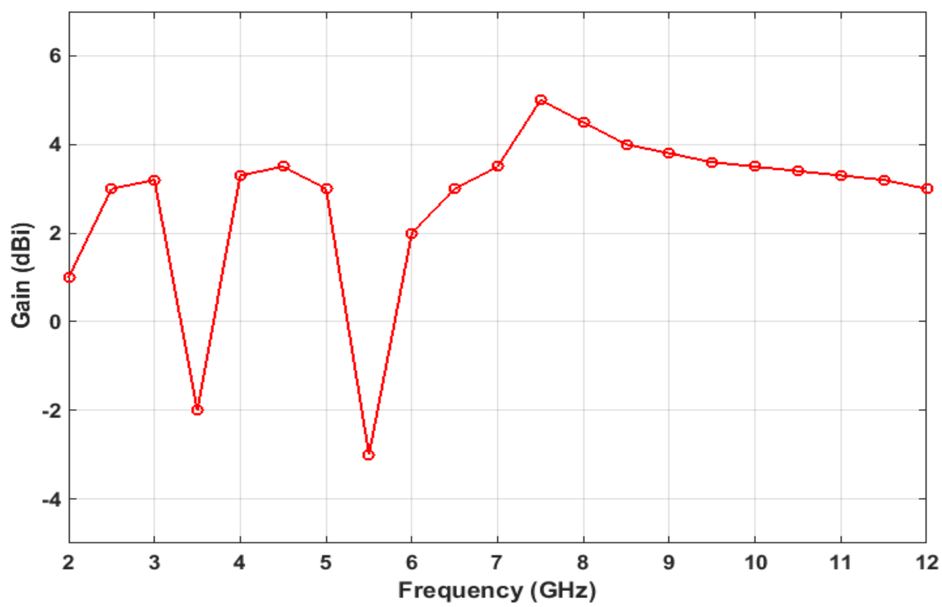


Figure 9: The Simulated Gain Of The Proposed Antenna.

5. CONCLUSION

In this paper, a novel disk-shaped monopole UWB antenna having size of 26mm x 31mm is proposed for portable devices. A C-shape slot is etched on the patch to achieve notch from 3.2-3.7 GHz. Second notch at 5-6 GHz is achieved by adding C-shaped strips nearer to the edges of the feed line. The antenna is operating well over frequency band from 2.4 to 11.8 GHz with good impedance matching (return loss<-10dB), VSWR (<2), and gain (>3dBi) except at those two notched bands. Thus, the proposed antenna efficiently rejects the inference from the WiMax and WLAN systems.

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