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Designing and Development of Metamaterial Inspired Antennas for Multiband Wireless Communications

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Abstract: Wireless communication plays a vital role in transmitting information from one point to another. Wireless devices have to be smart, intelligent, compact in size, and cost effective to meet the demand of wireless communication. A multi-layered, Split Ring Resonator (SRR), negative permeability material inspired antenna has been designed, analyzed, fabricated, and measured. The developed antenna resonates at 1.19 GHz, 2.31 GHz, 2.68 GHz, 4.75 GHz and 5.60 GHz frequencies with bandwidth of 2.10%, 2.81%, 3.05%, 4.16% and 2.09% respectively. The structure utilizes FR4 material as a substrate. The engineered model has applications in navigation, WiFi, mobile and satellite communication applications.

Index terms – Metamaterial antenna, partial ground, micro-strip feed, wireless communications

1. INTRODUCTION:

The growth of wireless communication demands a structural change in multiband antenna design to meet the present industry requirement. The requirement needs a smart, compact antenna that covers the application-oriented frequencies for navigation, WiFi, and satellite communication. In order to get the desired response, various feeding techniques could be utilized, viz., microstrip line feed, insert feed, and quarter-wave feed. The presented design utilizes a quarter-wave feeding technique to meet the maximum impedance matching requirement. The left-handed material helps to reduce the size of an antenna significantly and get the desired frequency bands for specific applications. Metamaterials are artificial materials that show negative permittivity and permeability for certain frequency spectrum [1– 4]. Split Ring Resonator (SRR) is considered a fundamental block for metamaterials. The artificial metamaterials make themselves suitable for enhancing the electromagnetic properties of any microwave devices such as antennas. It also enhances filter performance with overall structure compactness and application-oriented frequency resonance [5, 6]. Dual-band microstrip antennas could be used for higher frequency performances [7]. Complementary Split Ring Resonator (CSRR) could also be an effective technique to enhance antenna performance [8]. The literature also exhibits a combination of microstrip slot and SRR which plays a significant role in designing a miniaturized antenna for dual-band performance [9]. The radiation characteristics and miniaturization techniques have been systematically covered in [10]. The researchers have also tested the SRR technique to get an adequate response from reconfigurable antennas [11]. The literature also covers a wide spectrum of miniaturization without the presence of SRR/CSRR; however, optimum size reduction may not be achievable [12, 13]. There are many effective and interesting techniques are available for antennas miniaturization and bandwidth enhancement like negative refractive index materials [14-18], planar inverted antennas[19-21] and frequency selective surfaces. Dielectric Resonator antennas, however, without major fabrication stress can provide high gain and wide bandwidth. DRAs offer the benefits of high radiation proficiency, simplicity of excitation, little size, and wide data transmission [22,23]. Optimum designing of an antenna plays a major role in its application for wireless communication. Electrically small antenna could be utilised for RFID, GPS and IEEE 802.11 a/b/g/s Applications. In this manner, DRAs could be the appropriate candidate for wireless communication applications.

The figure 1 shows the systematic flow of claimed antenna development.

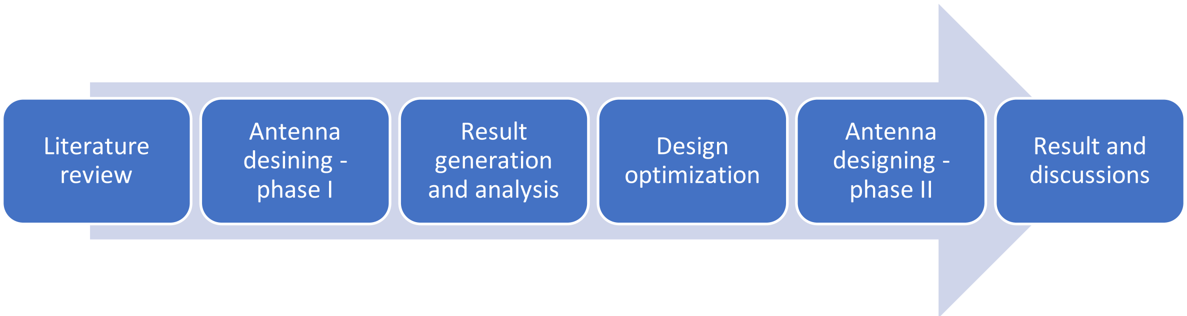
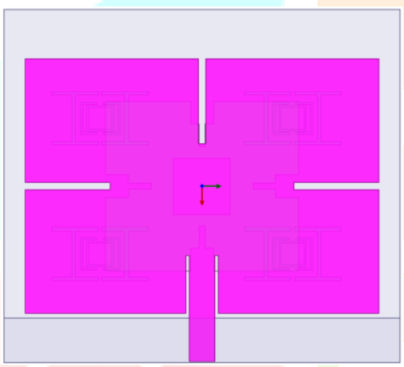


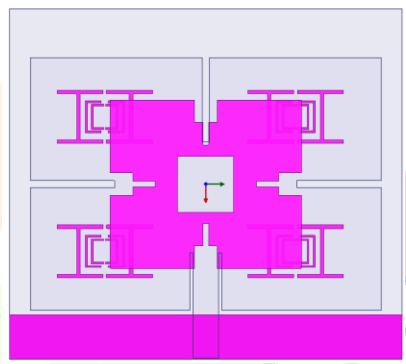
Figure 1: Flow of antenna development

II. ANTENNA GEOMETRY

The following figure 2 contains sandwich shape structure where the primary patch is developed at the top surface. Another patch kind of design is introduced at the middle portion of the structure. The partial ground plane is provided at the bottom surface. The four SRR cells are developed at the bottom surface to receive the optimal response.



(a)



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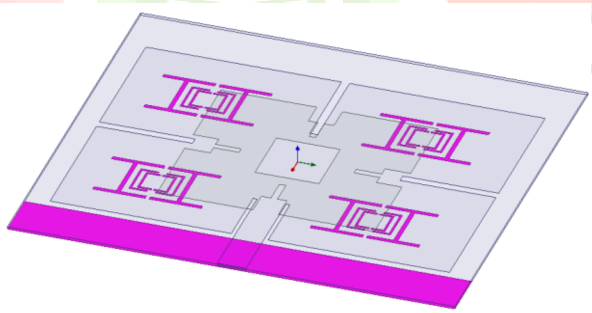


(c)

Figure 2: Antenna design (i) Top View (ii) Back View (iii) Bird eye View

III. RESULT AND DISCUSSIONS:

The figure 3 illustrates the graph of return loss values Vs. frequency variation. The antenna resonates at 1.19 GHz, 2.31 GHz, 2.68 GHz, 4.75 GHz and 5.60 GHz frequencies. The values of reflection coefficients could be improved. However, the similar kind of structure could be developed with additional efforts.

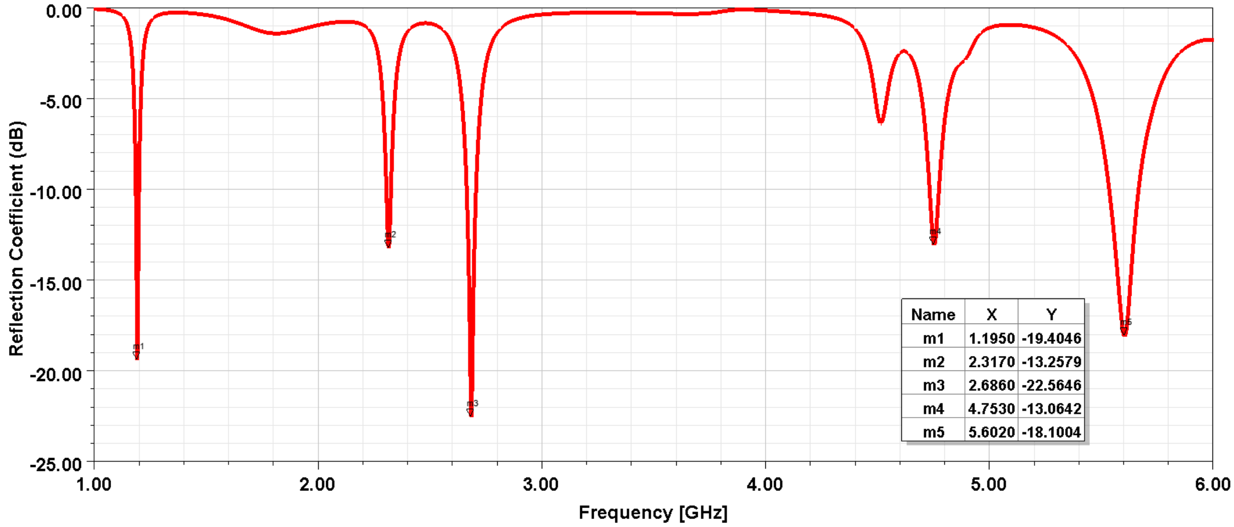
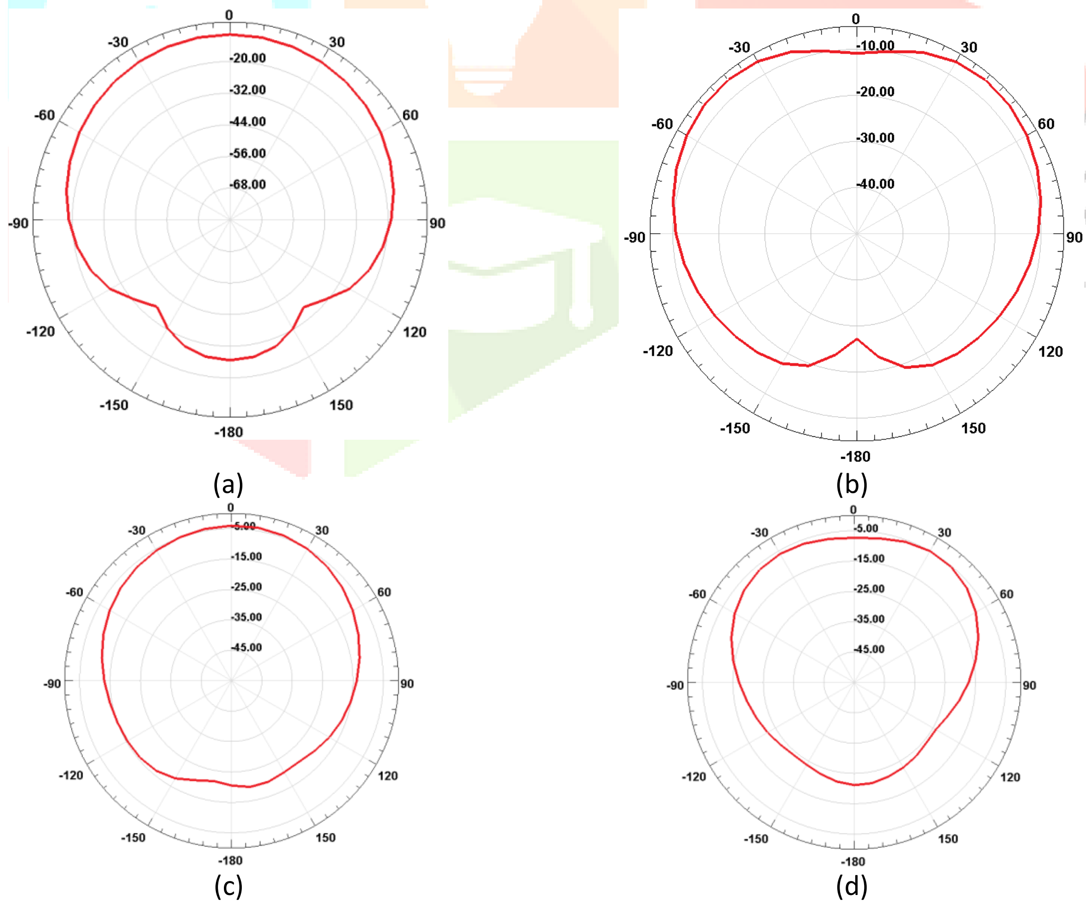
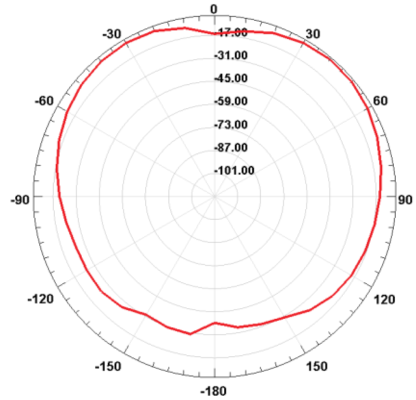


Figure 3: Graph of reflection coefficient vs. frequency

The figure 4.50 gives information regarding 2D radiation pattern of the developed structure at 1.19 GHz, 2.31 GHz, 2.68 GHz, 4.75 GHz and 5.60 GHz frequencies.





(e)

Figure 4: 2D radiation pattern at 1.19 GHz, 2.31 GHz, 2.68 GHz, 4.75 GHz and 5.60 GHz frequencies.

IV. CONCLUSION:

The proposed multilayer antenna meets all necessary parameters for end-user applications targeted at 1.19 GHz, 2.31 GHz, 2.68 GHz, 4.75 GHz and 5.60 GHz frequencies with bandwidth of 2.10%, 2.81%, 3.05%, 4.16% and 2.09% respectively. The developed antenna is well suitable for wireless applications. The desirable performance has been attained for other antenna parameters such as return loss and radiation pattern. The antenna gain can be further increased by using low loss dielectric laminates.

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