ABSTRACT

Cognitive Radio presents promising applications in creating a more intelligent and flexible radio and wireless system structures considering the increasing demands faced by spectrum usage and spectrum regulators for specific frequency bands. The flexibility and reconfigurability required by such systems place a significant burden on engineers and radio designers specifically on the radio front-end and antenna elements. This chapter aims to study and analyse the various reconfiguration techniques and types that could be employed in the antenna front-end that will allow cognitive radio to be more flexible and adaptable to different bands and environments. The chapter focuses on theoretical and experimental analyses of novel methods to frequency-reconfigure compact ultra-wideband antennas to work in different bands, and it also explores the possibility of pattern and polarisation reconfiguration of the antenna element. It ultimately shows a method of combining all reconfiguration techniques to realise an original antenna structure capable of adapting the cognitive radio unit to work in congested electromagnetic spectrum bands based on availability of other free gaps, usage rate, and environmental factors. The authors strongly believe the proposed design meets the growing demand of cognitive and smart radio devices for more intelligent and multi-functional antennas.

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INTRODUCTION

Reconfigurable antennas are distinguished from their conventional counterparts by the fact that they can change their operation parameters (such as frequency, patterns or polarization) upon request or feedback from a specific control mechanism. The reconfiguration is achieved through re-distribution of the surface currents; this will result in changes in the antenna impedance or radiation properties. Reconfigurable antennas apply various techniques and methods to achieve the required change in one or more of its operation parameters. The most common technique is based on using switches such as p-i-n diodes, Gallium Arsenide Field Effect Transistors (GaAs FETs) or Micro-ElectroMechanical System (MEMS) switches. Other techniques include the use of optical switches or mechanical structure alteration to achieve the necessary change in the antenna configuration and these are promising methods to overcome the enormous biasing problems of the electronic switches.

Reconfigurable antennas have recently received a substantial increase in interests from both academic and industrial groups and establishments due to their attractive characteristics in advanced and novel applications such as Cognitive Radio (CR), Multiple Input Multiple Output (MIMO) systems, personal communication systems, satellites, military communications and many other applications. Unlike current conventional communication systems, future wireless communication systems (e.g., Cognitive Radio and smart WLAN) will benefit most from flexible radio front-ends (flexibility in terms of operation and performance parameters).

Taking for example the main motivation behind Cognitive Radio (CR) systems, some frequency bands in the spectrum are heavily used while there are still some, at a specific geographical location or at a certain time, largely unoccupied. Hence reconfigurable antennas will allow CR to change its operational frequency according to spectrum availability and also user demands from link quality and data rate prospective (Mitola, & Maguire, 1999; FCC 2002). There are many approaches of how to deploy these reconfigurable antennas in CR systems; one of these approaches is to use an omnidirectional ultra-wideband antenna to sense the spectrum, while another reconfigurable narrowband (either on the same board or adjacent one) can be used for communication. Another approach can be achieved through the use of ultra-wideband antenna that can be reconfigured into multiple predefined narrow passbands and hence achieving both spectrum sensing and communicating functionality within one element saving cost and reducing complexity (Hall et al., 2009). The later approach might have its drawbacks in terms of power consumption and interference from the compact biasing circuitry; however, it provides significant advantage for the compact one unit CR device aimed for potential smart wireless applications.

According to (Hall et al., 2009), there are many approaches of how to deploy reconfigurable antennas in CR systems, one of these approaches is to use an omnidirectional ultra-wideband antenna to sense the spectrum, while another reconfigurable narrowband (either on the same board or adjacent one) can be used for communication. Some of the designed antennas that follow this approach can be found in (Ebrahimi, Kelly, & Hall, 2011; Tawk et al., 2011, 2012). Another approach can be achieved through the use of ultra-wideband antenna that can be reconfigured into multiple predefined narrow passbands and hence achieving both spectrum sensing and communicating functionality within one element saving cost and reducing complexity. Some of the designed antennas that follow this approach can be found in (Aboufoul, & Alomainy, 2011; Hamed, Gardner, Hall, & Ghanem, 2011). The later approach might have its drawbacks in terms of power consumption and interference from the compact biasing circuitry; however, it provides significant advantage for the compact one unit CR device aimed for potential smart wireless applications.
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