Microstrip Patch Antenna with Reconfigurable Band Notches for UWB-CR Applications using SRR, CSRR and ESRR

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Abstract

The proposed work focuses on a Reconfigurable Microstrip antenna to employ in inlay and prime layer Ultra-Wideband Cognitive Radio (UWB-CR) applications. The Defected Ground Structure (DGS) is employed on the ground plane of the antenna to operate at UWB, for prime layer CR and for sensing in the inlay CR. When used in the inlay CR mode, selectively have one, two or three notches in the Bluetooth (2.4GHz), Wi-MAX (3.1 GHz – 3.8GHz) and WLAN (5.1GHz-5.8GHz) to avoid interference to the direct users operating in these bands. The band notch characteristics are achieved by etching the three Split Ring Resonators on the patch namely, Split-Ring Resonator (SRRs), Complementary SRR (CSRR) and Elliptical SRR (ESRR). The SRRs are controlled using three electronic switches which are mounted over it to achieve the Reconfigurability of notch frequencies. The proposed antenna is simulated using CST STUDIO V.14.

I. INTRODUCTION

Due to interesting properties such as light weight, low production cost, low profile and reliability, reproducibility, conformability and compatibility with solid state devices. The Microstrip Patch antenna are used in numerous and wide areas like Biomedical Systems, Military systems etc. But the main drawback is its limited bandwidth which can be overcome by using low dielectric substrate [1], impedance matching [2], feeding techniques [3] and multiple resonators [4]. On the other hand by using the above techniques it may lead to increase in the antenna height, complexity in design [5] and spurious radiations [6]. So to handle the above factors, a new technique Defected ground structures (DGS) is implemented in the proposed design. Hence a DGS based complementary split ring resonator [7-9] with adjustable band notch for Ultra Wide Band Cognitive radio is implemented and simulated using CST MWS V14.0

II. DESIGN METHODOLOGY

Figure.1 illustrates the reconfigurable microstrip patch antenna with dimensions 45mm*55mm. The proposed antenna is laid on a Taconic TLY substrate with εr= 2.2 with a height of 1.6mm. The defected ground plane comprises a PEC material with the dimensions of 45mm*25mm*0.1mm. The shape of the patch is optimized to achieve the UWB operation in various steps.

Step 1: Initially, the designing of the patch started with a rectangular shape. The dimensions of the rectangular patch are 25mm*20.9mm.

Step 2: The ground structure was optimized using DGS and the dimensions of the ground structure are reduced from 45mm*55mm*0.1mm to 45mm*25mm*0.1mm.

Step 3: The patch is optimized using a split ring resonator of dimensions 17.4mm*8.4mm*0.1mm and having the same defected ground structure.

Step 4: A complementary split ring resonator is placed along with the existing SRR on the patch. The dimensions of the CSRR are 13.7mm*4.7mm*0.1mm. DGS is maintained as the previous designs.

Step 5: This design is optimized by placing an ESRR, along with the SRR and CSRR.

The complete design with all the dimensions is shown in figure 2. The designed antenna is able to cause three band notches, which are individually controllable, using three RF switches. The shape of the patch is rectangular and the corners of the patch near the feeding line are partially sliced to provide the matching section. To carve out the band notches, one SRR, CSRR and an ESRR are carved on the patch. Their shapes are preferred to suit the portion of the patch they are fitted in.
III. RESULTS AND DISCUSSION

Figure 3 illustrate the $S_{11}$ plot of the proposed antenna of the optimization step 1. The Return loss of basic design without DGS is -25.50dB at a resonating frequency of 8.864 GHz.

Figure 3. $S_{11}$ plot for the optimization design step 1

Figure 4. VSWR plot for the optimized design step 1
Figure 4 depicts the simulated VSWR plot for the designed antenna in optimization step 1. Practically, the required value for VSWR should be less than 2. This shows the value of VSWR is less than 2 in the operating frequency range of 8.6299 GHz to 9.0768 GHz. The bandwidth of this optimization step is 446 MHz. In second step of optimization the ground plane is etched. The $S_{11}$ is -21.63 dB at a resonating frequency of 5.419 GHz. The return loss plot of optimization step 2 is shown in figure 5. The Bandwidth of the optimization step 2 is 8.4 GHz i.e UWB frequency. VSWR value is less than 2 for the entire frequency range of 2 GHz-10 GHz. The VSWR plot depicted in the figure 6.

The $S_{11}$ plot of optimization step 3 is depicted in figure 7. The return loss is below -10dB for the entire frequency from 2GHz- 10GHz and it rejects frequency centered at 2.4GHz. The VSWR plot is illustrate in figure 8.

The $S_{11}$ plot of optimization step 4 is illustrated in figure 9. The $S_{11}$ of -30.33 dB is observed. In this optimization the two band notch frequencies are achieved at 2.4 GHz and 4.2GHz respectively. The VSWR plot is illustrated in figure 10.

The return loss plot of optimization step 5 is shown in figure 11. In this optimization the band notch frequencies are obtained at 2.4 GHz, 4.2 GHz and 5.2 GHz respectively. The VSWR plot is illustrated in figure 12.
Figure 13. 3D-Radiation field Pattern of the designed antenna

Figure 13 illustrates the 3D-radiation field pattern of final design. It gives the maximum directivity of 5.265 dB at a frequency of 7.976 GHz.

Optimizing the sizes of the SRR induces a notch in the 2.4 GHz band, the CSRR in the 3.5 GHz band, and the ESRR one in the 5.2 GHz band. To endure band notch Reconfigurability, three electronic switches (S1, S2, and S3) are affixed across the SRR, CSRR and ESRR. The switch combinations are illustrated in figure 14.
The eight switching combinations along with the band notch frequencies are tabulated in table-1.

### Table 1. Band Notch Frequencies along with Eight Switching Combinations

<table>
<thead>
<tr>
<th>Case</th>
<th>Notch Bands (GHz)</th>
<th>S₁</th>
<th>S₂</th>
<th>S₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>2</td>
<td>2.4</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>3</td>
<td>3.5</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>4</td>
<td>5.2</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>5</td>
<td>2.4, 3.5</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>6</td>
<td>2.4, 5.2</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>7</td>
<td>3.5, 5.2</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>8</td>
<td>2.4, 3.5, 5.2</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
</tbody>
</table>

### IV. CONCLUSION

The main aim of this work is to evolve the UWB wearable textile antenna, which can operate in the frequency band 3.1 GHz- 10.6 GHz. The work is validated and verified by using CST MW Studio. The performance of all the optimized designs of the proposed antenna is analyzed using CST MW Studio. All the results are analyzed in terms of S₁₁. The basic design, S₁₁ is -25.5044 at a resonating frequency of 8.864 GHz. The second optimized design provides a return loss value of -21.63 at a resonating frequency of 5.419 GHz. It has been further optimized with a return loss of -28.432 at a resonating frequency of 2.168 GHz. The fourth optimization step is obtained with a return loss of -30.33 at a resonating frequency of 4.328 GHz. The final optimized design provides a return loss at -22.86 at a resonating frequency of 7.976 GHz. We can selectively have one, two or three notches. One in the Bluetooth (2.4GHz), next in the Wi-MAX (3.1 GHz – 3.8GHz) and another in the WLAN (5.1GHz-5.8GHz) to avoid interference to the direct users operating in these bands. The band notch characteristics are achieved by etching the three Split Ring Resonators on the patch. They are SRRs, CSRR and ESRR. These are controlled using three RF switches affixed over these split rings to achieve the Reconfigurability of notch frequencies. Eight different combinations can be achieved by using these three switches and different band rejections can be made according to the necessity.

### REFERENCES


