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METAMATERIAL BASED NOVEL DUAL BAND ANTENNA

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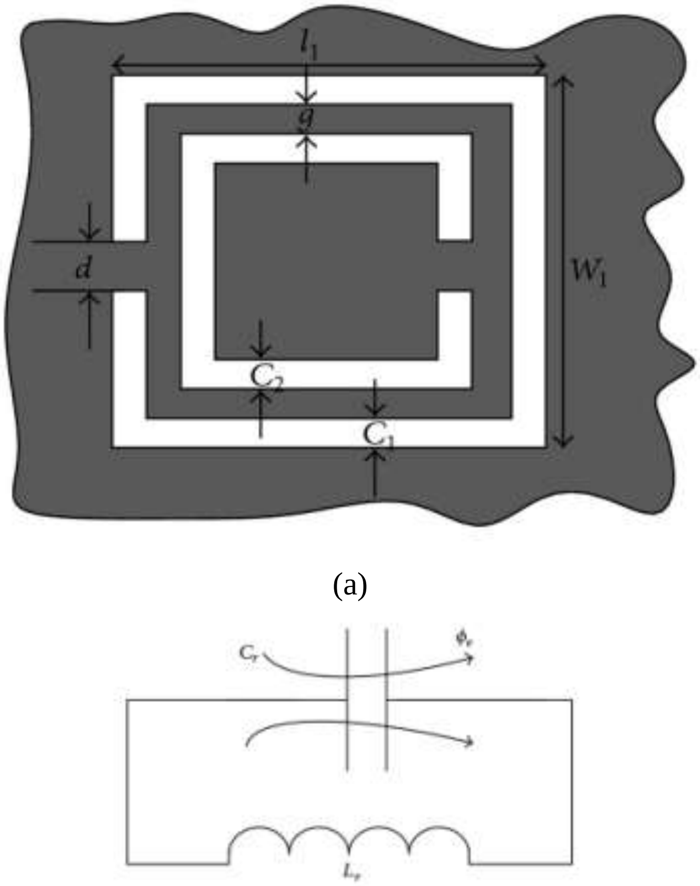
ABSTRACT

A dual-band microstrip patch antenna is designed and analyzed using metamaterial artificial substrate. Metamaterial based substrate is designed using Square Split Ring Resonator (SSRR) and Wire Strip. The antenna is tuned to work at two resonating frequencies in the frequency range from 1GHz to 4GHz depending on the geometric specifications of SSRR, strip line, radiating patch, and feed location point. Proposed antenna provides good return loss behavior at both resonating frequencies. The obtained VSWR at both resonating frequencies is very much near to 1. Proposed antenna covers applications in mobile communication and Wi-MAX. Proposed patch antenna is compared with the conventional patch antenna, which shows the significant miniaturization as compared to conventional patch antenna.

Keywords: Metamaterial, SSRR, Miniaturization, Negative Refractive Index, Finite Element Method.

I. INTRODUCTION

The demand for small, compact, low-cost antennas has increased tremendously over the past years. Various types of microstrip patch antenna and its applications are discussed. Due to the need for reduced antenna size in both military and commercial spheres, a new approach of miniaturization using metamaterial is proposed in this paper. Metamaterials are a new class of ordered composites that exhibit exceptional properties not readily observed in nature. These properties arise from qualitatively new response functions that are not observed in the constituent materials and result from the inclusion of artificially fabricated, extrinsic, low dimensional in-homogeneities. Such material exhibits permittivity and permeability both negative, and hence they are known as the double negative (DNG) materials, and so they have Negative Refractive Index (NRI), and hence they are also called as the Negative Refractive Index materials or Left-handed material LHM (as they follow left-hand rule). Because of their unusual properties, they offer some interesting changes in radiation characteristics of an antenna. The idea of MTMs has been quickly adopted in research, due to rapidly developing nanofabrication and sub-wavelength imaging techniques. The square split ring resonator and its equivalent electrical circuit are given in Figure 1.



(a)

(b)

Figure 1: (a) Topology and (b) its equivalent circuit model of the SSRR. Gray zone represents the metallization.

II. ANTENNA DESIGN

The Proposed patch antenna is a design using artificial substrate made up of metamaterial using SRR and wire strip. Here square-shaped split ring resonator and a wire strip are used to make metamaterial design. Wire strip ensures negative permittivity and SRR ensures the negative permeability. When both structures are combined together, then they simultaneously offer negative permittivity and negative permeability and hence it becomes double negative metamaterial. The geometry of proposed patch antenna with parameters is shown in Figure 2. The antenna is mounted on an FR4 epoxy substrate and fed by a coaxial transmission line. Patch and ground plane are made of copper having relative permittivity as. The substrate material FR4 epoxy has relative permittivity as and dielectric loss tangent. SRR and wire strip structure is made of copper and inserted in between the substrate as shown in Figure 2. Copper thickness is 0.03mm. Excitation to patch is given by coaxial wave port. Convergence was tested for each case separately in terms of evaluating (dB) at a single frequency for a number of times. Once convergence was obtained, simulations were conducted in order to obtain swept frequency response extending from 1 to 4GHz.

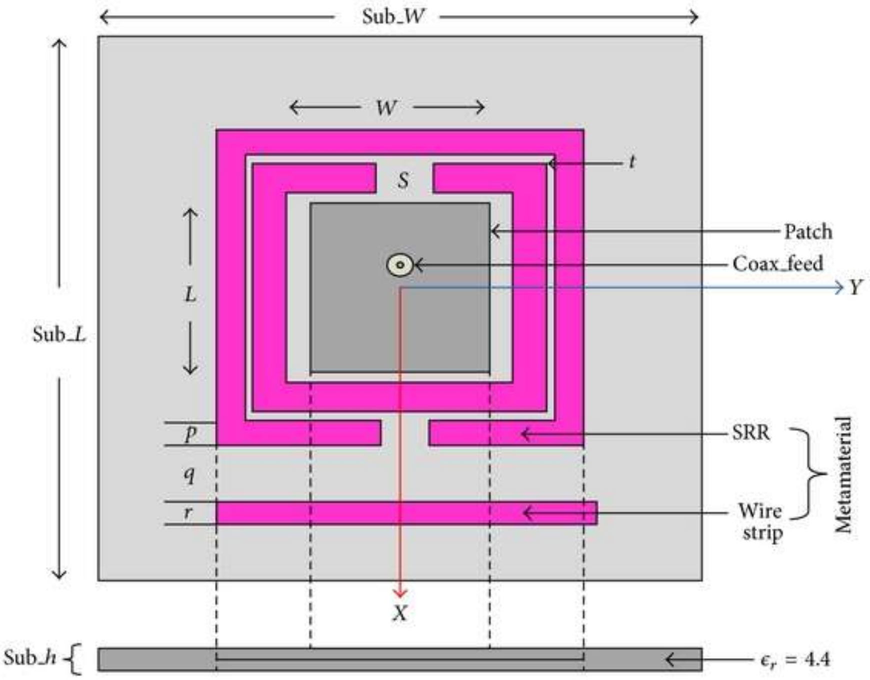


Figure 2: Square SRR based metamaterial inserted antenna layout.

The swept response gave us the, which was used to calculate the VSWR. Here the simulation is performed using Ansoft’s High Frequency Structure Simulator (HFSS) software package. HFSS provides -fields and -fields, currents, -parameters, and near and far radiated field results. It integrates simulation, visualization, solid modeling, and automation. Ansoft HFSS employs the Finite Element Method (FEM) for EM simulation by developing/implementing technologies such as tangential vector finite elements and adaptive meshing (Figure 5).

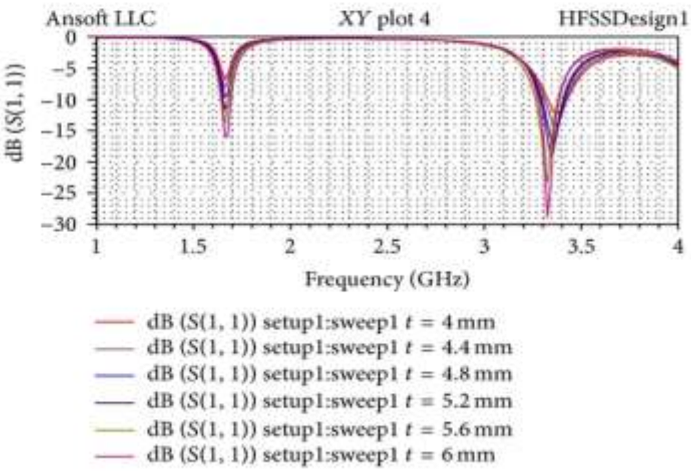


Figure 3: Optimize return loss characteristics of dual-band patch antenna.

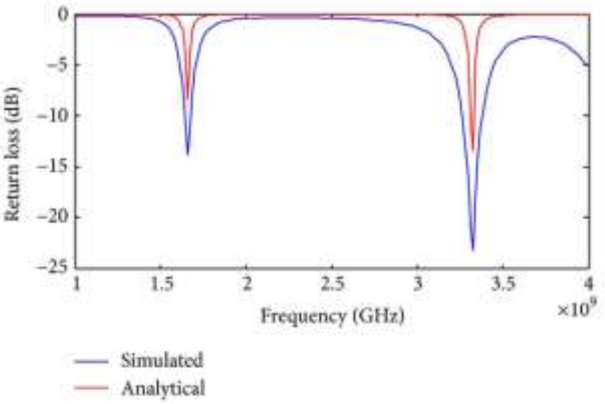


Figure 4: Return loss characteristics of dual-band patch antenna.

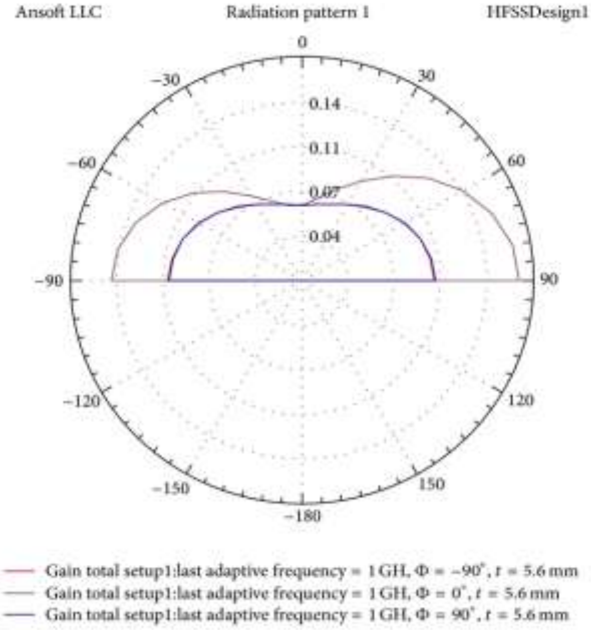


Figure 5: Radiation pattern (gain) of proposed patch antenna.

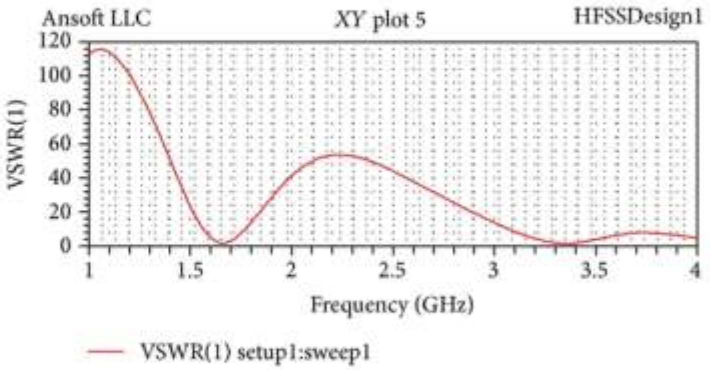


Figure 6: VSWR v/s frequency plot for dual-band proposed patch antenna.

III. ANTENNA MINIATURIZATION

Now we will do the comparative analysis of the proposed metamaterial antenna with the conventional antenna design. Both antenna configurations are shown in Figures 7 and 8. In both antennas, the material used for the substrate is the same FR4 epoxy having dielectric constant as. Patch and other conductive elements in both antennas are made of copper with the copper thickness of 0.03mm.

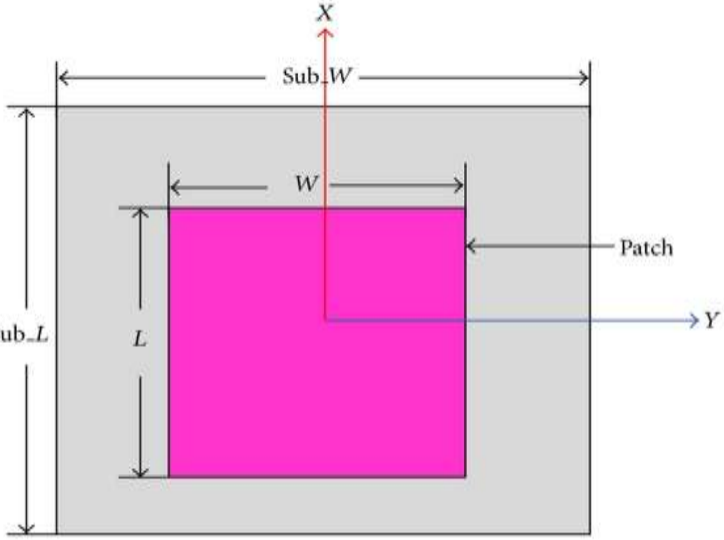


Figure 7: Conventional microstrip antenna.

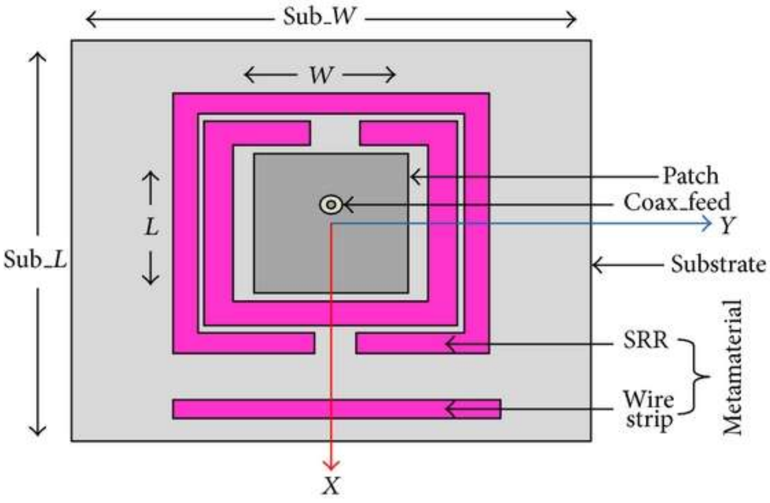
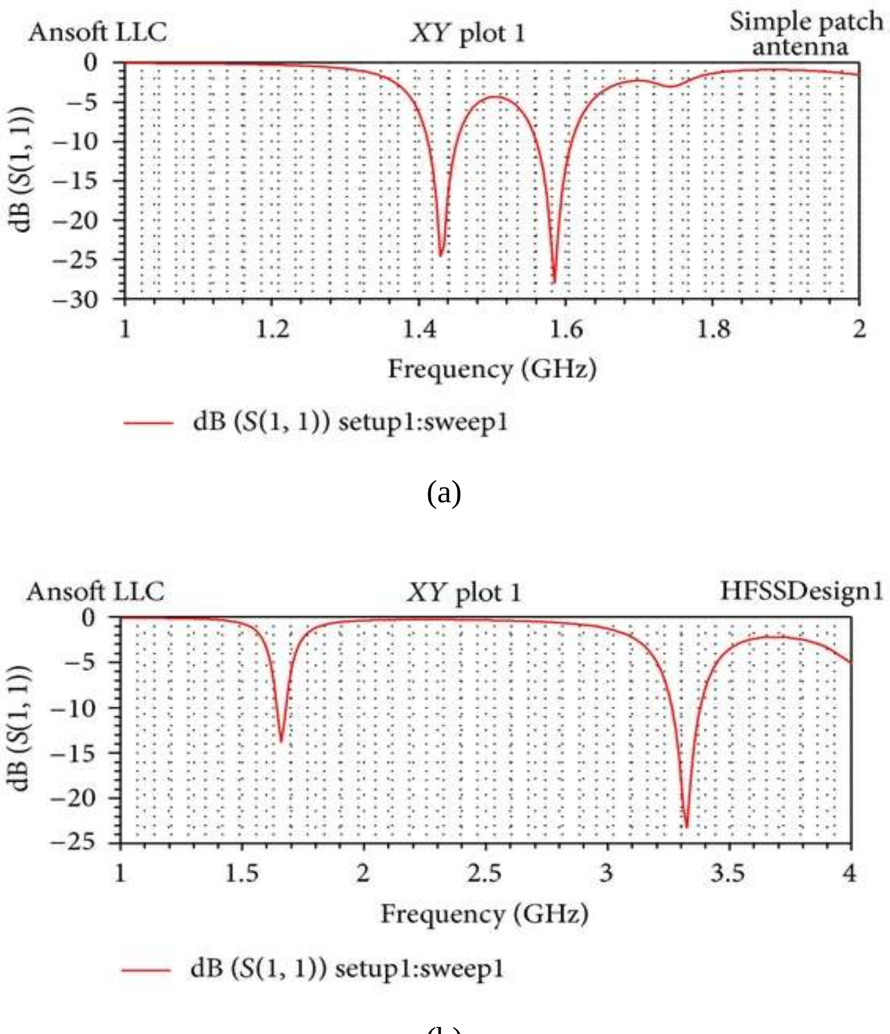


Figure 8: Metamaterial based microstrip patch antenna.

Return loss characteristics for both conventional antenna and proposed antenna are shown in Figure 9. First metamaterial antenna is designed and then conventional patch antenna is designed considering the same materials as discussed. Conventional patch antenna is tuned to have the same kind of response as that of the proposed metamaterial based antenna. From Figure 9, it is clear that both antennas have the same operating frequency and they offer almost the same bandwidth. After thorough analysis, it is found that proposed metamaterial based antenna requires smaller size compared to the conventional simple rectangular patch antenna. The reduction in patch size is about 84% which is shown in Table 1. So antenna miniaturization has been successfully carried out using metamaterial concept.



(a)

(b)

Figure 9: Return loss plots for conventional simple rectangular patch antenna (a) and proposed antenna design (b).

IV. CONCLUSION AND FUTURE SCOPE

A patch antenna miniaturization technique using metamaterial having square split ring resonator and wire strip is proposed and compared with conventional patch antenna. The SRR and strip wire loading reduces the physical size of the patch significantly as compared to the conventional one. Return loss characteristics are observed for the proposed antenna configuration by and depicted in Figures 3 and 4. It is shown as both simulated and analytical results very near to each other. From Figure 9, it is concluded that antenna gives dual-band of operation in between

1GHz to 4GHz range of frequency. From Figure 4: percentage bandwidth observed at −10dB return loss for the first band is 2.40% and for second band is 2.50%. Corresponding VSWR plot for the same antenna is shown in Figure 6. VSWR values obtained at first and second resonating frequencies are 1.3572 and 1.0942 which is very much nearer to ideal value 1 for both frequencies. The proposed antenna is a good candidate for a mobile communication and Wi-Max applications.

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