A New Omni-directional Monopole Antenna for Interference Reduction

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Abstract- A compact Ultra wideband (UWB) antenna with band- notched characteristic is presented in this paper. It has compact size of 30 mm x 31mm and has ultra wide band operation. A ‘C’ shaped slot was introduced to achieve band notch function from 4.8 GHz to 6 GHz to avoid interference from WLAN. The proposed antenna has ultra wide band frequency range from 3 GHz to 11.5 GHz for return loss below -10 dB, except for frequency stop band from 5 GHz to 6 GHz. Details of antenna are presented with parametric study for Ultra Wideband Applications. The bandwidth is varied by varying the width W_4 of inner tuning stub and height L_3 of feed and Ultra Wideband width is obtained. The antenna is Omni directional in operating bandwidth and it has good radiation efficiency. The fundamental parameters such as return loss, VSWR, radiation pattern are obtained, which meet standard specifications. Method of moments based IE3D simulator is used to analyze this antenna.

Keywords- Coplanar waveguide, UWB antenna, VSWR, Omni directional radiation pattern

I. INTRODUCTION

Ultra wideband communication systems have received great attraction in wireless world. It is popularly used technology in radar and remote sensing. Ultra Wideband technology provides promising solutions for future communication systems due to excellent immunity to multi path interference, large bandwidth and high speed data rate. A bandwidth from 3.1 GHz to 10.6 GHz is allocated for UWB systems by Federal Communication Commission (FCC) in 2002. From then, the design of UWB antenna became challenging task for engineers in UWB systems. One major issue in UWB is the design of compact size and wide band antenna [1]. Several UWB antennas have been studied for UWB applications [2-3].Recently slot antennas became popular for UWB applications [4-6]. Bow-tie antenna is one technique for UWB antenna systems [7]. Parasitic elements around the antenna also provide broad bandwidth but increases size of antenna [8]. The planar monopole antennas [9, 10] are better for UWB applications due to small size and stable radiation pattern. UWB antennas can be fed by microstrip line or Coplanar Waveguide (CPW). The CPW antennas are useful for microwave and millimeter applications because they offer low profile and wide bandwidth, ease of integration with circuits. The CPW has low radiation leakage and less dispersion than conventional microstrip lines. They have also low power consumption and high speed data rate for transmitter.

A UWB antenna is also susceptible to interference by narrow band signal of neighboring RF system such as IEEE 802.11a WLAN having operating frequency range 5.125-5.825GHz. So, it is desirable to design UWB antenna with band notch characteristic to avoid interference from the bands [11, 12].The conventional methods to achieve the notched band are cutting a slot (U-shaped, V-shaped and arc shaped slots) on the patch [13, 14] or embedding a quarter wavelength stub with in a large slot on the patch [15], inserting a slit on the ground [16]. Another way is based on placing parasitic elements near the printed monopole, which play role as filter to reject limited band. A miniaturized UWB antenna with 5 GHz band rejection is also reported [17]. But it has complicated logic. A good UWB antenna should have ultra wide band width, high radiation efficiency, directional or Omni directional radiation pattern.

So, we have proposed CPW-fed antenna for achieving notched band from 5 GHz to 6 GHz which avoids entire WLAN. The antenna provides stable radiation pattern and high radiation efficiency. The antenna geometry is introduced in section II. The antenna parameters return loss, radiation characteristics are discussed in section III. The effect of angle α and L_3 on antenna returns loss and bandwidth also investigated. Conclusions are given in section IV.

II. ANTENNA STRUCTURE

The antenna is fabricated with low cost FR4 substrate with relative permittivity $\varepsilon_r = 4.4$ and thickness h = 1.6 mm. It has compact area of 30 mm x 31 mm as shown in Figure 1. The antenna is fed by 50Ω CPW feed line. The gap ‘g’ between centre conductor and ground plane is 0.4 mm. The various optimized parameters of antenna are W = 30 mm, W_1 = 13.1 mm, W_2 = 5 mm, W_3 = 3 mm, W_4 = 15 mm,W_5 = 5.75 mm, W_6 = 3.5 mm, W_7 = 2.8 mm, W_8 = 6 mm, L = 31 mm, L_1 = 4.75mm, L_2 = 9 mm, L_3 = 14 mm, L_4 = 8.825 mm, L_5 = 1.175 mm, L_6 = 1 mm, L_7 = 0.5 mm, L_8 = 3.6 mm, L_9 = 6 mm. The antenna has two resonating frequencies 3.63 GHz and 7.51 GHz. The obtained resonant frequencies vary depending on the location of inner tuning stub and the gap between CPW-feed line and ground. The antenna has only one layer of substrate with singled sided metallization part. This allows easy manufacturing of antenna with low cost.

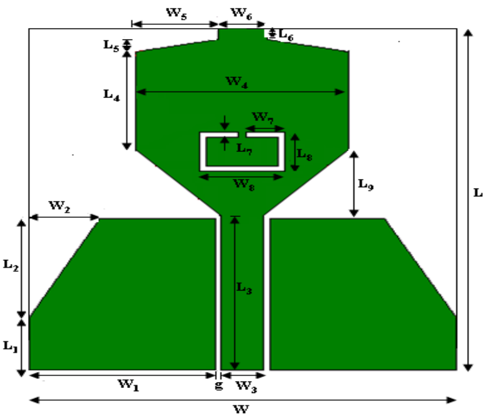


Figure:1 Proposed antenna structure

III. RESULTS AND DISCUSSION

The proposed antenna was simulated and optimized using Zeland IE3D simulator. Figure 2 compares the fabricated antenna with that of simulated antenna. The VSWR curve shows that the antenna achieves an impedance bandwidth of 7.6 GHz ranging from 3 GHz to 11.5 GHz for VSWR below 2 except for notched bandwidth from 5 GHz to 6 GHz. This band is avoided by inserting 'C' shaped slot in conductive layer to reduce interference from WLAN. The proposed antenna has good performance to reject unwanted WLAN band. By controlling the size and location of 'C' slot, desired notched band can be obtained. The important feature of proposed antenna is the capability of impedance matching at both resonating frequencies 3.62 GHz and 7.54 GHz using CPW feed line.

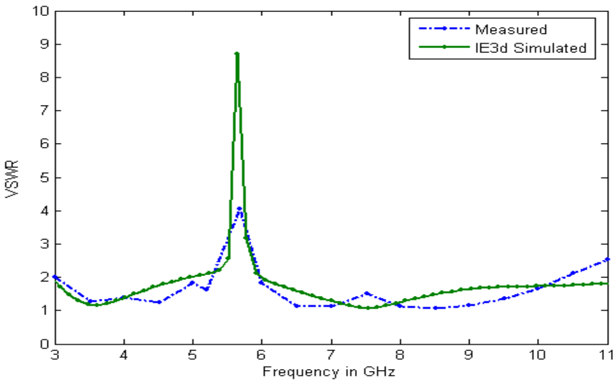


Figure: 2 Simulated and Measured VSWR for proposed antenna

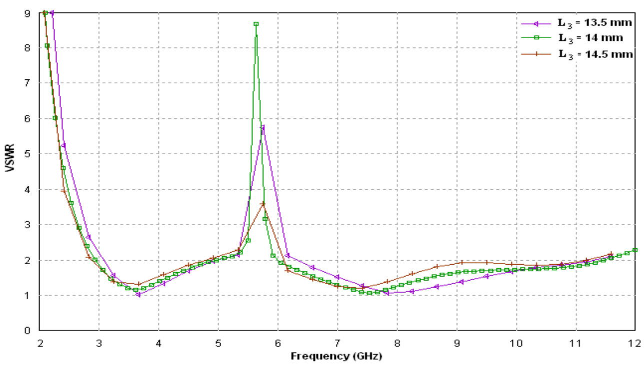


Figure:3 Return loss vs. frequency for the proposed antenna with L_3 = 13.5, 14, 14.5 mm

The performance of the antenna has been analyzed by using Method of moments based IE3D simulator. The effect of L_3 and W_4 on the antenna return loss and Band width are studied. These are most sensitive parameters. As L_3 increases from 13.5 mm to 14.5 mm, the band width increases to 7.6 GHz from 7 GHz and then decreases to 7.03 GHz. The higher resonant frequency decreases. When W_4 increases from 14 mm to 16 mm, band width increases to 7.6 GHz and then slightly changes. The higher resonant frequency is slightly shifted down. The effect of L_3, W_4 on resonant frequencies and bandwidth are shown in Figures 3 and 4. They are also represented numerically in table I and table II.

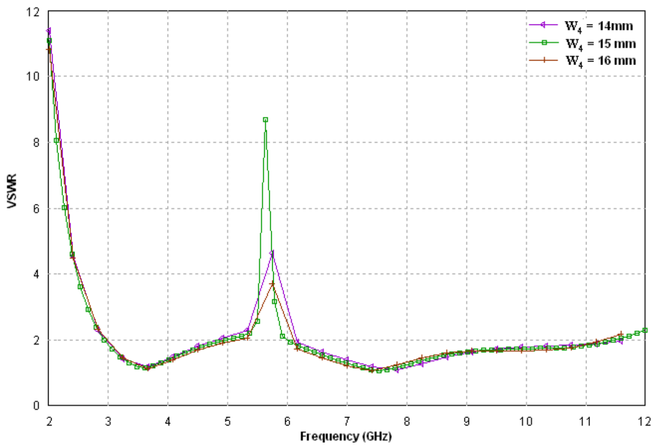


Figure: 4 Return loss vs. frequency for the proposed antenn with W_4 = 14, 15 , 16 mm Parametric study

TABLE I. EFFECT OF L_3 ON RESONANT FREQUENCIES AND BAND WIDTH

L_3 (mm)	Resonant frequency (GHz)	Band width (GHz)
13.5	3.66, 7.83	7.0
14	3.62, 7.54	7.6
14.5	3.66, 7.41	7.03

TABLE II. EFFECT OF W_4 ON RESONANT FREQUENCIES AND BAND WIDTH

W_4 (in degrees)	Resonant frequency (GHz)	Band width (GHz)
14	3.63, 783	7.3
15	3.62, 7.54	7.6
16	3.68, 7.45	7.4

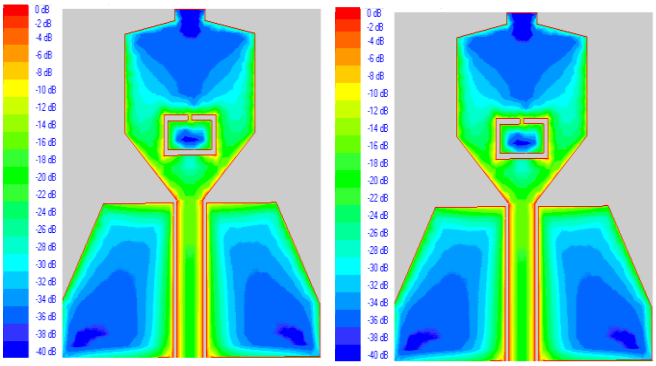
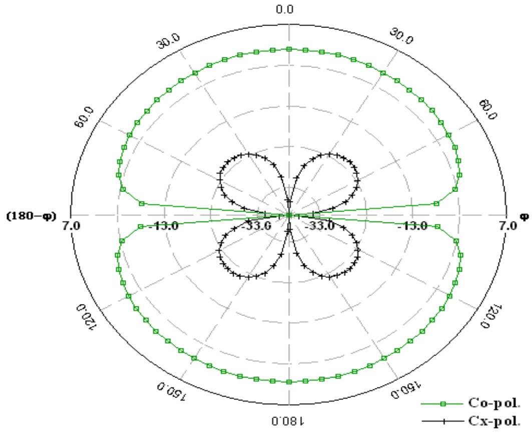


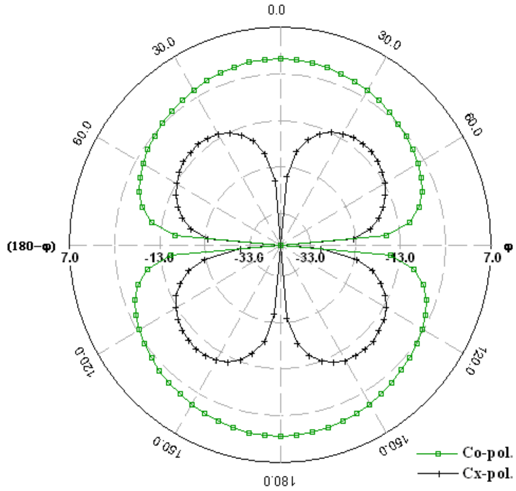
Figure: 5 Current distribution at a) 3.62 GHz b) 7.54 GHz.

The current distribution is more along the transmission line as shown in Figure 5. But, around the C-shaped slot, the current is small. Here, destructive interference takes place takes place for excited currents in the antenna, which makes antenna non responsive in the notched band.

Far field radiation characteristics were also studied. The Figures 6 and 7 present radiation patterns in E and H-planes at 3.62 GHz and 7.54 GHz. The gain patterns are Omni directional in H-plane and monopole like in E-plane. The different frequencies across the operating band width showed similar radiation patterns. So, stable radiation patterns have been obtained for proposed antenna. H-plane patterns show larger cross polarization than E-plane due to strong horizontal surface current components and electric field. The peak antenna gain of antenna varies from 1.5 dBi to 2.8 dBi as shown in Figure 8 and it has maximum value of 2.8 dBi at 4.3 GHz. This antenna has high radiation efficiency of 80% in the operating region.

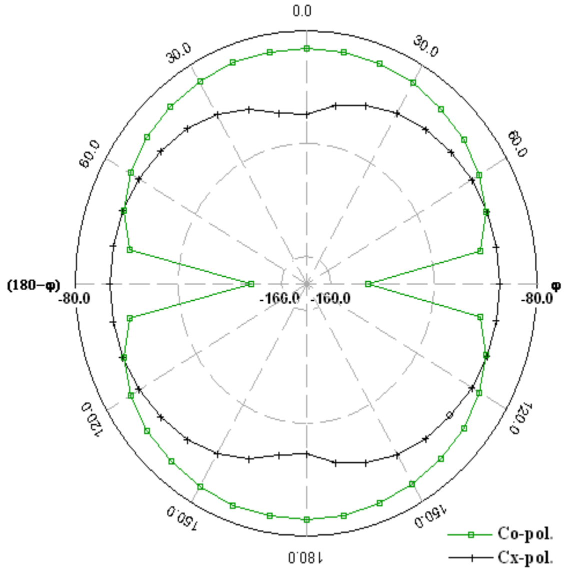


(a)



(b)

Figure: 6 Radiation pattern in E-plane at a) 3.62 GHz b) 7.54 GHz.



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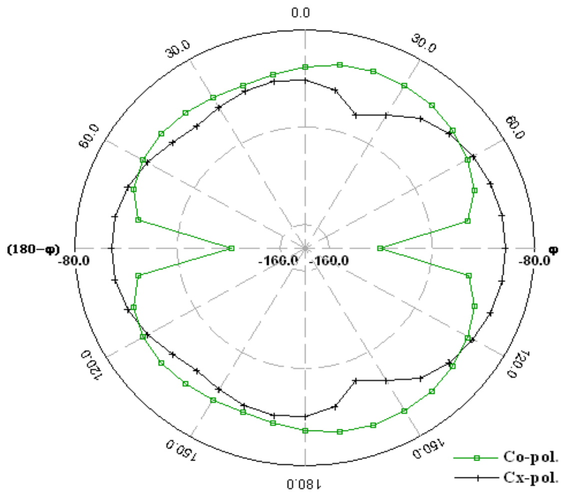

(b)

Figure: 7 Radiation pattern in H-plane at a) 3.62 GHz b) 7.54 GHz.

IV. CONCLUSION

A compact CPW fed monopole antenna with band notched characteristic is presented to avoid interference from WLAN. Notch band is achieved by inserting 'C' shaped slot in conductive layer. It has good impedance matching. It has total impedance bandwidth of 7.6 GHz. Parametric study is performed by varying width W_4 of inner tuning stub and height L_3 of conducing feed . The antenna exhibits Omni directional radiation pattern in H-plane with compact size. It has simple structure. The gain and radiation pattern of antenna have been investigated and found to be stable. The antenna has high gain of 2.5 dBi in the operating band width. The antenna has highest radiation efficiency of 80% in the operating region. The antenna is useful for radio communications.

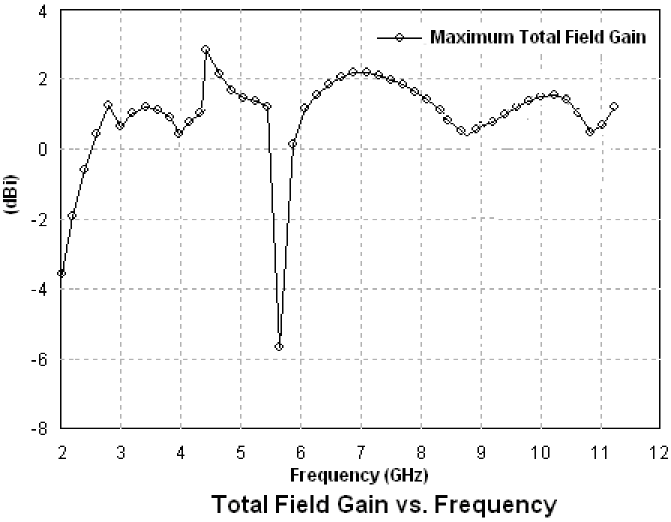

Figure: 8 Gain vs. frequency of proposed antenna

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