Design of Reconfigurable Meander-line MIMO Antenna for Cognitive Radio

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***Abstract*— A single substrate, multiband, frequency-reconfigurable multiple-input-multiple-output (MIMO) antenna system for cognitive radio is to be designed. Multiple-input, multiple-output (MIMO) technology is being utilized in 4G wireless standards to meet the high rate requirements in multipath wireless channels. The proposed antenna is used to cover a wide range of frequency bands above 1GHz. The complete system comprises of the frequency-reconfigurable meander-line planar MIMO 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 2GHz on a single substrate area of certain dimensions and to achieve better return loss.**

***Index Terms*— Reconfigurable antenna, cognitive radio, 4G wireless communication, MIMO technology.**

I. INTRODUCTION

The rapid growth in the field of wireless communication is been observed in recent years. With the rising number of users and limited bandwidth available, operators are trying hard to optimize the network for larger capacity and improved quality coverage. This led to the field of antenna engineering to constantly evolve and accommodate the need for wideband, low cost, miniaturized and easily integrated antennas. 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 rich 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 cognitive radio (CR) i.e., a software defined radio.

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 be aware of its spectrum usage with a switching capability to operate among different unoccupied frequency bands. For wireless communication applications such as Radio Frequency Identification Tags (RFID tags), USB dongle, Bluetooth headsets, mobile phones etc., Meander-line is an optimum solution for this type of implementation. 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 changing operating requirements.

II. DESIGN DETAILS

The proposed novel frequency reconfigurable meander line planar MIMO antenna system is shown in Figure 1. The complete system is integrated on single board of dimensions 7.9×56.6 mm2. The proposed design is fabricated on FR-4 substrate with Ɛr=4.4. The top layer of the board contains a meander line MIMO reconfigurable antenna with certain dimensions. The design procedure was started with an inverted F-shape antenna with certain length and height. 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. Figure1 shows the detailed view of the meander line reconfigurable MIMO elements. Patches are used for frequency reconfigurability.

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 as shown in Figure 1.The fundamental element in this case is formed by four right angled bends and the radiation mainly occurs from the discontinuities (bends) of the structure. The right angle bends are chamfered or compensated to reduce the right angled discontinuity susceptance for

impedance matching. The current directions are changing in every half wavelength and there are more than four half wavelength changes in this design. The radiations from the bend add up 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 substrate, FR4 and is shown in Figure 1, the top view of the proposed design with certain dimensions of the substrate.

III. LAYOUT

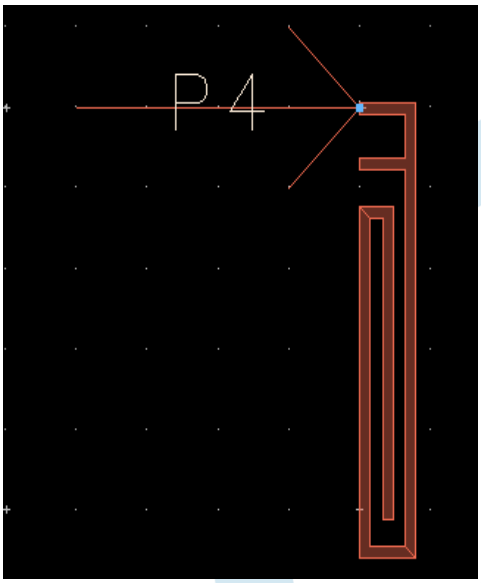

Figure1: Meander-line MIMO antenna

IV. 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 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.

V. MEANDER LINE ANTENNA

There are various techniques to miniaturize the size of micro strip antennas: 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. The basics of meander line antenna, is to fold the conductors back and forth to make the overall length of antenna shorter than the original length of straight wire. The design of meander line antenna is a set of horizontal and vertical lines which forms turns, as number of turn's increases, efficiency increases. In case of meander line if meander spacing increases with respect to that the resonant frequency decreases. In basic form meander line antenna is a combination of conventional wire and planar strip line which includes the benefits of configuration simplicity, easy integration to wireless devices and potential for low specific absorption rate features.

VI. SIMULATION

The proposed meander line based reconfigurable MIMO antenna was modeled and simulated using ADS software. The layout is designed on FR4 substrate in the software with certain dimensions and the required range of frequency is to be given. Simulation result is obtained for the designed system as per the required frequency and return loss of -10dB with better performance.

ADS (Advanced Design Systems) is used in designing 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, especially for RF PCB/laminates, Silicon Dummy metal fill utility.

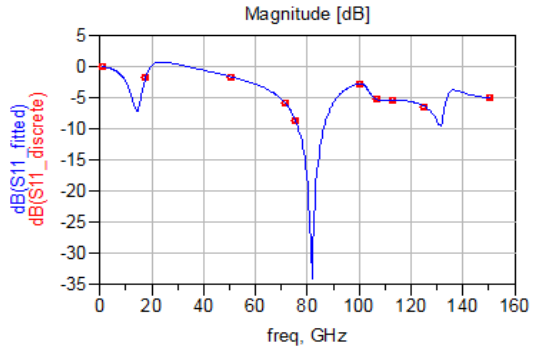

Figure 2 : Simulation result of meander-line antenna

VII. Conclusion

A novel, compact, single board antenna system is presented for mobile CR applications. The complete systems consist of planar reconfigurable MIMO antennas integrated with two meander line antennas on same substrate. The designed antenna covers the frequency bands above 1 GHz. The reconfigurable multi-band, multi-mode antenna was also evaluated for MIMO operation where it showed good performance. The total space occupied by whole design was 65×120×1.56 mm3 which is very compact covering the required bands of frequencies.

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