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Investigation of Single and Array of Microstrip Patch Antennas at 2.45 GHz

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Abstract

This paper presents the design, simulations and experimental investigations of single and arrays of microstrip patch antennas at 2.45 GHz. FR4-epoxy substrate is chosen to simulate and fabricate with a thickness h=1.6mm and dielectric loss tangent tanδ = 0.02. Microstrip patch antenna has a wide range of applications for IoT devices at 2.45 GHz. The reliability and proper functioning of a single and array of patch antennas are optimum because antennas were analyzed using 3D analysis tools based on Finite Element Method. The single patch and array of patches have been designed, simulated experimentally investigated on various antenna parameters like return loss, VSWR, gain, directivity and power radiated. In this paper the performance of arrays of microstrip patch antennas were found to be increased as compared to single patch.

Keywords: microstrip patch antenna; array; frequency; gain; return loss; radiating power

1. INTRODUCTION

Antennas are an essential part of any wireless communication system. Antennas can be considered as a transducer that converts electric currents or voltages into radio waves or vice versa. A microstrip antenna and an array of microstrip antenna is one of the simplest forms of antennas available, in which the characteristics of the antenna depends on the length and breadth of the metallic patch and substrate. The microwave or millimeter wave circuit is generally manufactured by photo-etching techniques together with a patch antenna. Modern communication system like mobile satellite communications, global position system (GPS), Direct Broadcast Satellite (DBS), military communications, IOT requires the antenna which is of very small size, low cost, low profile, high gain and high directivity antenna. Microstrip antennas or planar antennas are very versatile and are suitable for electronic communication, because of light weight, small size, low profile, compatibility with integrated circuit technology, required gain and field pattern. Microstrip patch antenna covers a broad frequency range from 100 MHz to 50 GHz [1], [2]. The simplest microstrip antenna consists of a radiating patch on one side of a dielectric substrate and has a ground plane on the other side. The radiating patch and a ground plane are normally of copper [3]-[7]. The rectangular microstrip antenna configuration, practical realization of a rectangular microsrip antenna and electric & magnetic field lines in a microstrip transmission lines are shown in figure 1.

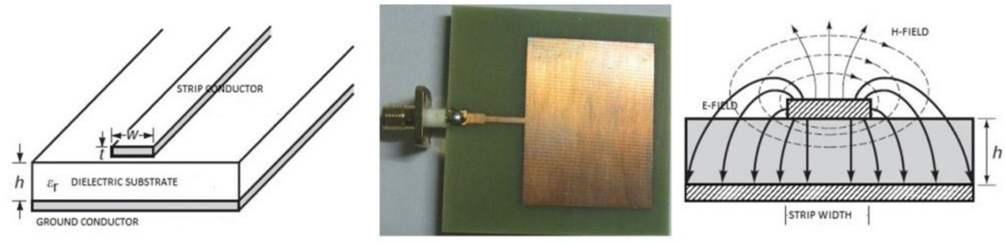

Figure 1 Rectangular microstrip antenna configuration, practical realization and E&H fields

2. MICROSTRIP ARRAY ANTENNA GEOMETRY

A microstrip patch antenna with a single radiating element has a moderate gain. For extensive distance communication directive antenna is required, but this cannot be done by the single element antenna as their radiation pattern is comparatively wide. In many applications antennas are designed for high gain to get a better directivity. To get a very directive antenna is to increase the electrical size of an antenna, this can accomplished by arranging an identical patch element on a single substrate. Microstrip antenna arrays are produced from group of antenna elements, which may then

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be interconnected and fed using microstrip transmission lines. The fed techniques in a linear array of microstrip patches are, series fed, parallel fed or combination of fed techniques. Microstrip array antennas are low cost, ease of installations and have found applications in many areas like wireless, satellites, aircrafts, navigations, radar and ground based systems for communications. The entire field of the array is determined by the vector summation of the fields radiated by the particular elements. To get a directive patterns, the fields from the elements of the array interfere constructively in the preferred directions, and interfere destructively in the remaining space [1]-[5]. Two and four elements parallel fed patch array is shown in figure 2. Fabricated two and four array patch antennas are shown in figure 3.

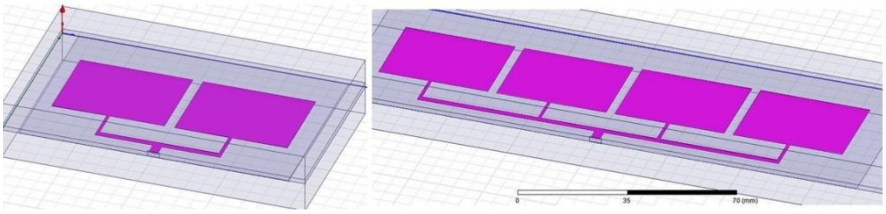

Figure 2 Two and four elements microstrip patch antenna array

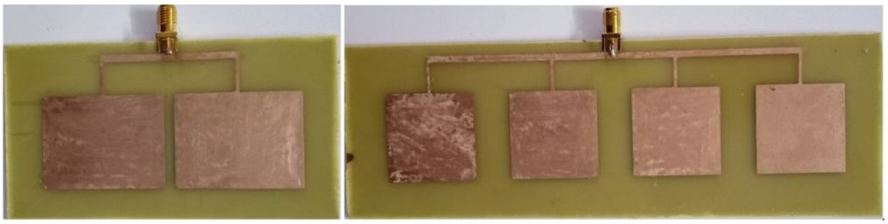

Figure 3 Fabricated two and four elements microstrip patch antenna array

3. ANALYSIS, DISCUSSIONS AND RESULTS OF MICROSTRIP ARRAY OF PATCH ANTENNAS

The single and array of microstrip patch antenna are designed, simulated and analyzed with initial versions of software's based on FEM. The microstrip patch antenna is designed, simulated and fabricated on FR4 substrate (ε_r = 4.4). The output parameters like return loss, VSWR, radiation patterns, and 3D pattern of field energy is investigated. The S-parameters values i.e. return loss S_{11}(dB) for single, dual and quad microstrip patch antennas were measured using R & S, ZNB8, VNA, with a frequency range 9 KHz…8.5 GHz. The microstrip single patch antenna resonates at 2.51 GHz and measured return loss S_{11}(dB) at 2.51 GHz is -27.958 dB. The microstrip dual patch antenna resonates at 2.367 GHz and measured return loss S_{11}(dB) at 2.367 GHz is -9.757 dB. The microstrip quad patch antenna resonates at 2.327 GHz and measured return loss S_{11}(dB) at 2.327 GHz is -15.621 dB. The simulated return loss S_{11}(dB) for single patch antenna is shown in figure 4 and experimentally investigated return loss S_{11}(dB) for single patch antenna is shown in figure 5. The simulated return loss S_{11}(dB) for dual patch antenna is shown in figure 6 and experimentally investigated return loss S_{11}(dB) for dual patch antenna is shown in figure 7. The simulated return loss S_{11}(dB) for quad patch antenna is shown in figure 8 and experimentally investigated return loss S_{11}(dB) for quad patch antenna is shown in figure 9. From simulated and experimental results it is clear that the return loss S_{11} (dB) for array of microstrip patch antenna is better as compared to single patch antenna.

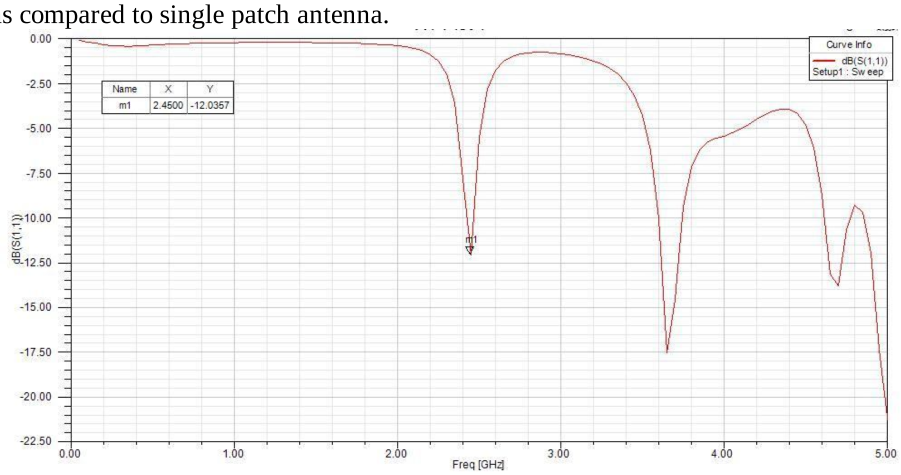

Figure 4 Simulated S_{11}(dB) on FR4 for single patch antenna

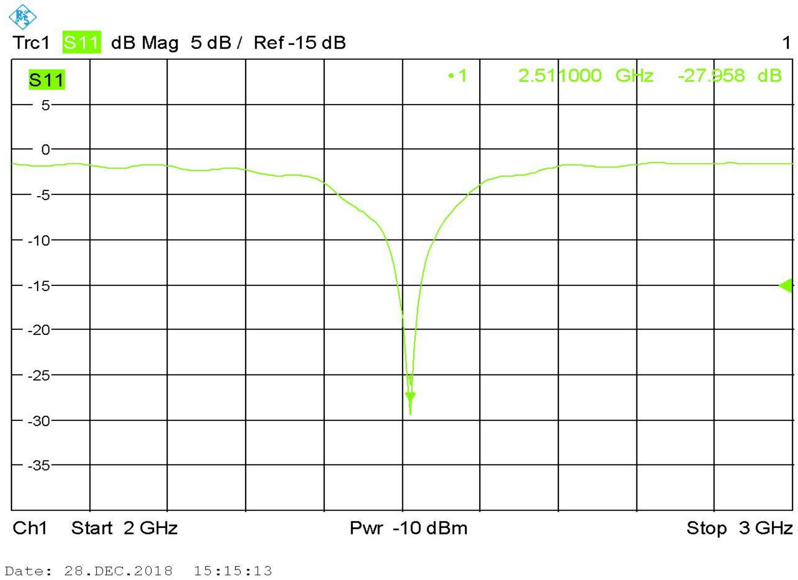

Figure 5 Experimentally measured S_{11}(dB) on FR4 for single patch antenna

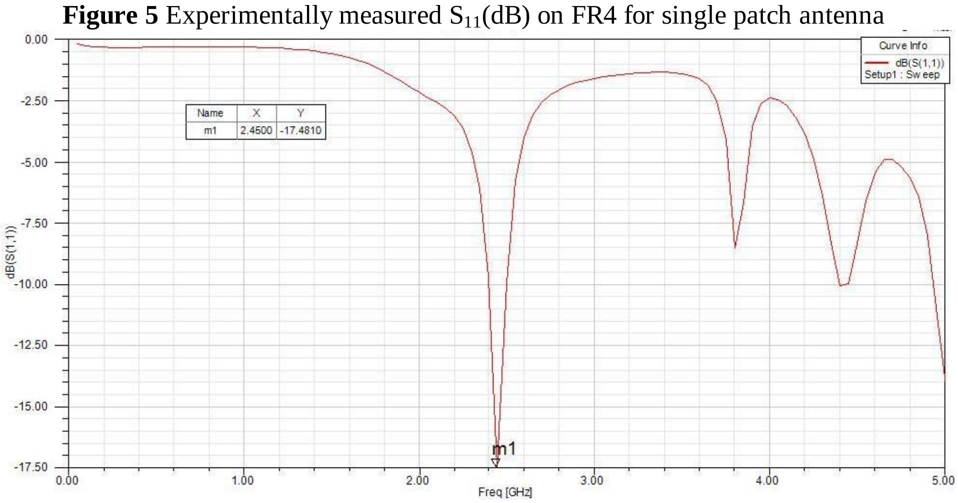

Figure 6 Simulated S_{11}(dB) on FR4 for dual patch antenna

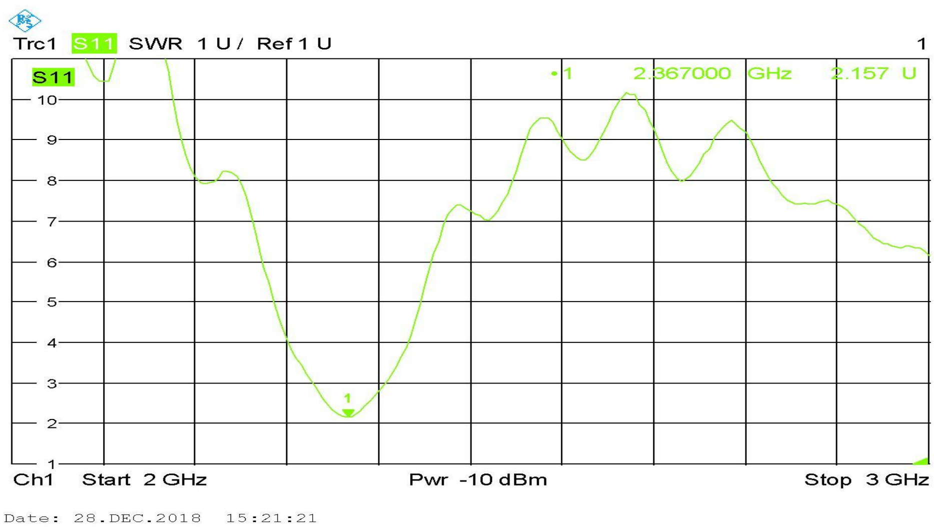

Figure 7 Experimentally measured S_{11}(dB) on FR4 for dual patch antenna

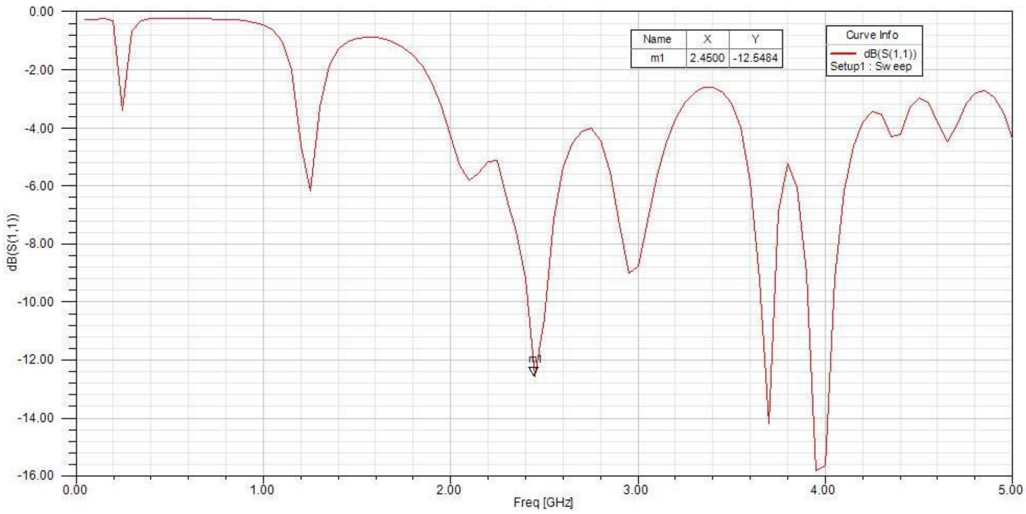

Figure 8 Simulated S_{11}(dB) on FR4 for quad patch antenna

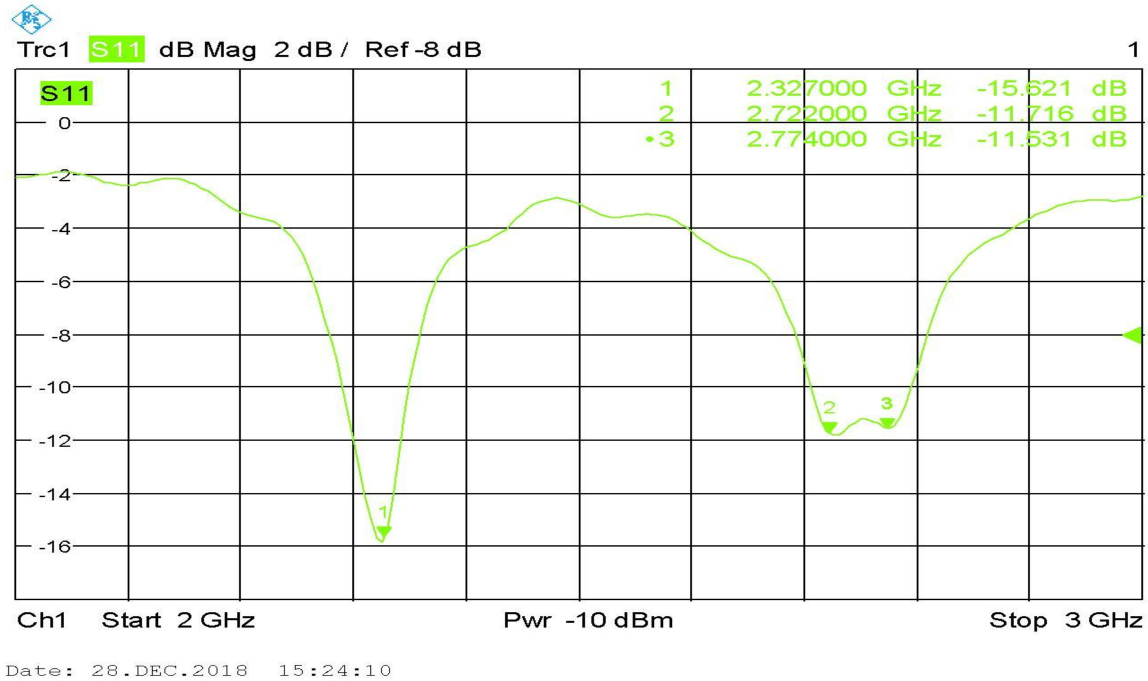

Figure 9 Experimentally measured S_{11}(dB) on FR4 for dual patch antenna

4. CONCLUSIONS

A single, dual and quad array of microstrip patch antennas is designed, fabricated, analyzed and studied here at 2.45 GHz. The design, simulation & fabrication of single and array of microstrip patch antenna are proved to be successful at some level. The original goal of simulating & fabricating single and array is to make comparative study at 2.45 GHz, are to get a minimum return loss, optimum radiation pattern, gain and directivity. From the analysis of single and array of microstrip patch antenna it is clear that at some level gain, radiation pattern and directivity is increased for the array of antennas as compared to single patch antenna.

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