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In this paper, the design of dielectric resonator antenna with elliptical patch and dual band notched characteristics for UWB applications is proposed. The size of the antenna is 40x40x1.6 mm3.The CPW ground plane of this antenna is like a half circle. The antenna consists of elliptical shape radiating patch with 50Ω transmission line. Two U- slots are inserted in the middle of the elliptical patch to achieve the dual band notched characteristics. The centre frequencies of two notched bands can be adjusted by modifying the length and width of inserted U slots. The proposed ultra-wideband (UWB) antenna is optimized to operate in the frequency range from 3 to 11 GHz for VSWR < 2.Good agreement is achieved between the simulated and measured results. These results also show good performances in terms of antenna gain and radiation patterns. With these features, this antenna is expected to be good candidate in various UWB systems.

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Abstract

In this paper, the design of dielectric resonator antenna with elliptical patch and dual band notched characteristics for UWB applications is proposed. The size of the antenna is 40x40x1.6 mm3.The CPW ground plane of this antenna is like a half circle. The antenna consists of elliptical shape radiating patch with 50Ω transmission line. Two U- slots are inserted in the middle of the elliptical patch to achieve the dual band notched characteristics. The centre frequencies of two notched bands can be adjusted by modifying the length and width of inserted U slots. The proposed ultra-wideband (UWB) antenna is optimized to operate in the frequency range from 3 to 11 GHz for VSWR < 2.Good agreement is achieved between the simulated and measured results. These results also show good performances in terms of antenna gain and radiation patterns. With these features, this antenna is expected to be good candidate in various UWB systems.

Key words: Ultra wide band, dual band notched, U shaped slots, VSWR, CPW (Coplanar waveguide)

1. **Introduction**

Ultra-wideband (UWB) communication systems attract great attention in the wireless world because of their advantages, including high speed data rate, extremely low spectral density, high precision ranging, precision, low cost, and low complexity, The Federal Communication Commission (FCC) has allowed 3.1-10.6GHz unlicensed band for UWB communication[1]. Challenges in the design of UWB antennas are the impedance matching, the compact size of the antenna, high efficiency, avoiding the interference problem, and getting constant uniform radiation pattern within operating band. The UWB system required the UWB antenna of unique features such as transmitting and receiving electromagnetic energy in shorter durations and avoiding frequency dispersive and space dispersive [2]. Several schemes have been suggested in recent years the ultra-wide band antennas. Some UWB antennas are much more complex than other existing single, dual band multiband antennas. It is a great challenge to design and fabricate dielectric resonator antennas (DRA) for UWB applications,

Dielectric resonator antennas (DRAs) were first introduced by Long et al in 1983[3].Different shapes of DRA has been designed and studied for various applications [4]. For example, stacked DRs with different materials have been studied by Shum and Luk and Kishk et.al have purposed a wideband DRA by using stacked DRs with different materials to obtain multi resonance operations. Following this other configurations of DR are also studied like tetrahedron and triangular shape DR, L shape and T shape DRs as an antenna [5]. Different feeding mechanism have been also introduced to enhance the bandwidth and for good coupling between DR and feed. Lianget.al have been used H shaped and L shaped dielectrics with inverted trapezoidal patch feed to achieve a bandwidth from 3.87 to8.17 GHz [6]. In addition, few of these designs can achieve a bandwidth range more then 3:1, which can be applied to commercial systems with ultra-wideband from 3.1 to 10.6 GHz [7].The UWB antennas presented in the literature mainly focus on the slot and monopole antennas. In this paper we propose a Hybrid DRA for UWB applications. The DRA consists of three parts: a dielectric resonator in which elliptical shape patch structure has been removed, second part is an elliptical patch and third part is CPW fed ground plane of half circle shape. In addition, despite the approval of the FCC for UWB to operate over 3.1-10.6 GHz, there are some other existing narrowband services that already occupy frequencies in the UWB band such as IEEE 802.11a in the USA(5.1-5.35 GHz.5.47-5.725 GHz)[8]. In some European and Asian countries, world portability for microwave access (WiMax) service from 3.3-3.6 GHz also operates in the UWB band. So it is necessary to notch out portions of these bands in order to avoid interference. For the above purpose, a simple CPW fed UWB DRA with dual band notch characteristic is proposed and discussed here. Two U slots structures are inserted in the middle of the radiating elliptical patch to notch out two frequency bands. The tuning of notched centre frequencies is done by changing the properties of dielectric resonator and the thickness of U slots.

2. Design of Proposed antenna

The geometry of purposed UWB antenna is shown in the figure 1. This antenna is denoted by antenna A. Two U slots structures are removed from the elliptical patch to get band notched characteristics and this antenna is denoted as an antenna B.

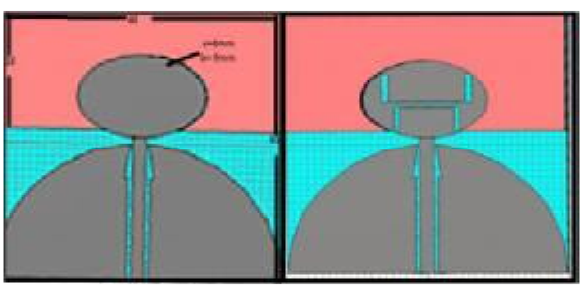


Fig:1 Antenna[A] Fig:2 Antenna[B]

The antenna B was fabricated on the FR4 substrate of dielectric constant (εr=4.4) with a thickness 1.6 mm.

From these structures we can see one elliptical patch structure is fed by a CPW transmission line which is connected with a SMA connector of 50Ω, Since CPW feeding is used to simulate the structure and cost of fabrication can be reduced due to this.

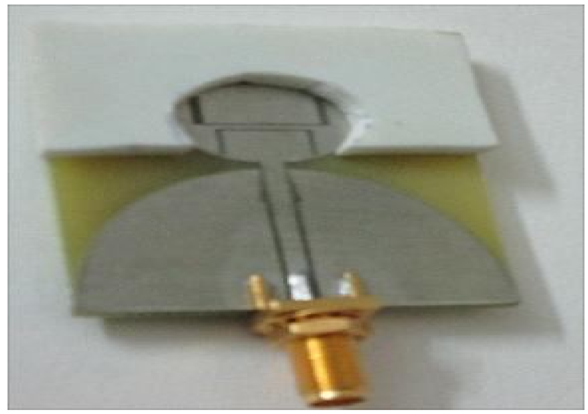
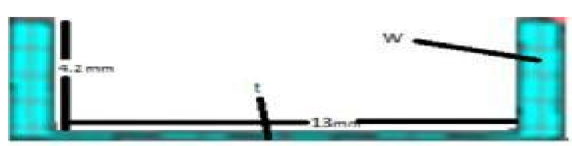


Fig:3 Fabricated Antenna B

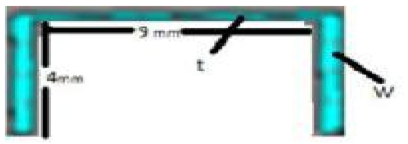
The parameter of radiating patch is a=6 mm and b=9 mm respectively. The dimension of DR is about 18X40mm2. The elliptical patch portion is removed from this DR for better impendence matching. The feed structure is cut out from the ground plane, the impendence bandwidth of the proposed antenna is broadened by cutting two extrude arcs beside the upper surface of the feed.

3. Single and dual notched UWB antenna and results

To avoid interference from IEEE 802.11a and WLAN system, a band notched function is desirable for UWB system. In order by etching two U slots in the middle of the radiating elliptical patch we can notch two frequency bands 3.3-3.6 and 5-6GHz.Since the design concept of notched function is to adjust the slot to be approximately half wavelength of the desire notched frequency.



Slot 1



Slot 2

Fig4: Slots structure

$$f_{notch} = \frac{c}{2L}\sqrt{\frac{2}{\varepsilon r1 + \varepsilon r2}} \qquad \textbf{[I]}$$

where c is the speed of light in vacuum, L is the length of slots and εr_1 and εr_2 are the relative permittivity of the substrate and dielectric resonator respectively. From eq 1 the length of slot is taken into consideration to determine to length of slot and we can adjust it according to our need for fabrication. This condition is applicable to both the U and C slots. But in the U slots the thickness of sides of U slots can also tune the centre frequency and this is to be studied in this paper. Fig 8(a, b, c, d) are showing the surface current distribution of current at four different frequencies. The surface current flows around the slot of the radiating patch. But in notched conditions at frequencies 3.3 and 5.3 GHz, the surface current in the antenna will cause destructive interference which make the antenna irresponsive in that region.

4. Results and discussion

Based on the optimal values obtained from the parametric studies, experimental prototypes for the UWB DRA were fabricated and measured. fig 4 shows the return loss of an antenna with and without DR and also with notched conditions. The optimization value of data which is used in the simulation process is analyzed before fabrication which is shown in Table 1.The VSWR measured and simulated results are also compared in the fig 5. The measurement results of VSWR were carried out with a network analyzer. The radiation patterns of measured DRA was also done in anechoic chamber. Fig 6 shows the plot of measured radiation patterns at four different frequencies. These results are approximately acceptable for UWB systems. The gain of DRA is shown in fig 7.

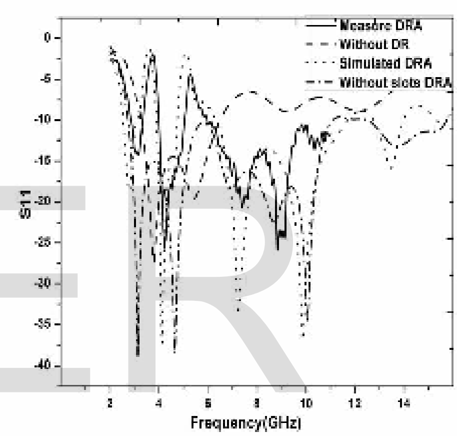


Fig: 4 Return loss Plot

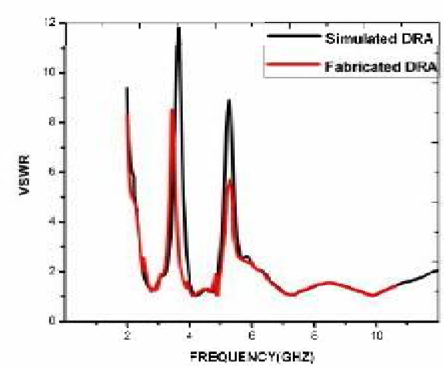


Fig: 5 VSWR plot

Parametric study of slots

SLOT1 Length(mm)	W(mm)	t(mm)	Notched Band (GHz)	SLOT 2 Length(mm)	W(mm)	t(mm)	Notched Band (GHz)
21.4	1.0	0.2	3.1-3.6	17	0.6	0.2	4.8-6
21.4	0.8	0.2	3.28-3.96	17	0.5	0.2	4.94-6.43
21.4	0.6	0.2	3.39-4.09	17	0.4	0.2	5.23-6.48
21.4	1.0	0.3	3.14-4.12	17	0.6	0.3	5.10-6.48
21.4	0.8	0.3	3.18-4.15	17	0.5	0.3	5.28-6.55
21.4	0.6	0.3	3.25-4.23	17	0.4	0.3	5.53-6.59
21.4	1.0	0.4	3.15-4.20	17	0.6	0.4	5.37-6.48
21.4	0.8	0.4	3.22-4.28	17	0.5	0.4	5.52-6.66
21.4	0.6	0.4	3.35-4.39	17	0.4	0.4	5.77-6.79

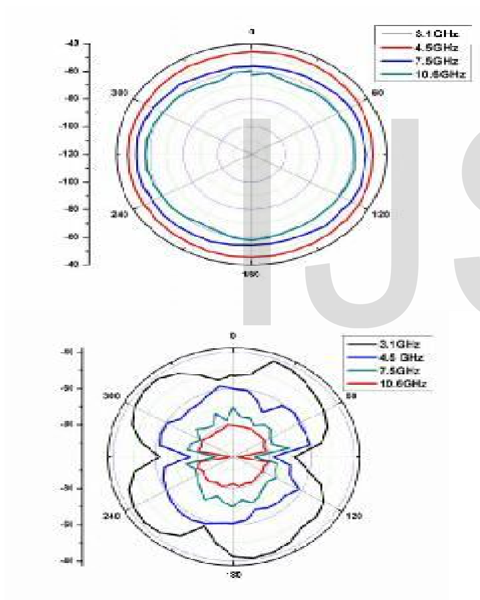


Fig: 6(a)H plane (b) E plane

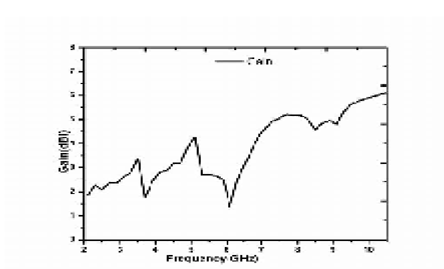
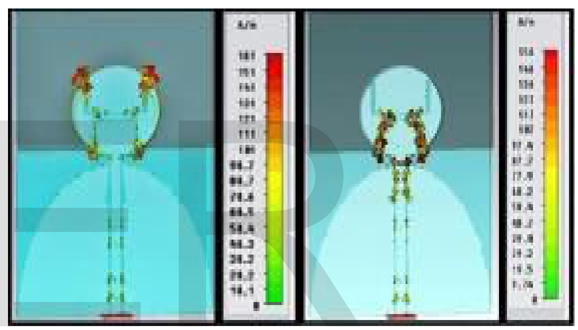
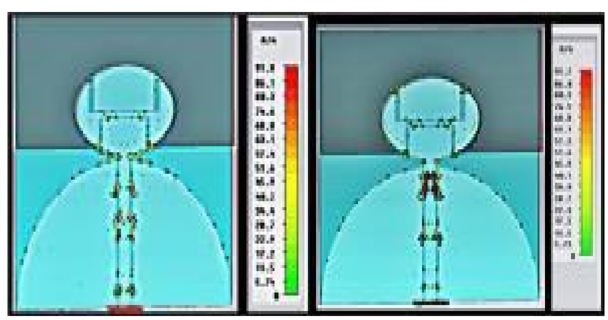


Fig: 7 Gain of Antenna



[a] [b]



[c] [d]

Fig: 8(a) 3.4 (b) 5.4(c) 7.5(d) 10.6 GHz

5. Conclusions

A compact dual band notched UWB antenna is presented and investigated. The radiation patterns in the H plane are omnidirectional over the entire ultra-wideband and the E plane of the antenna is like a dipole. The gain of antenna also shows stable with the sharp decrease characteristic in the notched frequency band. Consequently the proposed antenna is expected to be good candidate in various UWB applications.

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