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Dual - Band Notched Semi Circular Monopole Antenna for UWB Applications

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Abstract:
In this paper a compact semicircular monopole antenna is proposed for UWB applications. Generally UWB antenna operates in the frequency range of (3.1-10.6 GHZ). To avoid interference between UWB and existing wireless communication systems, band rejection characteristics are proposed.In this paper the author has come up with two rejection bands one is WLAN (4.94-5.85 GHZ) and other one is International Telecommunication union (ITU) band (8.0-8.55 GHz). In the proposed work the semi-circular monopole patch antenna is excited with micro strip line feeding. To get required notching bands concentric rings are placed on the patch. The antenna design is simulated using CST microwave studio. Some of the important antenna parameters like Return losses, VSWR, Radiation pattern are measured.

Keywords: *Concentric rings, Notched bands, micro strip line, semicircular patch..*

I. INTRODUCTION

Advancements in VLSI design leads to miniaturization of gadgets employed even in wireless communications. The situation demanded, in place of erstwhile antennas like wire, helical or horn antennas a compact low profile antenna that could be integrated with these devices is required.

In 2002 FCC has allotted a bandwidth of 7.5 GHz from (3.1 GHz to 10.6 GHz) to commercial applications allowing unlicensed usage, a band width range which can handle a large capacity of hundreds of Mbps[1-2]. In addition, UWB systems function at exceedingly low power levels. Hence, they are able to offer an extremely safe and dependable communications system because the low energy density makes accidental detection rather difficult.

The main reason for popularity of UWB technology is its fast data rate. With the rapid developments in the wireless communications systems (WCS), UWB have become prominent technology because of its large bandwidth and data rate [1-2].

Some of the existing wireless technologies are like Wireless Fidelity (Wi-Fi), Worldwide Interoperability for Microwave Access (WiMAX), C band downlink frequency, Wireless Local Area Network (WLAN), X Band downlink Satellite communication application, and International Telecommunication Union (ITU) band operations. They use certain frequencies within the UWB Band for their operation .So while designing a new UWB patch antenna interference with already existing bands of wireless technologies have to be avoided [3-14]. In order to avoid interference with

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the existing wireless bands with UWB band rejection is proposed in this paper. Many researchers worked on different shapes like square, rectangular, tri angular, hexagonal, elliptical etc[3-15]. The author developed a compact semicircular patch antenna with dual band notching characteristics. The performance of the antenna is verified by simulation and some of the performance parameters are measured.

In the present work rejection of the existing bands like WLAN and ITU bands is done using concentric rings with stub. To achieve two notching bands two concentric splitted rings are used. The effect of concentric splitted rings on the performance of the antenna is measured. Some of the important antenna performance parameters are measured.

II. ANTENNA DESIGN

A semi-circular patch is designed with resonant frequency of 4 GHz using Rogers RT/5880 substrate of thickness (h) 0.8mm and dielectric constant (ϵr) of 2.2. Patch dimensions are calculated using the design equations given in [16].

Radius (a) of the circular patch antenna is

$$a = \frac{F}{\sqrt{1 + \frac{2h}{\pi \epsilon_r F}\left[ln\left(\frac{F\pi}{2h}\right) + 1.7726\right]}}$$

Where F is given by

$$F = \frac{8.791 \times 10^9}{f_r\sqrt{\epsilon_r}}$$

Whereϵ_r=Dielectric constant of substrate and

f_r= Resonant frequency

h=Height of dielectric substrate

The length of the microstrip feed line is given as

$$L_{eff} = \frac{c}{4f_r\sqrt{\epsilon_{eff}}}$$

The width of the microstrip feed line having characteristic impedancecan beZ_c obtained using the following formula.

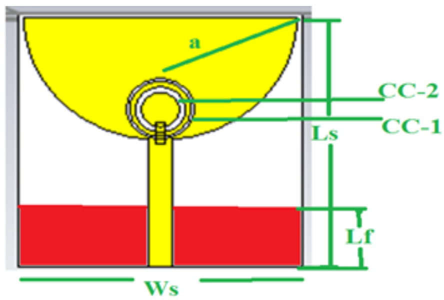
$$Z_c = \begin{cases} \frac{60}{\sqrt{\varepsilon_{eff}}} ln\left[\frac{8h}{W_f} + \frac{W_f}{4h}\right]; & \frac{W_f}{h} \leq 1 \\ \frac{120\pi}{\sqrt{\varepsilon_{eff}}\left[\frac{W_f}{h} + 1.393 + 0.667 ln\left(\frac{W_f}{h} + 1.444\right)\right]}; & \frac{W_f}{h} > 1 \end{cases}$$

The dimensions of the patch are calculated using the above equations and the dimensions are mentioned in Table 2.1

Table 2.1 Dimensions of semi-circular patchantenna

Sl.no	Parameters	Value in mm
1.	Width of Substrate(Ws)	30
2.	Length of substrate(Ls)	30
3.	Height of substrate(h)	0.8
4.	Length of Ground Plane(Lg)	15.4
5.	Thickness of Ground Plane , patch and feed line(t)	0.0256
6.	Radius of Patch(a)	14.5
7	Length of Feed line(L_f)	16
8.	Width of Feed line(W_f)	2.4

The Structure of the antenna is shown in Fig 1



Using CST microwave studio the antenna units are simulated and the results are discussed in next section. To get band notching characteristics, concentric rings are made on the patch. The dimensions of the concentric rings are calculated using the following formula

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$$r_i = \frac{1}{2\pi f_i \sqrt{\epsilon_{eff}}}$$

where $\epsilon_{eff} = \sqrt{\frac{\epsilon_r + 1}{2}}$ and f_i in GHz

Table 2.2 Dimensions of concentric rings

Parameter	CC-1	CC-2
Inner and Outer radius	3.6&3.27(mm)	2.7&2.05(mm)
Rejection Band	4.94-5.85 GHz	8.00-8.55 GHz
Application	WLAN	X-band satellite communication system
UWB range	3.1– 10.6 GHz	

III.RESULTS

In this section the basic antenna covering the entire ultra-wide band frequency from 3.1-10.6 GHz is first observed to get better radiation characteristics the antenna is excited with micro strip line feeding. In this antenna design, semi circular patch having radius 14.5 mm is taken. The results are shown in Fig 3.1 &3.2. From the simulated results it was noticed that the design is giving good return losses, gain and VSWR for the entire frequency range. It is observed that the radiation pattern is uniform throughout UWB frequency range.

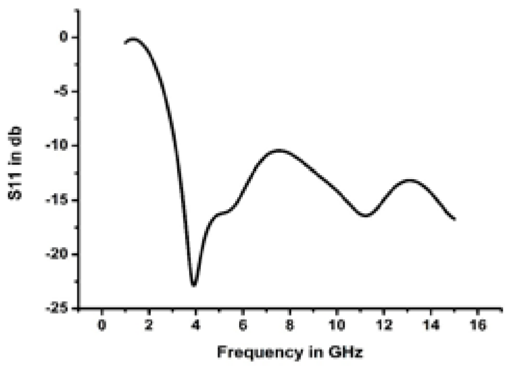

Fig 3.1: Frequency Vs Return loss of basic UWB antenna.

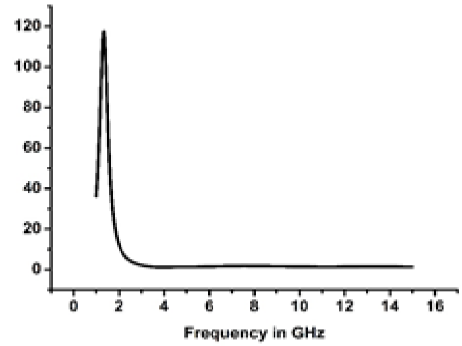

Fig3.2:Frequency VS VSWR of basic UWB antenna

III.A.ANALYSIS OF DUAL BAND NOTCHED ANTENNA

In this design dual concentric splitted rings having inner and outer radices mentioned in table 2 are placed on the patch. The position of thetwo splitted ringsare optimized to get dual band notched characteristics and the notching frequenciesare4.95-5.84GHz and other 8.00-8.55GHz .The antenna performance parameters likeReturn losses, gain, and VSWR are measured .

The variation of return loosesVs frequency fordifferent radius is shown in Fig 3.3.From the fig it was observed that the for the semicircular patch radius of 14.5mm better results are obtained.

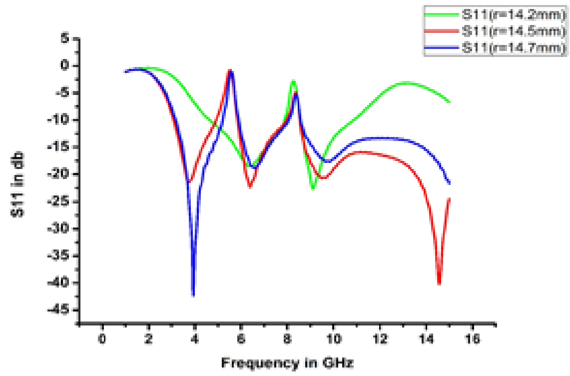

Fig 3.3 Variation of Return losses Vs Frequency

By keeping the patch radius of 14.5mm and placing the concentric rings (CC-1 and CC-2)return losses, VSWR, Gain and radiation patterns are measured and the results are shown in Figs.3.4-3.7.

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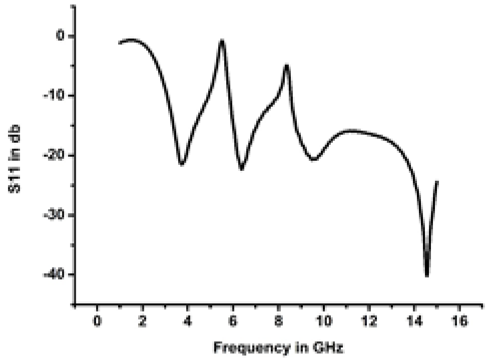


Fig3.4 Return lossVS Frequency of dual band notched antenna

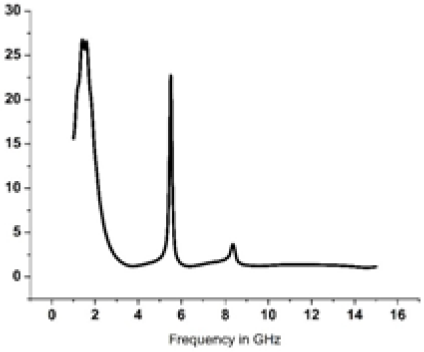


Fig 3.5: VSWR Vs Frequency of dual band notched antenna

The E plane and H plane patterns are imposedThepatterns inE plane and H plane are superimposedand is shown in Fig 3.6.In E planethe antenna shows directional characteristics andin H plane uniform radiation.

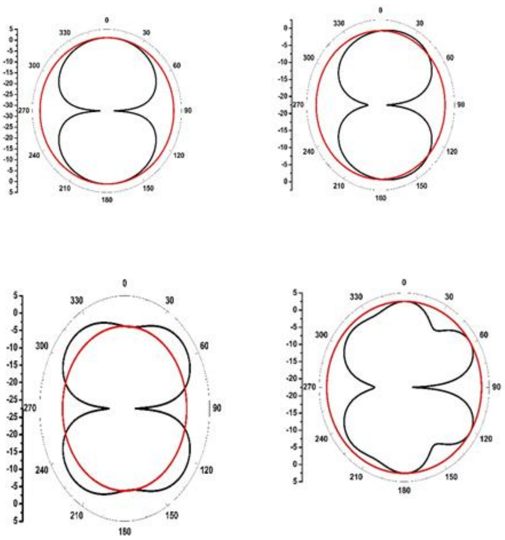
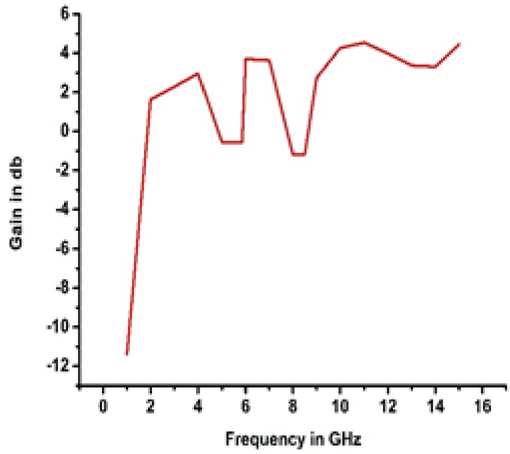


Fig 3.6.Radiation patterns.

The gain is measured at different frequencies and gain is shown in Fig 3.7



IV DISCUSSIONS

The semi circular dual band notched antenna developed by the author has provided a maximum gain of 5.3 dB in the pass band and in notch bandsthe gain values are -0.8dB and -1.2dB respectively. For the proposed antenna the values of S11 is below -10dB in pass band and at the middle of the notch bands the values of S11are -1dB and -5dB respectively. The radiation patterns are Omni directional.

V.CONCLUSIONS AND FUTURE SCOPE

A compact UWB monopole antenna operating in the frequency band of 3.1-10.6 GHz is simulated and the performance parameters are reported. The UWB antenna with double band notching characteristics is simulated and the results are also reported.

A compact UWB antenna with more notching bands can be designed using new materials.

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