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Design of A CSRR Based Directional Antenna for WLAN Application

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Abstract—*A CSRR based dual band, directional rectangular patch antenna is proposed in this paper. The proposed antenna is basically a rectangular patch with a CSRR structure on the top of the patch. There are two additional slots near the CSRR structure. It has a major lob normal to the direction of the patch and there is no significant back lobe or side lobe. Microstrip line based inset feeding technique is used to feed the antenna. There is an additional pair of slits along the sides of the feeding line. The antenna resonates at 2.4 GHz and 4.7 GHz. The antenna is basically a rectangular patch with a CSRR on the top of the patch. The antenna has a wide bandwidth of 100 MHz at each of its resonant frequencies.*

1. INTRODUCTION

Microstrip antennas have received wide attention in the past few decades because of its small size and easy installation in portable electronic gadgets. These antennas have made contributions in the miniaturization of modern electronic communication gadgets like mobile phones, bluetooth devices, dongles etc. Theoretically, the length of a rectangular patch antenna is slightly less than half of the resonant wavelength of the antenna [1]. A number of novel approaches have been evolved over the past two decades for improving these antennas by reducing the sizes and increasing their bandwidths. Research works are still going on all over the world for further improvement.

Complementary split ring resonator (CSRR) structures and its different variants are popular among researchers for enhancing the performance of microstrip antennas and different other microstrip transmission line based systems. The use of CSRR reduces the electrical size of an antenna [2-3] and also helps to get resonance at multiple frequencies [4-5].

In this work, a CSRR based rectangular slotted patch antenna is proposed. When a CSRR structure is etched from the ground plane below a rectangular patch, the antenna has a large back lobe [6]. In the present work, the CSRR structure is placed on the top of the antenna and hence there is no significant back lobe. The antenna is dual band with resonance at 2.4 GHz and 4.7 GHz. In both of the resonant frequencies, the antenna has a radiation pattern normal to the patch. The antenna is simulates using Ansoft HFSS® and fabricated in a dual layer copper-FR4 printed circuit board (PCB) board with the help of an aqueous solution of ferric chloride. The fabricated antenna is tested in a vector network analyzer (VNA).

The following sections of the papers are organized as follows. Section 2 covers the topology of the proposed antenna. The experimental results are discussed in Section 3. Finally, the work is concluded in Section 4.

2. TOPOLOGY OF THE PROPOSED ANTENNA

The antenna is designed on an FR4 epoxy substrate which has a relative permittivity (ε_r) value of 4.4. The antenna is basically a rectangular patch with a CSRR structure on the top of the patch. There are two additional slots near the CSRR structure. Microstrip line based inset feeding technique is used to feed the antenna. There is an additional pair of slits along the sides of the feeding line. The antenna is shown in Fig. 1.

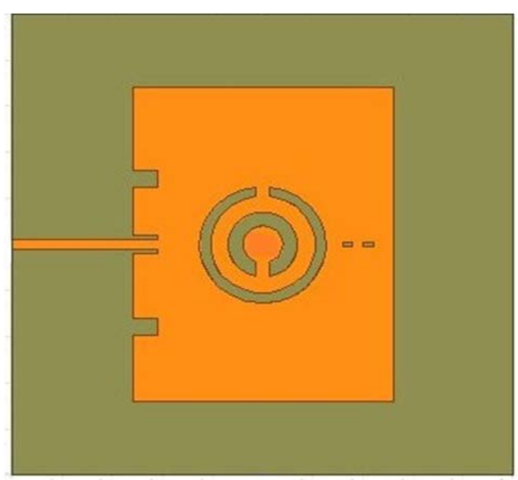

Fig. 1: The proposed patch antenna with CSRR at the top of the patch.

The width of the patch is 38mm and the length of the patch is 29mm. The thickness of the substrate is 1.5mm. The feeding microstrip line is 1 mm thick. The size of the substrate and the ground plane is 70mm × 60mm.

3. EXPERIMENTAL RESULTS AND DISCUSSION

In this section, the various simulation based experiments performed and their results are discussed. The fabricated a

3.1 Simulation Results of the Proposed Antenna

The frequency versus S11 parameter in dB plot of the proposed antenna is shown in Fig. 2. The antenna has a return loss of -17.5 dB at 2.4 GHz and -18.7 dB at 4.7 GHz.

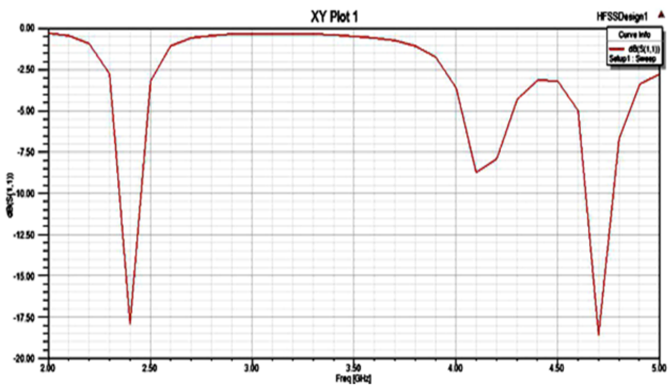

Fig. 2: Frequency vs. S11(dB) plot of the antenna

The far field gains of the antenna at the two frequencies are shown in Fig. 3(a) and Fig. 3 (b) respectively. It is observed that the antenna has a directional beam at 2.4 GHz along the Z axis, perpendicular to the patch antenna. At 4.7 GHz also the antenna has a directed beam along Z axis, but the lobe is wider.

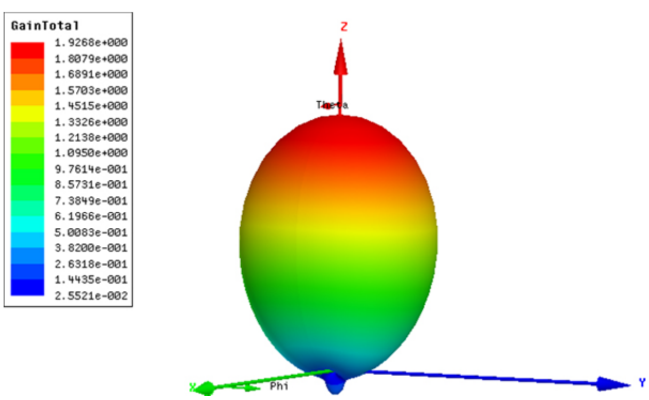

Fig. 3(a) 3D far field radiation pattern of the antenna at 2.4 GHz

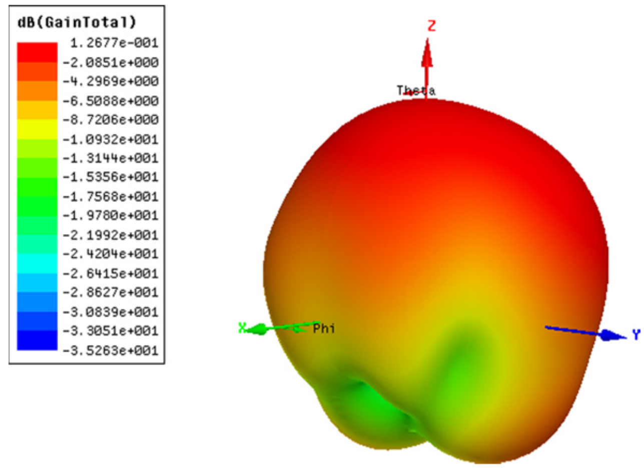

Fig. 3(b) 3D far field radiation pattern of the antenna at 4.7 GHz

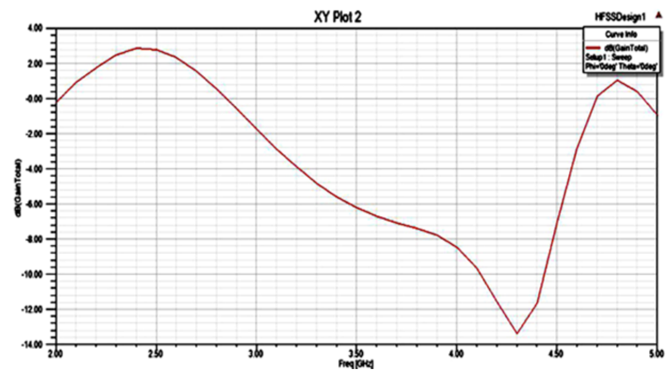

Fig. 4: Frequency vs. far field gain plot of the antenna

The frequency vs. far field gain plot of the antenna is shown in Fig. 4. It is observed that the antenna has a high gain at its resonant frequencies 2.4 GHz and 4.7 GHz. Although the S11 parameter plot at Fig. 2 suggests that the antenna also resonates at 4.3 GHz, the gain of the antenna is very low at that frequency. This is due to the negative permittivity effect of the CSRR structure. Due to this effect, the antenna is not usable at 4.3 GHz.

3.2 The Fabricated Antenna and Measurement Result

The antenna is fabricated in a dual layer copper-FR4 epoxy PCB with the help of am aqueous solution of ferric chloride. The antenna is then tested on a VNA. The fabricated antenna is shown in Fig. 5.

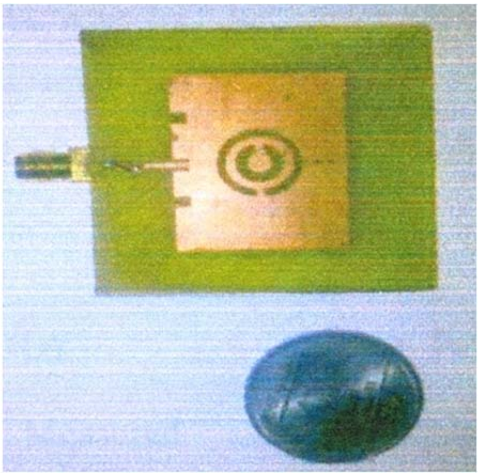

Fig. 5: The fabricated antenna

The frequency vs. S11 parameter (dB) plot of the fabricated antenna obtained from VNA is shown in Fig. 6.

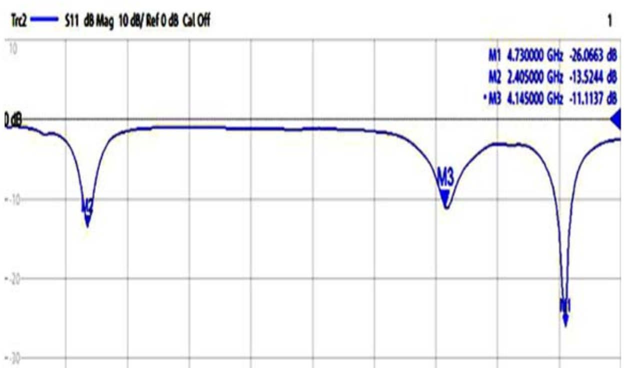

Fig. 2: Frequency vs. S11 (dB) plot of the fabricated antenna from VNA

From the VNA result is observed that the fabricated antenna resonates at 2.4 GHz and 4.73 GHz. The S11 parameters of the fabricated antenna at the two resonant frequencies are -13.5 dB and -26.03 dB respectively.

3.3 Discussion

It is observed that the resonant frequencies obtained from the simulation and the fabrication results match closely. However, the measured values of the S11 parameters differ from their simulated counterparts. This is due to some minor error in fabrication. The dimensions of the slots may be slightly different from the actual dimensions.

4. CONCLUSION

A complementary split ring resonator based dual band, directional patch antenna is designed and fabricated. The antenna is suitable for WLAN application at 2.4 GHz. In addition, it can also be used at 4.7 GHz. The antenna is tested on both simulation and measurement setup. Unlike the CSRR based antennas presented in [6], this antenna does not have a back lobe. This is due to the CSRR being etched from the patch instead of the ground plane.

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