Semi Circular -Semi Hexagon Microstrip Antenna Integrated With DRA for Cognitive Radio applications

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Abstract— **An ultra-wideband (UWB) planar microstrip antenna integrated with a narrow–band cylindrical dielectric resonator antenna (DRA) is presented for cognitive radio applications. The proposed antenna is a combination of semicircular-semi hexagon shape microstrip patch, which is fed by coplanar waveguide (CPW). The dielectric resonator antenna (DRA) is cylindrical in shape excited by a microstrip slot fed on the rear side which shows a narrow band (NB) characteristics. The microstrip antenna provides a wide bandwidth operates from 2.58 GHz to 14 GHz. The DRA provides a narrow bandwidth operates from 10.07 GHz to 11.38 GHz. The UWB antenna is used for sensing the spectrum and the narrow-band DRA used for communication operation. A very good isolation between the two antenna ports (S_{21} less than -15 dB) are also achieved. Compared to the existing designs the peak gain of the antenna is highly increased around 6.15 dB.**

Index Terms— Cognitive radio, coplanar waveguide, dielectric resonator antenna (DRA), ultra-wideband.

I. INTRODUCTION

UWB is defined by the federal communication committee (FCC) to have a range from 3.1 to 10.6 GHz bandwidth commercial uses. The UWB technology has attracted for short-range-cum high data rate communication by using a large portion of the radio spectrum [1] [2]. Several techniques are proposed to broaden the bandwidth of small microstrip antennas and there are several approaches like coplanar waveguide (CPW) fed slot [3], antennas using tuning stubs with rectangular, circular, forklike shapes [4] [5]. In recent years, some investigations for integrating both UWB and narrow-band antennas [6] have been reported for cognitive radio (CR) and medical imaging systems [7]. The challenge is

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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 [8]. Recently a combination of a planar antenna and a rectangular DRA have been studied, which operates from 3.06 GHz to 10.6 GHz [9].

In this paper a new integrated UWB and narrow band antenna are designed. The proposed design consists of two antennas: a semicircular-semi hexagon shape microstrip antenna. It is fed by coplanar waveguide (CPW) line for sensing the spectrum from 2.58 GHz to 14GHz. The cylindrical DRA antenna fed by the microstrip slot on the radiating patch which operates around 10.07 GHz to 11.38 GHz. The slot present on the micro patch excites HEM (hybrid electromagnetic mode) which exhibit narrow band characteristics. The designed configuration provides very good isolation between the two antenna ports, with transmission coefficient less than -15dB. The return loss curve shows that the microstrip antenna achieves high impedance bandwidth around 151.83%. DRA achieves impedance bandwidth around 12.30%, which makes it for narrow band applications. The radiation pattern of the proposed antenna is presented in two planes (E and H-planes).

II. ANTENNA GEOMETRY

Fig.1 shows the dimensional design parameters of the proposed (a) microstrip antenna with DRA (b) microstrip antenna without DRA (c) rear view of integrated antenna. The microstrip antenna is a combination semicircular-semi hexagon shape designed on a standard FR-4 substrate with dielectric constant $\varepsilon_r = 4.4$, loss tangent tan δ = 0.025 and thickness of 1.6 mm and area of 38 mm×39 mm. The microstrip patch antenna is excited by port 1 with CPW fed line having width W_f shown in the fig.1. The narrow band antenna contains cylindrical resonator antenna with radius 6 mm and height of 5 mm made up of RT-6002 with a relative permittivity of 2.94, loss tangent tan δ = 0.012. It is excited by port 2 with a slot of dimensions 6mm×1mm. The resonator mode of the DRA antenna is calculated by using the formula below [10].

$$f_{o(HEM_{11\delta})} = \frac{c(6.234)}{2\pi R_2 \sqrt{\varepsilon_{r1} + 2}} \left[0.27 + 0.36 \left(\frac{R_2}{2H_d} \right) + 0.02 \left(\frac{R_2}{2H_d} \right)^2 \right]$$
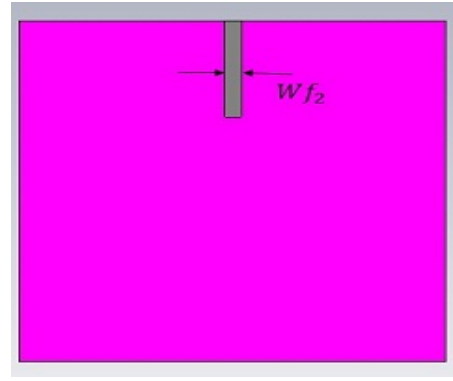
Where R_2 is the radius of the DRA and H_d is the height of the DRA. The operating frequency of the $HEM_{11\delta}$ mode is 10.6 GHz. The length of the slot calculated using the formula below [10].

$$f_{o(HEM_{11\delta})} = \frac{c\sqrt{2/(\varepsilon_r + \varepsilon_{r1})}}{2L_s}$$

where L_s is the length of the slot, c is the velocity of light in free space and $\varepsilon_r, \varepsilon_{r1}$ are the permittivity of substrate and DRA respectively.

(a)
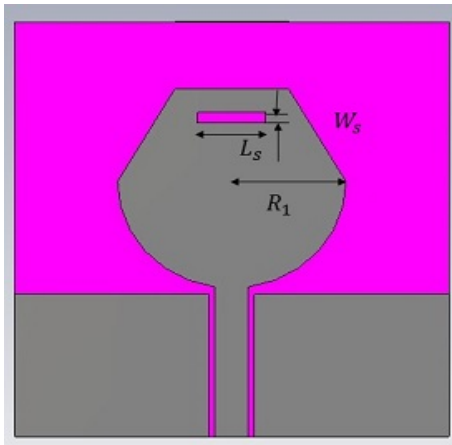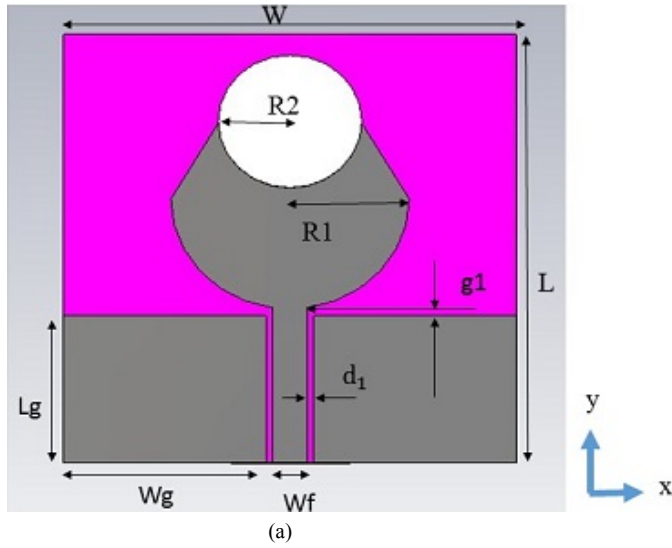
(b)

(c)

Fig.1 Geometry of proposed antenna (a) with DRA

(b) Without DRA (c) Rear view.

The dimensions of the proposed antenna are $W = 38$mm, $L = 39$mm, $R_1 = 10$mm, $R_2 = 6$mm, $H_d = 5$mm, $W_g = 17$mm, $L_g = 13.4$mm, $W_f = 2.9$mm, $g_1 = 0.4$mm, $d_1 = 0.55$mm, $L_s = 6$ mm, $W_s = 1$mm, Hs=1.6mm, $W_{f2} = 1.5$mm, $L_f = 14$mm.

III. SIMULATION RESULTS AND DISCUSSIONS

The simulation was carried out using CST Microwave Studio. The simulated reflection coefficient of the proposed antenna is plotted versus frequency in Fig.2. Fig.2 (a) shows that the microstrip patch antenna covers from ($S_{11} < -10$ dB) 2.58 GHz to 14 GHz and having an impedance bandwidth of 151.83%. The DRA antenna operates at 10.6 GHz it covers from ($S_{22} < -10$ dB) 10.07 GHz to 11.38 GHz and having an impedance bandwidth of 12.30%. The narrow band antenna is suitable for C – band applications. The integrated antenna can be used in cognitive radio (CR). Fig.2 (b) shows that the transmission coefficients ($S_{21} < -10$ dB) in the operational band from 10.07 GHz to 11.38 GHz. Hence that a good isolation exists between the antenna ports. Fig.3 shows that the simulated S_{11} parameters vs. frequency by varying the length of ground values (L_g) when the other parameters are fixed the length value affects the resonant frequency of the antenna.
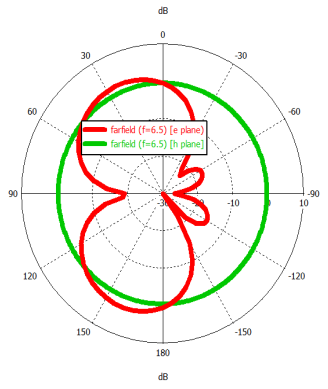
The radiation patterns of the integrated antenna are shown in the Fig.4. The E-plane and H-planes radiation pattern of microstrip antenna are shown at the resonant frequencies (a) 3.55 GHz (b) 6.5 GHz (c) 13.3 GHz when the port 2 is short with its characteristic impedance. The radiation pattern of the DRA antenna at (d) 10.6 GHz when the port 1 is short with 50 Ω line. E-plane shows the broadside radiation pattern and H-plane shows omnidirectional radiation pattern in the azimuthal plane. The simulated gain of wideband and narrow band antennas are shown in the Figs. 5 (a) and (b). The figures show that the gain of broadband antenna varying from 2.5 dB to 6.15 dB and the narrow band antenna reaching 5 dB at the operating frequency 10.6 GHz.
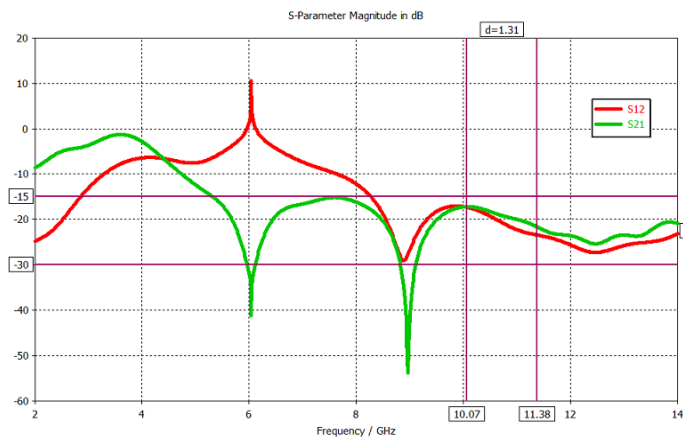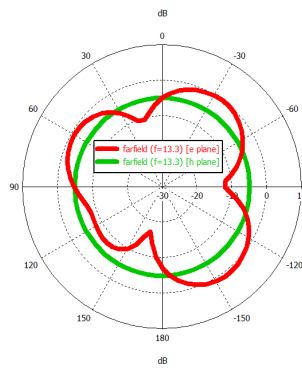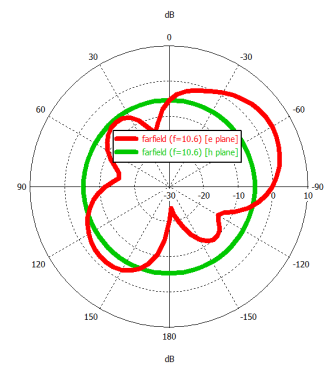
(a)

(b)
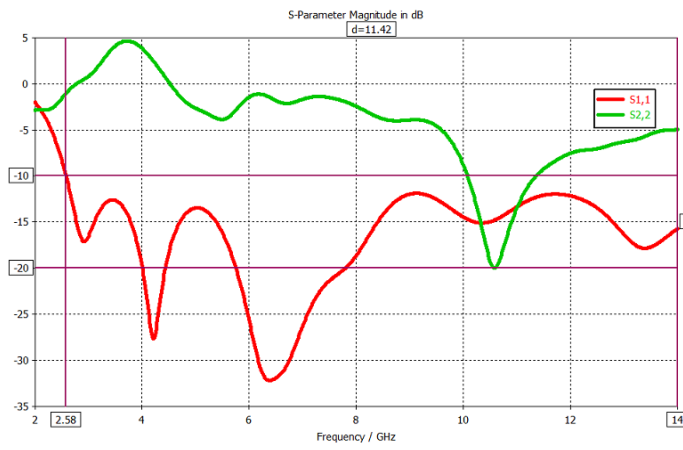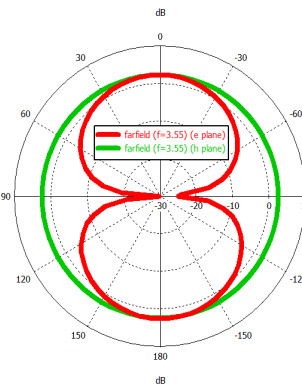
Fig.2 Simulated results of proposed antenna (a) reflection coefficients of integrated antenna (b) transmission coefficient.

(a)

(b)

(c)

(d)

Fig.4 Radiation pattern of the proposed antenna at (a) 3.55 GHz (b) 6.5 GHz (c) 13.3 GHz for microstrip antenna (d) 10.6 GHz for DRA antenna.
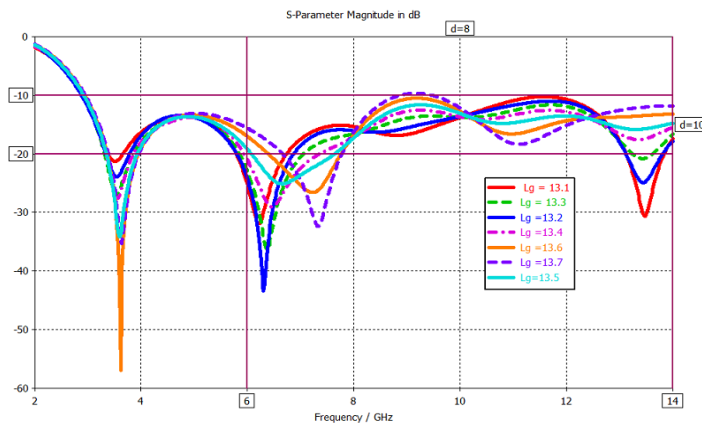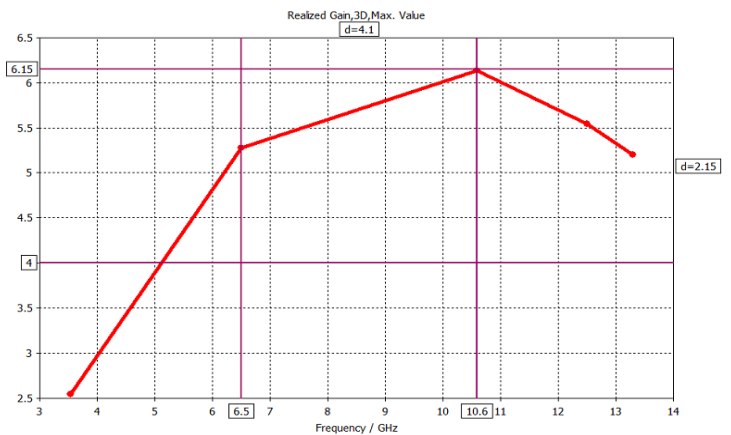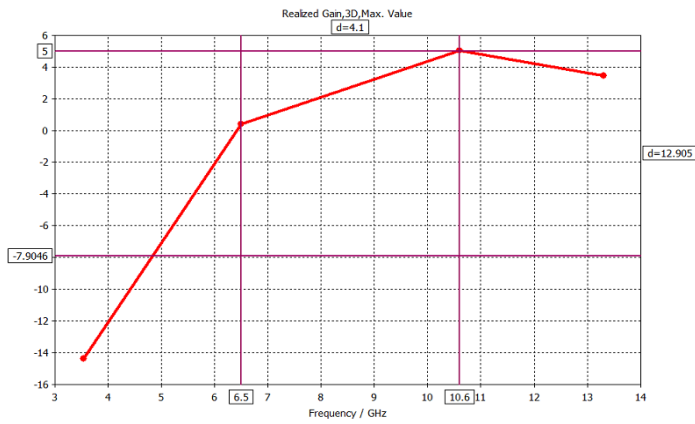

Fig.3 Reflection coefficients with different L_g values

(a)

(b)

Fig.5 Simulated gain vs. frequency (a) microstrip antenna (b) DRA antenna

IV. CONCLUSION

Microstrip antenna integrated with the narrow band antenna has been proposed for cognitive radio applications. The simulation results show that the microstrip antenna covers from 2.58 GHz to 14 GHz band it is suitable for sensing spectrum and DRA operates at 10.58 GHz which can be used for the communication operation. Compared to the existing designs the size of the integrated antenna is reduced by 31.5 % The proposed design provides a very good isolation between the ports in the operation band 10.07 GHz to 11.38 GHz ($S_{21} <$ - 15 dB). The peak gain of microstrip antenna achieved around 6.15 dB. The peak gain of the DRA is achieved around 5dB. This antenna can be used in radar, and medical imaging system.

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