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Design of Patch Antenna Based on Metamaterial

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Abstract: “Metamaterial” attracts researchers of various areas and research grown rapidly in this area. The unusual response of these metamaterials are often generated by artificially fabricated additions or in-homogeneities embedded in a host medium or associated to or implanted on a host surface. A microstrip antenna based on the concept of metamaterial has been proposed in this work. Various aspects of the antenna such as size, radiating frequency, bandwidth, beamwidth, gain and directivity have been taken under consideration. With this design the return loss of -38.4 dB has been achieved at the frequency of 2.2 GHz.

Keywords: Patch, Antenna, Microstrip, Metamaterial

I. INTRODUCTION

This work has tried to seizure the development in this area through the selected authors. What is the meaning of metamaterial? “meta” means beyond or away from in ancient Greek. Material with prefix “meta” has been used to express the materials with exceptional features not easily obtainable in environment [1]. By altering the chemistry, factually and conservatively the purpose or performance of materials can be altered. This is a long known fact [2]. Science inquires how nature works and technology inquires how the works of nature can be utilized. Metamaterial based small antennas are proposed to offer to manipulate the near field boundary conditions which could result in antenna size minimization. Metamaterial antennas open a way to overcome the restrictive gain-bandwidth limits for small antennas [3, 4].

II. PROPOSED DESIGN

A single layer antenna has proposed in this chapter. Dimensions of this antenna are 50 mm X 58 mm. Substrate FR-4 is sandwiched between two metallic layers. The permittivity of this substrate is taken as 4.4. At metallic ground plane there are two cuts, one is circular and another one is rectangular. Upper patch also has a rectangular cut. To energize this antenna, a discrete port is connected. The coordinates of this port are (19 mm, 5 mm). Radius of the ground layer circular cut is 10 mm and the center of this circle is at (25 mm, 33 mm). One rectangular is also there which extends from 4 mm to 46 mm in the direction of X-axis while in the direction of Y-axis, it extends from 51 mm to 53 mm. Hence we can say that it is a horizontal cut and the dimensions of this cut are 42 mm X 2 mm. Figure 1 shows the top view of the ground plane of the proposed antenna. Values of 'a' and 'b' shown in figure 1 are 50 mm and 58 mm respectively. Location of feed is also shown in the figure by a small circle. At upper metallic layer there is one vertical rectangular cut. This cut extends from 23 mm to 27 mm in the direction of X- axis and entire patch length in the direction of Y- axis. So the dimensions of this horizontal cut are 4 mm X 58 mm. Top view of this layer is shown in figure 2. Figure 3 (a) and figure 3 (b) show the top layer view and bottom layer view of the implemented antenna respectively. This design has been simulated with the help of CST simulation software.

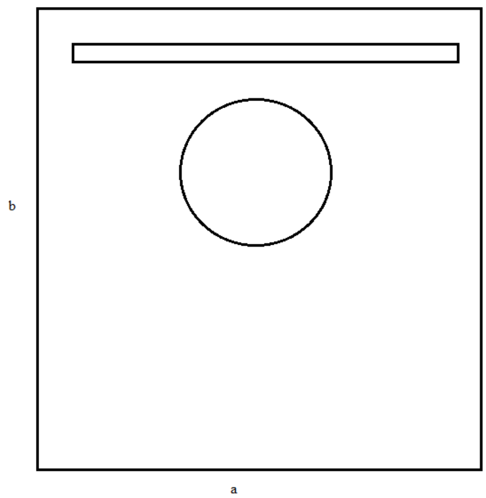

Figure 1: Top view of ground plane

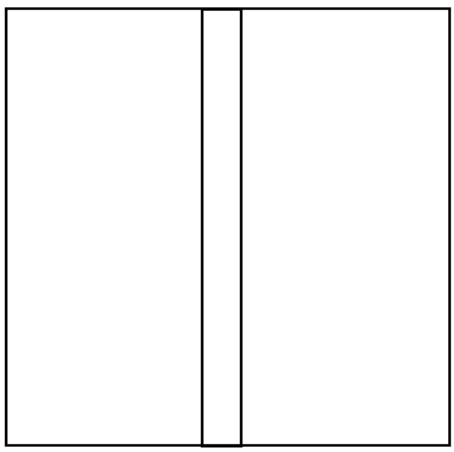

Figure 2: Top view of antenna

International Advanced Research Journal in Science, Engineering and Technology
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Figure 3 (a): Top layer view of implemented Antenna

Figure 3(b): Bottom Layer view of implemented Antenna

III. Results & Discussions

Antenna design, proposed in this chapter has simulated to investigate the responses of the antenna enclosed in meta-material. With this design the simulation result of return loss of -38.4 dB has been achieved at the frequency of 2.2 GHz. Laboratory results of the fabricated antenna verified the simulated result. The bandwidth of the proposed design is about 24 MHz. Figure 4 shows the variation of magnitude of return loss (in dB) with frequency (in GHz).

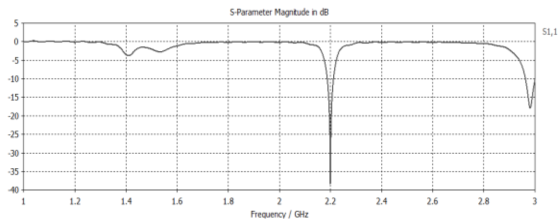

Figure 4: Variation of the magnitude of Return Loss with Frequency

Figure 5 shows the variation of directivity with frequency. At radiating frequency, the directivity of the antenna is above 6 dB.

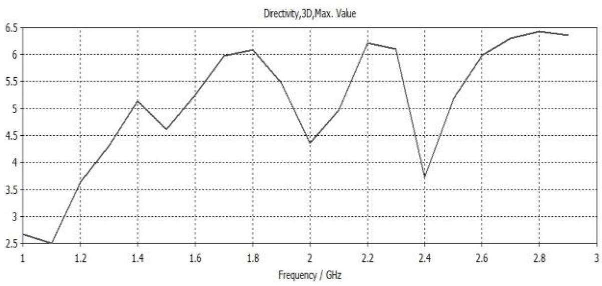

Figure 5: Variation of Directivity (in dB) with Frequency

Smith chart in figure 6 shows the impedance variation with frequency. Pattern of Power density (dB W/m^2) and Axial Ratio are also shown in figure 7 and figure 8 respectively.

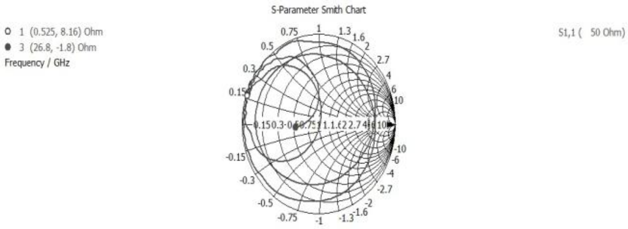

Figure 6: Smith Chart

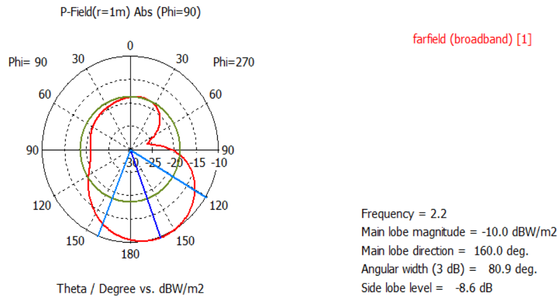

Figure 7: Pattern of Power Density at radiating frequency

At the frequency of 2.2 GHz, antenna radiates and we get the main lobe at 160^0 with half power beamwidth of 80.9^0. It shows that the 3 dB beamwidth of the antenna is fairly broad. Magnitude of main lobe and side lobe are also shown.

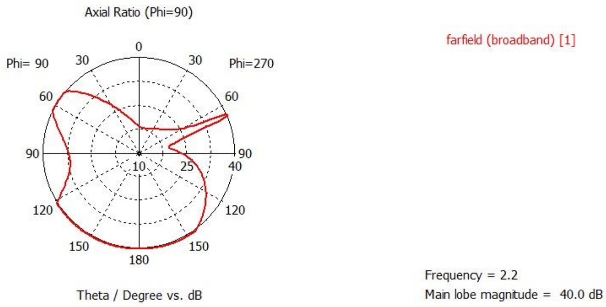

Figure 8: Pattern of Axial Ratio at radiating frequency

Figure 8 of Axial Ratio Pattern shows that at the radiating frequency, the magnitude of main lobe is 40 dB and this magnitude is constant for about 90^0. Hence the Return losses has been improved in the Designs proposed in this paper [10, 11, 12, 13]. Proposed designs is simple [12] and size is also reduced [11].

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