A Circular Monopole with a Rectangular Microstrip Antenna for Cognitive Radio Applications

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Abstract: **The paper presents a unique combination of an ultra wideband circular monopole antenna and a narrowband rectangular microstrip antenna one above the other with separate partial ground planes .The UWB antenna connected on one port behaves as a sensing antenna whereas a narrowband rectangular microstrip antenna connected on another port behaves as a communicating antenna for cognitive radio applications. The microstrip antenna with a switch in the slot structure makes the antenna reconfigurable. The simulation result shows that the sensing antenna works in the range of about 8 to 17 GHz while reconfigurable antenna shows frequency variation from 12.6 to 13.7 GHz and 14.1 to 15.4 GHz with the change in switch position.**

***Keywords*: cognitive radio, ultra wideband, sensing antenna, reconfigurable antenna, communicating antenna**

I. INTRODUCTION

In recent times, there has been an explosive growth in wireless communications. Also, it is expected that data traffic will double every year which will eventually result in the saturation of the dedicated spectrum. Currently, most spectrum bands have been allocated to licensed users. However, a lot of licensed bands such as those for TV broadcasting are underutilized resulting in spectrum wastage.[11]. As a result, the Federal Communications Commission (FCC) has been prompted to open licensed spectrum bands to unlicensed users through the use of Cognitive Radio (CR) technology.[10] With the advent of 3G and 4G mobile communications, CR schemes have begun to receive a lot of attention. Presently various research communities have different definitions of CR and its unique defining features. Some view it as primarily about dynamic spectrum sharing while some consider it as a device capable of Cross-layer optimization. The possibilities for antenna to play an active role in system level performance are lost amid all these conceptions of CR. However, an antenna is the most important section of a CR system. Designing an antenna which carries out spectrum sensing as well as transmission is extremely difficult. Some research has been done related to the design of antennas for cognitive radio systems.

In [2], the sensing and communicating antennas in the same volume is presented. The sensing antenna is a printed hour glass shaped coplanar waveguide (CPW) fed monopole which is operating at 3.9 GHz to 11 GHz, accomplishing the UWB characteristic. The communicating antenna is printed on the reverse side of the substrate which is designed to operate from 5.15 GHz to 5.35GHz. In [3], the sensing antenna also has the UWB characteristic with slotted polygon – shaped patch with partial ground on the reverse side of the patch. While the frequency reconfiguration is achieved by rotational movement of the triangular shaped patch communicating antenna. A dual port antenna design for cognitive radio system also presented in [4], where the sensing and communicating antenna proposed have different structure and are positioned apart. The sensing antenna has the egg – shaped radiating patch with tapered microstrip line fed which operates at UWB range. The frequency reconfiguration of communicating antenna is achieved by the switches placed on the antenna structure resulting various resonance frequencies at range 4 GHz to 9 GHz. [1]

This paper presents a unique antenna for cognitive radio applications which consists of a wide band circular monopole antenna connected on one port and a narrowband reconfigurable microstrip antenna on the other port. The UWB circular monopole antenna used for sensing applications operates over the frequency range from around 8GHz to 17GHz and the narrowband reconfigurable antenna operates in two bands 12.6 GHz to 13.7 GHz and 14.1 GHz to 15.4 GHz corresponding to the switch in open and closed position.

II. PROPOSED ANTENNA DESIGN

The proposed UWB monopole antenna is shown in Fig. 1. The printed circular monopole antenna with radius r and microstrip feed line are printed on the same side of FR 4 substrate .A circular disc with a radius of 3mm mm, a 50 Ω microstrip feed line with the dimension 8 mm x 2mm are printed on one side of the dielectric substrate. In this study, the FR4 substrate used has a thickness of 1.6 mm and dielectric constant of 4.4. The length and the width of the dielectric substrate are 30 mm x16 mm. The partial ground plane is used in the design. The dimensions the ground plane are16 mm x16 mm.

The re-configurable antenna is a simple rectangular microstrip structure with 7mm x 2.6mm dimensions with a switch placed in the slot as shown in figure1.The microstrip antenna is located above the circular monopole with a separate partial ground with the dimensions 16 mm x 16mm .The switch on the microstrip antenna in different positions make it operate in different frequency ranges which make the design frequency reconfigurable.

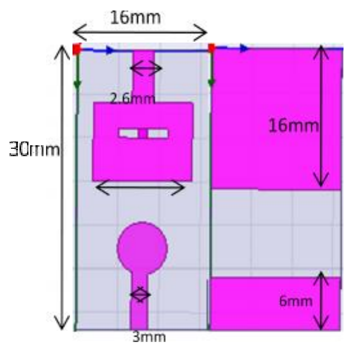

Fig.1 Design of circular monopole with rectangular microstrip antenna

III. SIMULATION RESULTS

The proposed antenna has been simulated in HFSS 13.0 software. The simulated antenna parameters viz. input impedance, return loss and radiation pattern are shown. Fig.2 shows the return loss plot for the circular monopole antenna. Fig.3 & Fig.4 shows mutual coupling between circular monopole and rectangular microstrip antenna. Fig.5. shows the impedance plot of circular monopole. Fig 6. Shows vswr plot. Fig.7 shows the 2D and 3D radiation pattern of antenna.

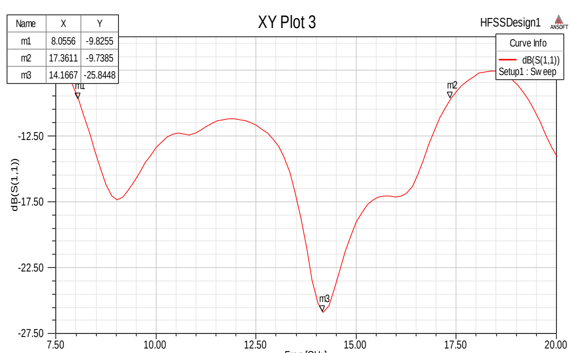

Fig.2. Reflection coefficient [dB] versus frequency [GHz]

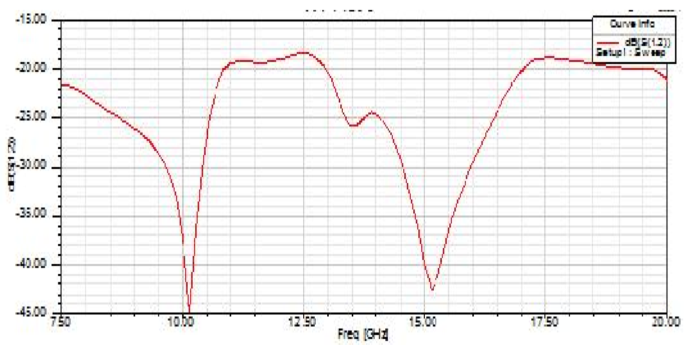

Fig.3. S12 [dB] versus frequency [GHz]

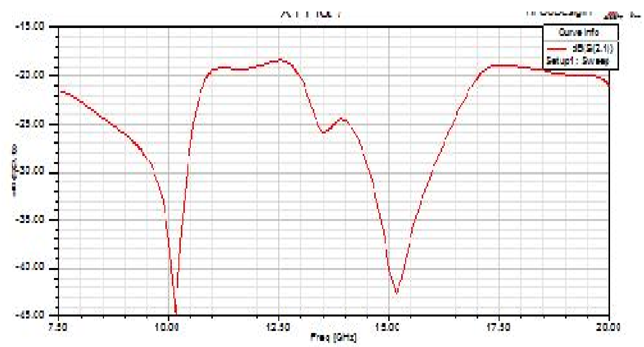

Fig.4. S21 [dB] versus frequency [GHz]

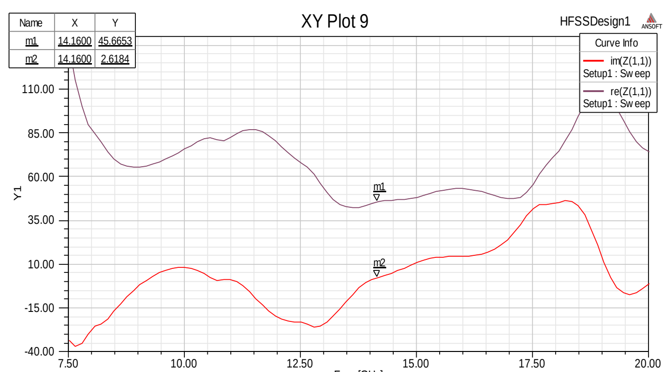

Fig.5. Impedance (Real & Imaginary) versus frequency [GHz]

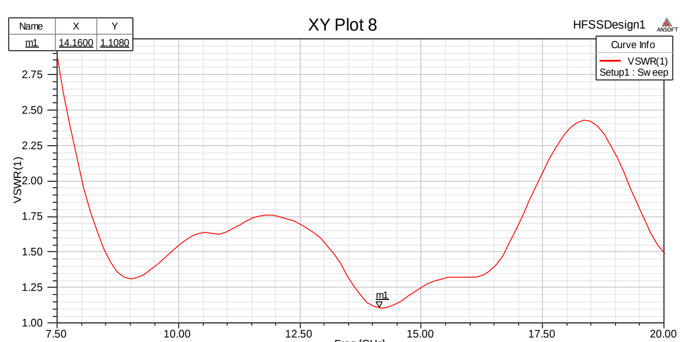

Fig.6. VSWR versus frequency [GHz]

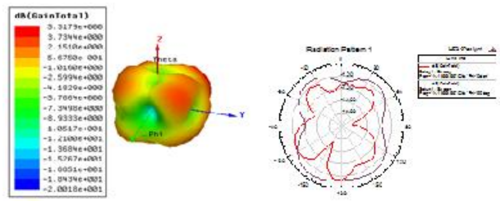

Fig.7. 2D and 3D Radiation Pattern

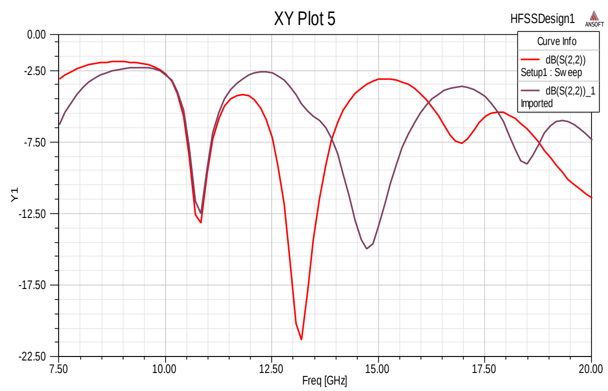

Fig. 8. Reflection coefficient [dB] versus frequency [GHz]

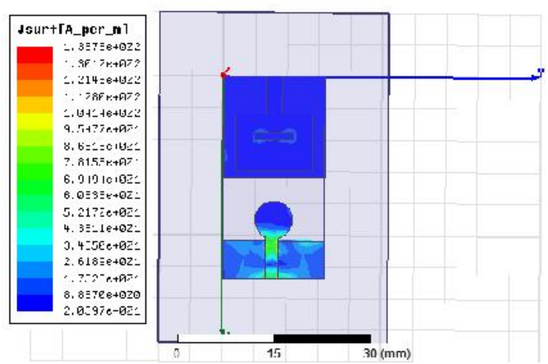

Fig.9. Surface current distribution

IV. .RESULTS AND DISCUSSION

The proposed antenna has been simulated using the e.m.design tool HFSS 13.0. Impedance plot shows that the impedance value 45.66 at 14.16 GHz which is close to 50Ω. The return loss plot of the simple monopole antenna shows a wide bandwidth which ranges from 8.05 GHz to 17.361 GHz. Thus the antenna shows a large bandwidth of about 9.361GHz .The impedance bandwidth is calculated by considering the range of frequencies below -10dB.The maximum return loss for the antenna is found to be -25.84dB at 14.66 GHz.

The VSWR plot shows the impedance bandwidth from 8GHz to 17.5 GHz and the lowest value of VSWR is found to be 1.10 at the frequency of 14.16GHz .The impedance bandwidth is calculated by considering VSWR in between 1 to 2.

The gain of the antenna is found to be 5.31dB and the 3D radiation pattern shows almost Omni-directional radiation pattern and 2D radiation pattern shows a pattern of eight in E plane while it shows almost circular pattern in H plane.

The return loss plot of the rectangular microstrip antenna shows a reconfigurable antenna which operates in two bands 12.6 GHz to 13.7 GHz and 14.1 GHz to 15.4 GHz corresponding to the switch in open and closed position.

IV CONCLUSION AND FUTURE SCOPE

The antenna is simulated using the simulation tool HFSS 13.0. The antenna can be used in a cognitive radio application for sensing and communicating purposes. The reconfigurable functions are obtained using only one switch. By switching ON and OFF status of the switch, antenna can work in two cases for underlay mode applications. The proposed antenna can also be used as multiband or multimode antennas. As a result, they can well meet the WB cognitive radio communication requirement and effectively change the modes to prevent potential interference between secondary users and primary users.

In the future, we will investigate the real switches, such as PIN diodes or switch circuit networks.

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