To Enhance the Bandwidth of Small Printed Inverted T- Shaped Patch Antenna for Wireless and WBAN Applications

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ABSTRACT
In this paper, the radiation performance of a monopole inverted T shape patch antenna designed on glass epoxy FR4 substrate. The proposed design is capable of providing enhanced bandwidth to cover Wi MAX, Wi Fi , WBAN and Bluetooth operations at Absolute Bandwidth (GHz) Below -10 dB is 2.4GHz to 3.8 GHz = 1.4 GHz Second 5.2 GHz to 6 GHz = 0.8 GHz and Third 7 GHz to 8.6 GHz =1.6 GHz allotted by IEEE 802.16 working group for Wi MAX applications. The performance of proposed antenna is optimized considering at different conditions to obtain an antenna with dual band and high bandwidth performance. The Simulated results for various parameters like radiation patterns, total field gain, return loss, VSWR, input impedance and radiation efficiency of proposed antennas are also calculated with high frequency structure simulator HFSS. The value of return loss, VSWR and input impedance are measured using VNA.

Keywords
Ultra-wide band, Multiband Band, Patch antenna

1. INTRODUCTION
FCC (Federal communications commission) allocated a block of radio spectrum from 3.1GHz to 10.6 GHz for UWB operations [1].UWB systems can support more than 500 Mbps data transmission within 10m [1]. Compact size, low-cost printed antennas with Wideband and Ultra wideband characteristic are desired in modern communications. The Ultra wide band antennas can be classified as directional and omni-directional antennas [3]. A directional antenna have the high gain and relatively large in size. It has narrow field of view. Whereas the omni-directional antenna have low gain and relatively small in size. It has wide field of view as they radiates in all the directions [3].

The UWB antennas have broad band. There are many challenges in UWB antenna design. One of the challenges is to achieve wide impedance bandwidth. UWB antennas are typically required to attain a bandwidth, which reaches greater than 100% of the center frequency to ensure a sufficient impedance match is attained throughout the band such that a power loss less than 10% due to reflections occurs at the antenna terminals. Various planar shapes, such as square, circular, triangular, and elliptical shapes are analyzed and reported. Compared with monopole based planar antennas, the design of ultra wide band circular ring type antennas is difficult because of effect of the ground Plane.

The bandwidth of the micro strip antenna can be enhanced by modifying the ground plane [6]. Many designers have tried various ways to improve the structure of the traditional circular antennas, and many valuable results have been obtained.

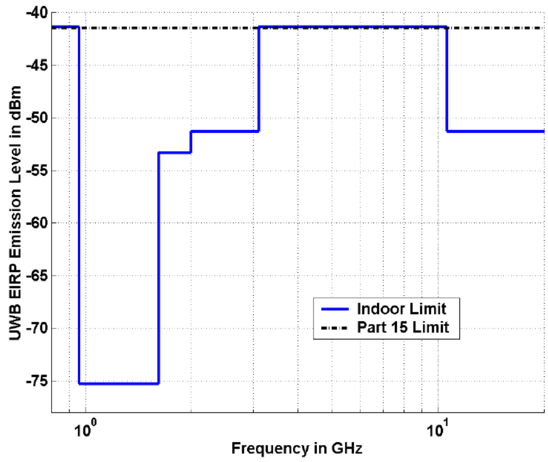

Figure 1. UWB Spectral Mask per FCC (Modified) Part 15 Rules [1]

2. ANTENNA CONFIGURATION AND DESIGN
For patch antenna the length and width of patch antenna are used as calculated from the equations. The first step is of dimension 2.5 × 1 mm^2 and second step is 4 mm on Y-axis and 1 mm on X- axis. The ground plane is of 50 × 50 mm^2. The slot present at patch is 4 × 8 mm^2. The ground plane is modified to enhance the bandwidth of the antenna. The whole structure of patch antenna is shown in **Fig. 2**.

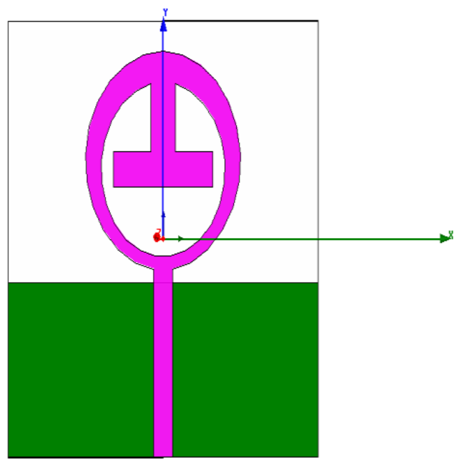

Figure 2. Structure of circular patch for Wireless communication

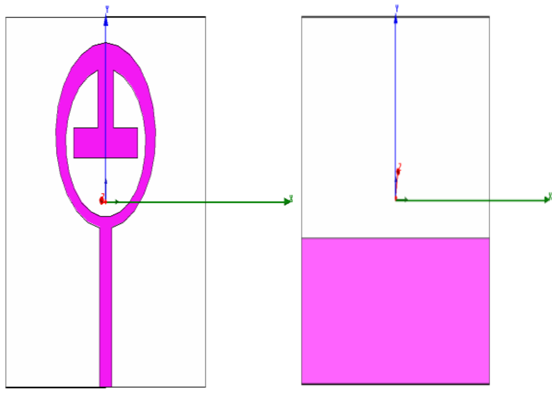

Figure 3. (a) Top View Fig. 3 (b) Bottom View

Top view and bottom view of design geometry of patch antenna is indicated in Fig.3 (a) and Fig. 3(b). The proposed antenna designed on a Rogers RT/duroid 5880TM substrate with dielectric constant ε_r= 4.4 and height of the substrate is h = 1.6 mm. The substrate has length L= 50 mm and width W = 50 mm.The substrate is mounted on ground of 20 mm length and 50 mm width. The dimensions of proposed antenna are shown in Table 1.1 and Table 1.2.

Table 1.1 Dimensions (in mm) of a CPM antenna

Wsub	LSub	Wf	Lf	Wg	Lg	R	r
50	50	3	22	50	21.5	12.5	10

Table 1.2 Dimensions (in mm) of Inverted T slot

Ws1	Ls1	Ws2	Ls2
4	8	15	4

3. SIMULATION RESULTS

Fig.4 & 5 Shows that S_{11} and VSWR of Multiband band patch antenna. This antenna is suitable for operating frequency 2.4GHz to 3.8 GHz = 1.4 GHz second 5.2 GHz to 6 GHz = 0.8 GHz and Third 7 GHz to 8.6 GHz =1.6 GHz allotted by IEEE 802.16 working group for Wi MAX applications. The VSWR obtained is less than 1.1 the patch antenna is found to have the compact size and 45%, 14%, 20% Maximum Fractional Bandwidth. The return loss value of first band is -24 at 2.8GHz and for second band are -23.0 at 7.9GHz.

Fig.6. Shows the relationship between frequency and impedance for the real and imaginary part of proposed design and gives the value of input impedance (Z_{in}) which will be ≤ 50 Ω for the perfect matching with transmission line.

The plot curve for Gain, E – H Plane, Directivity and Polar Plot are shown in Fig. 7, Fig. 8, Fig. 9 and Fig. 10 respectively at 5 GHz.

From Fig.7, we see that the gain of antenna is low (~3dBi) and maximum radiations are normal to the patch antenna geometry.

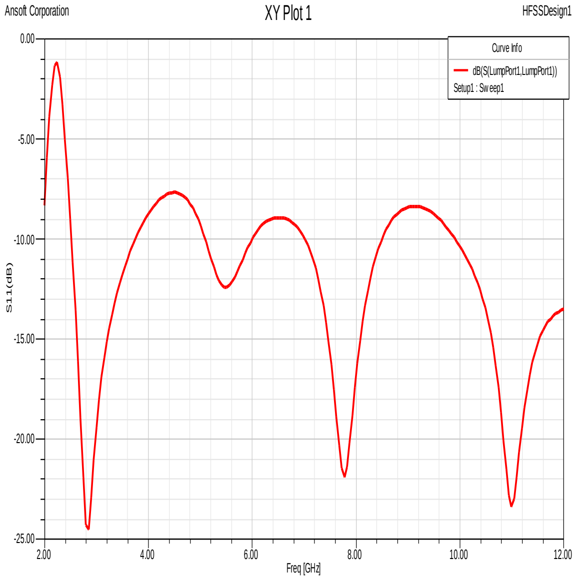

Figure 4. S_{11} of dual band patch antenna

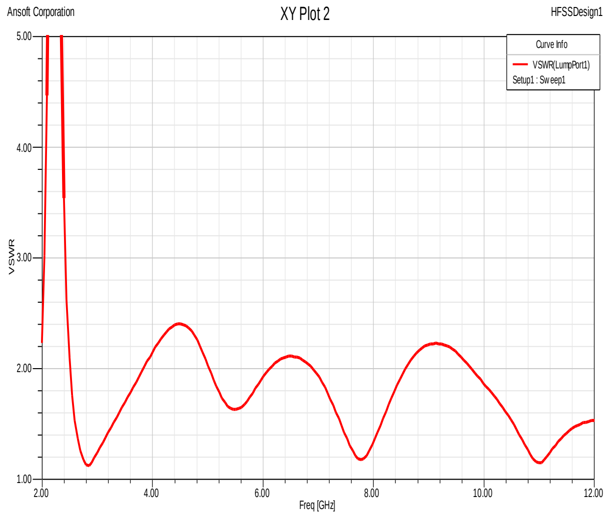

Figure 5. VSWR of dual band patch antenna

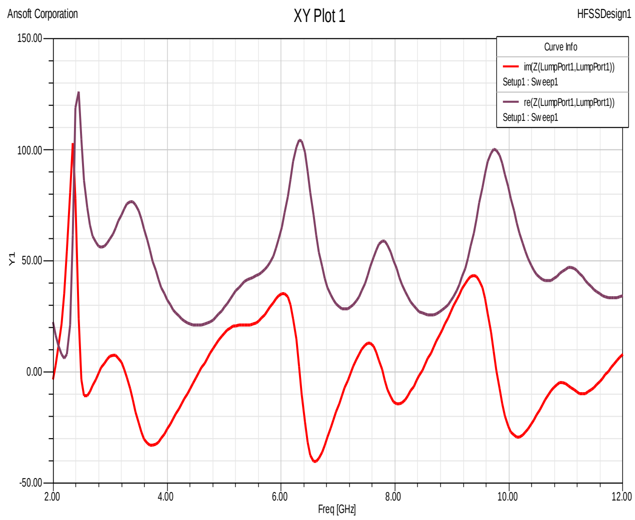

Figure 6. Z- Parameter of dual band patch antenna

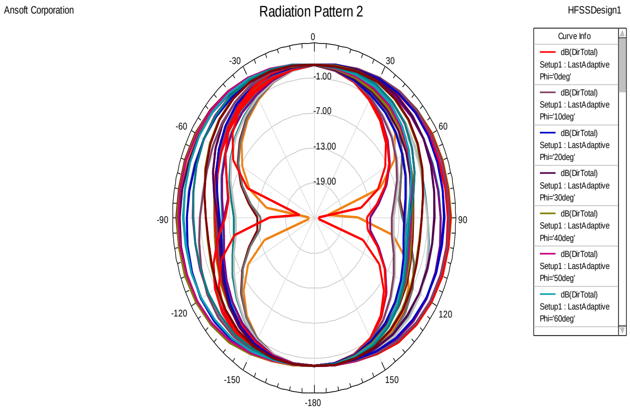

Figure 7. Gain in db at 5GHz

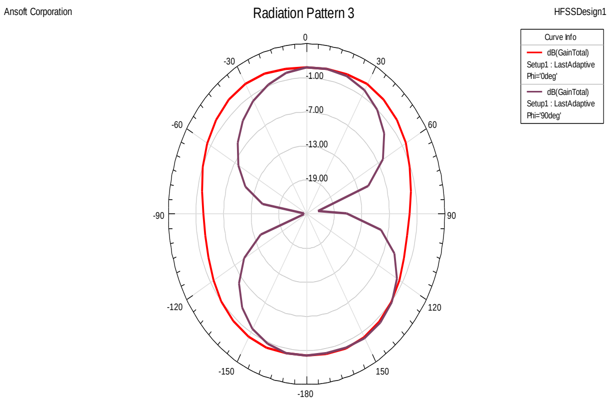

Figure 8. E-H Plane at 5GHz

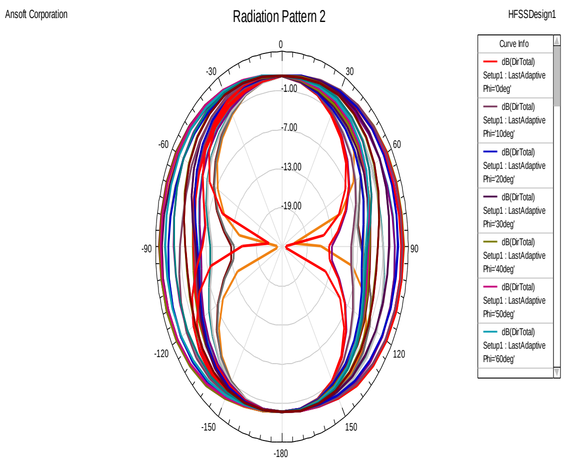

Figure 9. Directivity at 5GHz

Fig. 10 shows the complete gain of multiband antenna in 3D polar at 5 GHz.

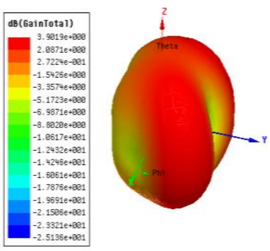

Figure 10. Gain in 3D Polar at 5GHz

The Surface current distribution of multiband antenna at 5 GHz is shown in Fig. 11.

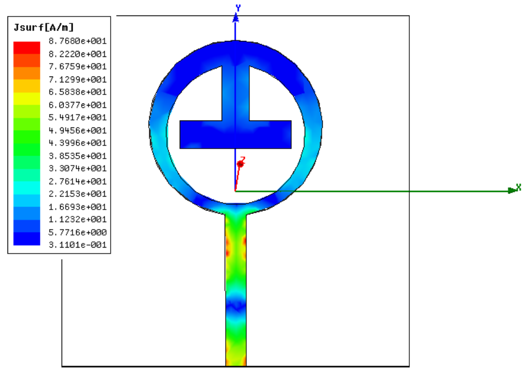

Figure 11. Surface current distribution at 5GHz

Fig. 12 shows the comparative analysis for to optimized the ground length for dual band antenna at Lg = 21.5 mm.

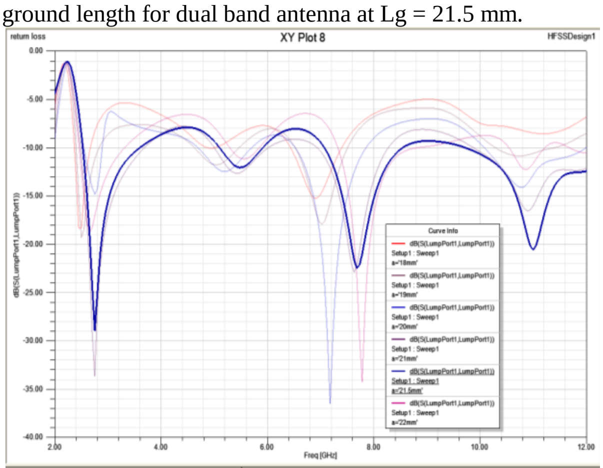

Figure 12. To optimize the ground length Lg = 21.5 mm at 7GHz

Fig. 13 shows the comparative analysis for to optimized the VSWR for dual band antenna at Lg = 21.5 mm.

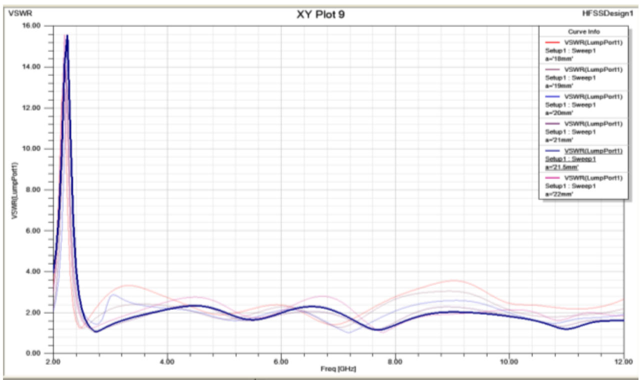

Figure 13. VSWR with optimized ground length Lg = 21.5 mm

Form the fig. 12 we can conclude that if we decrease the ground length (Lg) of Substrate up to a specific manner, we can obtain the higher values of return loss and our antenna offers excellent performance in the range of 2 GHz -12 GHz in ultra wide band rather than various different shapes antennas used in this range to obtain higher values of return loss and notch frequencies.

4. FABRICATION

The antenna structure is fabricated on a printed circuit board (PCB) using Photolithography technique and tested. The top view and bottom view fabricated antenna is shown in Fig 14 and Fig. 15.

Table 1.3
Summary of Measured results for return loss with various Frequency bands

Measured results			
S.No.	**Frequency band**	**Resonant frequency (f_c)**	**Return loss in dB**
1	2.2-2.6 GHz and 3.1-3.4GHz	2.38 GHz	-10.419
		3.27 GHz	-26.394
2	6.0-7.99 GHz	6.32 GHz	-18.117
		7.01 GHz	-19.267
3	9.0-10.50 GHz and 11.2-11.5 GHz	9.60 GHz	-20.438
		11.33 GHz	-10.990

Table 1.4
Summary of simulated results for return loss with various Frequency bands

S.No.	Simulated results		
	Frequency band	**Resonant frequency (f_c)**	**Return loss in dB**
1	2.50-3.55 GHz	2.38 GHz	-20.221
		3.27 GHz	-12.562
2	5.06 -8.38 GHz	6.32 GHz	-8.925
		7.01 GHz	-15.256
3	9.58 -12.00 GHz	9.60 GHz	-10.521
		11.33 GHz	-17.523

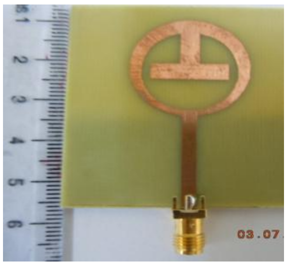

Figure 14. Top view of monopole patch antenna

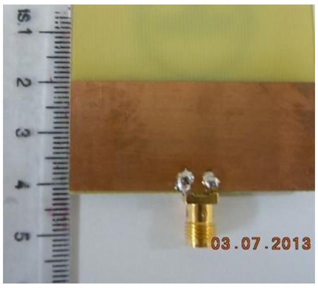

Figure 15. Bottom view of monopole patch antenna

Table 1.3 and Table 1.4 Shows the complete summary of measured and simulated results for return loss with various Frequency bands which shows the antenna is suitable for complete band of 2.38 GHz to 12.0 GHz.

5. SET UP OF ANTENNA MEASUREMENT

The set up for antenna measurement using vector network analyzer is shown in fig. 16 in this the calculation of return loss Values of the entire UWB ranges is measured and conclude that this antenna covered less then -10dB value for almost UWB.

Figure 16. Set up of antenna measurement using VNA

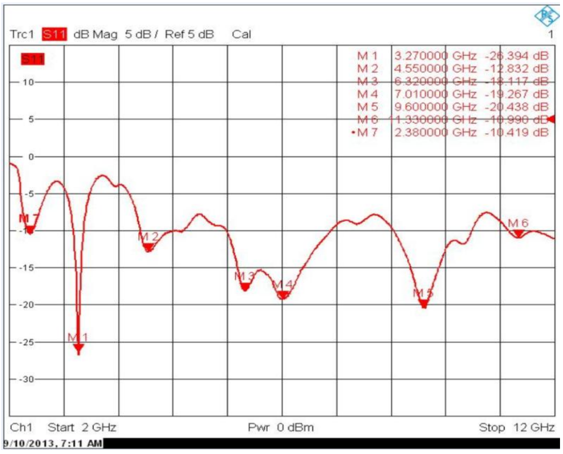

Figure 17. Measurement of return loss using VNA

Using the vector network analyzer instrument, result of return loss values for 2GHz to 12 GHz can be obtained and compared with simulated results for desgned antenna. The measured result of VSWR are shown in fig. 18 using VNA.

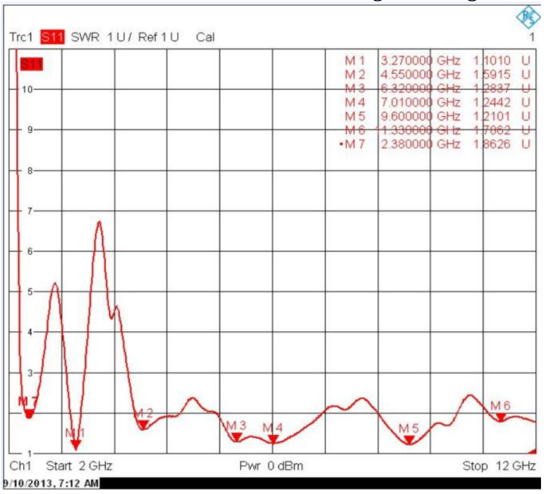

Figure 18. Measured result of VSWR of fabricated antenna with VNA

Fig. 19 shows the measured result of input impedance using VNA. Which shows that the measured results are almost closer with simulated results.

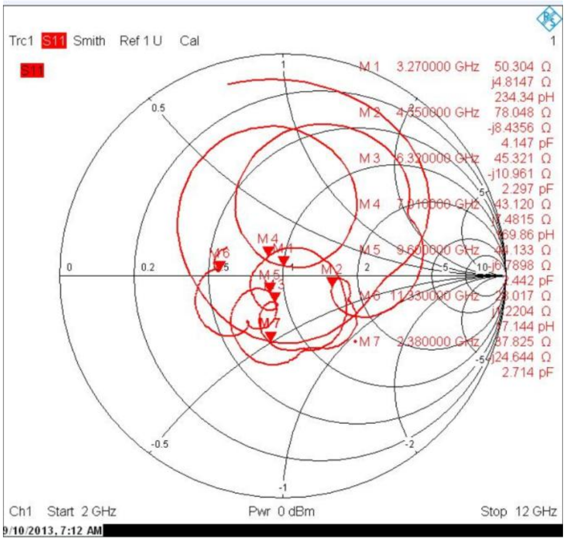

Figure 19. Measurement of input impedance using VNA

6. CONCLUSION

In this paper, Monopole circular Patch Inverted T shaped micro strip antenna suitable for wireless communication systems is simulated using HFSS-11. The fabricated antenna has advantages of small size, easy fabrication and simple construction. Antenna is circularly polarized and operates at three centre frequency first is 2.4GHz -3.8 GHz with Absolute Bandwidth 1.4 GHz ,second is 5.2 GHz -6 GHz with Absolute Bandwidth 0.8 GHz and third 7 GHz -8.6 GHz with Absolute Bandwidth 1.6 GHz. Radiation performance of inverted T-Shape circular patch antenna is also presented in this thesis. The simulated results indicate that an ultra wide band antenna with Maximum Fractional Bandwidth 45%, 14%, 20% can be designed by cutting an inverted T-Shape in a complete circular patch. The radiation efficiency 82% and antenna efficiency 79% may be achieved and we conclude that proposed geometry is applicable for three different pass bands in the range of ISM (2.4GHz-2.4835GHz) Bluetooth (2.4GHz-2.484GHz), WBAN (4-7 GHz) and Wi max IEEE 802.16 (3.3GHz-3.7GHz).

7. ACKNOWLEDGMENTS

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