A Very Compact UWB Antenna with L Shaped Resonators for Dual Band Rejection

Surya Rajan
M.Tech Scholar (Wireless Technology)
Department of Electronics
Toc H Institute of Science and Technology
Ernakulam, Kerala, India

Prof. A. K Prakash
Professor (P.G studies)
Department of Electronics
Toc H Institute of Science and Technology
Ernakulam, Kerala, India

***Abstract*—We present here a very compact Ultra-Wideband (UWB) microstrip fed monopole antenna with dual band rejection characteristics. The antenna has been fabricated on a FR4 substrate with a thickness of 1.6 m.m.The dimension of the antenna is 22*14 m.m^2.For rejecting Wimax(3.3-3.6 GHz) we used a quarter wavelength open slot stub on the patch and for WLAN(5.15-5.85 GHz) rejection we used a half wavelength resonating 'L' shaped structure on bottom side of antenna. The antenna is simulated using HFSS VER 13 software and the VSWR band and radiation pattern at different frequencies are evaluated. The frequency measured showed a bandwidth of 7.97 GHz over 3.09–11.06 GHz with a Voltage Standing Wave Ratio(VSWR) less than 2 with two eliminated bands centered at 3.5 GHz and 5.5 GHz to reject the aforementioned frequencies. The omnidirectional radiation patterns and compact size of the proposed antenna make it suitable for Wireless Personal Area Network(WPAN) UWB applications.**

Keywords—Ultra Wide Band, Beveling technique, Dual Band Rejection,Quarter wave Resonator, Half Wave Resonator, Microstrip fed, VSWR.

I. INTRODUCTION

Since U.S. Federal Communications Commission (FCC) allocated an unlicensed spectrum of 3.1 -10.6 GHz for ultra-wideband (UWB) commercial purposes, both academical and industrial researches into UWB technology has risen drastically [1]. Among the proposed UWB antennas design for UWB, printed monopole antennas is a well suited candidate for future UWB applications when compact size, stable radiation pattern and easiness of fabrication is to be considered [2-3].Anyway the design of UWB antennas faces many problems of which most headache for designers is the interference with co-existing bands such as wireless local area networks (WLAN), WiMAX.Therefore it is essential need for UWB antennas to be band notched for interfering bands.

Many antenna designs are proposed with single and dual band rejection characteristics. Some antennas are also proposed with multiple band rejection. Most of the designers have used half wavelength and quarter wavelength open stub slots of various shape like U, L, C, E [4-11] etc.Some of them have also used Split Ring Resonators (SRR) [12] also. A detailed study of different parametric element is done by [13].

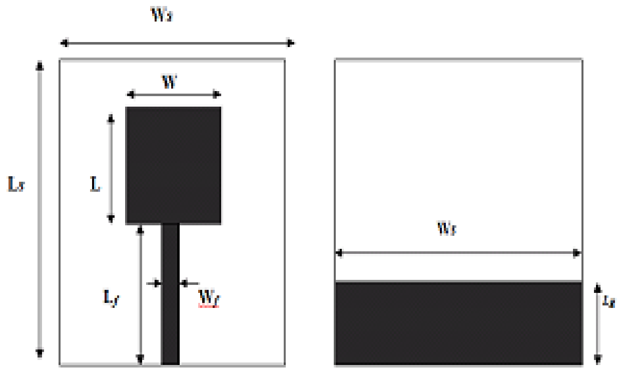
It is found that using most of these designs a major part of useful bandwidth is rejected along with rejection bandwidth. Also the radiation pattern is also distorted at the higher frequencies. So there is a need for a compact and simple co-existing band rejected UWB antenna with stable radiation pattern.

In this paper we first design a square monopole antenna and then will expand its bandwidth using techniques like beveling technique and truncating ground technique to achieve UWB bandwidth. Then we propose a simple and very compact microstrip fed UWB antenna with dual band rejection at 3.5 GHz and 5.5 GHz. The dual band stop characteristics is obtained by using a open quarter wavelength resonator on patch for 3.5 GHz and a newly proposed 'L' shaped half wave resonator on bottom side near ground plane for 5.5 GHz rejection.

II. ANTENNA GEOMETRY AND DESIGN

A. *Basic UWB Antenna.*

In this section the basic UWB antenna without band notch is described. Figure 1 and 2 shows the geometry of basic square monopole antenna and figure 3 and 4 shows its transformation to fully UWB bandwidth using ground truncation and beveling technique. The substrate used is FR4 material of $\sum_r$ of 4.4 and thickness 1.6 m.m.with size 22*14 m.m^2. The patch design equations are taken from [14]. A 50 Ω microstrip feed line is designed with a width of 2 m.m and length 9 m.m which is taken from [15].Then the ground truncation and beveling techniques are used to extend bandwidth.



(a) (b)

Fig. 1.Basic UWB square monopole antenna

(a) Front view

(b) Bottom view

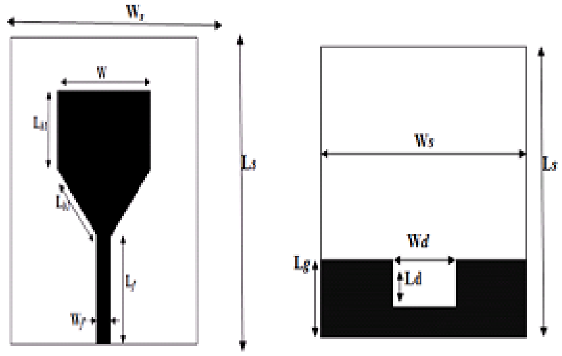


Fig. 2.Modified UWB square monopole antenna

(a) Front view –Beveled Patch

(b) Bottom view-Truncated Ground

TABLE 1.Dimensions of UWB antenna without notches

Dimensions	**Values (mm)**
Width of the Substrate (W_s)	14
Length of the Substrate (L_s)	22
Patch length and width(L=W)	12
Feed width(W_f)	2
Feed length	9
Ground length,L_g	5
Width of Truncated Ground slot,W_d	4
Length of Truncated Ground slot,L_d	3
Top Length of beveled patch,L_{b1}	6
Top Length of beveled patch,L_{b2}	7.8

The optimized values of square monopole UWB antenna and modified UWB antenna without notches are given in the Table1.

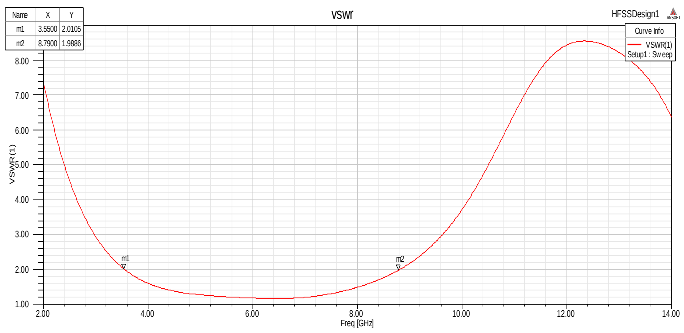


Fig. 3.VSWR Bandwidth of Basic UWB square monopole antenna

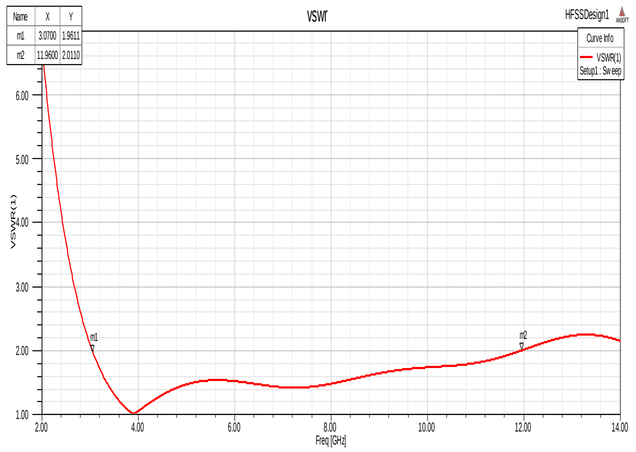


Fig. 4. VSWR Bandwidth of Modified UWB square monopole antenna

In the simple square monopole antenna shown in Fig.1. there is a discontinuity in the connecting point between the microstrip-feed-line and the patch, that is an important factor for lowering the bandwidth and degrading the radiation pattern at the higher frequencies. To eliminate this issue, the square monopole patch antenna in Fig. 1.(a) is turned to beveled structure in Fig. 2(a) which provide a smooth transition from microstrip feed to patch and improves impedance matching .Bottom side in Fig.1(b) is reconstructed to truncated ground structure behind the microstrip feed line as shown in Fig. 2(b) which act as an impedance matching element, since the truncated ground creates a capacitive load that neutralizes the inductive effect of microstrip feed line which results in a purely resistive input impedance. Together this two modifications result in an improved impedance matching and hence an improved VSWR bandwidth as shown in Fig. 4. ranging from 3.07-11.6 GHz compared to bandwidth of basic square monopole patch which ranges only from 3.55-8.79 GHz. The antenna is designed in x-y plane which has normal direction towards z axis.

B. Dual Band Notched Antenna.

In this section details about our dual band notched antenna is described in detail.

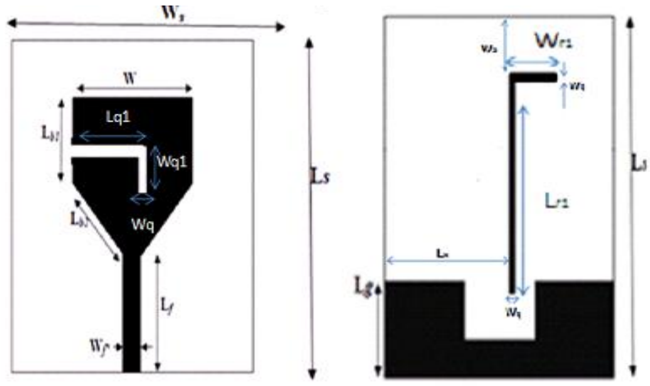


Fig. 5.Modified UWB square monopole antenna with dual band notches

(a) Front view

(b) Bottom view

Fig. 5. shows the final design of dual band notched antenna which is optimized by taking several things into consideration like optimum rejected bandwidth, stable radiation pattern etc.

The dual band notching is achieved by cutting horizontal 'L' shaped slot in the patch for WiMax rejection (3.5 GHz) and providing an inverted 'L' shaped resonator on bottom side of the antenna for rejecting WLAN(5.5 GHz).The 'L' shaped slot in the patch act as a open stub quarter wavelength resonator at WiMax frequency. Similarly the 'L' shaped resonator at bottom side will act as a half wave resonator at WLAN frequency. So the notching frequency at which maximum rejection happens can be found using the following equations:

$$f_{r1} = \frac{c}{4L_{n1}\sqrt{\mathcal{E}eff}} \quad (1)$$

$$f_{r2} = \frac{c}{2L_{n2}\sqrt{\mathcal{E}eff}} \quad (2)$$

Where

$$L_{n1} = L_{q1} + W_{q1} + W_q \quad (3)$$

$$L_{n2} = L_{r1} + W_{r1} + W_q \quad (4)$$

$$\varepsilon_{eff} = \sqrt{\frac{\varepsilon_r + 1}{2}} \quad (5)$$

where fr1 and fr2 are resonant frequencies at 3.5 and 5.5 GHz respectively,'c' is the velocity of light in free space,$\mathcal{E}_{eff}$ is the effective dielectric constant calculated by (5),$\mathcal{E}_r$ is the dielectric constant of substrate which is given as 4.4and other parameters are given in fig. 5.

TABLE 2.Optimized dimensions of UWB antenna with dual band notch

Dimensions	**Values (mm)**
Slot length1 on patch (L_{q1})	11
Slot length2 on patch (W_{q1})	2
Slot Width (W_q)	.5
Slot length1 on ground plane(L_{r1})	10.5
Slot length2 on ground plane(W_{r1})	4.5
Distance from top of substrate to 'L'resonator(W_2)	7.3
Distance from edge of substrate to 'L'resonator(L_x)	7.8

Fig. 6. shows the VSWR graph of our proposed antenna with dual band rejections characteristics. The length of quarter wave open resonator for rejecting WiMax at 3.5 GHz and WLAN at 5.5 GHz are optimized in such a way that the interfering band is rejected and also the positions of resonators are selected like that there is least coupling between the notching structures and a stable radiation pattern is maintained.

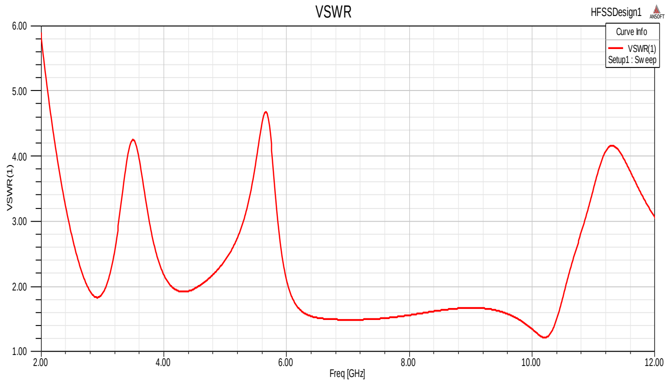


Fig. 6. VSWR Bandwidth of proposed dual band notched antenna.

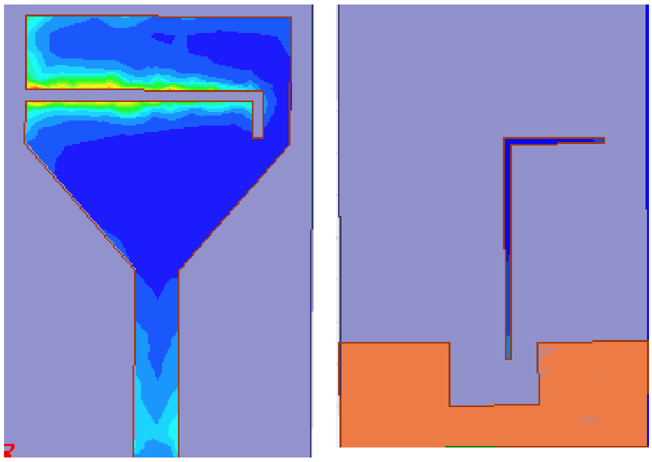


Fig. 7. Surface Current pattern of proposed dual band notched antenna at 3.5 GHz.

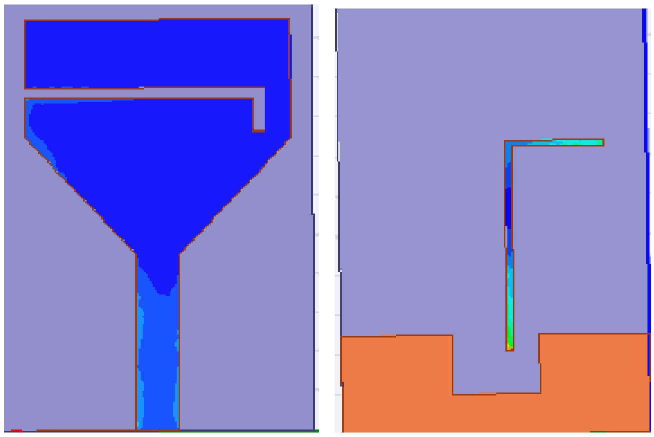


Fig. 8. Surface Current pattern of proposed dual band notched antenna at 5.5 GHz.

From Fig. 6. it is clear that our proposed antenna reject the interfering WiMax and WLAN frequencies with VSWR>2 while maintaining the elsewhere in UWB bandwidth from 3.1 GHz-10.6 GHz with a VSWR< 2.

For better understanding of the band notching characteristics the current pattern of proposed antenna at 3.5 and 5.5 GHz shown in Fig. 7.It can be seen that current is concentrated around the open quarter wavelength resonator around 3.5 GHz and around the half wavelength resonator on bottom plane at frequencies around 5.5 GHz.

III. RADIATION PATTERN OF PROPOSED ANTENNA

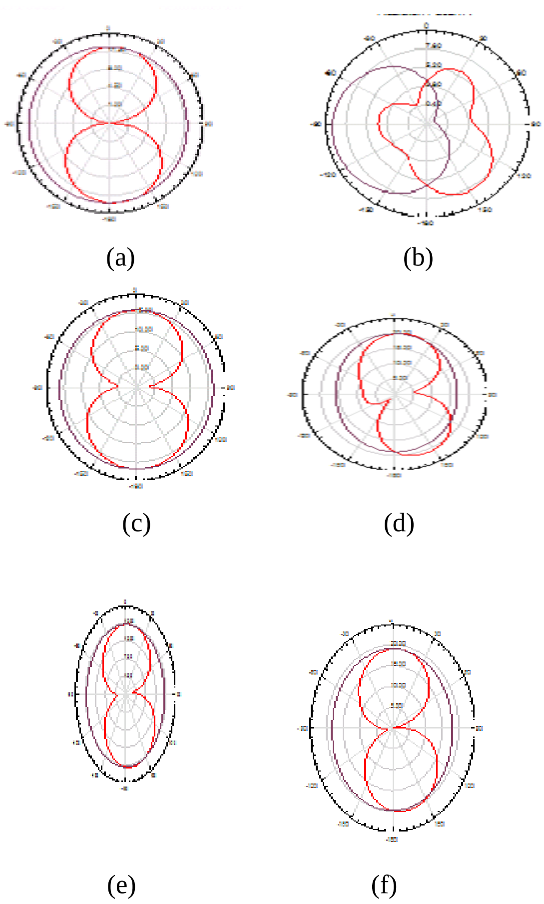


Fig. 9. Radiation patterns at different frequencies proposed dual band notched antenna.

(a) 3.1 GHz (b) 3.5 GHz (c) 4.5 GHz (d) 5.5 GHz (e) 7.5 GHz (f) 10 GHz

Fig. 9. shows the radiation pattern in 'E' and 'H' plane of proposed antenna at various frequencies. It should be noted that the radiation pattern is distorted at notching frequencies and stable for other frequencies. So antenna can be said to be omnidirectional in UWB band.

IV. CONCLUSION

Design of a modified UWB antenna and a dual band notched antenna for rejecting WiMax and WLAN frequencies are discussed in this paper. A quarter wave length open stub resonator on patch is used to reject 3.5 GHz WiMax frequency whereas a half wave resonator is used at the bottom plane to reject the WLAN frequency at 5.5 GHz. The interesting point to be noted is that the antenna proposed is a very compact antenna of dimension 14*22*1.6 $m.m^3$ which makes it suitable for UWB WPAN applications. Also we have obtained a constant radiation pattern and VSWR bandwidth with notched bands at >2 and UWB band <2, when the proposed antenna is simulated using HFSS VER 13 [16].

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