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# Donut Shaped Ultra wideband Antenna for Cognitive Radio Application

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***Abstract***—In the last few decades there have been significant use of Cognitive radio and UWB technologies. These technologies are used for efficient use of Spectrum for short range wireless communications. In 2002, FCC has released a wideband of 7.5 GHz (From 3.1GHz to 10.6GHz) as unlicensed to use it . UWB antennas proves to be a suitable candidate for spectrum sensing in cognitive radio and in UWB transceiver. Since antenna dimensions are frequency dependent, designing an antenna for wideband is a tough job. This paper discusses the gradual techniques to obtain ultra wide bandwidth (2.23GHz-11.4GHz) from narrowband patch antenna. Also the various antenna parameters of proposed antenna design and its simulated results are analysed.

***Keywords-*** *Ultra wideband Antenna, Cognitive radio (CR),Patch antenna, finite ground plane, slot*

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## I. INTRODUCTION

According to the Federal Communications Commission (FCC), a cognitive radio is "a radio that can change its transmitter parameters based on interaction with the environment in which it operates." The transreceiver in Cognitive radio can detect which channels are in use and which are vacant, and accordingly use the vacant channels without affecting the occupied ones. Thus, a cognitive radio should be able to recognize spectrum availability and reconfigure itself for more efficient communications and spectrum use [1].Thus the cognitive radio must be capable of sensing the available spectrum and accordingly reconfigure itself.UWB antenna can be considered effective for spectrum sensing operation . UWB antennas must be of small size and easily integrated into RF circuits. The motivation of UWB antenna design is to design a small and simple antenna that introduces low distortions with large bandwidth.With the Brisk development of wireless communications, the requirement of compact and planar antenna is increasingly stringent. In recent years, many people are devoted to the research of planar broadband antennas for UWB applications using a wide variety of antenna configurations [2]-[6]

In this paper a simple to fabricate, donut shaped planner microstrip UWB antenna is proposed.This antenna is having acceptable return loss of -10dB and below in the frequency range from 2.2GHz to 11.GHz and also omnidirectional radiation pattern as expected.

## II. ANTENNA DESIGN

Dimensions of antenna play an important role as the frequency is dependent on the dimesions. With increase in frequency the size of the antenna reduces. Designing a narrowband antenna is an easy task as formulae for calculating the dimensions are available . However there are no such formulae for designing the ultra wideband antennas. To meet this limitatation, first a narrowband antenna is designed using the formulae .By introducing step by step techniques in the narrowband antenna ultrawideband antenna is obtained.

A rectangular narrowband patch of dimension 11.2mmx15.7mm is designed for resonant frequency of 5.8Ghz using FR4 epoxy substrate of thickness 1.6mm and permittivity of 4.4 as shown in fig 1(a). The dimension for the substrate is 20.8mmx24.8mm.The antenna patch is fed by a microstrip of 50Ω feed line of width $W_f$ = 3mm and $L_f$= 4.8 mm distance from one edge of the substrate. The width of the ground plane is Wg = 24.8 and Length $L_g$=20.8mm. From the figure we can see that the patch is resonating at 8.5Ghz,with return loss of -38.13db,bandwidth 286Mhz with gain 3.845db.

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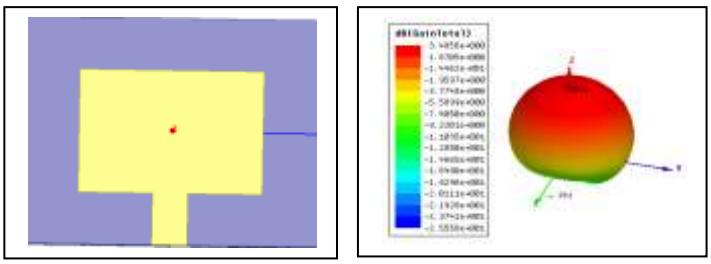
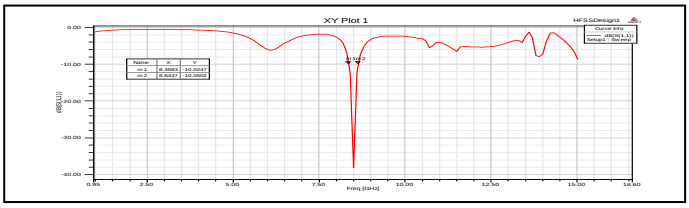


(a) (b)



(c )

**Fig -1**: (a) patch antenna design (b)gain in db (c) return loss graph

For increase in the performance parameter ie bandwidth,return loss & Gain, Circular patch is used instead of rectangular patch[7]. The circular patch with radius 7.4 mm is as shown in fig 3(a) with partial ground plane 4.65mmx24mm.The substrate dimension is 21mmx24mm.the result obtained of the above design is shown in fig 3(b) & 3(c ).

The use of partial ground plane helps in obtaining omnidirectional radiation pattern. In order to find the optimum dimension for the partial ground plane we use the optimetric parametric analysis. The results of parametric analysis is as shown in fig 2

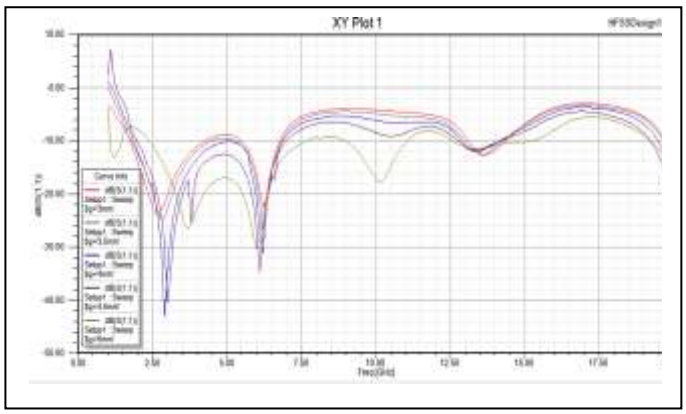
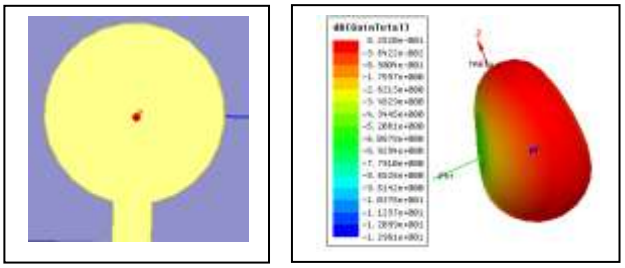


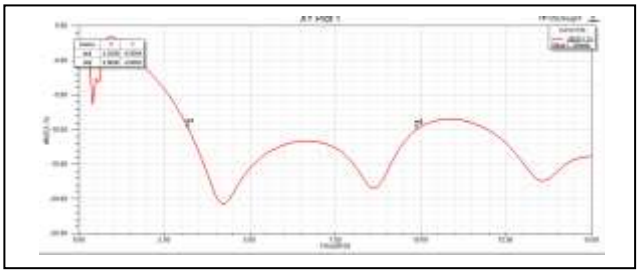

Fig 2: parametric Analysis of Ground Plane

We get optimum results when we select the ground plane dimension as 5mm*24mm.

The result obtained from fig 3 clearly shows an immense increase in the bandwidth from 286Mhz to 6.7Ghz, having a frequency range from 3.2GHz to 9.9GHz with gain 8.25db and an omnidirectional radiation pattern is obtained.



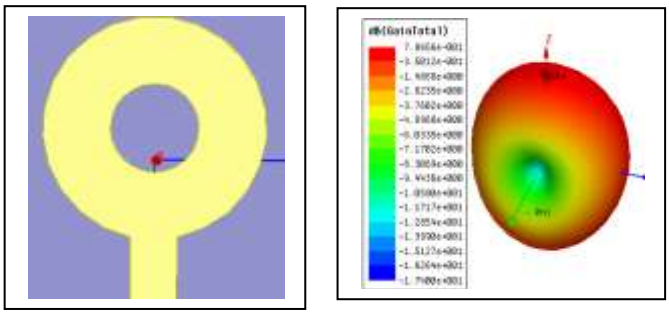
(a) (b)



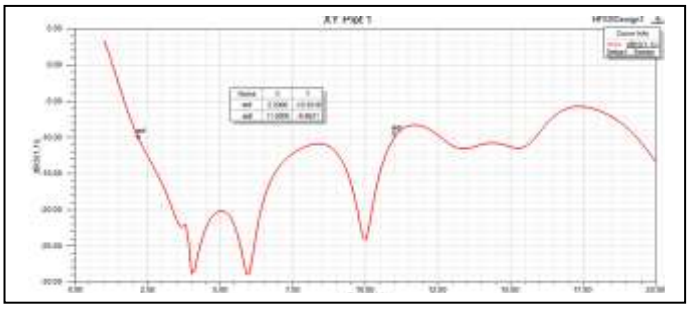
(c )

Fig3: (a)patch antenna design (b) gain in db (c) return loss graph

In order to further improve the result and obtain the UWB range a slot is added in the patch.Addition of slot results in improvement in the bandwidth.The dimension of the circular slot is obtained by parametric analysis and the optimized value is found to be 2.85mm



(a) (b)



(c )

Fig 4:patch with slot (b) gain in db (c ) return loss graph

With this the final design of proposed antenna and its simulated return loss is shown in the fig. 4(a) and fig.4(b).

As seen from Fig. 4 (c) the curve starts from frequency 2.2 GHz and continues till 11.GHz which includes 5.8GHz ISM band as well as 3.1GHz-10.6GHz FCC band.

Below table provides dimension of the whole geometry

| Objects in Antenna | Dimensions (mm) |
|---|---|
| Substrate | 22*24 |
| Patch | 7.4 |
| Microstrip line | 5.8*3 |
| Ground | 5.1*24 |
| Slot in Patch | 2.85 |

**Table 1:** Antenna Dimension

## III. RESULTS & ANALYSIS

All the designs and simulations are performed using Ansoft HFSS software.

The results obtained from the three antenna designs are tabulated below:

| Parameter | Rectangular Patch | Circular Patch | Circular Patch With Slot |
|---|---|---|---|
| Patch Dimension(mm) | 11.2x15.7 | 7.4 | 7.2 |
| Return loss | -38.13db | -21 | -29 |
| Peak gain(db) | 3.84 | 8.25 | 7.85 |
| Bandwidth(GHz) | 286Mhz | 6.7 | 8.8 |

**Table -2:** Comparison of three Antenna Designs

From the table 2 it is evident that by insertion of a slot in the patch ,there is an improvement in the characteristics such as bandwidth,gain and return loss

## IV. CONCLUSIONS

This paper has proposed a simple design of patch antenna having a UWB range for communication as well as spectrum sensing purpose in cognitive radio. Dimensions of antenna are obtained by doing rigorous simulations; also various techniques are employed to achieve wideband. The antenna return loss for each technique has investigated individually. Dimensions of ground plane width, and slot on radiating patch are found using parametric analysis. The antenna shows a maximum power gain of 7.85dB and has acceptable return loss for 2.2GHz to 11GHz. The antenna is having omnidirectional radiation pattern as required in sensing antenna.

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