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Defected microstrip structure based UWB antenna with reconfigurable band stop filter design

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Cognitive radio is an inventive system to wireless technologies in which radios are designed with an astonishing level of intelligence and agility. This handles the available spectrum in an expedient manor to avoid spectrum scarcity. The cognitive radio antenna consists of integrated wideband and narrow band antenna in same substrate which is taxing task. A wideband antenna is pondered with a minimum bandwidth of 7.5GHz for sensing white space in the spectrum. For narrowband antenna, frequency Reconfigurable antenna is employed which is for the purpose of transmitting the data through the white space from the outcomes of UWB antenna. In this paper the novel design of cognitive radio antenna is designed with low-profile and miniaturized size using ansys HFSS V.14 and the simulation result are investigated tremendously.

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1. Introduction

The radio spectrum is naturally available scarce resource. The FCC regulates the available spectrum to users according to the requirement. The wireless communication technology is rapidly evolving in day by day so limited spectrum services become more congested. The wireless world research forum states that 7 trillion wireless devices are serving 7 billion people in 2017 Reports of recent FCC measurements conclude that many licensed frequency bands are unused 90% of the time [1]. To provide future wireless communication technological development the cognitive radio is the way to avoiding bottleneck of shortage of spectrum resources [2]. In cognitive radio the dynamic spectrum sensing is the novel method [3]. In CR paradigm, two users are accessing the spectrum called primary (licensed user) and secondary (unlicensed user). Generally the primary user has more spectrums with very less utilizing but the secondary user has very less spectrum with over utilization. Here the CR serves for both the users with neutralized spectrum access and very negligible amount of interference between them. The conventional regularity of spectrum causes under utilization of available spectrum. The dynamic spectrum access method is doing wide role in CR systems [4].

The cognitive radio working intelligently in all modules like modulation, coding and RF front end. In this paper the cognitive radio antenna system is discussed. The spectrum is shared dynamically by three different methods as given in Fig. 1. The hierarchical access model is briefed also the underlay and overlay access methods are proposed [6].

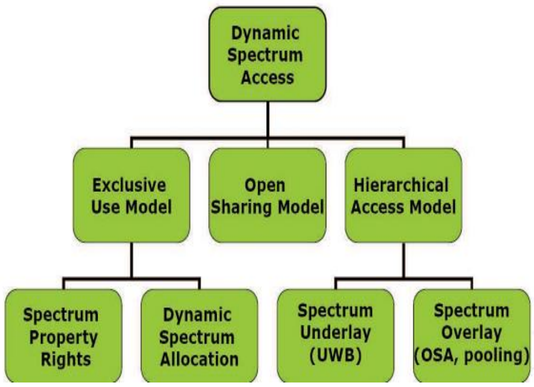

Fig. 1.Dynamic spectrum access method.

From literature Microstrippatch antennas are commonly used in cognitive radio due to their benefits in many aspects.The integrated wide and narrow band antenna is operating for CR system as following in Fig. 2.

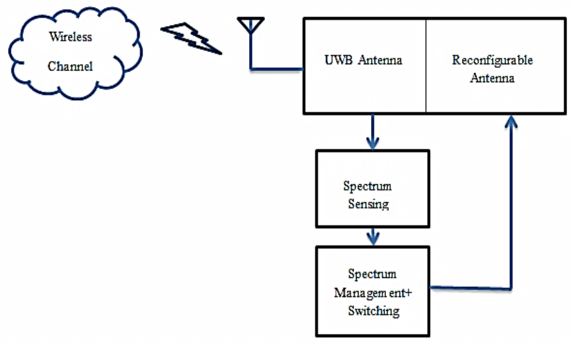

Fig. 2.Cognitive Radio Antenna.

In cognitive radio, the RF antenna is operating intelligently according to the environmental condition. The antenna working for two different scenarios one used for spectrum sensing and other for communication. The spectrum sensing is done by the UWB antenna which receives the entire UWB spectrum and the sensing is carried out by the effective spectrum sensing algorithm [7].Depending upon the sensing outcome the spectrum is managed for communication purpose then the switch control unit taking appropriate action to configure the reconfigurable mode. Still there are so many researches going on to get fully reconfigurable antenna according to the white band available.

2. Cognitive radio antenna

Access to naturally available spectrum is restricted by radio regulatory regime. Generally for communication in wireless environment uses 3KHz to 300GHz respectively. The regulated use of spectrum is to avoid interference between the each radio system. In case of open spectrum anyone can access any range of frequency with limited rules. But completely upgrade and open spectrum is very difficult so the dynamic spectrum policy is used for improving spectrum efficiency. Because paradoxically, 90 to 95% of the licensed radio spectrum is not used frequently. The dynamic spectrum access (DSA) method accesses this unused licensed spectrum while not in use.

The spectrum sharing methods are very important because to achieve DSA [4]. The underlay approach is used to use the same spectrum simultaneously by both users. The primary user access with higher power in back the secondary user also utilize that the same band with minimum power like UWB and some advance technologies are used for avoiding interference among them [8]. The secondary user using the UWB with a power of below the noise margin as shown in Fig. 3. This does not require spectrum sensing and cognizance system. But this application is limited. The overlay access method is very cognizance because it is well adapted to DSA concept shown in Fig. 4. It sense the spectrum utilize it until and unless primary user not exist. If the primary users enter the spectrum then secondary user use the low transmitting power according to the situation dynamically until it gets another white space and hence quality of service of both the users are not affected.

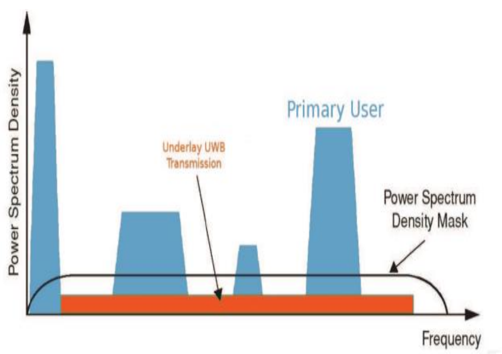

Fig. 3. Underlay approach.

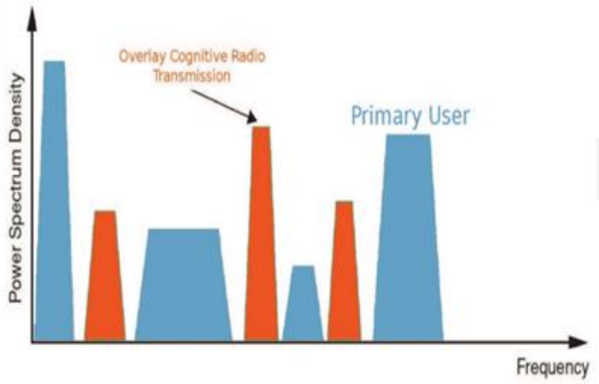

Fig. 4. Overlay approach.

The cognitive radio with overlay spectrum access and its antenna design have been discussed in the next section.

3. Proposed antenna design

The proposed design is based on circular patch with defected microstrip and band-stop filter. The proposed antenna structure is compact and low-profile design compared to literature. The substrate dimension [10] is 80×70mm for MIMO based CR antenna. In case ofonly spectrum sensing antenna [12] the substrate size 33×68mm but the reconfigurability is not considered. In [11] with two ground plane is designed so the complexity of design increased. The proposed design is very minimum dimension compare to conventional design shown in [13-16]. The proposed design substrate size is 34x30mm and material dielectric constant is 2.65 with the thickness of 1.6mm. The specified characteristics of this substrate is 1.6mm in thickness and 4.6 in relative permittivity (ε_r) with dielectric tangent loss of 0.023 respectively. The antenna structure is shown in the Fig. 5.

Presently planar antenna research is growing rapidly because of its advantages. In planar concept, the filter incorporation is done by defected ground structure, electromagnetic band gap and photonic band gap. The DGS and PBG is well suit for higher performance in various RF components such as power amplifier and filters etc., Moreover the DGS has defect in ground planes so it causes radiation from ground that leads interference to other microwave components [17].

The other two methods are difficult to design and is also band gap dependent [18]. Here the directed microstrip structure is used due to its compact size and immunity on electromagnetic interference [19-23]. Also DMS is far better then DGS, PBG and EBG 26.

The proposed design uses BSF which need to independence of interference so that DMS is well fit for filter design also suppressing the crosstalkarise in parallel microstrip lines [19-23]. The circular patch with DMS-BSF is used and as shown in Fig. 5. The design is simulated by using Ansys HFSS v.13.The reconfigurability is achieved by controlling the switch in the BSF at microstrip line feed.

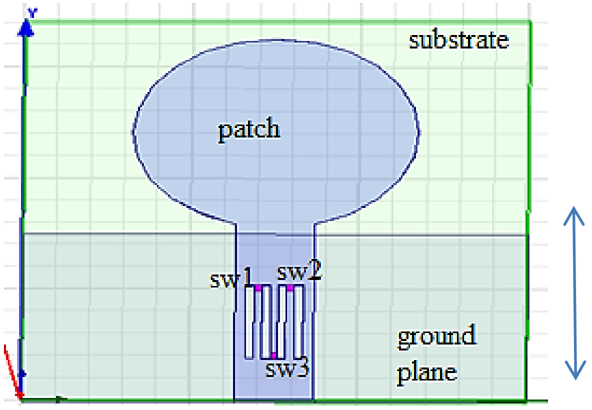

Fig. 5. Antenna structure.

The three switches are used to control the capacitance and inductance value of the filter. The equivalent circuit of DMS-BSF in feed position. The various L and C values is obtained from [24].

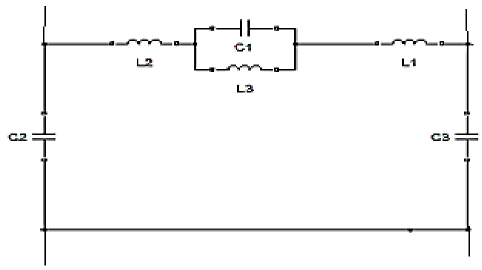

Fig. 6. Equivalent circuit of BSF antenna.

By changing the switch case the appropriate L and C values set and the antenna is triggered to resonant on a particular frequency. This mode operates on reconfigurable manner which is a narrow band antenna.

4. Result and discussion

A. Ultra-Wideband Operation

In UWB mode, the antenna is used for sensing the white space. The result shows the UWB antenna has a bandwidth of 10GHz. This is also called as enhanced wide band design. The return loss for the entire spectrum is resonating below -10dB. The UWB mode is obtained when all switches are in ON stage. The return loss graph shows that the antenna under this mode is resonating over all frequencies.

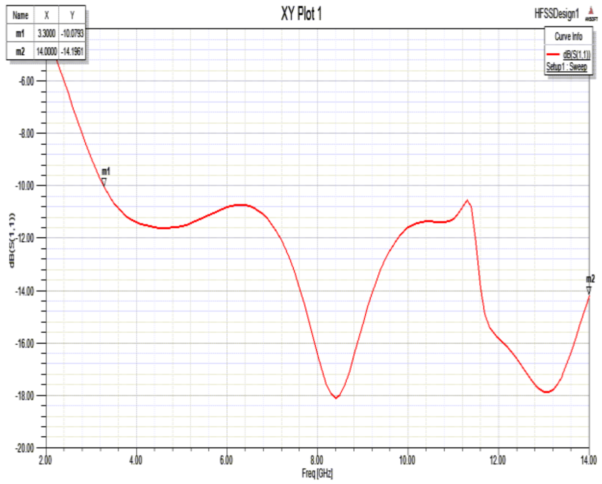

Fig. 7. Return Loss of UWB mode.

In case 1, Fig. 7 shows return loss for all switches ON. If all switch ON the inductance and capacitance value of BFS is high to make the antenna resonate over wide band from 3.3GHz (point m1) to 14GHz (point m2).

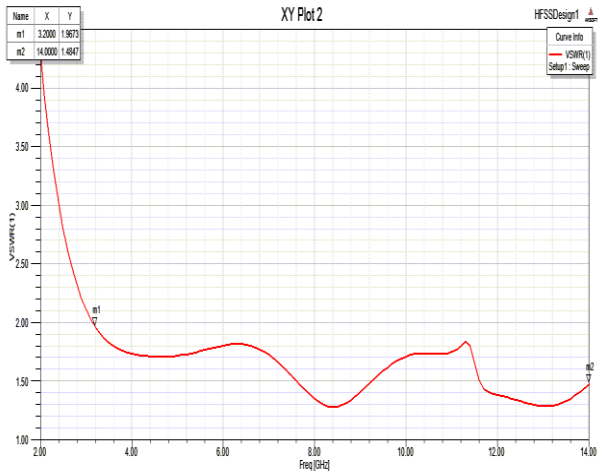

Fig. 8. VSWR of UWB mode.

The VSWR is related to impedance matching and Ideally it need to be low (between the range of 1-2) from Fig 8, it is clearly shown that the proposed antenna has the VSWR ranges between 1-2 from the point m1 to m2.

B. Reconfigurable antenna

The DMS-BSF based antenna is operating over reconfigurable mode by controlling the switches ON and OFF. The return loss with respective switch cases given below.

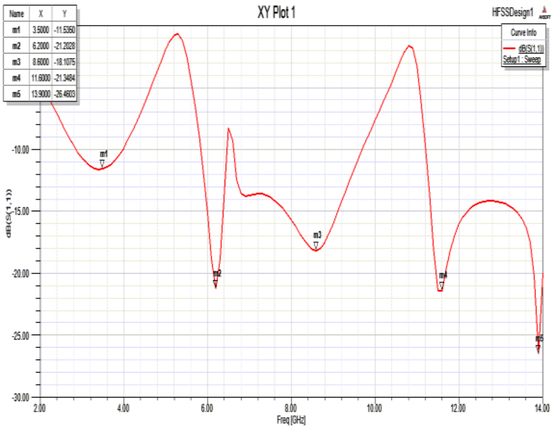

Fig. 9. Return Loss of all switches OFF.

In case 2, the antenna is operating at maximum number of notch bands such as 6.2, 8.6, 11.6, 13.9GHz with the return loss of -20,-19,-22,-26dB respectively which is shown in Fig. 9.

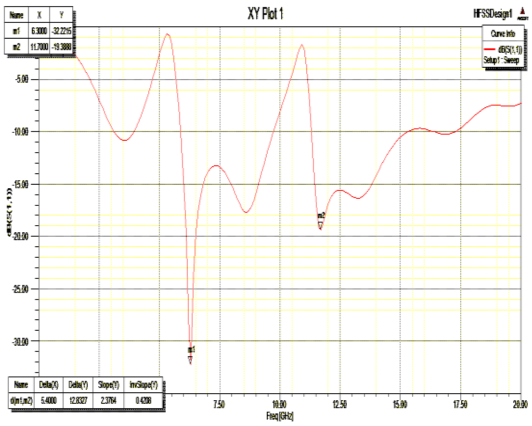

Fig. 10. Return Loss of Only Sw1 On.

The return loss of case3is shown in Fig. 10 the antenna is resonating at two bands such as 6.3 and 11.7GHz with the return loss of -32 and -20dB respectively.

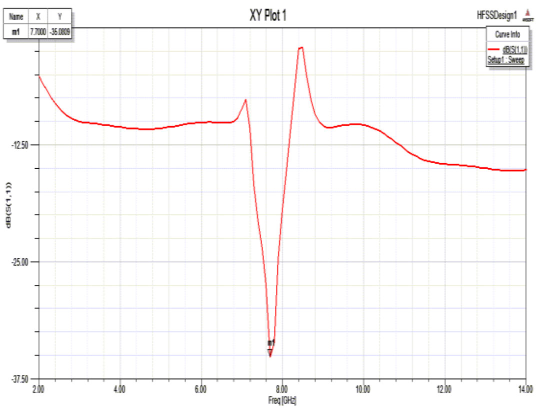

Fig. 11. Return Loss of sw2,sw3 ON.

The return loss of case 4 is shown in Fig. 7.4 f, the antenna is resonating at 7.7GHz with the return loss of -35dB. The corresponding impedance match obtained at the same frequency range.

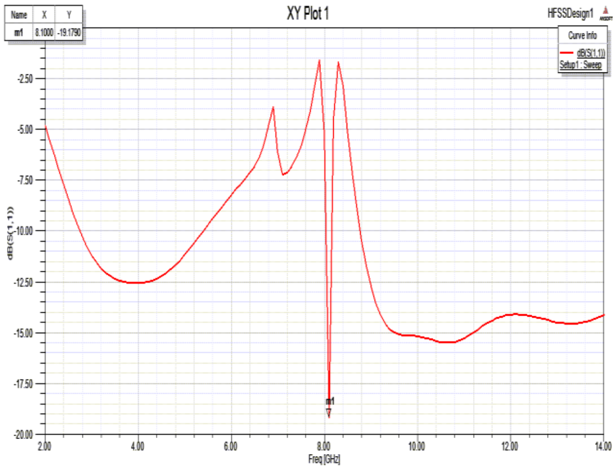

Fig. 12. Return Loss of only sw1 OFF.

The return loss of case 5 is shown in Fig. 12 the antenna is resonating at 8.1GHz with the return loss of -20dB. The comparative switchable cases are given in the Table 1. The bandwidth of the narrow band antenna is convenient to transmit even video information. The radiation pattern of the proposed antenna is shown in Fig. 13.

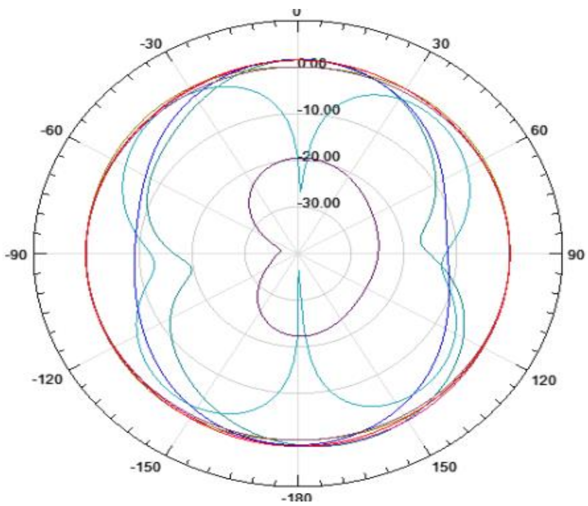

Fig. 13. Radiation pattern of UWB mode.

The result shows the antenna is omnidirectional in wideband mode. The omnidirectional antenna has less directivity.

Table 1.Switchable Cases and Corresponding Notch Bands.

CASE	NOTCH BANDS (GHZ)	SW1	SW2	SW3
1	None	ON	ON	ON
2	6.2,8.6,11.6,13.9	OFF	OFF	OFF
3	6.3,11.7	ON	OFF	OFF
4	7.7	OFF	ON	ON
5	8.1	ON	OFF	OFF

If the three switches are adjusted for ON and OFF then the capacitance and inductance value changes accordingly. The return loss calculation considers both standing wave ratio and refection co-efficient.

5. Conclusion

A novel design of circular patch antenna with DMS-BFS based integrated wideband and narrowband has been proposed. The configuration of reconfigurable and wideband antenna are controlled using three switches incorporated in microstrip line feed. The proposed antenna is of miniaturized size with reduction in size of 18% compare to literature. Normally cognitive radio is an evolving technology and presently working microwave devices are using conventional fixed frequency allocation scheme. This leads to interference between CR device and other devices. The proposed antenna avoids this EMI appropriately. Making the cognitive radio network as globalized technology the cost of the system is reduced by carefully choosing antenna parameters. In future the reconfigurable antenna is designed with MEMS to improve software control and frequency reconfigurable mode as more flexible.

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