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Design of Reconfigurable Meander-line Antenna for Cognitive Radio Applications

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ABSTRACT

This paper presents the design of a multiband, frequency reconfigurable antenna with meandered line structure for cognitive radio applications. The proposed designed antenna is used to cover a wide range of frequency bands above 3GHz. The complete system comprises of the frequency-reconfigurable meander-line planar antenna for CR (Cognitive Radio) applications. The reconfigurable antenna which is capable of modifying dynamically its frequency and radiation properties in a controlled manner. Meander-line is a type of printed antenna that can achieve miniaturization in size by embedding a wire structure onto a dielectric substrate. The antenna system is developed to operate at high frequencies above 3GHz on a single substrate area of certain dimensions and to achieve better return loss.

Keywords: Cognitive radio, Reconfigurable antenna, Meandered line.

1. INTRODUCTION

The rapid growth in the field of wireless communication is been observed in recent years. With the rapid growth of users and limited bandwidth available, operators are facing difficulties to optimize the network for larger capacity and improved quality coverage. This led to the field of antenna engineering to evolve and accommodate the need for wideband frequency for low cost and small size which are easily integrated. Antennas play an important role in any wireless communications. Some of them are patch Antennas, parabolic reflectors, and Slot Antennas and Folded Dipole antennas. Each type of antenna is good in their own properties and usage. Antennas are the backbone and almost everything in the wireless communication without which the world could have not reached at this age of technology. The key concept of dynamic usage of inefficient and highly underutilized spectrum resources has led to the concept of software defined radio [1]. The purpose of a cognitive radio system is to provide better spectrum utilization by interacting with the operating environment. A Software defined radio system has the ability to identify the unoccupied frequency bands to operate in different frequencies with different switching mechanisms [2].

Reconfigurable antenna is an antenna which dynamically changes its operating frequency and hence efficiently utilizes the available bandwidth. This differs from smart antenna because the reconfiguration mechanism lies inside the antenna rather than in external beam forming network. It is used to maximize the antenna performance in a changing scenario or to satisfy the changing operating requirements. Boyle *et al* proposed a design with two different antenna structures which can be operated in five cellular radio bands [3]. There are some of the possible antenna requirements for cognitive radio applications and some design approaches [4].

II. COGNITIVE RADIO

A Cognitive Radio is a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, instantly move into vacant channels while

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avoiding occupied ones. This advanced technology enables radio devices to use the spectrum (i.e., radio frequencies) in entirely new and sophisticated ways. Cognitive Radio systems and networks are a revolutionary new concept in wireless communication.

Built on the novel software defined radio architecture, they have powerful signal processing capabilities to sense spectrum under utilization. These networks can thus dynamically allocate spectrum to multiple users thereby easing network congestion to meet the growing wireless broadband demands of billions of users worldwide by efficiently utilizing spectrum resources in wireless networks, which are scarce and expensive. The 4 major CR network functions are spectrum sensing, spectrum management, spectrum mobility, spectrum sharing.

Cognitive radio (CR) is currently the new intelligent network paradigm to face the challenge of high data rate wireless transmission, inefficient use of the scarce spectrum resource, and dynamic spectrum access [5]. A CR is a versatile transceiver system empowered with two components: (1) awareness of radio environment mainly by spectrum sensing for monitoring the available spectrum bands, searching and detecting spectrum holes. (2) Reconfigurability or "adapt and response": the ability to learn and adapt its system parameters (such as transmit power, carrier frequency, and modulation strategy) according to the variations in the environment. The radio frequency (RF) front-end design for cognitive radio networks (CRN) is challenging because the antenna system should also be reconfigurable so that the unused frequency bands as specified dynamically by the sensing antenna be actually used for transmission. The sensing antenna should have wide bandwidth with an Omni-directional radiation pattern to make sensing of the whole spectrum. But, narrowband antenna is preferable for communication purpose to filter out-of-band signals [6]. Some recent applications in CR have also identified the need of both wideband and narrowband spectrum sensing and such integrated antennas can be useful for sensing purposes as well.

3. MEANDER LINE ANTENNA

Meander-line is a type of printed antenna that can achieve miniaturization in size by embedding a wire structure onto a dielectric substrate. There are various techniques to miniaturize the size of micro strip antennas viz. use of high primitive substrates, shorting pins, and meander line antenna designs. Meander line antenna is a type of printed antenna that can achieve miniaturization in size by embedding a wire structure onto a dielectric substrate. In order to reduce the antenna length and width, a straight conductor will be folded back and forth to make the meander line antenna structure. The design of meander line antenna is a set of horizontal and vertical lines which forms turns. As number of turn's increases, efficiency also increases. In case of meander line, if meander spacing increases then the resonant frequency decreases. Meandered line antenna has the advantage of simplicity because of its combination of normal conventional wire and strip line, easy to integrate in wireless devices and potential for low specific absorption rate features.

4. DESIGN DETAILS

In cognitive radio applications, reconfigurability is one of the major constraints for improving the antenna performance. The proposed novel frequency reconfigurable meander line structure with F shaped slot is shown in Figure 1. The complete system is integrated on single board of dimensions 7.9×56.6 mm^2. The proposed design is fabricated on FR-4 substrate with relative permittivity of ε_r=4.4. The top layer of the board contains a meander line reconfigurable antenna with certain dimensions. The design procedure was started with an inverted F-shape antenna with certain length of 56.6mm, width of 7.9mm and height of 1.48mm. The given structure was resonating at low frequencies. The target was to achieve above 2GHz operation using the constraint size. The design was optimized by selecting the position and width of the shorting walls.

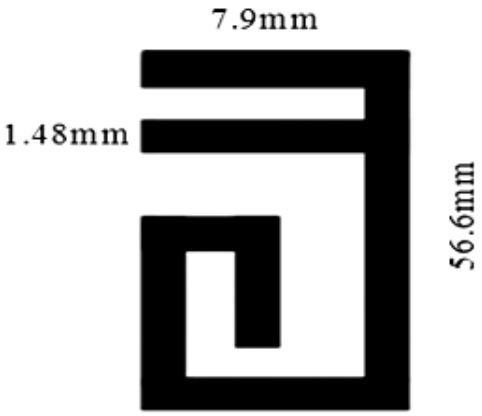

Figure 1: Meander-line structure with inverted F shaped slot

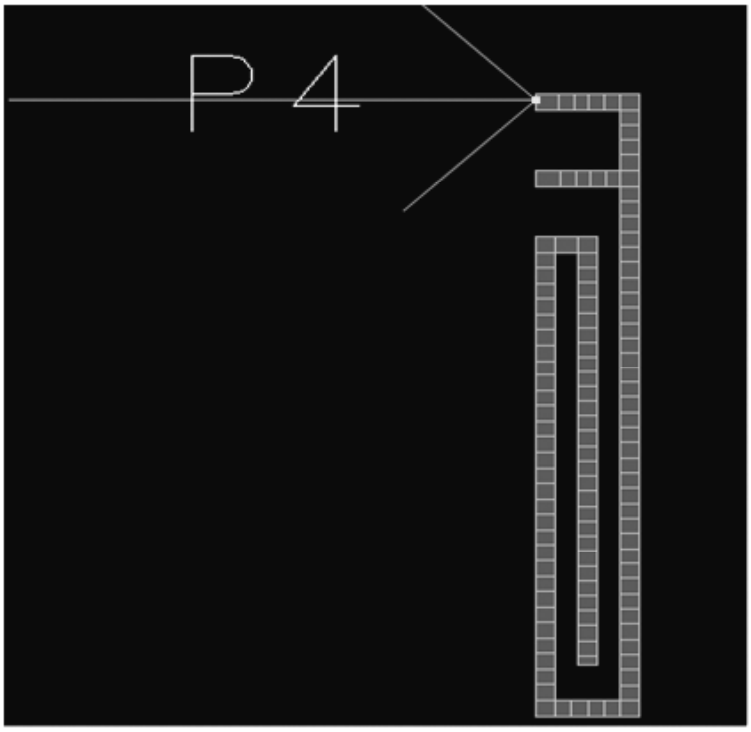

Figure 2: Designed Meander-line antenna

5. LAYOUT DESIGN

In a meander line antenna, the radiating element consists of a meandering micro strip line formed by a series of sets of right angled compensated bends. Figure 2 shows the design of the proposed meander line antenna. The fundamental element in the proposed design is formed by four right angled bends and the radiation mainly occurs from the discontinuities of the structure. The right angle bends are used for better impedance matching. The current directions are changing in every half wavelength and there are more than four half wavelength changes in this design. The radiation from the bends will help to produce the desired polarization depending on the dimensions of the meander line antenna. The fabricated model of the proposed design was realized on commercially available FR4 substrate. Figure 2 shows the top view of the proposed design with the dimensions of 7.9×56.6 mm^2 and thickness of 1.48mm.

6. SIMULATION RESULTS

The proposed meander line based reconfigurable MIMO antenna was modelled and simulated using ADS (Advanced Design System) software. The layout was designed on FR4 substrate with certain dimensions and the required range of frequency was to be given in the software to simulate the deigned antenna. Simulation result is obtained for the designed system as per the required frequency and return loss of -10dB or less than -10db will gives better performance.

ADS software is used in the design of microwave, RF, different types of antennas. Schematics, circuits, layouts of any different antennas can be designed using this software. ADS provide users with significant technology advances in signal integrity (SI), power integrity (PI), RF PCB, Laminate, Module, and Silicon RFIC Technologies. Numerous usability improvements make ADS Layout more efficient and intuitive for design, editing and verification.

Figure 3 shows the simulation of the designed meander line antenna. A return loss of -32dB at 80 GHz and -26dB at 130GHz was obtained for the design. Figure 4 shows the radiation pattern of the meander line

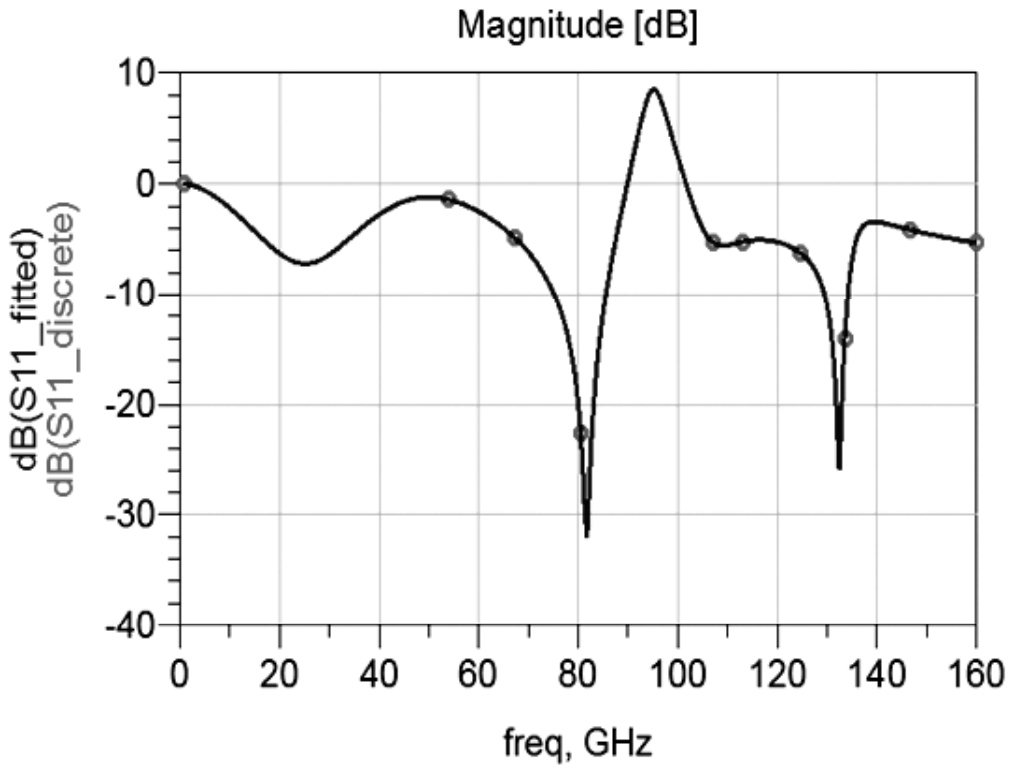

Figure 3: Simulation result of meander-line antenna

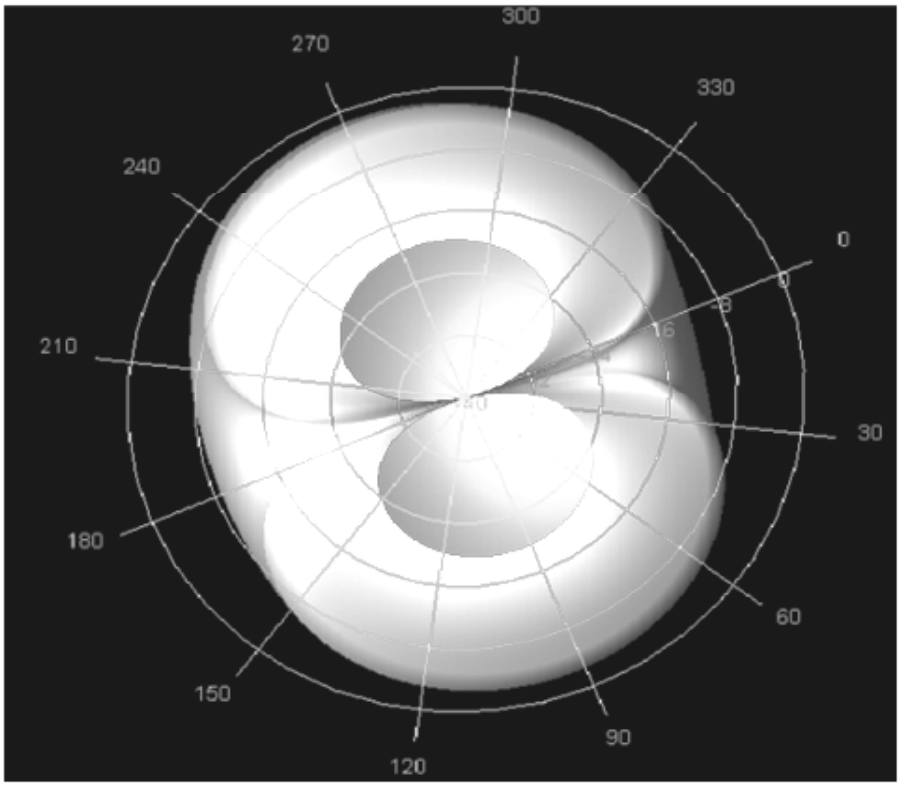

Figure 4: Radiation Pattern of Meander Line Antenna

antenna. It is observed that a high gain was achieved at higher frequencies. This is due to the high directive gain at those frequencies. It is observed from the design that reconfigurability is been achieved at very high frequency. The future scope of this design is to add another meandered line structure to reduce the operating frequency bands.

7. CONCLUSION

A novel, compact, single board antenna system is presented for Cognitive Radio applications. The designed antenna covers the frequency bands above 3GHz. The reconfigurable multi-band, multi-mode antenna was also evaluated for operation where it showed good performance. The total space occupied by whole design was $7.9 \times 56.6 \times 1.48$ mm^3 which is very compact covering the required bands of frequencies. The single meandered line antenna proposed is working at very high frequencies.

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