DESIGN OF COMPACT MONOPOLE ULTRA WIDE BAND ANTENNA STRUCTURE FOR COGNITIVE RADIO APPLICATIONS

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Abstract— A novel antenna structure is proposed by incorporating the PIN diodes within the slots of a octagonal patch antenna structure for achieving the reconfigurability. This technique is employed to achieve multiband operation of the antenna and the reconfigurability is achieved through switching. The octagonal patch is of compact size and is fed through a 50Ω microstrip. The antenna parameters have been investigated through simulation using CST software and the relative parametric analysis is presented. It has been demonstrated that the proposed antenna provides an ultra-wideband width (UWB) from 3GHz to 10.6 GHz completely covering the range set by the Federal Communication Commission (FCC) for UWB applications also in cognitive radio (CR) applications. The slots at suitable size and position are intended for operating the antenna at multiple frequencies i.e Ultra Wide Band operation (UWB) and the switching has been employed for achieving the desired frequency ranges. This operation is better utilized for communicating with the spectrum which is the primitive requirement of the CR. The combination of PIN diode switches in the slots provided along with the antenna changes the frequency by dynamic operation of the switching state to either on or off mode. The electrical lengths are varied by operational switches on and off. By the proper activation/deactivation of the switches alters the present flow and changes resonance frequency. This paper presents a simulated compact, low cost, high gain, good radiating properties monopole octagonal shaped frequency reconfigurable antenna for multiband operation together with the results.

Index Terms— Monopole Octagonal shaped, Slots, switching, Reconfigurability, Cognitive Radio, Ultra Wide Band, CST.

I. INTRODUCTION

The blooming growth rate of modern wireless communication throws an important challenge on the effective usage of the electromagnetic spectrum which is a natural recourse. There is a vast necessity of the new communication technique to exploit the effective utilization of the spectrum. The Cognitive Radio (CR) first introduced by Joseph Mitola III in 1991 provides the capability to share the spectrum in an efficient way by the dynamic allocation techniques. This technique provides the spectrum to the unlicensed users when it is idle and without disturbing the licensed users by utilizing the white holes i.e., the unused portion of the spectrum.

The dire need of frequency reconfigurability, software control capability, necessitates the modern antenna systems in many of the applications in wireless communication including CR/ SDR networks. Thus, the antenna systems for CR must sense the wide band and should operate at the desired and available frequencies. Therefore the antenna systems for CR must have the competence of operating over wide band and also have the capability of the reconfigurability to communicate with the spectrum at the available frequencies.

Spectrum Overlay and underlay techniques for the effective spectrum sharing have been considered and Ultra wideband Technology is the most promising way to enable this technology [1]. Ultra wide band (UWB) technique is the most promising technology for operating over wide bandwidth i.e from 3.1GHz-10.6GHz as per the recommendations by the Federal Communication Commission 2002 [2]. Among the UWB techniques, the planar monopole structures are the most suitable structures owing to their high transmission rate, extremely low power consumption and simple hardware configuration and nearly omni directional patterns [3]. Many of the structures have been proposed [4-8] in the literature, but they cover partial parts of the UWB and are complex.

This paper describes a brand new technique of obtaining the narrow band reconfigurable antenna together with UWB, a octagonal patch with rectangular, triangular slots incorporated with PIN diode switching of suitable dimensions and is fed with a 50 Ω microstrip line. The proposed antenna is operating in ultra Wide Band (UWB) range and dynamic switching can be employed for desired frequency range of operation for the communication purposes. The simulations shows that the proposed structure can cover the UWB range a single structure with the better operating performance. This reduces RF front end circuitry, the size of the antenna structure will increase the flexibility to operate at the desired frequencies.

II. ANTENNA GEOMETRY

The geometry of the proposed antenna is shown in Fig.1. The antenna is printed on the FR4 substrate with thickness of 1mm and has the dielectric constant of 4.4 with a dimension of 30mmX25mm. It consists of an
octagonal radiating patch with two slots one is rectangular and the other is in triangular in shape. The slots have been introduced to improve the antenna performance at high frequencies. The antenna has got the dimension of 30mm X25 mm of Length and width. It is fed with a 50Ω microstrip having 8.5 mm length and width of 1.85 mm. A partial ground plane has been introduced on the other side of the substrate with a width of 9mm i.e aligning with the microstrip feed for better impedance matching. The widths of the triangular, rectangular slots are given by 14mm and the rectangular slot is having height of 1mm and triangular slot is of 5mm. The distance between the slots is taken as 8mm. Two PIN diodes have been in corporate in the slots. The size, location and shape of the switches have been achieved by the trial and error approximations. The values of various parts of the slots are first set as aforementioned and to have good matching and low cross-polarization level for all of the three resonances.

![Geometry of proposed antenna Top view](image1)

### III. EXPERIMENTAL RESULTS AND DISCUSSION

#### A. Impedance Bandwidth

By changing the states of the switches the desired frequencies are obtained. The structure without switches will have a normal UWB operation. When both the switches are in OFF state it resonates at three frequencies given by 3.72 GHz, 6.09 GHz, 7.96 GHz with a return loss of -22.60, -19.87, -15.69 respectively as shown in Fig 2.1.

When both the switches are in ON state that is state 2, the structure is resonating at 3.95GHz, 6.83 GHz with a return loss of -28.58, -25.48 respectively as shown in Fig 2.4.

<table>
<thead>
<tr>
<th>State</th>
<th>Switch I</th>
<th>Switch II</th>
<th>Resonance frequencies(GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>State 1</td>
<td>No Switches</td>
<td></td>
<td>UWB OPERATION</td>
</tr>
<tr>
<td>State 2</td>
<td>ON</td>
<td>ON</td>
<td>3.95, 6.83</td>
</tr>
<tr>
<td>State 3</td>
<td>OFF</td>
<td>OFF</td>
<td>3.72, 6.09, 7.96</td>
</tr>
<tr>
<td>State 4</td>
<td>ON</td>
<td>OFF</td>
<td>4.86</td>
</tr>
<tr>
<td>State 5</td>
<td>OFF</td>
<td>ON</td>
<td>7.38</td>
</tr>
</tbody>
</table>

![Fig 2.1 Return Loss for both the switches in OFF State](image2)
The simulation was carried out by using CST (Computer Simulation Technology) Microwave Studio suite [8]. The simulated return loss for various switch positions is shown below and the combinations of switching as tabulated. It can be clearly seen from the results that the proposed antenna structure exhibits a multi band characteristic. Three resonant frequencies at 3.72 GHz, 6.09 GHz, 7.96 GHz with return losses reach -22.60, -19.87, -15.69 respectively. The antenna bandwidth is lower than -10 dB occupies from 3 GHz to 10 GHz. It can operate well in the UWB and cognitive radio applications. The following figures from 2.1 to 2.4 illustrates the return loss of the proposed antenna for different switching conditions.

**Fig 2.2 Return Loss for Switch 1 in OFF state and Switch2 in ON State**

**Fig 2.3 Return Loss for Switch 1 in ON state and Switch2 in OFF State**

In the State 4, when the switch is in OFF and switch 2 is in ON condition it is resonating at 7.38GHz with a return loss of -48.46 alone as shown in Fig 2.2. In state 5, i.e when Switch 1 is ON state and switch 2 is in OFF state the structure is Resonating at 3.86 GHz with a return loss of -28.75 alone as shown in Fig 2.3.

**Fig 2.4 Return Loss for Switch 1 in ON state and Switch2 in ON State**

**B. Radiation Pattern**
The Figures 3.1 – 3.4 shows the simulated E-Plane & H-plane patterns at various frequencies for various switching positions. Fig 3.1 illustrates the at X-Z ($\phi=0^\circ$) and Y-Z ($\phi=90^\circ$) plane radiation patterns for 3.94 GHz, 6.82 GHz for state 2 condition, i.e both the switches are in ON state. The result shows that the radiation pattern of X-Z plane at 3.94 GHz, 6.92 GHz is two-way with the main lobe at $\theta=0^\circ$ and 180. it is same as that of a simple monopole antenna. The radiation pattern of Y-Z plane at these frequencies is almost omni-directional which is appropriate for UWB communications.

Fig .3.1 Radiation patterns for $(\phi=0^\circ),(\phi=90^\circ)$ at 3.94 GHz when both the switches are in on state

Fig .3.2 Radiation patterns for $(\phi=0^\circ),(\phi=90^\circ)$ at 6.82 GHz when both the switches are in on state

The Fig 3.3 shows the patterns for the State 4 condition, i.e switch1 ON & switch 2 OFF at 3.83 GHz and Fig 3.4 illustrates the patterns for the State 5 condition, i.e switch1 OFF & switch 2 ON at 7.38 GHz.

Fig .3.3 Radiation patterns for $(\phi=0^\circ),(\phi=90^\circ)$ at 3.83 GHz when Switch 1 is ON and Switch 2 OFF

Design of Compact Monopole Ultra Wide Band Antenna Structure For Cognitive Radio Applications
The main lobe magnitude of above all frequencies varies from 2.6 dB to 5.2 dB. And the gain variation is less than 2.6 dB. This tiny gain variation can cut back the signal distortion at the transmitting and receiving antenna terminals.

CONCLUSION

A novel design of UWB monopole antenna for CR applications has been investigated in this paper. Simulated results show that the proposed antenna exhibits an ultra-wide operation bandwidth from 3.1GHz to 8GHz, with good radiation properties. Future work will be done on validating the simulated results in anechoic chamber and designing a new structure to reduce the interference in the optimization process.

REFERENCES


