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Review of Reconfigurable Antenna For Cognitive Radio

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ABSTRACT

In wireless sensor networks, cognitive radio plays an emerging role for dynamic spectrum access. The dynamic spectrum switches the connection from licensed user to unlicensed user. However, the researchers develop many reconfigurable antennas for spectrum sensing. Wireless communication needs an intelligent system for switching the frequency according to the requirement. The allocation of frequency to multiple users is through various IEEE wireless standards in cognitive radio. The cognitive radio a branch in wireless communication system solves the problem of spectrum allocation. This paper discusses the reconfigurable antenna of a cognitive radio RF system.

1. INTRODUCTION

In wireless communication, the frequency change the mode of operation is essential. The wireless system allocates the spectrum to multiple users as per the standards. The non-uniformity in spectrum allocation leads to the problem of unbalanced spectrum usage. A cognitive radio system gives a solution for spectrum usage. A cognitive radio, a future wireless communication system improves the spectrum efficiency and reduces the spectrum crowding. The cognitive radio operation does not fix the channels to different users. Instead, frequency band made available to any users. The user classified into two types such as primary user and the secondary user[1]. The primary users of cognitive radio system assign to a fixed part of the channel and free to access the channel at any time. During the idle time of the primary user, a secondary user becomes active for data transfer. The secondary user dynamically occupies the spectrum of a primary user when the primary user is inactive. The dynamic occupation of secondary user relies on the spectrum sensing of an antenna. In cognitive radio system, the antenna design and sensing plays a vital role for a mode of frequency changing. The cognitive radio spectrum efficiency lies with two modes of operation such as Interweave or Underlay mode[1].

2. ANTENNAS FOR COGNITIVE RADIO

The cognitive radio device search for white space and achieves communication by allocating the appropriate channel used. A cognitive radio device operates in either Interweave or the Underlay mode for better spectrum efficiency.

3. INTERWEAVE MODE

The cognitive radio looks for possible white space in any of the frequency band sensed. There are primarily two types of spectrum sensing technique used in the Interweave mode wideband and narrowband sensing[1. Wideband sensing reads the entire spectrum band, while narrowband sensing reads the different parts of the channel. The cognitive radio RF front-end in Interweave mode consists of either one or two antennas. The use

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of one antenna drives the cognitive radio device to operate in a slotted time scheme by alternatively switching between sensing and communication. In this mode, a committed antenna for channel sensing and separate reconfigurable antenna for communicating with white space is used. The sensing antenna detects the white space; correspondingly, the reconfigurable narrowband antenna tunes its operating frequency within the white space. The reconfigurable antenna allows the secondary user to transmit at full power. The use of reconfigurable antennas in cognitive radio is essential because they avoid any interference with primary users. However, the two antennas are isolated to avoid RF interference that affects the performance of a CR device.

4. UNDERLAY MODE

For the Underlay mode, a cognitive radio RF front-end consists of a wideband antenna. The antenna transmits ultra-wideband (UWB) signal with reconfigurable notch frequency[1]. The ultra-wideband transmission allows secondary user to occupy larger area of spectrum, while minimizing interference with active primary user. The reconfigurability in notch frequency depends on the presence of primary user. This reconfigurability is present in Underlay mode, in case a given primary user does not allow sharing of its spectrum resources with other secondary users. The cognitive radio identifies the allowed interference level of primary user; it can transmit UWB signals without periodically sense the spectrum. The function of the Underlay mode is not to locate the white space, but to identify the maximum interference caused by the secondary users present. This interference level should provide a good service for the primary user. The Underlay mode of operation is used when the primary user are active and can allow a certain level of secondary user interference. The existence of both users in the same frequency bands leads to a more efficient utilization of the spectrum in comparison to the Underlay case. Under certain circumstances, some primary users cannot tolerate any level of interference for secondary user. This channel sensing determines the interference level identify the sensitive user and avoid them during communication. The primary user can tolerate the interference of the secondary user; the sensing antenna is not required to possess notch frequencies. However, the sensing antenna with reconfigurable notch frequencies is required to identify the sensitive primary users.

5. RECONFIGURABLE ANTENNA

Reconfiguration is the capacity to change individual radiators operating characteristics through electrical, mechanical, or by material change. Reconfigurable antenna alters their operating frequencies, impedance bandwidth, and polarization and radiation pattern independently to accommodate changing operating requirements. Frequency-reconfigurable antenna classified into two categories. They are Continuous and switched. Continuous frequency tunable antennas allow for smooth transitions between operating bands without jumps. Switched tunable antennas use some switching mechanism to operate at distinct or separated frequency band. Both antennas, in general, share a common theory of operation and reconfiguration.

6. CLASSIFICATION OF RECONFIGURABLE TECHNIQUES

The reconfiguration mechanism used to change the effective length of the antenna, although some of these are more effective while others in maintaining the radiating characteristics of the original configuration. Fig 1 shows the classification of reconfigurable antenna. The following section provides different reconfiguration techniques and discusses the benefits and drawbacks of each approach.

Reconfigurable antennas can be implemented through;

i) RF-MEMS, PIN diodes, varactor diodes.

ii) Photoconductive switching elements.

iii) Physical structure alteration.

iv) Material change.

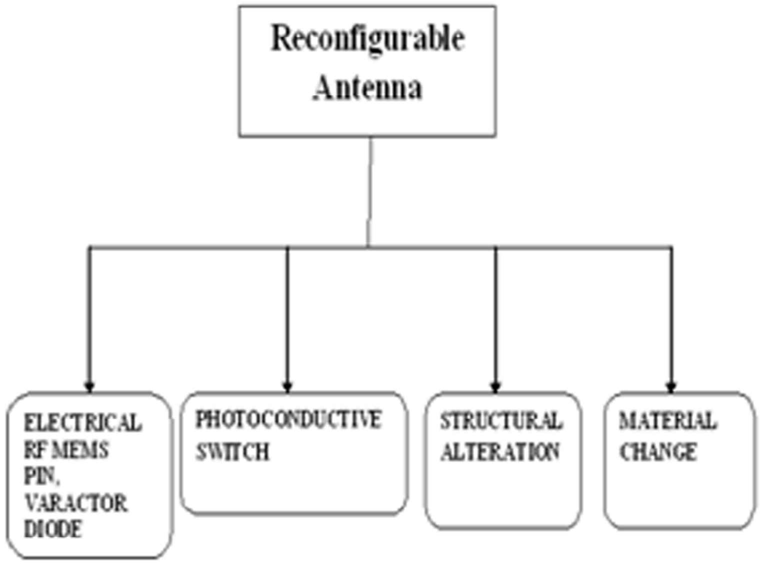

Figure 1: Classification of Reconfigurable Antenna

6.1. Reconfigurable Antenna Using Switch

The effective length of the antenna and its operating frequency varied through electronic, optical, mechanical changes. Different switching technology, such as optical switches, PIN diodes, and RadioFrequency micro-electromechanical system (RF-MEMS) switches, for frequency tunable monopole and dipole antennas for various frequency bands explained in the following section.

The antenna shown in fig 2[2] is a polarization diversity antenna with ultra wideband (UWB) / narrow-band (NB) switching capability. It consists of a two port, uniplanar design. The antenna utilizes an open annular slot with orthogonally excited through two identical coplanar waveguide feed line from the center to achieve polarization diversity performance across the UWB band for a frequency band 2.9 GHz to 11GHz. A slot resonator-based filter used to achieve UWB / NB switching between the sensing and

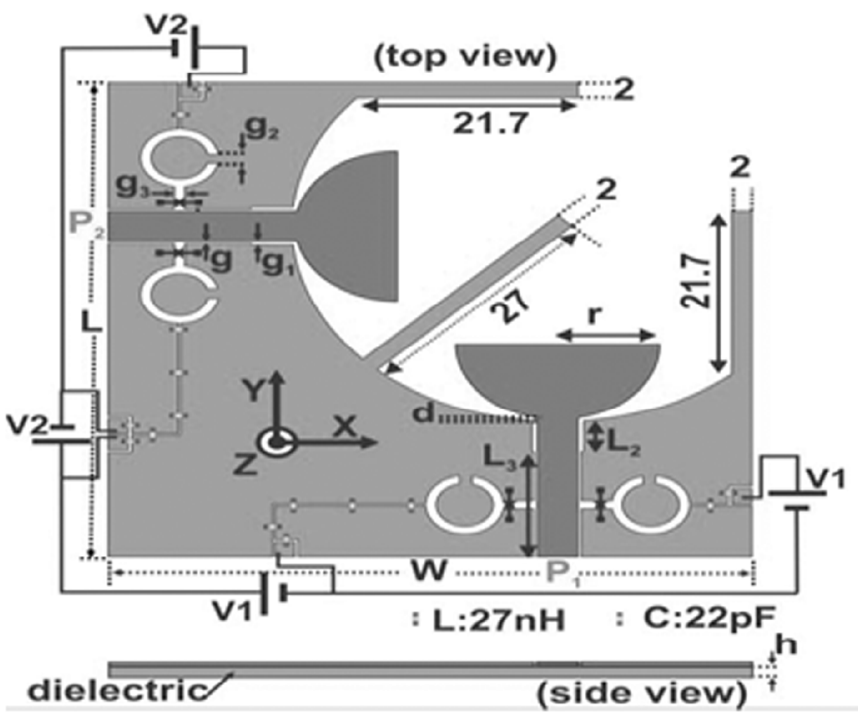

Figure 2: Polarization Diversity Antenna

communication band. It consists of two lg/4 slot resonators to generate two stop bands far spread out to form a pass band. The electronic control achieved by using Schottky Diode across the slot entrance. The ultra wide band and narrow band antenna provide a bandwidth of 2.9GHZ to 11GHZ and 4.9GHZ to 5.5GHZ. The gain plotted and the variations are from 3.2dBi to 6.5dBi and 4.5dBi to 5.1dBi for ultra wide band and narrow band antenna respectively[2].

6.2. Reconfigurable Antenna Using Capacitors or Varactors

The reconfigurable antenna integrated with pin and varactor diodes for frequency reconfiguration shown in fig 3[3]. There are two modes used for antenna reconfigurability. Pin diodes and varactor diodes used for frequency reconfiguration[3-5]. The pin diodes are used to connect the radiating parts to switch the operating bands, where varactor diodes used for tuning over a low-frequency band3. The single pin diode connecting two antennas result in two modes of operation with frequency variation by the varactor diode. The ultra wide band-sensing antenna covers a frequency band of 720 to 3440 MHZ.

6.3. Reconfigurable Antenna based on Radio-Frequency microelectromechanical systems (RF-MEMS)

The antenna provides a method to design reconfigurable antenna with a radio frequency microelectromechanical system. The RF MEMS switch changes the dimension of the patch to make the antenna resonate at various frequencies. By implementing RF switch, the dimension of the slots altered. The resonant modes manipulated by turning the switches ON and OFF. A frequency reconfigurable E-Shaped patch design used in cognitive radio systems. This provides a method to design reconfigurable antenna with Radio Frequency Microelctromechanical System (RF-MEMS) switches. The reconfigurability achieved in the frequency range from 2.2GHz to 4.2GHz respectively[8]. The RF MEMS switch has insertion loss of -80 dB and return loss <-10 dB

6.4. Reconfigurable Antenna based on optical switch

An optically controlled reconfigurable antenna with an integration of wide-band and narrow-band for cognitive radio system is shown in fig 4[6]. The frequency reconfiguration done using four conductive silicon switches. The switch behaves as short circuit conductor when the light illuminates one of switch and will be off when there is no beam of light and behaves as an insulator[6]. The structure or ground of the inner antenna varied by combining different slender ring parts and optically controlled switch. The four

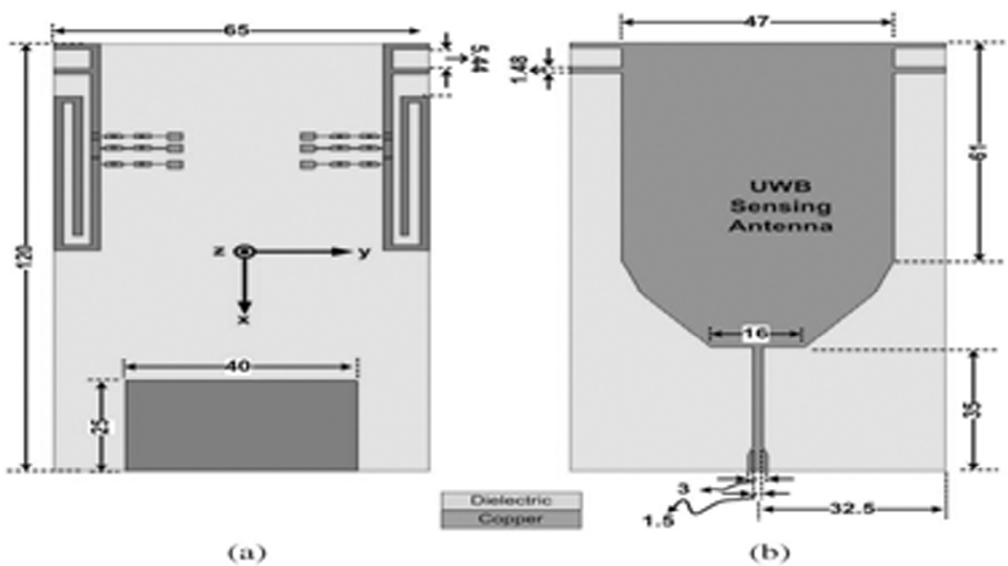

Figure 3: MIMO Antenna For Cognitive Radio

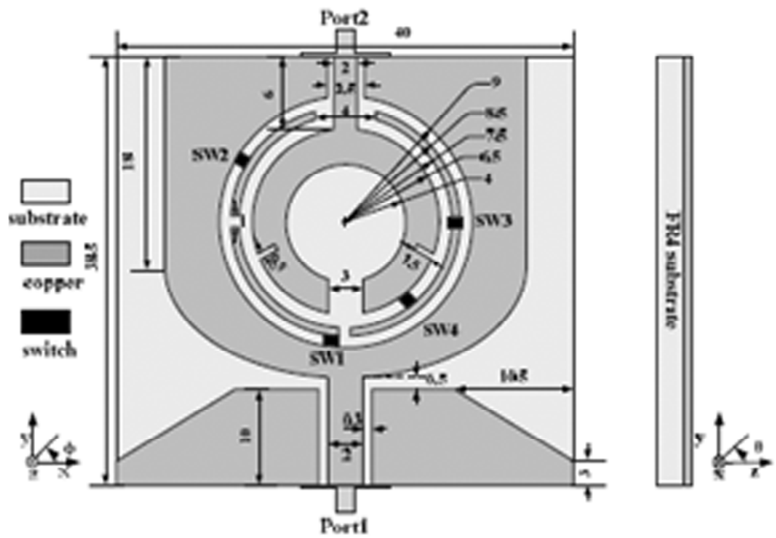

Figure 4: Reconfigurable Antenna Using Optical Switch

reconfigurable frequency band are obtained from 5.8-6.8 GHz, 6.7-7.3 GHz, 7.0-8.4 GHz, and 7.9-9.2 GHz, which focus on the upper frequency sub-band of obtained ultra wide band. The ultra wide band antenna changes in range from 2.6 to 4.1 dBi and the narrowband antenna varies from -0.1 to 4.5 dBi at the four operating band.

6.5. Reconfigurable Antenna Using Physical Angular Alteration

Mechanical changes in antenna structure can deliver larger frequency shifts when compared to electrical changes. The main challenges with these antennas lie in the physical design of the antenna, actuation mechanism, and the maintenance of other characteristics in significant structural changes. The complete cognitive radio antenna system, shown in fig 5[7] has two antennas. One antenna for channel sensing and the second antenna used for communication. The sensing antenna a printed monopole antenna positioned

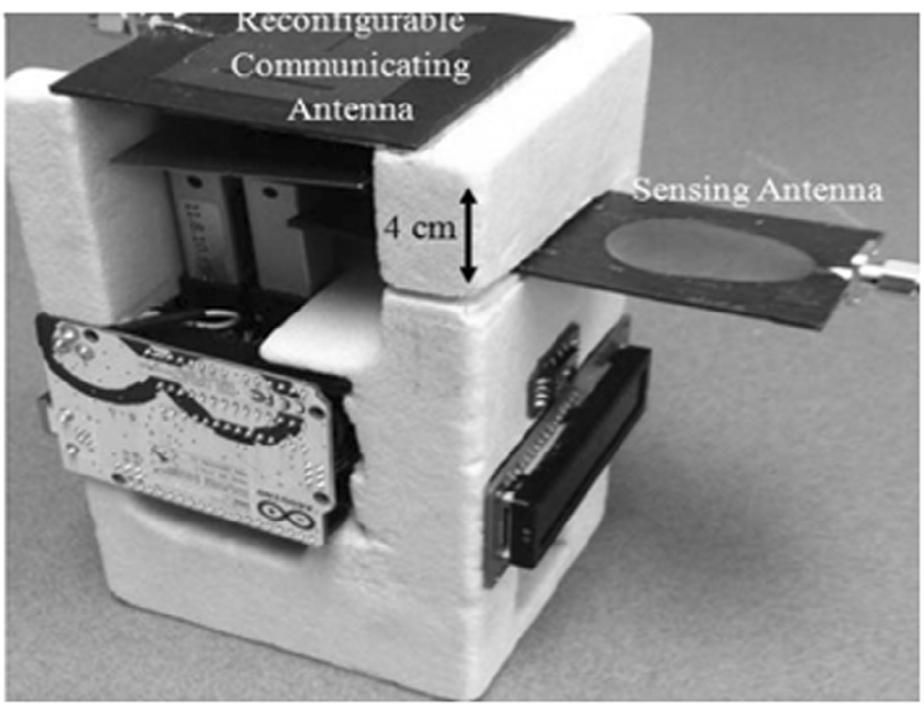

Figure 5: Reconfigurable Antenna Using Structural Alteration

out of the plane of a reconfigurable antenna some height below the surface of Patch. As shown in fig 5[7], a slit cut into the hardened wall supports the whole antenna system and the sensing antenna positioned inside the slit. The sensing antenna positioned for better isolation with the communicating antenna. For sensing antenna a wideband antenna, that has a partial ground plane with a size of 4.7cmX0.75cm, fed through a stripline that has an opening width of 0.4 cm. The radiating patch has a modified shaped monopole of length 3.75 cm and width 2.79 cm.

The communicating antenna, shown in Fig. 3(a), is a microstrip line fed rectangular patch. The antenna ground plane composed of three sections. The antenna has two fixed ground planes (ground planes 1 and 2) and a moving ground plane.

The moving ground plane controlled by two actuators that allow vertical movement and tilting position. The actuators are pulse width modulated and software controlled by Arduino board.

6.6. Reconfigurable Antenna Based On Material Change

Change in the material characteristics of the design can tune antenna in the different frequency. The applied static electric field can change the relative permittivity of the ferroelectric material. The applied static magnetic field can vary the relative permeability of ferrite. The variation in relative permittivity and permeability used to change the effective electrical length of an antenna, results in operating frequency shift. As relative permittivities and permeabilities are high compared with commonly used substrate materials, translating in to greatly reduced antenna size. Aside from any complexities resulting from the necessity of the bias structure, the main drawbacks to using standard ferroelectric and ferrite bulk materials (typically with thicknesses on the order of millimeters) are their high conductivity about other substrates that can severely degrade the efficiency of the antenna.

6.7. Comparison Between Different Reconfiguration Techniques

All techniques presented in the previous section have advantage and disadvantage. In comparison of all the design, there is a shift in use from RF-MEMS to p-i-n diodes to achieve switching. While p-i-n or Schottky diodes require less biasing lines, the difficulties encountered with biasing RF-MEMS are not greatly alleviated by the use of p-i-n or Schottky diodes. The use of variable capacitors is considered an efficient reconfiguration method; however, many issues appear regarding voltage variations or biasing varactors. Mechanical and physical alteration of an antenna structure is difficult to implement for designers, still looking for an easy way for mechanical reconfiguration.

7. SIMULATION AND MEASUREMENT RESULTS

The micropatch antenna design Ansoft's High Frequency Structure Simulator (HFSS). The antenna designed on a trace material Graphite and Teflon based dielectric with thickness of 10mm. Antenna parameters vary

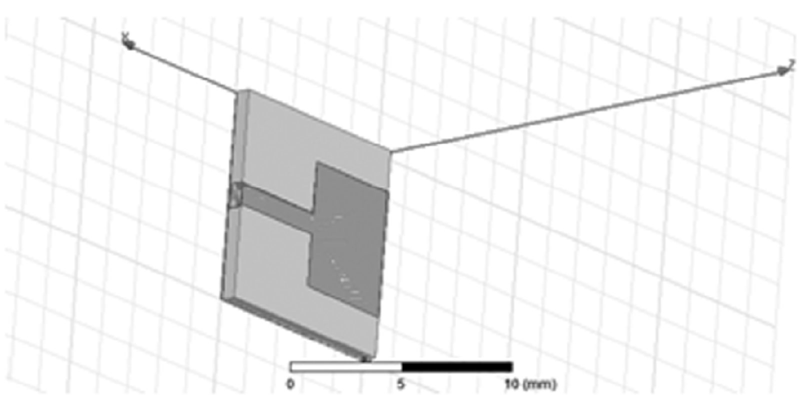

Figure 6: Micropatch Antenna In HFSS

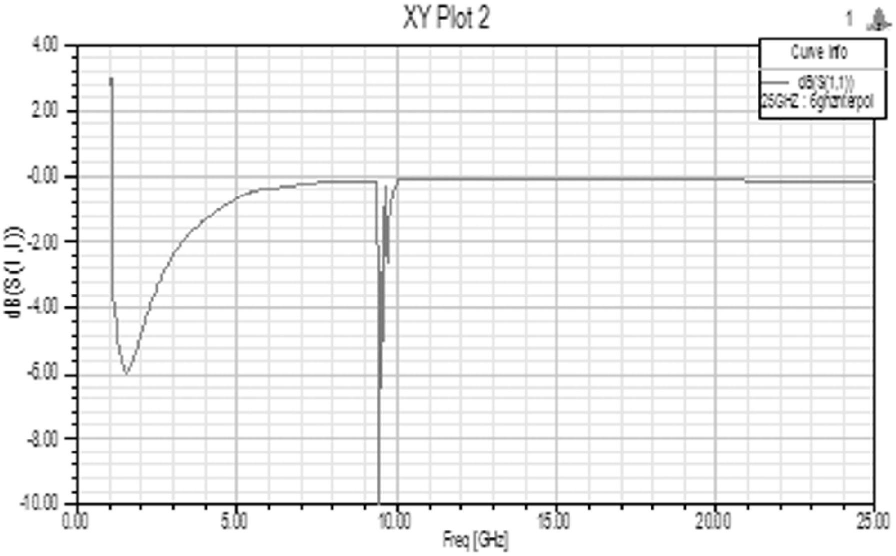

Figure 7: Frequency vs return loss plot

depending on the Patch material. Rectangular patch antenna resonates at 9.3 GHz for Graphite and for perfect conductor at 20GHZ patch antennas. Simulations results obtained and compared to analyze the performance of rectangular patch antenna with different patch materials. Copper patch antennas also have good simulated results. The antenna has following dimensions Trace L1- 10mm H1-10mm W1-0.03

8. CONCLUSION

In this, paper a review antennas requirement for Cognitive Radio is presented. The reconfigurable antennas provide an approach for sensing the ultra wide band spectrum to transmit over any narrow band. An ultra wide band antenna can sense the complete range for white spaces. The antenna meant for communicating purpose would communicate over these white spaces. The communication antenna must be frequency reconfigurable to transmit at any frequency. The sensing antenna must be continuously sensing the spectrum and provide the channel to communicating antenna. The multi-antenna system provides a solution to the problem of transmitting at different frequency band.

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