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A Frequency Reconfigurable Monopole Antenna with Switchable Symmetric Slot Strcture

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Abstract: *In this paper, a novel compact frequency-reconfigurable monopole antenna with switchable symmetric slot structure is presented. The frequency-reconfigurable capability of the antenna is achieved by using a switchable slotted structure on the ground plane. The designed antenna has a simple structure and compact size of 40X40 mm . The antenna, which supports most applicable frequency bands above 2 GHz The UWB monopole antenna can be reconfigured by using a slotted structure placed on the ground plane.The antenna is further modified with a symmetric slot structure.By placing slot on the patch makes this antenna to avoid a particular band of frequency.So the resulting antenna posses band notch effect.,can be used in multiradio wireless systems. Moreover, the proposed antenna, which has a combined dual and narrowband functionality.The antenna is intended for use in multiradio wireless applications, cognitive radio,(MIMO) and satellite communication.*

Keywords: *Antenna, p-i-n diode, reconfigurable, switchable filter, cognitive radio(CR), Ultra-wide and(UWB*)

I. Introduction

The IEEE Standard Definitions of Terms for Antennas defines the antenna or aerial as "a means for radiating or receiving radio waves". For a wireless communication system, antenna is one of the most critical component. A good design of the antenna can relax system requirements and improve overall system performance. Microstrip patch antennas are widely implemented in many applications, specially in wireless communication. This is mainly due to attractive features such as low profile, light weight, conformal shaping, low cost, high efficiency,simplicity of manufacture and easy integration to circuits. However the main disadvantage of the micro strip patch antenna is its inherently narrow impedance bandwidth.

Due to the fast development of electronics and wireless communications, the demand for mobile devices operating at different standards or for different applications is extending. On the other hand, wireless systems are evolving toward multi-functionality. A reconfigurable antenna has the tunable fundamental characteristics, including operating frequency, impedance bandwidth, radiation pattern, and polarization, is a well-suited candidate for providing multi-functionality.Cognitive radio (CR), which is considered as the future of communications, needs a sensing antenna with the capability to monitor the spectrum, and a communicating antenna that can be reconfigured to communicate over a chosen frequency band. This has led to an elevated interest in the development of frequency reconfigurable antennas to utilize the spectrum efficiently [2].Also can be used for multiradio wireless applications, and satellite communication.

Frequency-reconfigurable antennas are antennas only capable of switching between different narrowband modes. In [3], a switchable antenna by using a micro electromechanical systems (MEMS) switch has been proposed. By controlling the states of switches, the patch antenna in [4] can operate in different frequencies. Recently, a number of reconfigurable antennas have been presented that combine wideband and narrowband functionality. By using four photoconductive switches, Configuration of the UWB monopole antenna. Reconfigurable antenna that has dual band mode and narrowband modes has been designed. In [9], two reconfigurable monopole antennas with combined wideband and narrowband functionality have been proposed—the first antenna by employing p-i-n diode switches, and the other using varactor diodes. In this letter, we propose a frequency-reconfigurable antenna with symmetric slot structure is designed. The designed antenna is able to operate in dual band and narrow band modes. The proposed antenna different switchable states: 2.51-6.09 GHz, 2.33-5.04 and 7.09-9.57 GHz, 1.72- 3.72 and 3.96 -4.08 GHz, 3.69-4.34, 4.83- 5.8 GHz. The antenna uses a switchable symmetric slotted structure for configurability, has a simple structure and smallest size. Then the antenna is modified by placing a slot on the patch. This wiil introduce the antenna to a band notch effect in the range of 5.2-5.8 GHz. Details of the proposed design are described..

II. Ultra Wideband Antenna Design

2.1.Introduction

For the design of a reconfigurable antenna we require a wide band antenna. So, a UWB monopole antenna has taken as the basic antenna. By including slots and switches appropriately in the designed structure the antenna can be reconfigured in the UWB range.

A reconfigurable antenna has tunable fundamental characteristics, such as operating frequency, impedance bandwidth, radiation pattern, and polarization, is a well-suited candidate for providing multifunctionality.The antenna system for a cognitive radio is an integral part for its implementation. Two antennas are required for a CR system, first a wide band antenna which is usually a UWB antenna and the other is a narrow band antenna which have the frequency reconfiguration property. A UWB antenna is used to sense the spectrum in the range of 3.1GHz to 10.6GHz in order to find a vacant slot. The moment a vacant slot is obtained, the secondary user uses the narrow band antenna for transmitting data through that vacant slot. If the primary user needs that slot back for its use, then the frequency reconfiguration property which is integrated with the narrow band antenna helps to continue the data transmission through another vacant slot in the specified spectrum.

2.2. UWB Antenna Design

Here a circular monopole antenna has been chosen as a basic structure due to the fact that it can operate over wide bandwidth and has good radiation characteristics. Fig. shows the configuration of the proposed UWB monopole antenna. The antenna is constructed on an FR4 substrate with the relative permittivity of 4.4 and thickness of 1.6 mm. The size of the substrate is 40X40 mm. The radiating element is a circular patch with radius of 10 mm, which is fed with a 50- microstrip feed line with the length of 20 mm and width of 2.86 mm. On the bottom of substrate, there is a ground plane with 19X40 mm dimensions below the microstrip feed line.

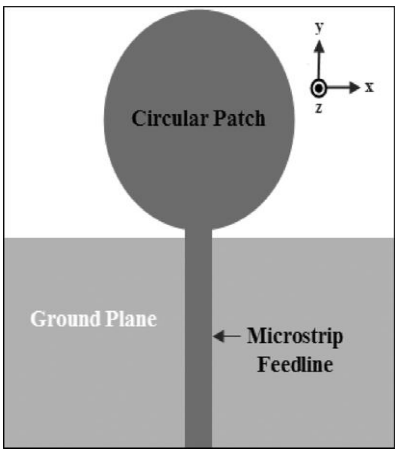

Fig.1 configuration of the proposed UWB monopole antenna.

Designing of circular monopole antenna can be done using the transmission line equations.In typical design procedure,

The essential parameters are Frequency of operation(fr):The resonant frequency of antenna must selected appropriately. resonant frequency selected for my design is 3.1 Ghz

Dielectric constant of the substrate(ɛr): Dielectric constant of the substrate playes an important role in antenna design.A substrate with high dielectric constant reduces the dimensions of the antenna but also affect the performance.So,there is a trade of between size and performance of patch antenna

Hight of the substrate (h):For the microstrip antenna to be used in communication systems,It is essential that the antenna not bulky.Hence the hight of the dielectric should be less.

III. Design Of Frequency Reconfigurable Antenna With Symmetric Slot Structure

3.1 Introduction

In the designed the uwb antenna a symmertric solt structures is placined on the ground plane. The main slot has a length and width of 35mm and 1mm . vertical arm length is designed at a length of 1.2mm and width of 3.5mm.The slot structure placed on the ground act as a filter.it passes certain frequency bands.By tuning the diode conditions the antenna is able to operate at single and dual band modes.

The symmetric slot structure results a reasonable gain and acceptable return loss in different diode configurations.

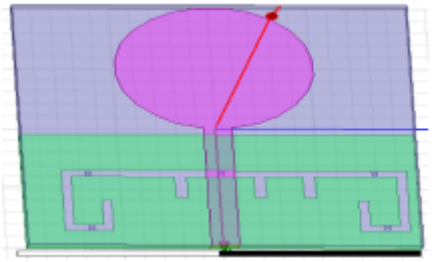

Fig 3.1. Frequency reconfigurable antenna

Details Of P-I-N Diode Combinations And Simulated Frequency Bands In Each State

Diodes	D1 D2 D3 D4 D5	Frequency of operation(GHz)
State 1	on on on on on	2.51-6.09
State 2	on off on off on	2.33-5.04 and 7.09-9.57
State 3	off off off off off	1.72- 3.72 and 3.96 - 4.08
State 4	on off off off off	3.69-4.34
State 5	on on off on on	4.83- 5.8

3.2 Design Of Frequency Reconfigurable Antenna

The frequency-reconfigurable capability of the antenna is achieved by placing four switches inside the slot structure. Then we can adjust the condition of switches .This will make changes in the ground slot structure of the antenna, and make the antenna reconfigurable. Reconfigurable capability is achieved by inserting a set of p-i-n diode switches inside slot structure on the ground plane. Upon varying the switch conditions different operating frequency bands of antenna will obtain. For
applying the dc voltage to p-i-n diodes, metal strips with dimensions of 2 to 0.6 mm were used inside the main slot. Moreover, for each p-i-n diode, a 100-pF dc blocking capacitor was placed in Moreover, for each p-i-n diode, a 100 pF dc blocking capacitor was placed in the slot to create the RF connection of the p-i-n diode and also to isolate the RF signal from the dc.

In the design, HPND-4005 beam lead p-i-n diodes with extremely low capacitance were used. For biasing of p-i-n diodes a 0.7-V supply is applied to metal strips. The p-i-n diodes exhibit an ohmic resistance of 4.6 and capacitance of 0.017 pF in the ON and OFF states, respectively. By turning diodes on, the metal strips are connected to the ground plane and become a part of it. The desired frequency band can be selected by varying the states of p-i-n diodes, which changes the total equivalent length of the slot.This equivalent length will determines the operating frequency of the antenna at that state. The performance of the proposed antenna was simulated and optimized with the Ansoft High Frequency Structure Simulator (HFSS). According to the technical data sheet of the HPND-4005, p-i-n diodes are simulated as a 4.6- resistor and 0.017-pF capacitor in the ON and OFF states.

IV. Band Notch Activity

4.1 Introduction

In order to avoid a particular band of frequency a slot is included in the patch of the antenna.here the slot is designed to attenuate a specific frequency. From all the results we can found that the antenna is not operating in the frequency range of 5.2 5.8 GHz. consider the simple monopole antenna in which it ' s range of operation is 3 to 10 GHz.When we included the monopole with the slot of the patch attenuates
this frequency(5.2 5.8 GHz).

4.2. Band Notch Activity In UWB Monopole Antenna

The below figure 4.1 shows that frequency of operation of antenna without placing a slot on the patch.The proposed antenna operating in the UWB(3.1-10.6 GHz) range.figure 4.2 shows frequency of operation of antenna with slot on the patch.Now the antenna is tuned in to single band mode.The resulting antenna is not operating in the range of 5.2 to 5.8 GHz.So, from this we can see that the antenna shows a band notch effect at these frequency range

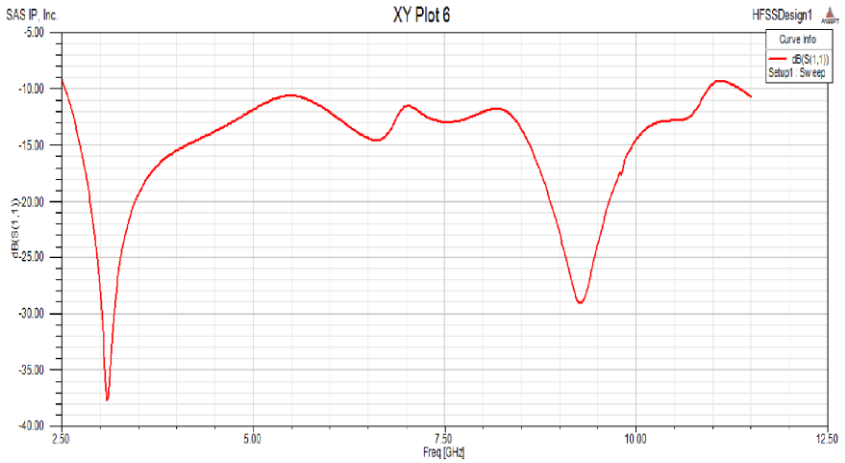

Figure 4.1: Return loss curve of monopole without slot on the patch.

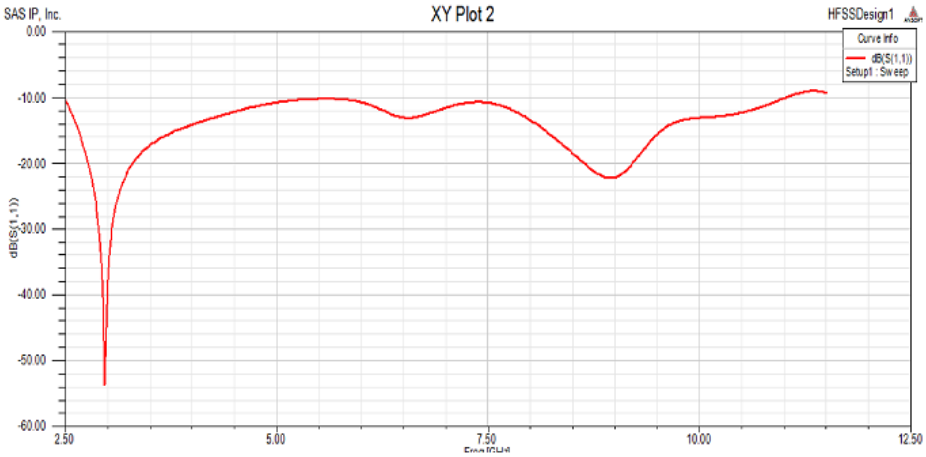

Figure 4.2: Return loss curve of monopole with slot on the patch.

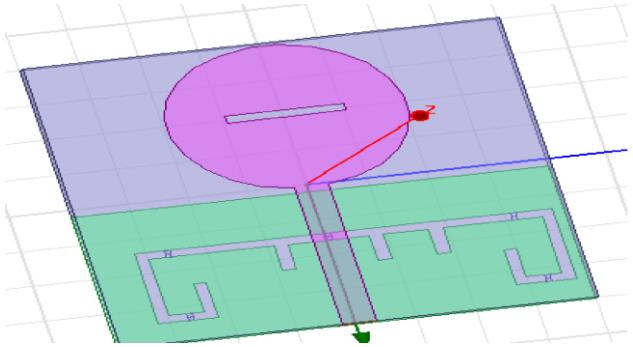

Figure 4.3: Reconfigurable antenna with slot on the patch.

The main reason to choose this frequency to attenuate is ,in most times this is the most usable frequency .When we avoid data transmission through this frequency.this will reduce unwanted delay in transmission. So it increases the data transmission rate. The reconfigurable antennas are mainly used for cognitive Figure 15.1: Antenna with a slot on patch radio applications.The antenna is a part of the entire system,The algorithm in CR checks which frequency is available.Whenever it found that a particular frequency is not used by user.Then using a cognitive radio system we can transmits data through that band

Details Of P-I-N Diode Combinations And Simulated Frequency Bands In Each State

Diodes	D1 D2 D3 D4 D5	Frequency of operation(GHz)
State 1	on on on on on	2.1-4.17
State 2	on off on off on	6.67-9.33 and 2.9-5.11
State 3	off off off off off	2.13-3.73
State 4	on off off off off	2.11-2.83 and 3.71-4.21
State 5	on on off on on	5.32-5.94

5.2 Results

Consider state 1 to state 4 the antenna is tuned to single band and dual band modes.Now consider the state 5,in this case the frequency operation is 5.32 to 5.94GHz.But gain of the antenna is in negatives.Therefore the designed antenna will not operate efficiently in this frequency range. From all these results we can see that the band 5.2 - 5.8 is removed.The resulting antenna operates in different narrow band and dual band modes with acceptable gain and return loss.With the elimination of the particular band the data transmission rate increases also unwanted delay for transmission reduces.

In this work,a circular UWB antenna has designed and simulated, also slots are included in the ground plane.The software used to model and simulate the proposed antenna was Ansoft HFSS, which is an industry-standard simulation tool for 3D full-wave electromagnetic field simulation. .

Here we designed and simulated ultra wide band antenna and also included slots on the ground plane.The designed UWB antenna now operates at two different narrowband frequencies(5.15-5.9 GHz and 3.32-3.7 GHz). First we designed bandwidth of 3.1GHz -10 GHz having circular patch antenna on a FR4 substrate with dimensions of 40X40mm.

V. Conclusion

A novel reconfigurable monopole antenna with completely switchable frequency bands has been presented. The antenna uses a switchable slotted structure on the ground plane to deliver the reconfigurable capability. The proposed antenna is simple to design and fabricate and exploits five p-i-n diodes for switching in to different bands. The designed antenna operating at single and dual-band modes. On the desired frequency bands the antenna is able to operate at different switching states with a reasonable return loss. More narrow bands can be achieved by inserting additional p-i-n diode switches inside the structure. Good radiation patterns and acceptable gain values were obtained for different operating states of the proposed reconfigurable antenna. The slot on the ground plane is modified in to a symmetric structure, the resulting antenna becomes more compact and light weight. Also the radiation patterns are omnidirectional. The designed slot on patch, makes this antenna to avoid a particular band of frequency. So the proposed antenna possess band notch effect, by avoiding data transmission through this frequency. This will reduce unwanted delay in transmission.so the antenna can achieve high data transmission rate. The antenna is intended for use in multiradio wireless applications, cognitive radio,(MIMO) and satellite communication.

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