



DESIGN OF MULTIBAND ANTENNA USING DGS FOR UWB APPLICATION

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Abstract : A compact coplanar waveguide (CPW)-fed ultra-wide band (UWB) antenna with multi-band-notched attributes is simulated. The antenna has minimized size of 22 x 32 mm². Two sets of rectangular L-shaped slots are embedded on the antenna ground plane to get band notch at 3.5GHz and 5.2 GHz which eliminates the WiMAX and WLAN applications individually. An embedded C-shape slot in the patch rejects potential interference from Satellite uplink communication corresponding to 8.3 GHz. The time domain group delay of antenna is within 1 ns except in notched band, which indicates good linear phase response.

IndexTerms - Micro strip Antenna, Group delay, Return loss, VSWR, radiation pattern.

I. INTRODUCTION

Ultra-wide band innovation got a noteworthy boost particularly in 2002 since the US Federal Communication Commission (FCC) allowed the approval of utilizing the unlicensed frequency band beginning from 3.1 to 10.6 GHz for commercial communication applications. There is an increasing interest in the use of UWB systems because of their attractive advantages such as Ground punch throw capability, Low Group delay, ability to work with low signal to noise ratio, resistance to multipath fading, and low cost. Antenna plays a vital role in wireless communication systems. As an important part of the UWB system, the UWB antenna must be compact in size and have large impedance bandwidth. The ever developing UWB system and the short range civil applications, working in the frequency band from 3.1–10.6 GHz created demand for a compact transmitter and receiver module. The size of the transmitter and receiver can be made compact by a small size of the antenna. In this perspective, it has become essential to study the electrical characteristics and radiation pattern of small, compact, and low profile UWB antenna. The effective antenna size, operating resonant frequency and impedance bandwidth of the antenna decide its wireless application. Compact antenna design for UWB applications still faces a problem of interference from the existing narrow band wireless communication systems.

In this paper we discuss the design of the CPW fed pentagonal shaped UWB monopole antenna. The wide bandwidth of the antenna is segmented into multiband operation using L-shaped rectangular slots and a C-shaped slot to remove the radiation of undesired frequencies. Each band-notch structure is studied individually, for segmentation of UWB and to reject the interference from existing narrow band applications like WLAN, WiMAX, Satellite communication etc.

II. DESIGN

The proposed pentagonal shaped compact UWB monopole antenna is designed using an FR4 substrate of $W \times L = 32 \text{ mm} \times 22$ mm. The pentagon shaped radiating patch and thin ground plane is printed on the substrate of 1.6 mm thickness, Dielectric constant of 4.4 and loss tangent ($\tan \delta$) 0.02. The Aperture radius of pentagonal patch antenna is calculated as Eq 1 and Eq 2.

$$R_s = \frac{c}{4f_c} \sqrt{\frac{2}{1+\epsilon_{\text{reff}}}} \quad (1)$$

$$\epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} \quad (2)$$

Where, R_s = Aperture radius, f_c = centre frequency and ϵ_{reff} = Effective dielectric constant.

All the side lengths S of the pentagon shaped radiating patch are equal. The pentagonal radiating patch is chosen because it satisfies the need for wideband operation. The pentagonal radiating patch is excited from a 50 Ω CPW feed line.

The thin rectangular coplanar ground plane forms the distributed matching network with the monopole, which results in the wideband characteristics. At the optimum values of $R_s=8.1$ mm, $W_f = 2.8$ mm, $S = 9.522$ mm. The wider bandwidth is formed over the UWB range i.e. from 3.1892 GHz to 11.9728 GHz with less than 2 VSWR which is shown in the Fig 2 Due to the effect of matching stubs, the antenna is able to radiate linearly in all the frequency range of UWB. The Fig 4 shows the VSWR curve with the value nearly equal to 1.7 throughout the band. Table 1 provides the numerical value of the antenna design

Table 1 Antenna Parameters

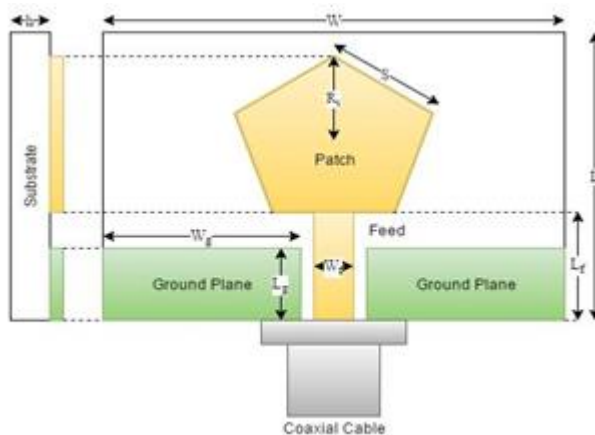


Fig. 1 Pentagonal patch antenna.

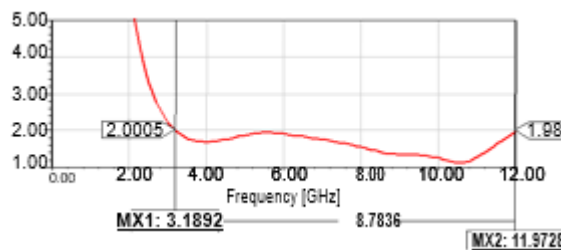


Fig. 2 VSWR curve of CPW monopole antenna

(1)UWB Monopole Antenna with Single Impedance Matching Stub

The proper stub length is calculated as given in Eq 3

$$l_{stub} = \frac{c}{4f_r \sqrt{\epsilon_{reff}}} \quad (3)$$

The geometry of Antenna is illustrated in Fig 3. The pentagonal patch is excited by a CPW feed via the staircase step stubs. The impedance matching stubs of 0.64×6 mm² and 0.5×4.4 mm² dimensions respectively is added to the bottom length of the pentagonal patch. The thin ground plane and staircase stubs play the key role of good impedance matching, so that the maximum feed signal is radiated by the pentagonal shaped monopole.

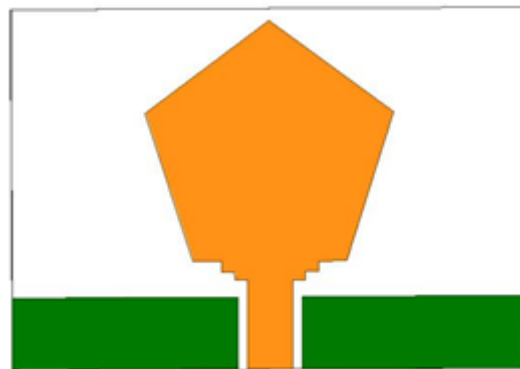


Fig. 3 UWB antenna with matching stubs.

Due to the effect of matching stubs, the antenna is able to radiate linearly in all the frequency range of UWB. The Fig 4 shows the VSWR curve with the value nearly equal to 1.7 throughout the band.

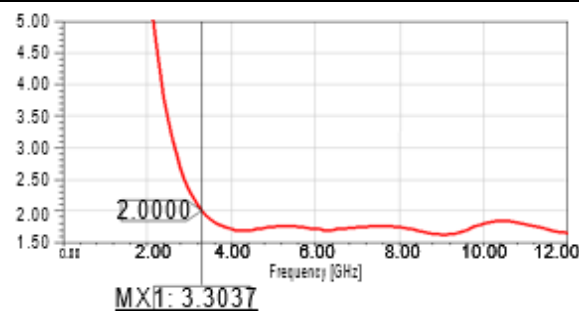


Fig. 4 VSWR Vs Frequency of antenna with stubs

(2) Design of 3.5 GHz Band-Notched pentagonal patch with a pair of open-ended L shaped rectangular slots in ground plane

A pair of open ended L-shaped rectangular slots is etched in the thin ground plane as a notch structure. The notch band at 3.5 GHz (3.4–3.9 GHz) minimizes the interference of the WiMAX system. The generated dual band can be used for various wireless applications. The length of each L-shaped slot is optimized at 13.54 mm, to achieve band-notch at 3.5 GHz. The Geometry and VSWR curve of the antenna is shown in the Fig 5 and Fig 6 respectively. The notch frequency of rejected band is determined by Eq 4 and Eq 5.

$$f_{notch} = \frac{c}{4L_{eq}\sqrt{\epsilon_{reff}}} \quad (4)$$

$$L_{eq} = x_1 + x_2 - t \quad (5)$$

Where, L_{eq} = equivalent length of slot, t = slot width and Where c is the speed of light in the free space, ϵ_r is the dielectric constant, and $(w' + L' = 2.45 \text{ mm} + 11 \text{ mm} = 13.45 \text{ mm})$ is the length of L-shaped slot. The peripheral length 26.9 mm is twice of the L-shaped slot length of 13.45 mm.

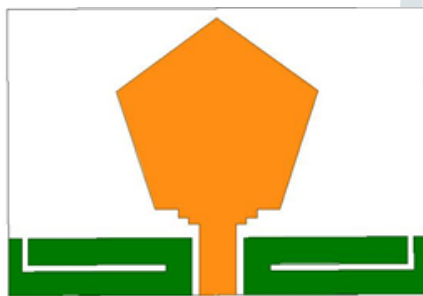


Fig. 4 VSWR Vs Frequency

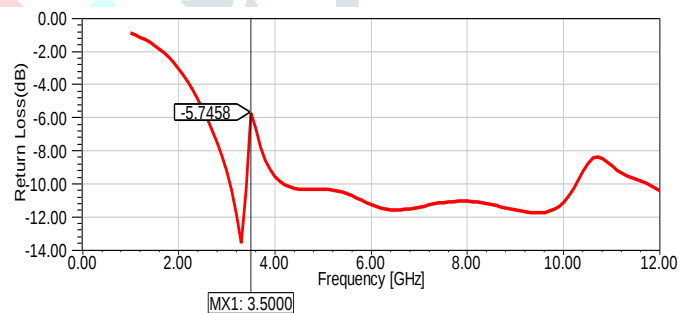


Fig. 6 Return Loss of the antenna with L slot in Ground plane

(3) Design of 5.2 GHz Band-Notched pentagonal patch with a pair of open-ended Double L shaped rectangular slots in ground plane

With the inclusion of one more pair of slot and slight modification in the previous slot (3.5GHz band) in the ground plane rejects the frequency corresponding to WLAN (5.2GHz) along with WiMAX. The length of the notches are 13.99 mm and 8.75 mm respectively. The geometry of the antenna is shown in the Fig 7.

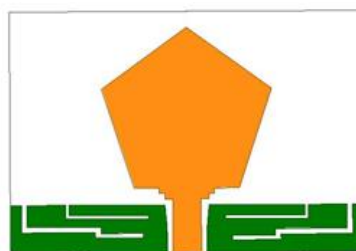


Fig. 7 Pentagonal patch with slots for dual band notch

The two bands corresponding to WiMAX and WLAN is notched out at 3.5GHz and 5.2 GHz. The triple band is achieved centered at 3.3, 4.5 and 8 GHz as shown in the Fig 8(a) and Fig 8(b).

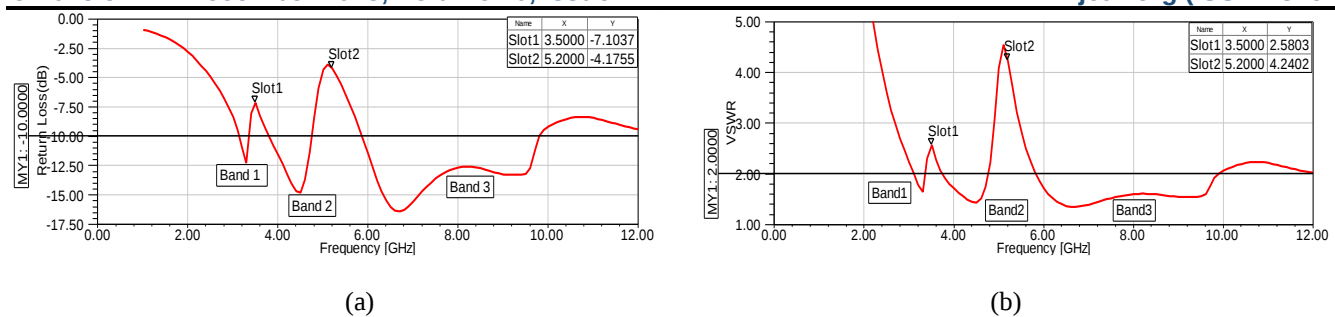


Fig. 8(a) Return loss Vs Frequency (b) Vswr Vs Frequency

Due to the effect of slot in the ground plane the upper frequency has been shifted from 10.8 GHz to 9.9 GHz. The VSWR of band notched antenna is shown in Fig 8(b). The fig 8(a) shows the return loss curve which shows the 2 bands notched at 3.5 and 5.2 GHz. The notch bandwidths are 400 MHz (3.4 to 3.8 GHz) and 1 GHz (4.8 to 5.8 GHz).

(4) Design of 8.3 GHz Band-Notched pentagonal patch with C-shaped slot in radiating patch

The third notch band is designed at 8.3 GHz by incorporating a circular C-shaped slot in the radiating patch. The circumference of the C-shaped slot is designed at a quarter wavelength of the center rejection frequency 8.3 GHz. Thus, the third notch band avoids potential interference of the Satellite uplink frequency. The geometry is shown in the Fig 9.



Fig 9: patch antenna for 8.3GHz band notch.

Finally a third band corresponds to Satellite Uplink frequency (8.3 GHz) is notched out yielding a multi resonant antenna. The VSWR curve is shown in the Fig 10.

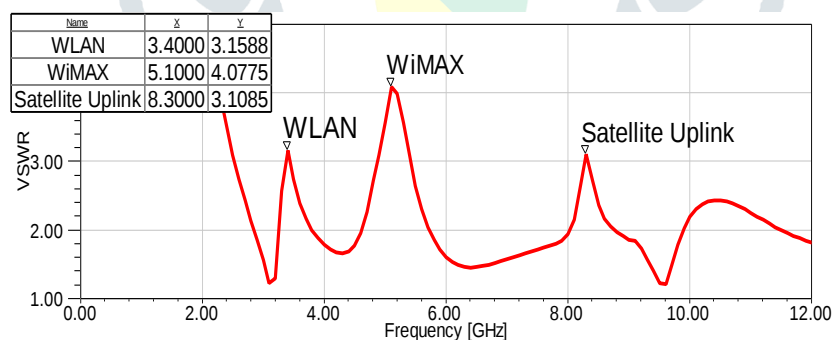


Fig.10 VSWRVs Frequency

The fig 10 shows the return loss of the multiband antenna. It is observed in the simulation results that four bands are achieved over the range of UWB bandwidth. The -10 dB bandwidths of the four antenna are Band1(2.9 GHz to 3.3GHz), Band2 (3.9 GHz to 4.7GHz), Band3 (5.8 GHz to 8.1 GHz) and Band4 (8.6 GHz to 9.9 GHz).

III. CONCLUSION

The study of Coplanar Monopole Slotted with Defective Ground plane has been carried out to achieve the research objectives. These UWB antenna designs are characterised by their compact size, multiple wide band, and multi band-notch functions. The study of the UWB antennas developed is with respect to impedance bandwidth, FRB, Group delay, and notch bandwidth. This research work has illustrated prototype of a compact UWB antenna. Further work can be carried out for the development of an UWB antenna array as a directional system with high gain for high-quality communication link.

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