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Design of integrated ultra wide band and narrow band antennas for future wireless applications

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Abstract : *Antenna is the exploring origin of wireless communication for the efficient utilization of bandwidth to make future wireless applications through an integrated antenna. In this work, The design and analyze two antennas are proposed. One is for spectrum sensing and another for communication. Cylindrical Dielectric Resonator antenna (CDRA) is used for communication at multiple narrow band and rectangular micro strip patch antenna for spectrum sensing in the range of Ultra Wide Band to meet communication applications. These two antennas are integrated using Electro Magnetic 3D solver software, High Frequency structural simulator (HFSS). To provide isolation between the two antennas we use switching network to set a change over form spectral sensing to communication and vice versa. In proposed Antenna, Micro Strip Patch Antenna covers Ultra Wide Band Characteristics form 2.707 to 11.07 GHz and gain 6.14dB and CDRA ha Multiple Narrow Band Characteristic of range 7.33 to 8.4 GHz and 9.8 to 10.26 GHz with Centre Frequency 8.33Ghz and 10.26 GHz and 5.334 dB used for satellite, Radar and Medical imaging Systems. Analysis and design are verified by using Radiation pattern, Gain, Return Loss and Voltage Standing wave Ratio (VSWR).*

Keywords – *High Frequency Structural Simulator (HFSS), Gain, Voltage standing Wave Ratio,(VSWR).*

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I. Introduction

Wireless Communication are becoming as a part of day-to-day life of human beings. So, to achieve efficient and affordable wireless communications, compact and efficient radiators required. UWB is defined by the federal communication committee (FCC) to have a range from 3.1 to 10.6 GHz bandwidth commercial uses[1]. The UWB technology has attracted for short-range-cum high data rate communication by using a large portion of the radio spectrum. Several techniques are proposed to broaden the bandwidth of small micro strip antennas and there are several approaches like coplanar wave guide(CPW) fed slot [2], antennas using tuning stubs with rectangular [3], circular, forklike shapes. The challenge is to integrate two antennas in a limited space and provide good isolation between the two antenna ports. In cognitive radio system, two types of antennas are required one antenna is used for sensing the spectrum and a narrow-band antenna for the communication operation in the suitable band. Micro strip patch antennas are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. The dielectric loading of a micro strip antenna affects both its radiation pattern and impedance bandwidth.

The dielectric resonator (DR) has primarily been used in microwave circuits, such as oscillators and filters [4]. Analysis of their resonant modes, radiation patterns, and method of excitation made it clear that these dielectric resonators could be used as antennas and offered a new and attractive alternative to traditional low gain radiators and suitable for wireless applications [5]. A rectangular DRA is proposed based on strip feeding to improve the matching bandwidth [6-7]. To enhance the radiation and bandwidth a modified rectangular DRA is proposed[8]. An integrated wideband and narrow band antenna with low mutual coupling for cognitive radio applications[9].

II. Design of Ultra wideband and narrow band antennas

The performance of dielectric resonator antenna depends on its resonant frequency, dimensions.
Depending on the dimension, the operating frequency, radiation efficiency, directivity, return loss are influenced. For an efficient radiation, the practical radius (a), height (h) of the CDRA can be calculated by using the equations 1 & 2.

$$\frac{h}{a} = \frac{E_s}{\varepsilon_r} + \sum_{i=1}^{4} \frac{1}{\varepsilon_r^{4-i}} \left(\frac{A_i}{e^{\frac{B_i f_2}{f_1} + C_i}} \right) + D_i \quad (1)$$

$$a = \frac{c}{2\pi\sqrt{\varepsilon_r^{4-i}}} \left(\frac{A_i}{e^{\frac{B_i f_2}{f_1} + C_i}} \right) + D_i \quad (2)$$

II.I Cylindrical DRA Geometry

The slot length L_s is chosen to achieve strong coupling between DRA and the feed line and is given eq.3

$$L_s = \frac{0.4\lambda_0}{\sqrt{\frac{\varepsilon_r + \varepsilon_s}{2}}} \quad (3)$$

Where λ_0 is free space wavelength

The slot width W_s is $w_s = 0.2 l_s$

The stub extension s is

$$S = \frac{\lambda_0}{4} \quad (4)$$

The dimensions of the proposed antenna is shown in Table 1.

Table 1. Design dimensions of Proposed Antenna

Dimensions(mm) (f_0 = 6.5GHz, ε_r = 9.4, loss tangent = 0.0025)		CDRA Dimensions(mm)
CDRA	Radius(a)	6
	Height(h)	11.5
Ground Plane	Length	38
	Width	39
Substrate (Rogers NMM10i) ε_s = 10	Length	38
	Width	39
	thickness	1.6
Slot	Length	6
	Width	1
Micro strip line	Length	14
	Width	1

Fig.1 shows the integrated antenna designed based on specifications given in Table.1 .

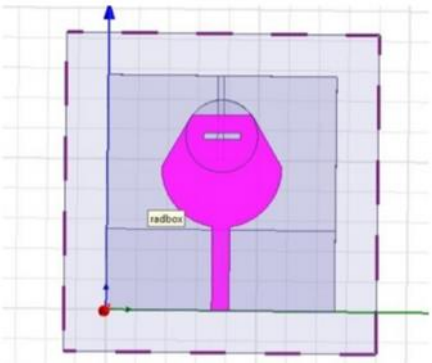


Fig.1 .2D model of the integrated antenna with cylindrical DRA

III. Results And Discussion

The Antenna design and analysis was carried out using commercially available EM simulator. The analysis of the antenna is carried out using the Return loss, Voltage Standing Wave Ratio (VSWR), Radiation parameters and Gain. Fig 2. shows the simulation Return Loss (S parameter) for Integrated Micro strip Patch Antenna and CDRA. The desired frequency is in the range of 2.707 to 11.07GHz for ultra wide band and at 8.33GHz and 10.26GHz for Multiple Narrow band is achieved.

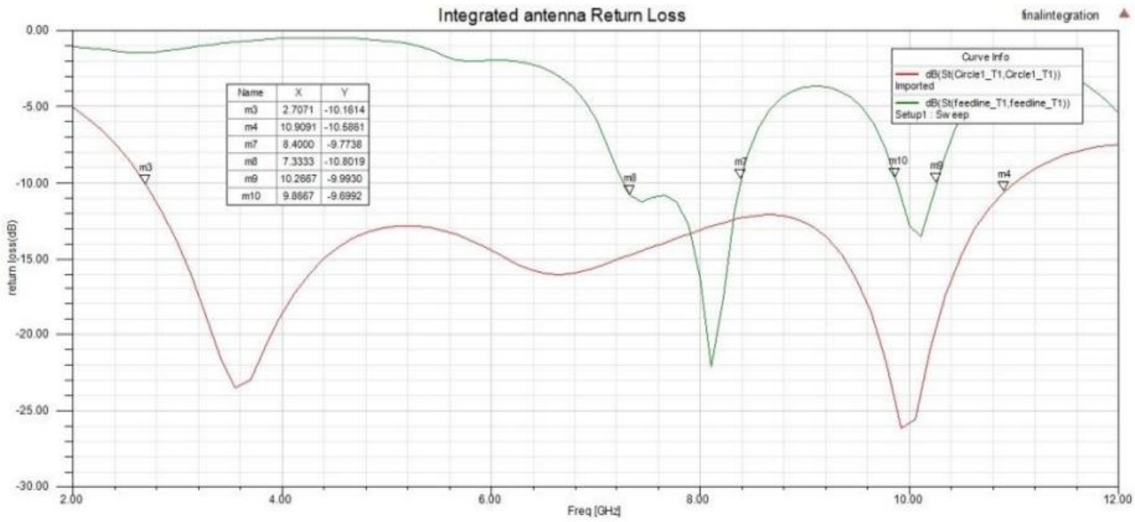


Fig.2 Return Loss Vs Frequency Plot for Integrated Antenna

Fig 3. shows the simulation VSWR for Integrated antenna. The value of VSWR for Integrated Antenna is approximately to 1 at resonant frequency.

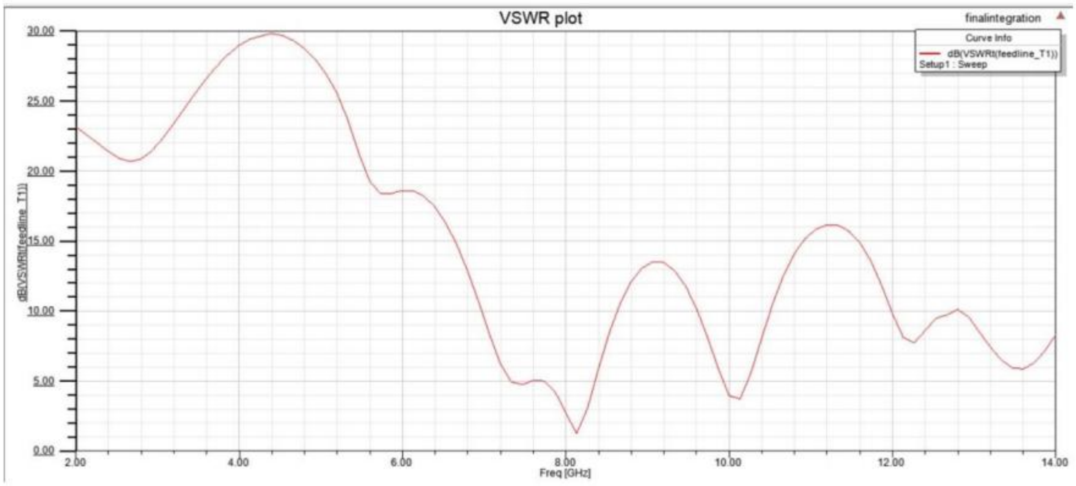


Fig3.VSWR Vs Frequency Plot for Integrated Antenna

Both the 2D polar plots and 3D patterns are generated and presented as shown in Fig 4 to through Fig 5.

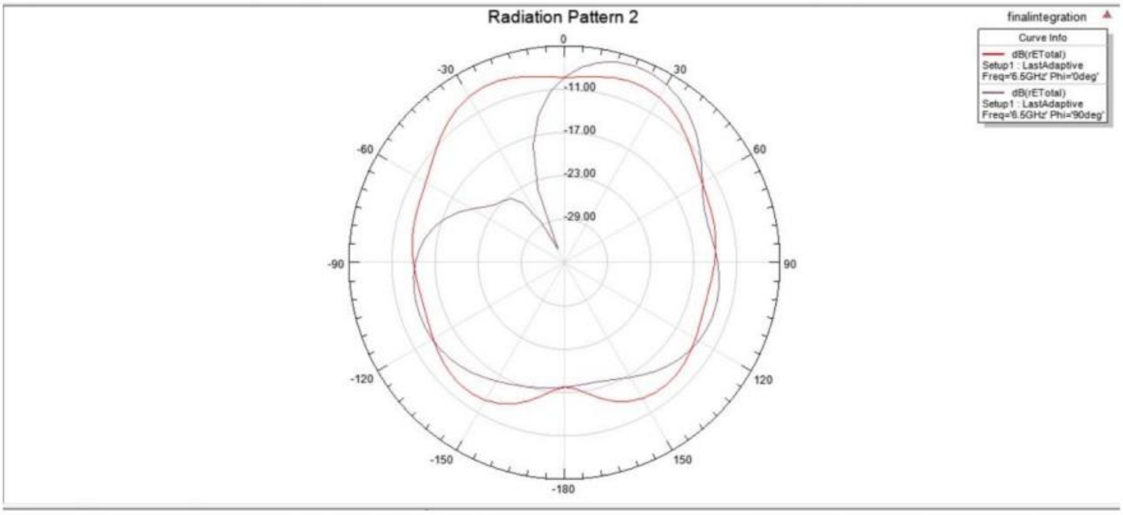
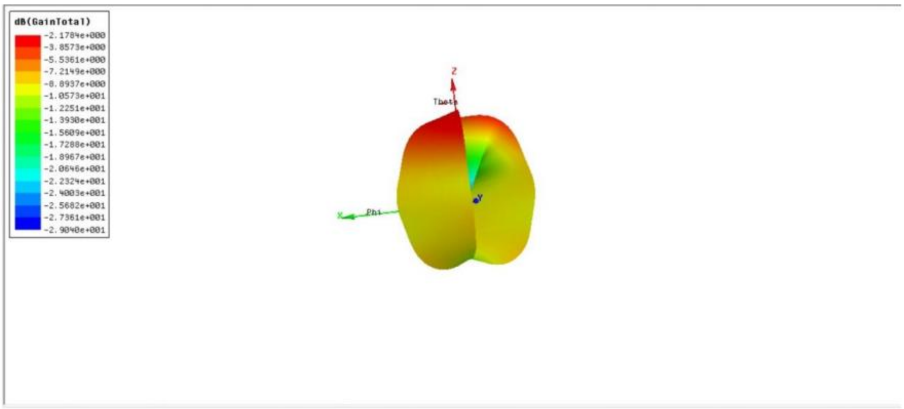


Fig.4.2D Radiation Pattern for Integrated Antenna



3D Far Field Radiaiton Pattern for Integrated Antenna

IV. Conclusion

In modern wireless communication system and increasing other wireless applications, wider bandwidth is required. Traditionally each antenna operates at a single frequency band where a different antenna is needed for each aplliction. Therefore, large space is required for different antennas. As frequency increases, the metallic loss increases which results inefficient antenna. The bandwidth under usage has many white spaces that makes wastage of bandwidth. Inorder to overcome this problems, the /DRA is designed to reduce the metallic losses and also can operate in dual frequency bands. The Microstrip patch antenna is designed for spectrum sensing to identify the white spaces. Futhermore, to reduce the space we integrate both antennas on the same plane. The simulated results show the designed antenna has the Ultra Wide Band of range from 2,707 to 11.07GHz and Multiple Narrow band at frequencies 8.33GHz and 10.26GHz. This frequency range has radar and satellite applications.

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