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UWB Antenna Design with Required Band Suppression Characteristics For Cognitive Radio Applications

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Abstract:
This paper presents the design of ultra wideband monopole antenna that can resonate over a range of frequencies from 2GHz to 10GHz which is appropriate for cognitive radio applications. The antenna is equipped with Split Ring Resonators which can notch two narrow band frequencies 4.47GHz to 4.82GHz, 6.94GHz to 7.77GHz and wide band greater than 8.41GHz. The design is simulated and the results are obtained using HFSS electromagnetic simulation software.

Keywords: *wideband monopole, split ring resonator, wideband, cognitive radio.*

1. Introduction

Cognitive radio is an emerging field which addresses the problem of shortage of available spectrum through dynamic spectrum allocation. In the cognitive radio environment, a group of secondary users coexist along with licensed primary users. The unlicensed users (SUs) can access the spectrum allocated to licensed users (PUs) when the licensed users are not accessing the spectrum. The licensed spectrum which is not being accessed by the primary users is called a spectral hole. These vacant spaces need to be identified to allocate them to the secondary users. This task requires the wideband antenna to continuously scan the spectrum over frequency band to detect the presence of a primary user. To access the spectral holes dynamically, narrow band antennas may be used. The microstrip antenna design for narrow band cognitive radio applications was presented in [1]. In the presence of a licensed primary user, the spectrum cannot be allocated to a secondary user. Hence the narrow band frequencies where the licensed primary user is identified need to be notched to prevent the allocation to the secondary users.

In addressing the above two issues, ultra wideband antennas with frequency notching characteristic play a prominent role. This was clearly demonstrated in the research work contributed by Jawad Y. Siddiqui et al [2]. Notching of dual frequency bands and wide band was demonstrated using a circular monopole antenna equipped with two pairs of split ring resonators. Antenna response in three different configurations using SRRs, CRRs and parallel strips for obtaining notched, narrowband and UWB responses was also demonstrated in [3]. Different approaches for notching triple bands using an UWB antenna were presented in [4-5]. Several designs of

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the extensively used monopole planar antenna are covered in [6-10]. The use of electromagnetic band gap structure for notching two frequency bands using an UWB was presented in [11]. The microstrip antenna design calculations for circular shaped radiating are covered in [12]. The paper is organized into two sections. The first section presents UWB antenna design which can resonate over 2GHz to 10GHz with out incorporating split ring resonators. The second one presents UWB antenna design with the incorporation of split ring resonators to notch the frequency bands.

2. a)The Proposed Antenna Design and Geometry without Split Ring Resonators

The ultra-wideband monopole antenna is designed for the frequencies 1GHz to 10GHz. The proposed consists of a circular patch in the top layer of radius 11.7 mm with feed line of width of 5 mm and length 22.7 mm. The space between the ground plane and the feed line is chosen as 0.5mm. The height of the circular radiating area above the ground plane is 1.58 mm. The ground plane's length and width to the right and left of feed line are 22 mm and 22.7 mm respectively. FR4 substrate of 1.575mm thick, ϵ_r=4.4 and tan δ=002 is used. The structural specifications and the proposed design parameters are shown in the Fig.1 & Table.1 respectively.

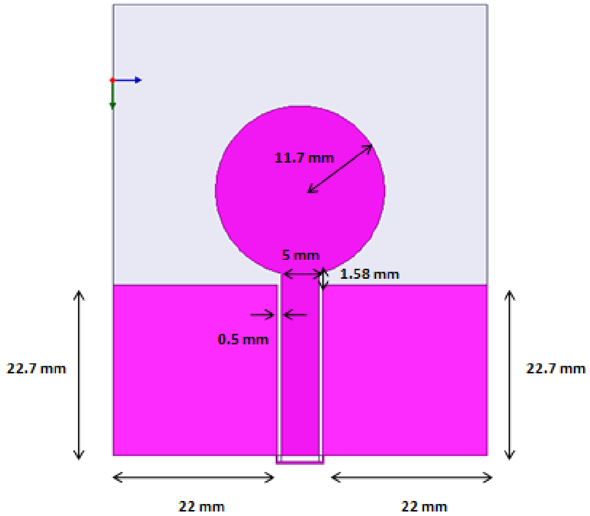

Fig.1 Structural and Design Specifications for the antenna proposed

Table 1. Design Specifications

Dimension	Size (mm)
Radius of the circular patch	11.3
Length of the transmission Line	22.7
Width of the Transmission Line	5
Thickness of the micro-strip substrate	1.575
Gap between feed line and ground plane on either side	0.5

2. b) The Proposed Antenna Design and Geometry with Split Ring Resonators

The wideband monopole antenna proposed is equipped with two single split ring resonators of rectangular shape and two square shape split ring resonators with concentric rings in the bottom layer on an FR4 substrate of thickness 1.575mm. The proposed antenna when equipped with Split Ring Resonators is presented below Fig.2.

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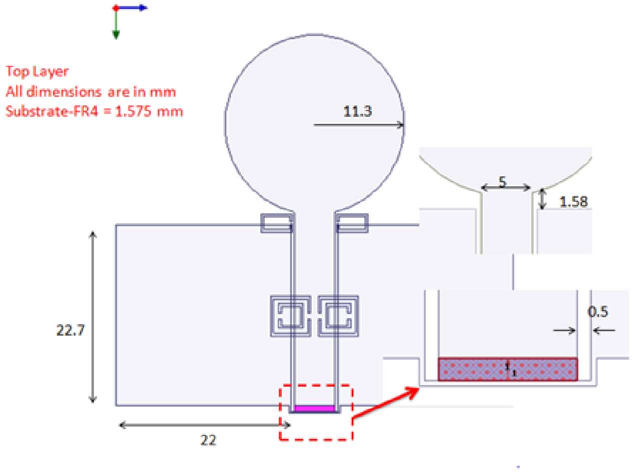

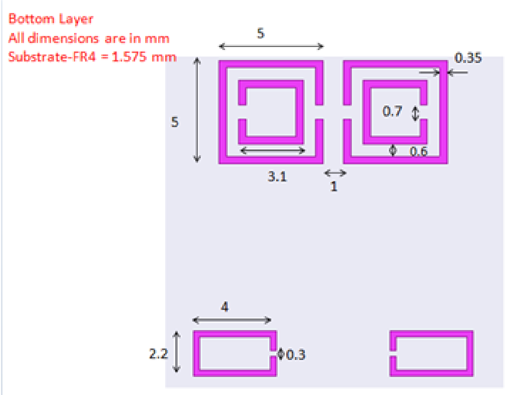

Fig.2a Proposed Antenna Design with SRRs   Fig.2b SRR Specifications

Fig.2 Structural and Design Specifications for the antenna proposed with SRRs

3. Results and Interpretation:-

Simulation results for the proposed design with out SRRs are presented in the figures 3a through 3d.

The S_{11} parameter characteristics is obtained for the ultra wide band. The resonant bands are achieved for less than -10dB for the frequencies between 2GHz to 10GHz as shown in Fig.3a. The maximum and minimum resonant frequencies are obtained at 2.3GHz and 9.3GHz respectively.

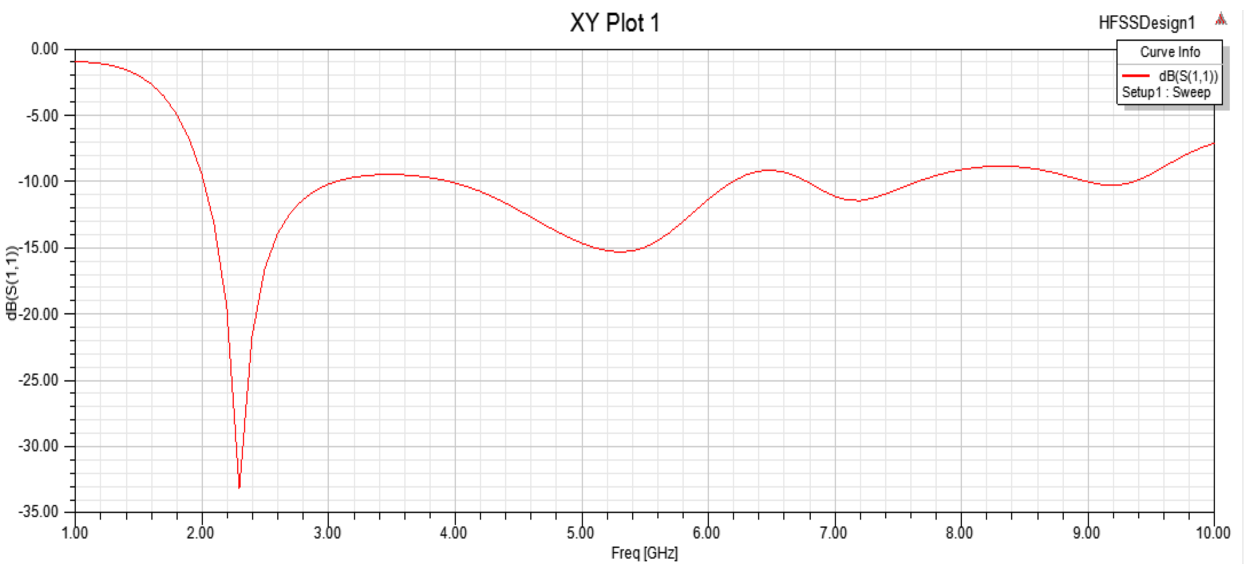

Fig.3a: Frequency v/s S_{11} parameter of the proposed design

Simulation results for Frequency v/s VSWR are satisfactory with the value of VSWR <2 for the frequencies between 2GHz to 10GHz as shown in Fig3b.

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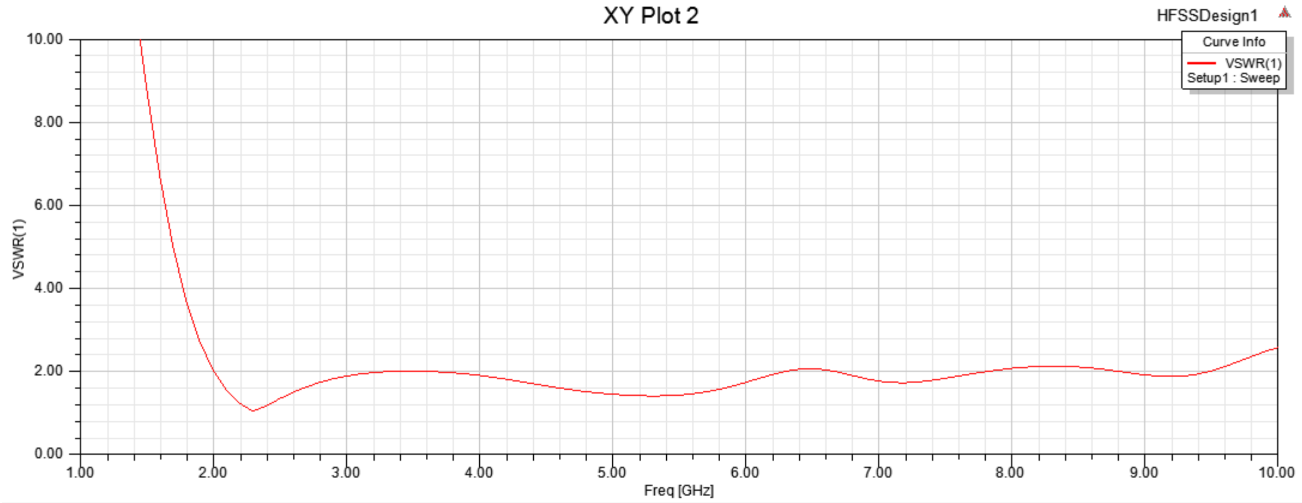

Fig.3b: Frequency v/s VSWR of the proposed design

The obtained results for impedance are satisfactory over the range from 2GHz to 10GHz as shown in the figure 3c.

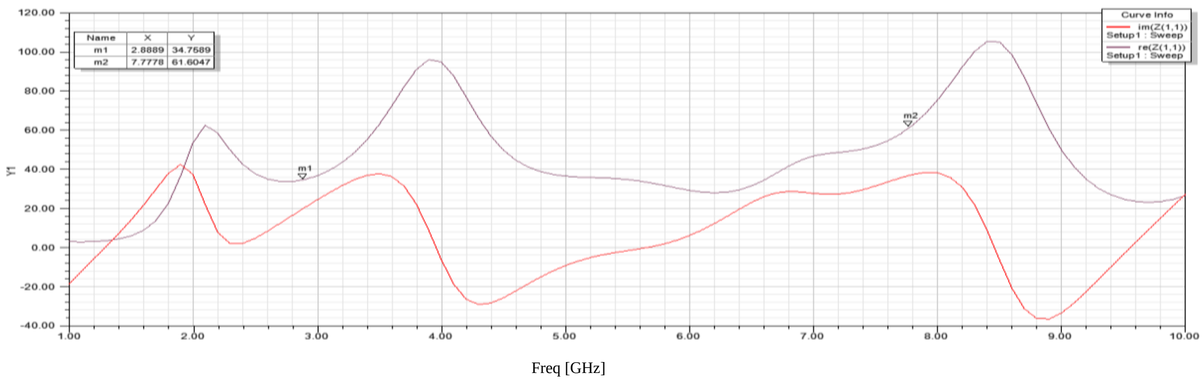

Fig.3c: Frequency v/s Impedance curve of the proposed design

Results show that Gain values of the proposed design are satisfactory with the maximum gain of 4.9dB over the frequency range of 2GHz to 10GHz as shown in Fig.3d.

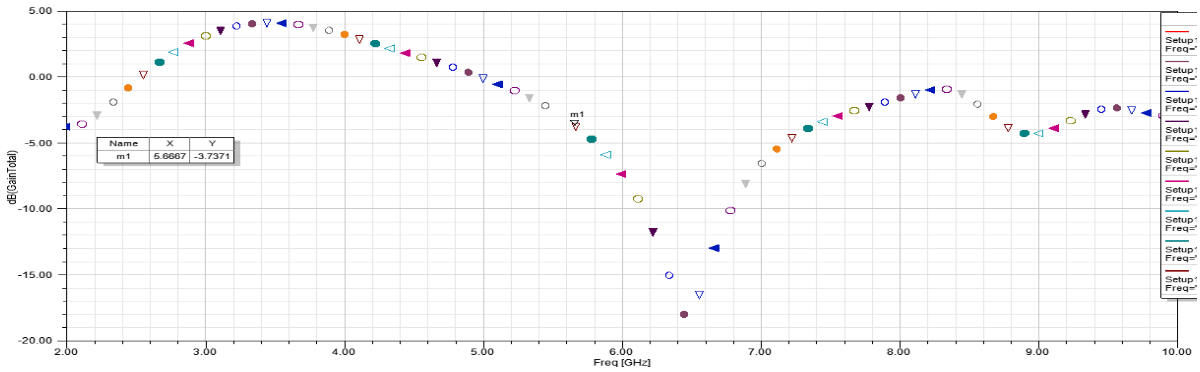

Fig.3d: Frequency v/s Gain curve of the proposed design

Simulation results for the same design when equipped with SRRs to notch particular frequency

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bands is shown in Figs 3e through 3i.

The notching of narrow band frequencies viz. 4.47GHz to 4.82GHz, 6.94GHz to 7.77GHz and wide band greater than 8.41GHz is achieved as shown in the VSWR characteristics curve in Fig.3e.

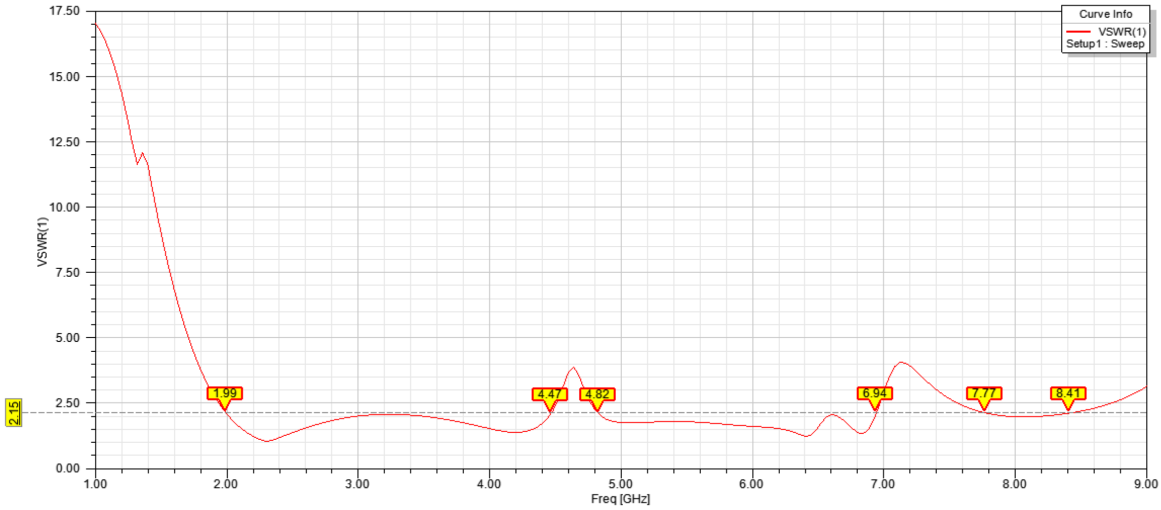

Fig.3e: Frequency v/s VSWR of proposed design with SRR

Results in Fig.3f show that except for the notch band frequencies shown in the Fig.3e, the value of S_{11} is less than -10dB.

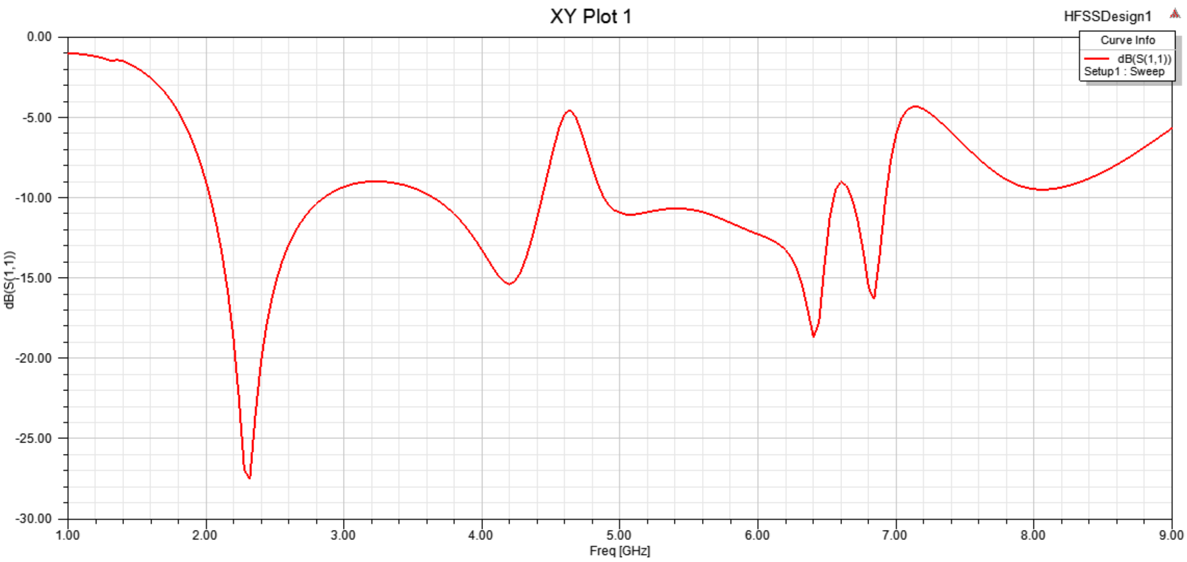

Fig.3f: Frequency v/s S_{11} of proposed design with SRR

Results of impedance for proposed UWB design resonating between 2GHz to 10GHz are close to 50Ω except for the notch band frequencies mentioned above as shown in the Fig.3g.

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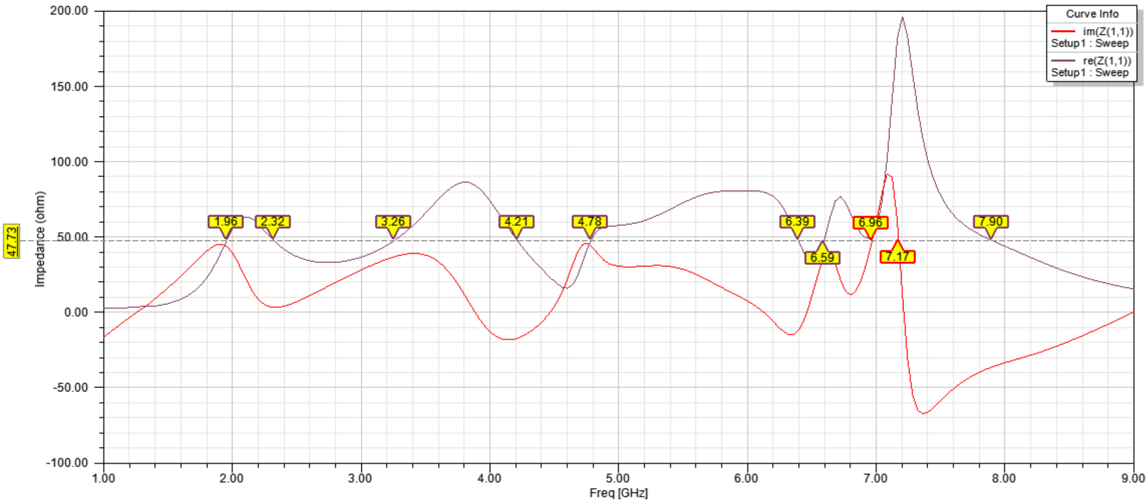

Fig.3g: Frequency v/s impedance of proposed design with SRR

The simulations of radiation patterns obtained for xy plane and yz plane shown in Figs. 3h and 3i are satisfactory.

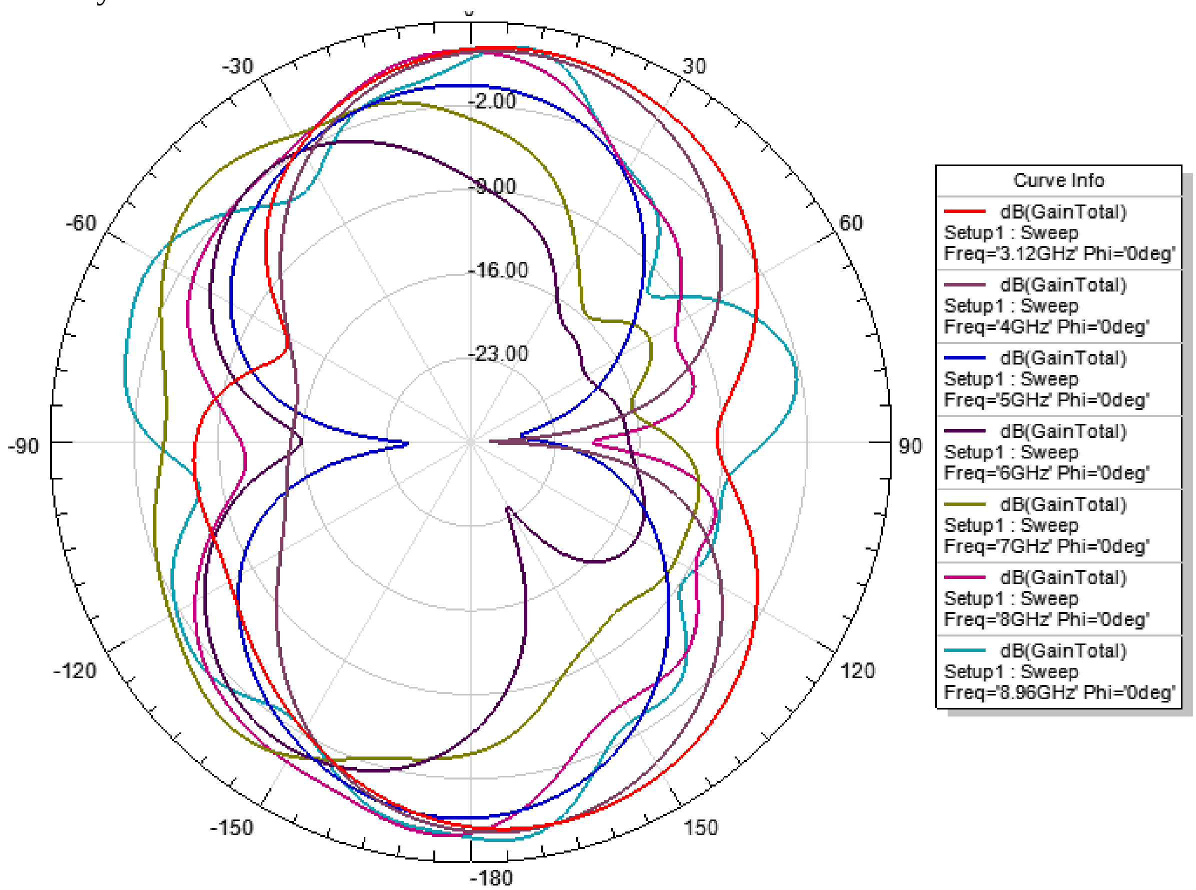

Fig.3h: Radiation Pattern for xy plane

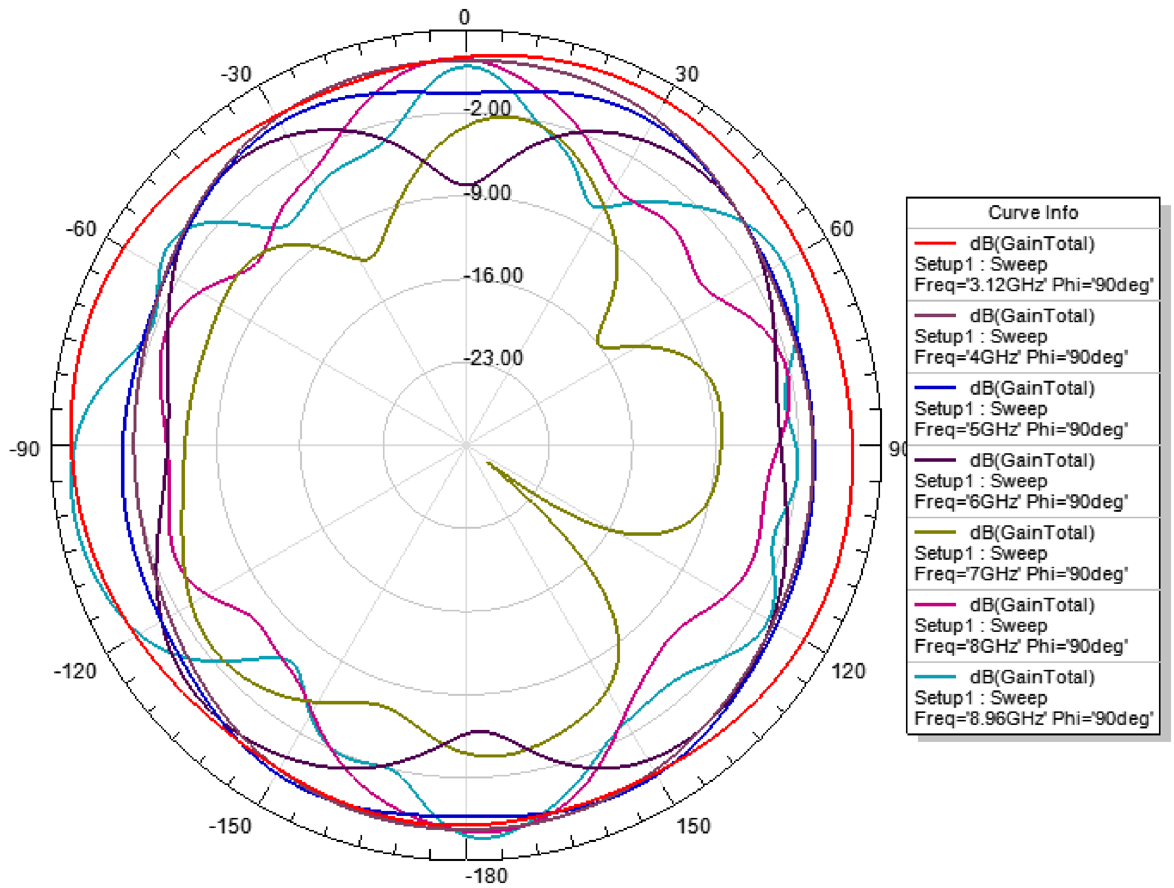

Fig.3i: Radiation Pattern for yz plane

Conclusion:-

The UWB antenna design with a circular patch which can resonate over 2GHz to 10GHz for cognitive radio applications was obtained. The notching of narrow frequency bands between 4.47GHz to 4.82GHz, 6.94GHz to 7.77GHz and wide band greater than 8.41GHz was achieved by equipping the proposed design with two rectangular shaped single split ring resonators and two square shape split ring resonators with concentric rings in the bottom layer. Simulation results of the proposed antenna before and after insertion of SRRs are with in the acceptable limits for ensuring reasonably better performance of the proposed antenna design.

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