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Microstrip Antenna with Switchable Band Notch for Smart Communication Systems

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Abstract: *In this paper, a microstrip antenna is proposed with an ultrawideband (UWB) design and reconfigurability for cognitive radio. The antenna has a small size of 17×24 mm, while showing the radiation performance in the frequency band of UWB with two switchable band-rejection performances in the frequency bands of WiMAX and C-band satellite. Simulated result obtained for this antenna shows a good radiation behavior within the UWB frequency range. It has also a reconfigurable frequency band-notched function in the range of application that can eliminate the interference between UWB frequency band and other existing wireless communication systems. This paper provides a detailed discussion of the existing UWB spectrum sensing reconfigurable microstrip antenna designs for cognitive radio applications. The comparison between the simulated return loss by Ansoft HFSS and CST-Microwave Studio has been also carried out.*

Keywords: *UWB, Reconfigurable Microstrip Antennas, Cognitive Radio, band-rejection*

1. INTRODUCTION

Ever since the dawn of radio communication systems, the antenna has been the key component in the construction and performance of every wireless system. With the proliferation of new radio systems, a cognitive radio is a radio that has the capability to sense, learn, and autonomously adapt to its environment. The hardware components are essential to optimizing performance. Antenna hardware for cognitive radio applications presents distinctive problems, since in theoretical terms, a cognitive radio can operate anywhere in the spectrum [1]. It is important that engineers designing wireless communications systems have some fundamental knowledge of antenna performance and radio wave propagation characteristics. This knowledge is essential to the proper selection of system antennas to ensure system coverage and performance. A properly selected antenna system has the capability of improving overall system performance and may lead to a reduction in system cost. Conversely, a poorly selected antenna system may degrade system performance [1]. 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. 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. With the advent of 3G and 4G mobile communications, CR schemes have begun to receive a lot of attention [2]. The monitoring of the wireless spectrum is the key in cognitive radio since the spectrum can be idle for 90% of the time. Therefore, in such a system, we should differentiate between a primary user that owns the spectrum and a secondary user that wants to access the spectrum whenever it is idle [3]. Recently, reconfigurable antennas for cognitive radio applications that generate band-notch functions have been investigated and successfully implemented by using various techniques; for example, two structures incorporated together into the same substrate [4]. The scheme consists of a ultrawidebhand antenna and a reconfigurable narrowband antenna in close proximity to one another [5] .The design of Filter antennas with reconfigurable band stops [6] two rectangular parasitic patches are embedded within the antenna's structure in [7], and a slot split-ring resonator was added on the microstrip-fed monopole antenna in [8]. PIN diodes and micro-electro-mechanical systems (MEMS) switches have been employed in antennas to achieve frequency [9] or radiation pattern [10] reconfiguration. In this paper, a new reconfigurable antenna structure whit switchable band- notched in bands of C-band satellit and WiMAX for cognitive radio applications is presented.

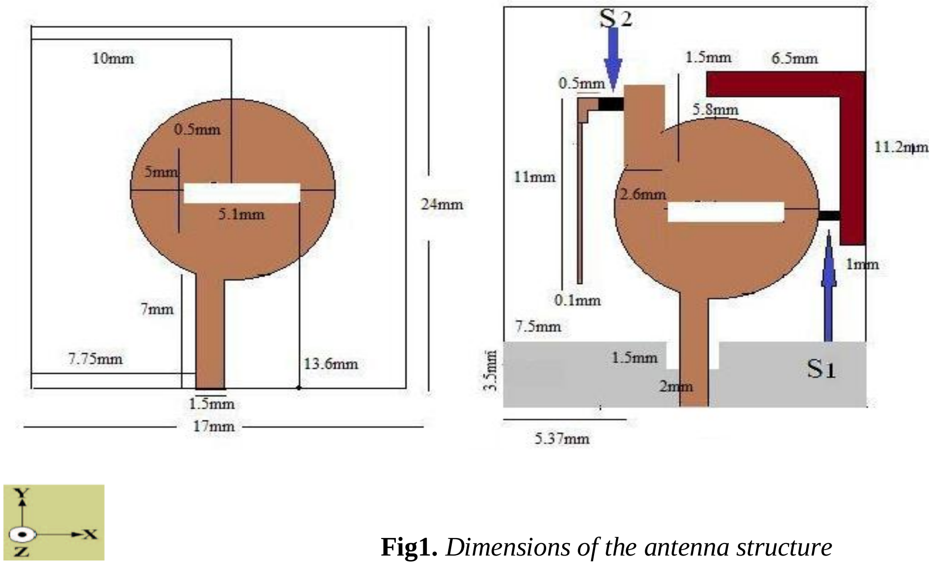


Fig1. *Dimensions of the antenna structure*

2. COGNITIVE ANTENNA DESIGN

A wideband antenna is necessary in order to be able to achieve the channel sensing [4]. This section details the "sensing" UWB antenna structure. The aim of this paper is to attain a sensing antenna and a reconfigurable communicating antenna in the same substrate. The UWB structure and the dimensions of the proposed antenna are shown in Fig 1. It uses a 17 × 24 × 1.57 mm3. The dielectric material selected for the design was FR-4 which has a dielectric constant of 4.4 and height of dielectric substrate "h" is 1.57 mm, a circular patch which its diameter is 5mm,a T-shaped slot exist on the patch which is critical for achieving the range of UWB antenna. a microstrip feed line which its dimension is 1.5 × 7mm, and the bottom layer is the partial ground which its dimension is shown in Fig 1. As it is demonstrated in the Fig1(b) a rectangular slot is on the ground plane. All simulations were done using HFSS ver. 11 and CST-Microwave Studio.

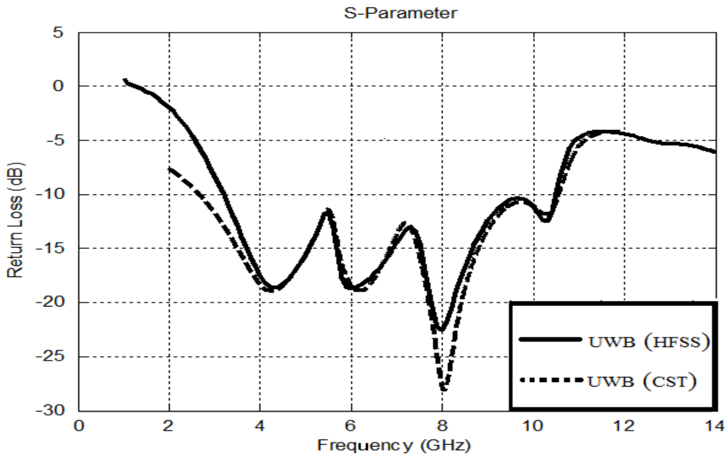


Fig2. *The return loss for the sensing antenna structure*

As it is obvious in Fig 2 the comparison between the simulated return loss by Ansoft HFSS and CST for the "sensing" antenna. The corresponding antenna return loss covers the range from 3.18–10.6 GHz by HFSS and 2.7-10.7 GHz by CST which covers the entire UWB band (3.1 to 10.6 GHz), making it suitable for channel sensing in cognitive radio application. Applications requiring frequency band switching such as Cognitive Radio could benefit from the proposed reconfigurable antenna as we can use the UWB mode or the Notched UWB mode in sensing and the reconfigured bands for communication purpose [11].

3. RECONFIGURABLE ANTENNA FEATURES

In this section, the structure of the reconfigurable antenna is detailed. Reconfigurable antennas have drawn considerable attention, especially for broadband wireless communication, space-time adaptive processing, multiple-input–multiple-output (MIMO) systems, and cognitive radio [12]. The reconfigurability is achieved by using active switches. The "reconfigurable structure antenna is shown in Fig1. For the purpose of achieving frequency reconfigurability, two L-shaped patch are placed around the cicular patch, and two electronic switches, each 1 × 0.5 mm2 in size, are placed as shown in Fig 1(b). For simulation of the switches, we used ideal switches (e.g. putting metal copper bridge to resemble an ON switch state and removing it for the OFF case. By switching the left L-shaped patch, the band-notch in C-band satellite is achieved and by the switching the right L-shaped patch, the band-notch in the range of WiMAX is achieved.

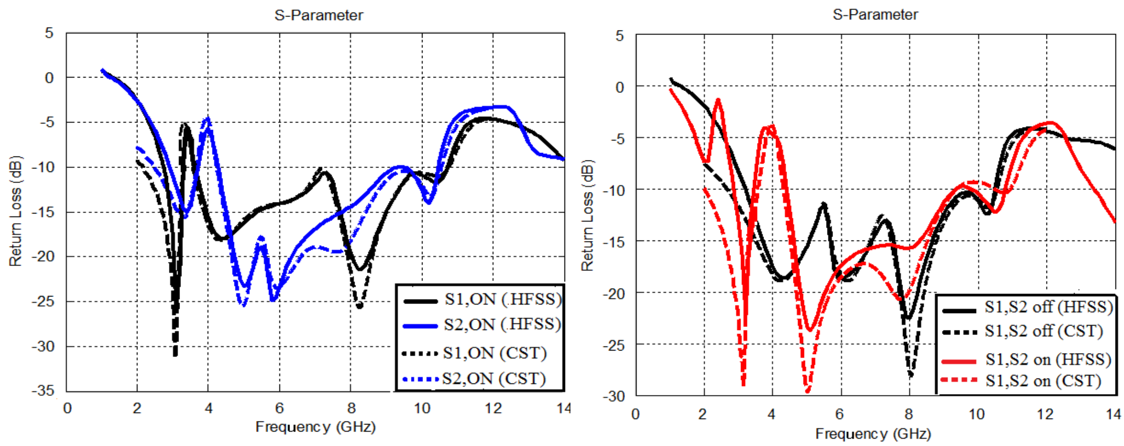


Fig3. *Simulated return loss characteristics for different states of switches*

The size of the designed antenna is smaller than the UWB antennas for cognitive radio reported recently [4]. Now, we explain in detail four state of operation of switches. The first is occurred when S1. is in ON state and S2 is in OFF state . In this case the notch is in Wimax frequency. The second when S2 is in ON state and S1 is in OFF state. In this case, the notch is in C-band (3.7–4.2 GHz) satellite the simulated return loss curve of different states shown in Fig 3. As shwon in Fig3 the comparison between the simulated return loss by Ansoft HFSS and CST_ Microwave Studio .The third occurred when two switches are in OFF state, that is. UWB structure that stated in section II. The fourth is occurred when two switches are in ON state. In this case, the notch is in renge of 3.7-4.25 GHz. The simulated return loss curve of third state and fourth state shown in Fig 4. Comparison between simulated result whit Ansoft HFSS and CST is shown in table(I).

Table 1. Comparison between simulated result whit Ansoft HFSS and CST

State of switches	Simulated result (Ansoft HFSS)	Simulated result (CST Microwave studio)
S1,ON& S2,Off	3.3-3.66 GHz Band-Rejection	3.28-3.67 GHz Band-Rejection
S2,ON& S1,Off	3.7-4.25 GHz Band-Rejection	3.69-4.25 GHz Band-Rejection
S2,S1,ON	3.43-4.3 GHz Band-Rejection	3.45-4.27 GHz Band-Rejection
S2,S1,Off	3.18-10.6 GHz	2.7-10.7 GHz

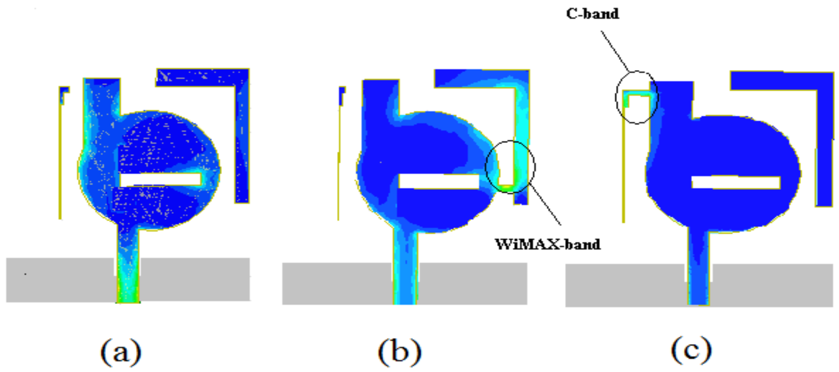
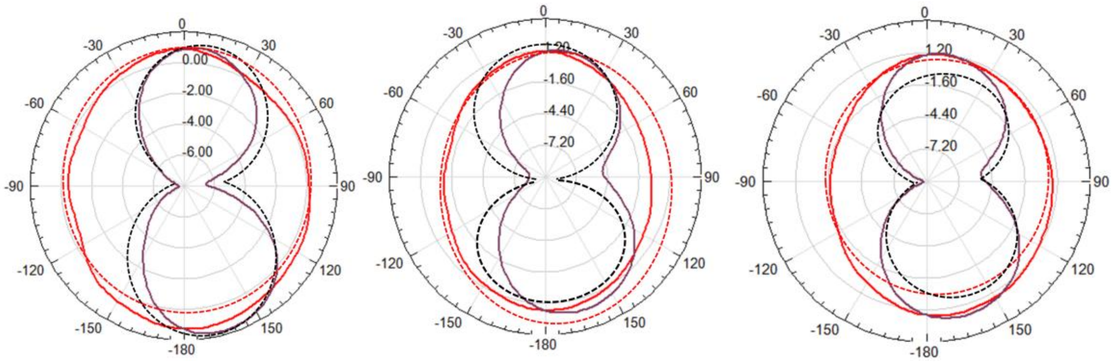


Fig4. *Simulated surface current distributions on the radiating stub for (a) the UWB proposed antenna at frequency (7 GHz), (b) the proposed antenna at the notched frequency (3.5 GHz), and (c) the proposed antenna at the notched frequency (3.9 GHz)*

In order to understand the phenomenon behind switching electronically between band-notched and additional resonance performances, the simulated current distributions on the radiating stub of the proposed antenna, for on and off statuses of the switches, are presented in Fig. 4(a)and(b) and (c), respectively. As shown in Figs. 4(b) and (c), at the notched frequency (3.5 GHz) and (3.9 GHz), the current mainly concentrates on the connection of L-shaped stubs with the patch. There are various possible configurations and architectures for cognitive radio applications. In general the decision making about spectrum allocation can be made locally by the individual users/terminals and the spectrum allocation is carried out at the central terminal/base station [13]. One of the approaches to deploy reconfigurable antennas in Cognitive Radio is to use an UWB antennas with a reconfigurable band notch. Several designs of UWB antenna with band rejection characteristics have been successfully implemented [14-16]. The proposed reconfigurable antenna here is similar to the mentioned approach. This antenna features wide operating bandwidth, very simple and compact structure, ease of fabrication, good radiation patterns over the entire bandwidth and good time domain performance. A notch in certain bands helps to prevent interference to a primary user or the service operated in that band.



(a) (b) (c)

H-Plane (HFSS) E-Plane (HFSS)

H-Plane (CST) E-Plane (CST)

Fig5. *Simulated E and H Plane Radiation Patterns at (a) 3.5 GHz , (b) 3.9GHz and (c)7 GHz*

The simulated radiation pattern of in the UWB mode is shown in Fig. 5. As shown in Fig. 5 the antenna can provide a nearly omnidirectional characteristic in the H-plane and a dipole-like radiation characteristic in the E-plane.

4. CONCLUSION

In this letter, a new reconfigurable antenna design for cognitive radio is explained. The miniature antenna structure consists of two switches. In one hand by changing the state of switches, we can use the UWB mode which is suitable for sensing the spectrum; and on the other hand, by putting notched on applications requiring frequency band, i.e. C_ band and WiMAX band, we can eliminate the interference between UWB frequency band and other existing wireless communication systems.

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