International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 05, May-2015

Design of UWB Microstrip Antenna with Band-Notch for Broadband Application

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***Abstract:-* In this document a novel design of ultra-wideband (UWB) microstrip antenna with frequency band stop performance is anticipated. The anticipated antenna consists of an regular square radiating patch with a two rotated T-shaped slits , and a customized ground plane with an inverted Ω shaped and a two rectangular ring slots in the ground plane, additional resonances are excited and hence much wider impedance bandwidth can be produced .This proposed antenna provides a wide bandwidth from 3.4-16.2 GHz. For generating band notches firstly single band notch by cutting a pair of rotated T-shaped slits in the square radiating patch. Secondly by inserting an inverted Ω shaped slot in the ground plane with two rectangle slot, a dual band – notched function is achieved. And thirdly by increasing the dimension of inverted Ω shaped slot , a triple band notched function is achieved. After measuring all the result of presented band – notch monopole antenna offers a wide bandwidth, with notched bands, covering 3.5/5.5 GHz WiMAX, 5.2/5.8 GHz WLAN and 4GHz C band. The proposed antenna has a small size of 12×18mm2. By doing the simulation we get good return loss, antenna gain, radiation pattern, VSWR.**

Key Word: Ultra-Wideband, Anticipated antenna, Resonance, Band Notch, Antenna Gain, Radiation Pattern, VSWR.

I. INTRODUCTION

UWB is a radio communication technology that uses very low energy pulses and it is intended for short-range-cum high bandwidth communication. But in the UWB major problem is the design of a compact antenna with wideband characteristics over the operating band. A number of microstrip antennas with different geometries have been experimentally characterized.[1]

As the UWB having advantages, the frequency range for UWB is from 3.1to 10.6 GHz. This will cause interference to the existing wireless communication system, such as the wireless local area network(WLAN) for IEEE 802.11a operating in 5.15-5.35 GHz and 5.725-5.825 GHz, WiMAX (3.3-3.6 GHz), C band (3.7-4.2 GHz), so the UWB antenna with a single and dual band stop performance is required. In different shapes of the slots, slits are used to obtain the desired band notch characteristics. [2, 3]

In this paper to avoid the interference between UWB and WLAN/WiMAX/C band, we cut first radiating square patch by cutting a pair of rotated T-shaped slits we get the first notch. Secondly by cutting the pair of rectangular ring slot in the ground plane we get second band notch and finally by increasing the dimensions of inverted Ω shaped slot in the ground plane we get third band notch which offers wide bandwidth with notched bands, covering WLAN (5.2/5.8 GHz), WiMAX (3.5/5.5 GHz) with 4GHz C band.

II. ANTENNA DESIGN

The existing small monopole antenna structure consists of a square patch, a feed line, and a ground plane. Antenna fed by a microstrip line shown in fig. , which is printed on an FR4 substrate of 1.6mm thickness, permittivity 4.4 and loss tangent 0.018. The width of the square patch denoted by 'W' and length by 'L'. The patch is connected to a feed line by rectangle having width Wx and length Lx. On the additional side of the substrate, a conducting ground plane with defected ground structure is placed. The planned antenna is connected to a 50Ω SMA connector for signal transmissions.

Formulas used for the patch design is explain as [4].

1. Calculate the width of the patch as

$$W=\left(\frac{1}{2f_r\sqrt{\mu_0\epsilon_0}}\sqrt{\frac{2}{\epsilon_r+1}}=\frac{\vartheta_0}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}}\right)$$

Where υ_0 is the free space velocity of light.

2. Calculate the effective dielectric constant
For (W/h > 1)

$$\epsilon_{reff}=\frac{\epsilon_r+1}{2}+\frac{\epsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2}$$

3. Calculate the length correction due to fringing

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{reff}-0.28)\left(\frac{W}{h}+0.8\right)}$$

4. Calculation of effective length.

$L_{eff.} = L + 2\Delta L$

5. The length of the patch can now be calculated as

$L = L_{eff.} - 2\Delta L$

6. Calculation of resonant frequency(f_r)

$$f_r = \frac{\upsilon 0}{2L\sqrt{\varepsilon r}}$$

7. Ground length

$L_g = 6h + L$

8. Ground width

$W_g = 6h + W$

9. The feed point position for 50 Ohms can be calculated using the following expression

$$R_{in}(y = y_0) = R_{in}(y = 0)\cos^2\left(\frac{\pi}{L}y_0\right)$$

Where R_{in} (y=y0) is 50 Ohms and R_{in} (y=0) is roughly given as (Neglecting the mutual coupling of the slots)

$$Z_{in} = \frac{1}{Y_{in}} = R_{in} = \frac{1}{2G_1}$$

$$G_1 = \begin{cases} \frac{1}{90}\left(\frac{W}{\lambda_0}\right)^2 & W \ll \lambda_0 \\ \frac{1}{120}\left(\frac{W}{\lambda_0}\right) & W \gg \lambda_0 \end{cases}$$

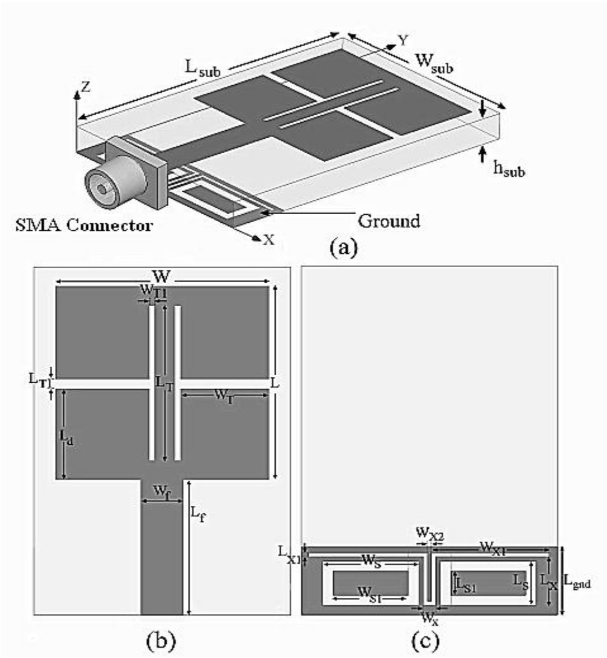

Fig.1 Proposed microstrip fed monopole antenna Geometry shows a) Side View b) Top View c) Bottom View

In this proposed antenna, we start work by selecting the dimensions of designed antenna. It consists of substrate which is Wsub×Lsub=12mm×18mm at 4.2 GHz. The values of proposed antenna design parameters are as follows: [2]

Basic configuration	Variable	Dimensions (mm)
Substrate	Ws_{ub}	12
	L_{sub}	18
Feed line	W_f	2
	L_f	7
Patch	W	10
	W_s	4.25
	L_T	8
	W_{T1}	0.25
	L_{T1}	0.5
	L_d	4.75
	L	10
Ground	W_s	4.5
	L_s	2.5
	W_{s1}	3.5
	L_{s1}	1.5
	W_x	0.6
	L_x	2.75
	L_{xa}	0.25
	W_{x1}	5.5
	W_{x2}	0.2
	L_{gnd}	3.5

III. RESULT AND DISCUSSIONS

The proposed microstrip antenna with various design parameters was constructed, and the results of the return loss, radiation pattern are presented and discussed. The parameters of this antenna are studied by changing one parameter at a time. Ansoft HFSS simulation is used to optimize the design.

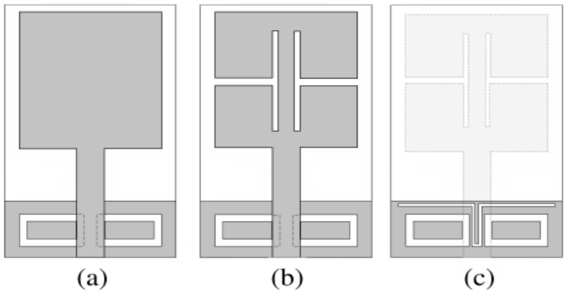

Fig. 2 Antenna with two ring slot in ground Plane b)Antenna with two ring slot and two radiating T slits in the square patch c) Final Proposed Antenna Structure.

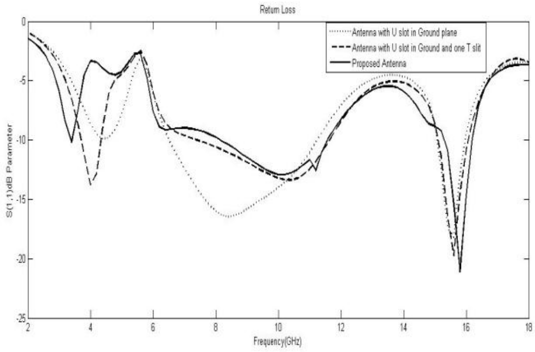

Fig.3 Simulated return loss characteristics for the various antenna structures

- *Return loss, S11:*

Figure illustrates the simulated return loss against frequency of the three different antenna. Based on the simulated result, the antenna shown in figure (a) displays resonant frequencies at 4.4GHz with S11 of -10dB, 8.4GHz with -16.46dB and 15.6GHz with -18.17dB. These frequencies are due to the pair of rectangular ring slot in the ground plane with inverted Ω shaped slot. Antenna having pair of rectangular ring slot in the ground plane, with inverted Ω shaped slot and one T-shaped slit on the patch displays resonant frequencies at 4GHz with -13.78dB, 10.4GHz with -13.37dB and 15.6GHz with -19.75dB. Figure (c) displays resonant frequencies at 3.4GHz with -10.2dB, 10.2GHz with -13.1dB and 15.8GHz with -21.73dB. These frequencies are due to the pair of rectangular ring slot in the ground plane with inverted Ω shaped slot and pair of T-shaped slits on the patch.

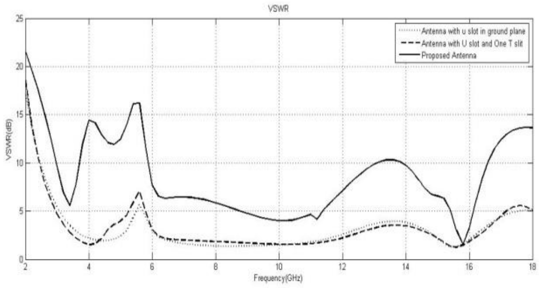

Fig.4 Simulated VSWR characteristics for the various antenna structures

- *Voltage Standing Wave Ratio (VSWR):*

Figure illustrates the simulated voltage standing wave ratio against frequency of the three different antenna. The VSWR value ranges from 1 to 2 at frequencies 4.4GHz with 1.9, 15.6GHz with 1.2 and 16 GHz with 2 for the antenna having structure as pair of rectangular ring slot in the ground plane with inverted Ω shaped slot. The VSWR for the antenna having pair of rectangular ring slot in the ground plane with inverted Ω shaped slot and one T-shaped slit on the patch is 1.51 for frequency 4 GHz and 1.22 for 15.6 GHz. The frequency region from 6.6 GHz to 12 GHz displays VSWR value 2. The VSWR for the antenna having pair of rectangular ring slot in the ground plane with inverted Ω shaped slot and two T-shaped slits on the patch is 1.42 for frequency 15.8GHz

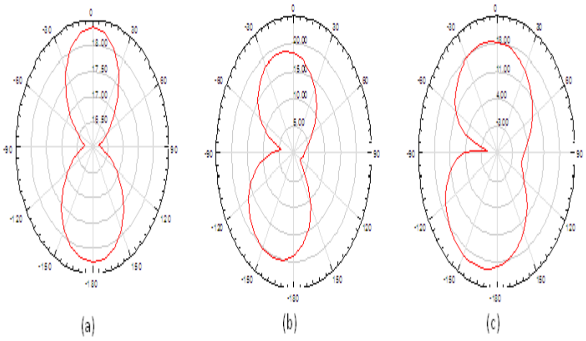

Fig.5 radiation Pattern for the various antenna structures

VI.CONCLUSION

A proposed antenna with dual band-notched function has been presented. The basic monopole antenna structure consists of a square radiating patch, feed-line, and a ground plane. By cutting pairs of rectangular-ring slots and rotated T-shaped slits an also by embedding an inverted Ω-shaped slot in antenna configuration, the proposed antenna can operate from 3.4 to 16.2 GHz, having fractional bandwidth of 131%. The antenna complies with the return loss of S11<-10dB throughout the impedance bandwidth. The directivity of an antenna is good and the radiation pattern exhibit an isotropic behavior. Simulated results show that the proposed antenna could be a good candidate for UWB application.

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