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Monopole Antenna for Bluetooth and Ultra Wideband Applications with Notched WiMAX Band on Teflon

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Abstract: A dual band circular monopole antenna for Bluetooth and Ultra wideband applications with WiMAX notched band is presented. The antenna shows return loss characteristics less than -10dB for Bluetooth (2.40-2.47 GHz) and Ultra wideband (2.73-11.5 GHz) except at notched band. High VSWR is obtained at 2.6 GHz and WiMAX band (centre frequency 3.5 GHz) .The radiation patterns show omni directional characteristics at lower frequencies with good polarisation isolation.

Keywords: Ultra wideband, Bluetooth, return loss, group delay

I. INTRODUCTION

In 2002, FCC has allowed the unlicensed use of ultra wideband spectrum (3.1GHz-10.6GHZ) with restricted power emission of -41dBm/MHz under part 15 rules [1]. The ultra wideband technology offer many advantages like high data rate at short ranges, low power, noise immunity, relatively simple receiver architecture. This has led to huge research in Ultra wideband (UWB). Bluetooth is another technology existing in globally accepted unlicensed Industrial, scientific, medical(ISM) band for low power short range communication. Integrating Bluetooth and UWB in a single antenna provides compatibility between 3G and 4G technologies in the area of wireless personnel area networking. Wireless technologies like Bluetooth and UWB has applications in body area networks since they have long battery life and have low power emissions. Performance of UWB in terms of data rate is very high compared to Bluetooth in short ranges<10m.At Ranges greater than 10m Bluetooth provides better data rate than UWB. These technologies also differ in the modulation schemes used and application profiles. Dual band Bluetooth and UWB antenna thus provides scalability in all the parameters mentioned above. But when UWB is developed the coexistence with other wireless technology like WiMAX has to be considered. So in order to avoid the interference notches has to be added in the UWB band.

Lately monopole antennas of various shapes having ultra wide bandwidth have been reported [2-5]. Several antennas were designed for ultra wideband having notched bands for interfering bands like WLAN and WiMAX [6, 7]. Single band antenna integrating Bluetooth and UWB with large impedance bandwidth has come up [8]. Usual methods of band notching do not work for integrated Bluetooth and UWB antennas since Bluetooth band is very narrow. Conventional methods for dual band antenna design are by reactive loading with $\lambda/4$ stub [9], $\lambda/4$ strip monopole [10] and slots [11] in FR4 substrate.

In this paper a dual band Bluetooth and UWB antenna using offset ring slot in polytetrafluoroethylene (PTFE) substrate is presented. PTFE substrate commonly known as Teflon is characterized by low dielectric constant ε_r =2.1 and low loss tangent, $\tan\delta$ =0.0004.The substrate is characterized by hydrophobic nature, high non reactivity, high melting point about 621°F.

II. ANTENNA DESIGN

Comparing different monopole antennas circular monopole antenna provides largest bandwidth. The lower edge frequency, 'f_l' in GHz, corresponding to VSWR<2 for planar circular monopole is given by [12]

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$$f_l = 7.2/(2.25r + g) \tag{1}$$

Where 'r' is the radius of patch and 'g' is the gap between ground and radiating patch in centimeters. A small correction factor occurs in this formula due to the substrate. The wide bandwidth of UWB is obtained by modifying the ground.The width of 50 Ohm microstrip line is calculated at 2.4 GHz. Circular slot inside the monopole does not affect the bandwidth of monopole. The dual band nature is obtained by embedding another smaller circular monopole inside the slot. The notching of WiMAX band is obtained using a folded slot in the upper half of the radiating patch.

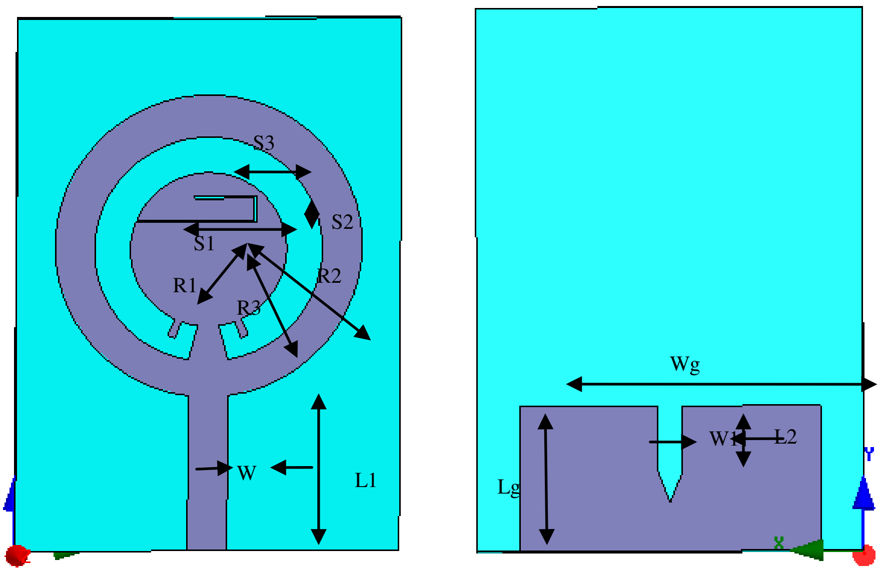

Fig. 1 Dual band antenna for Bluetooth and Ultra wideband front view and back view.

The initial dimensions of inner monopole and outer monopole is calculated from (1) for frequency corresponding to lower edge frequency 3.1GHz of UWB and 2.4GHz of Bluetooth respectively. The gap between the inner monopole and ground plane is kept high so that it has smaller bandwidth. Various parameters like slot width affect the frequency ratio of two resonances. The angle of the slot affects the impedance matching of lower resonant frequency. Two symmetrical strips are added to the lower edge of inner circular monopole for tuning of lower band frequency. The length of folded slot is initially designed for quarter wavelength corresponding to notched frequency. The notch frequency 'f' is given by

$$f = c/(4L\sqrt{\varepsilon_{eff}}) \tag{2}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} \tag{3}$$

Where 'L' is the total length of slot. The antenna is simulated in Ansoft HFSS 14.0. The size of antenna is 32mm*45mm*1mm. The optimized dimensions are R1=6.5mm, R2=12.8mm, R3=9.5mm, L=45mm, W=3.3mm, Lg=12mm, Wg=23.5mm, L1=13mm, W2=2mm, W1=2 mm, L2=4mm, Wg=23.5mm, S1=.10mm, S2=2.2mm, S3=4.3mm

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III. Results and Analysis

A. Return Loss

The simulated return loss of antenna as shown in Fig 2. The antenna shows impedance bandwidth characterized by return loss less than -10dB for Bluetooth is from 2.4GHz-2.47GHz and that of UWB is from 2.73 GHz-11.5 GHz. The WiMAX notched band is characterised by return loss greater than -10 dB from 3.3 GHz-3.6 GHz.

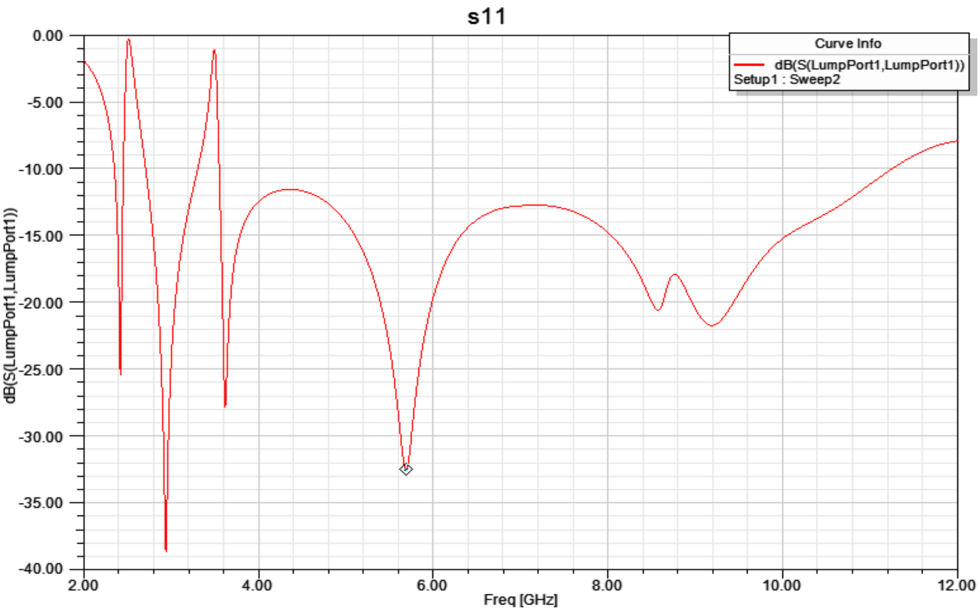

Fig. 2 Simulated return loss

B. VSWR

Fig. 3 shows the simulated VSWR of the antenna .The VSWR is less than 2 over Bluetooth (2.4GHz-2.53GHz) and UWB (2.82-10.6GHz) expect at WiMAX notched band. VSWR at 2.6 GHz is about 60 and 3.5 GHz is about 16. This indicates good rejection of band between Bluetooth and UWB (2.47GHz- 2.73GHz) and WiMAX (centre frequency 3.5 GHz) is obtained.

C. Surface Current Distribution

Surface current distribution at notch frequency 3.5 GHz is shown in Fig. 4. The upper end of folded slot has high current distribution at 3.5 GHz confirming the quarter wavelength resonator behavior of slot.

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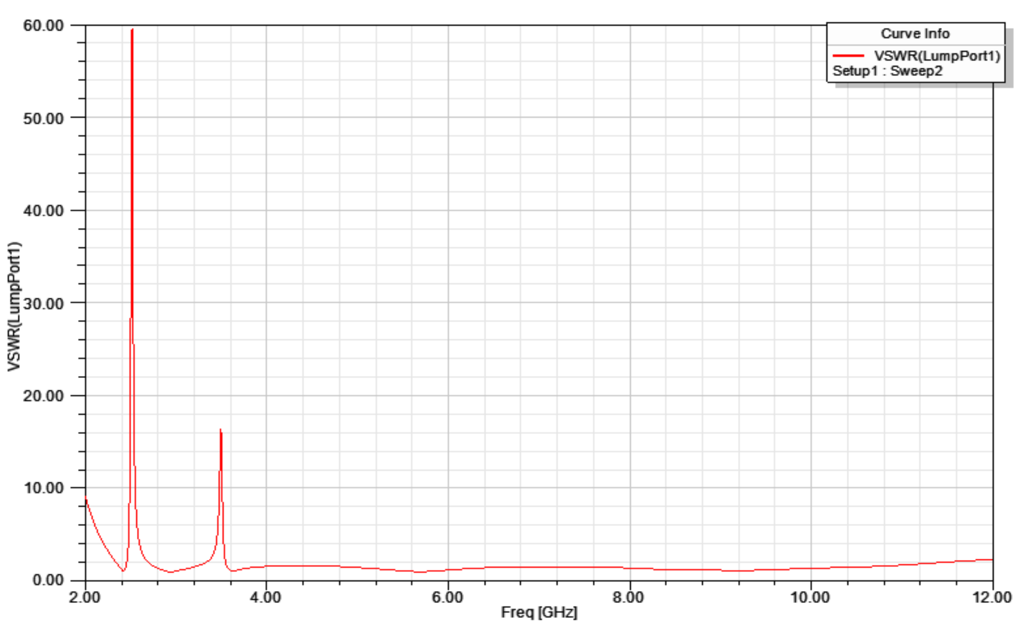

Fig. 3 Simulated Voltage standing wave ratio (VSWR)

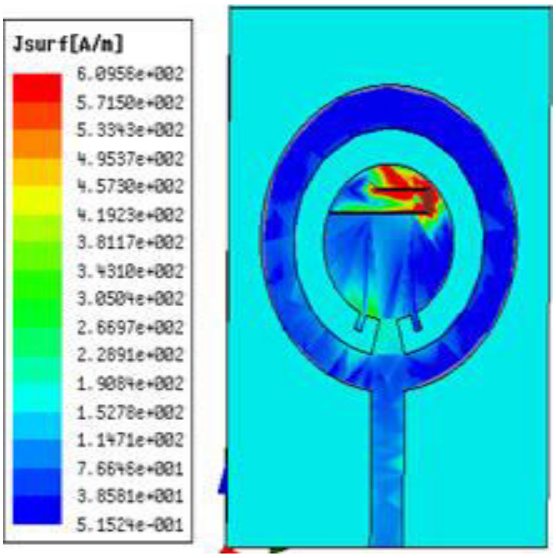

Fig. 4 Current distribution at 3 .5 GHz

D. Radiation Patterns

E plane and H plane radiation patterns at 2.46 GHz, 3.1 GHz, 5.6 GHz, and 7 GHz are shown in Fig. 5. At low frequencies the H-plane patterns are circular while the E-plane patterns show a bilobial nature implying omnidirectional radiation patterns of typical monopole. At low frequencies cross polarization component is poor implying reduced interference. At high frequencies the patterns become more distorted with increased cross polarized component

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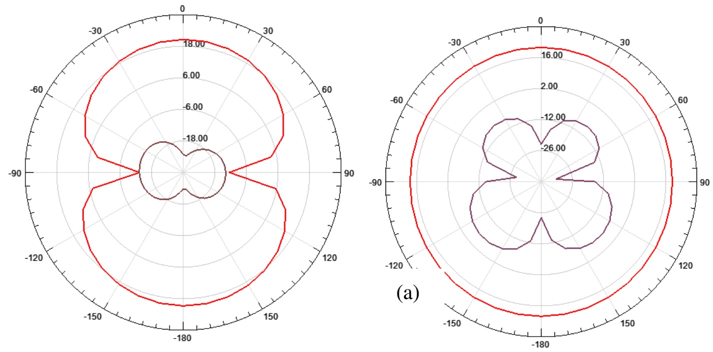
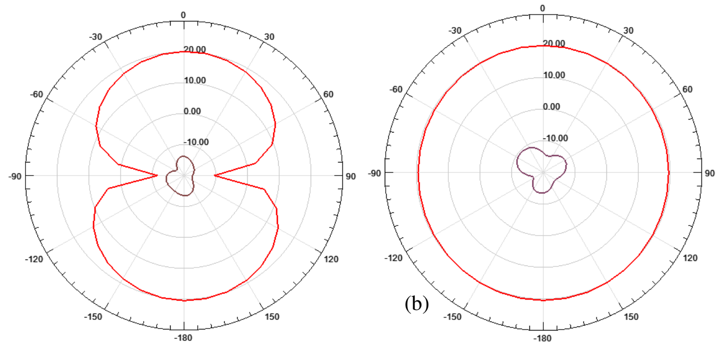
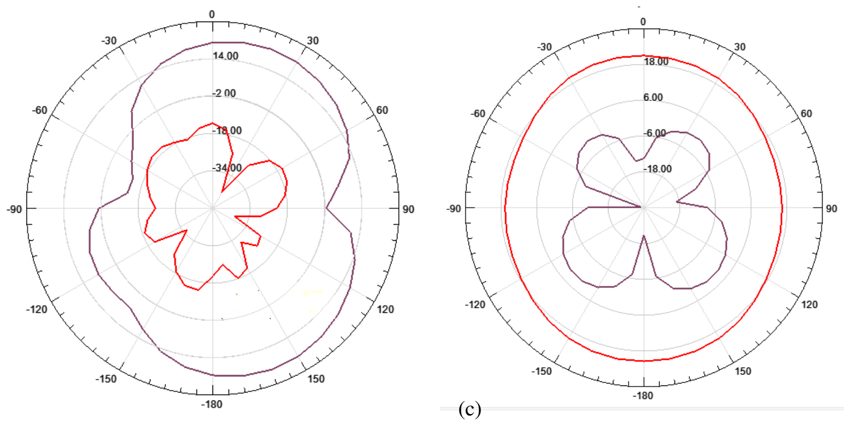


(a)



(b)



(c)

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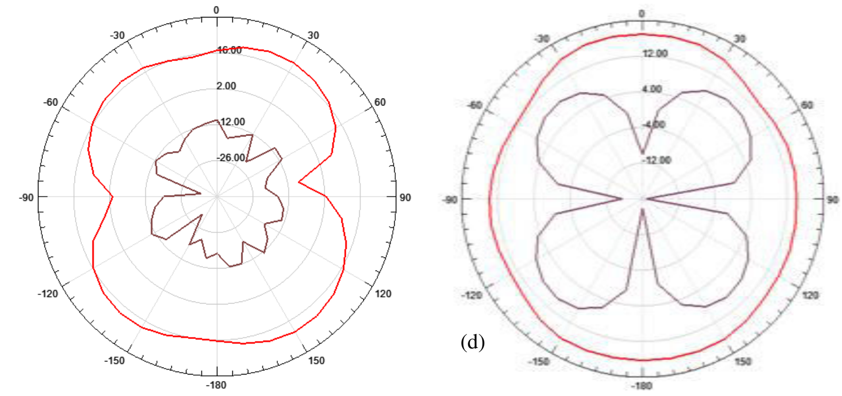

Fig. 5 E plane and H plane patterns at (a) 2.46 GHz (b) 3.1 GHz (c) 5.6 GHz (d) 7 GHz

IV. CONCLUSION

A Bluetooth (2.4 GHz-2.47 GHz) and UWB (2.73 GHz-11.5 GHz) antenna with notched WiMAX band (centre frequency 3.5 GHz) has been simulated. Good rejection of notched bands is achieved. The radiation pattern is omnidirectional with reduced cross polarised component at low frequencies. Further work has to be done to obtain a stable radiation pattern throughout UWB band. Time domain analysis can be performed to investigate time domain characteristics of Ultra wideband.

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