iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** X **Month of publication:** October 2018

DOI:

Metamaterial Design with Defected Ground Structure for Wireless Applications

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Abstract: The paper presents a metamaterial design antenna with defected ground structure to obtain the multiband characteristics for wireless applications. The FR4 glass epoxy substrate is used to design the antenna with relative permittivity 4.4 and thickness 1.6mm. The proposed antenna has a compact size of 48.78 × 36.58 × 1.6 mm^3 and is fed by two coaxial probes. The -10dB impedance bandwidth of proposed antenna is from 1 GHz to 10 GHz. The antenna is designed and simulated by using HFSS (High Frequency Structure Simulator) version 13 software. Defected ground is used to increase the performance of the antenna. Proposed antenna can be used for various wireless communication applications such as WLAN, satellite communication, long distance radar telecommunication etc.
Keywords: Microstrip Antenna, Defected Ground Structure, Directional antenna, Meta material.

I. INTRODUCTION

The microstrip antennas are considered to be a key component for these applications due to its advantages such as, low profile, low cost, ease of integration with microwave integrated circuits (MIC) and light weight. It consists of a perfect conducting patch over a thin dielectric material called the substrate that is placed above a ground plane. There are many different patch shapes such as the rectangular, circular, elliptic, circular ring, triangular and hexagonal. There are various techniques for feeding the antenna such as microstrip line feed, coaxial probed feed, aperture-coupled and electromagnetically coupled [3]. The major disadvantages of microstrip antennas are low power handling capability and narrow bandwidth [4]. There are continuous works for increasing the bandwidth using different techniques. One of them a technique with less complexity in structure depends on small cut on the outskirts at the upper and lower edge of patch [5]. There are many techniques to improve antenna gain, such as antenna array, yagi antenna and disk antenna….etc. but they also increase unfavourable antenna volume, wet and cost. In the past few years, new methods to improve antenna gain by using metamaterial technology are proposed. Recently the performance of microstrip antennas is admired by the antenna and microwave researchers due to their astonishing and extraordinary electromagnetic Properties. These antennas are becoming functional for modern satellite, wireless and mobile communication technologies for high speed voice, data and multimedia communication. The bandwidth can be improved by increasing the no. of cut on the patch which will reduced the size of antenna and make it compact. A larger patch with an etched slot at the lower edge of antenna with vertical slot on patch and small cut on ground plane so modified the impedance bandwidth of antenna [8]. All these techniques and others are based on the modification of the surface current destruction to enhance the antenna bandwidth. In this paper, the configuration is inter digital capacitor design based Antenna which consist of rectangular substrate, two patch in form of fingers and two feed point. The antenna, which has compact dimensions of 48.78×36.58 mm^2, is printed in the front of Substrate FR4_epoxy of thickness 1.6 mm, relative permittivity 4.4 and tangent loss is 0.02.the dimension of the ground plane is of DGS (Defective Ground Structrue) shape made by combining two rectangular structure having dimension 30×2 mm^2 and 6×2 mm^2 The excitation of 50 ohms through co-axial probe feed is given to the patch. The design dimensions of the proposed antenna are obtained using HFSS (High Frequency Structural Simulator). The HFSS is based on the Finite Element Method (FEM) to simulate the proposed antenna..

II. PROPOSED WORK

In this section, the designing procedure will be discussed for proposed antenna. The high frequency structure simulator is used to analyse the results. The purpose of this structure is to implementation of a multi-band antenna, reducing the size of antenna and improvement in various parameters such as gain, bandwidth, return loss and VSWR. The results obtained are analysed in terms of return loss, radiation pattern, voltage standing wave ratio (VSWR) and bandwidth. To the dimension point of view, the geometrical details of the metamaterial antenna with defected ground structure having substrate size 48.78 × 36.58 × 1.6 mm^3 mm^3 with FR4 epoxy material having dielectric constant is 4.4. The structures are simulated using HFSS electromagnetic simulator software. The patch is excited by two coaxial feed. The operating frequency of the proposed antenna is between 1 GHz to 10 GHz.

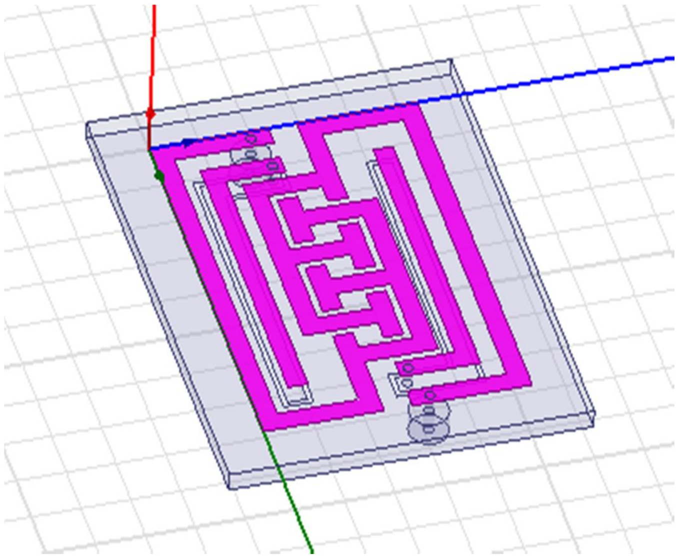

Figure 1. Proposed Design

III. RESULTS

Return loss or VSWR is good when the curve has a deep and wide dip, which shows the antenna with good bandwidth. The VSWR, which can derive from the level of reflected and incident waves, is also an indication of how closely or efficiently antenna terminal input impedance is matched to the characteristics impedance of the transmission line. Consequently, the narrower the dip is, the bigger the risk that desired channels would be also reflected away. A 4-5 GHz frequency range below -10dB VSWR is obtained. Multiband operation of the designed antenna is explained by using the Return loss versus frequency graph shown in figure 5.4. The return loss of -24.1885, 21.1705, 21.993 and 20.3121dB is obtained at 4.9, 5.3, 7.5 and 5.6 GHz respectively. The bandwidth of the proposed antenna is greater than that of reference antenna. It can be found by locating two points on the return loss curve which shows the more bandwidth rather than reference model.

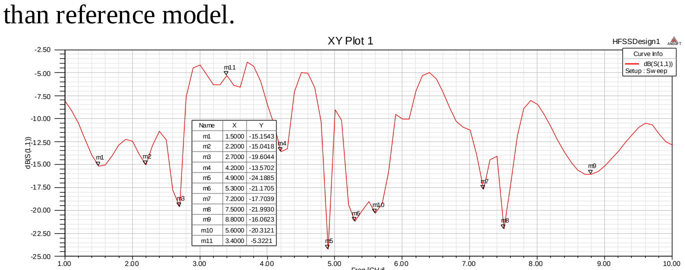

Figure 2 Return Loss

Radiation pattern for proposed antenna is also depicted in the figure 3. Radiation pattern explains that antenna is radiating in Omni-directional. This is always desirable for the applications like mobile applications and multiband support make it multi-application compatible. Also, as shown in figure 3 there are single main lobes due to which the proposed antenna works as a directional antenna which is quite acceptable for the applications like radar systems, ultra wide band systems etc. It also shows that the maximum radiated power is lies in the main lobe which is represented by the red color. The red color specifies the maximum intensity of power followed by yellow, green and blue which has less intensity than red color respectively. The total radiated power of the main lobe is greater than the power radiated by the side lobes as shown in figure 3.

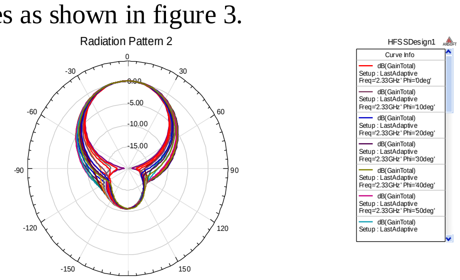

Figure 3 3D Radiation Pattern Plot

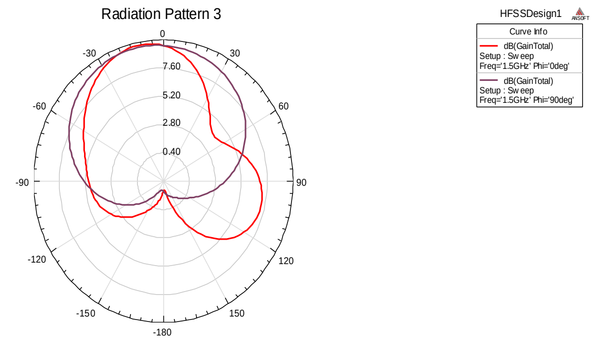

Figure 4 Radiation Pattern for 1.5GHz and Return Loss 15.72 dB

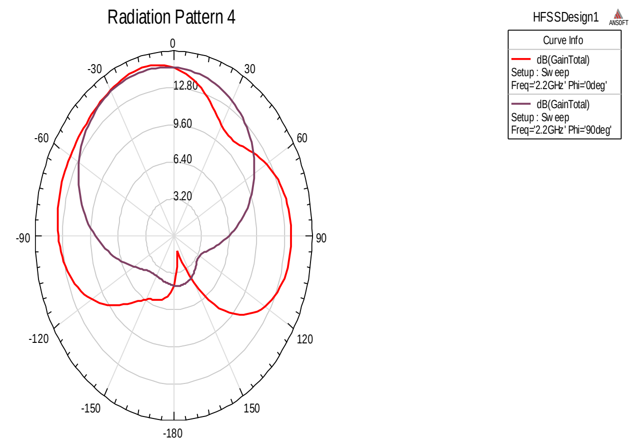

Figure 5 Radiation Pattern For 2.2 GHz And Return Loss 15.4 dB

IV. CONCLUSION

In this paper, multiband split ring patch antenna has been obtained by applying interdigital geometry and split ring resonator. The proposed geometry was based on square ring in which a slit was inserted on one side. The ground plane used here is Defective ground structure (DGS) which increase the performance of the antenna. The proposed antenna is desinged with interdigital geometry with four finger which works as resonant circuits. The fingers of the patch works as inductance and the gap between the fingers wokrs as capacitance. The proposed geometry was simulated in HFSS using FR4 as the substrate material. The design were compared minutely in terms of return loss, bandwidth, VSWR and gain. The designs are showing multiband performance ranging between 1.0 GHz to 10.0 GHz. There has been a considerable improvement in Gain by using FR4. In terms of size the patch area has been reduced to 53.27% and 78.99% when compared to simple rectangular patch using FR4.

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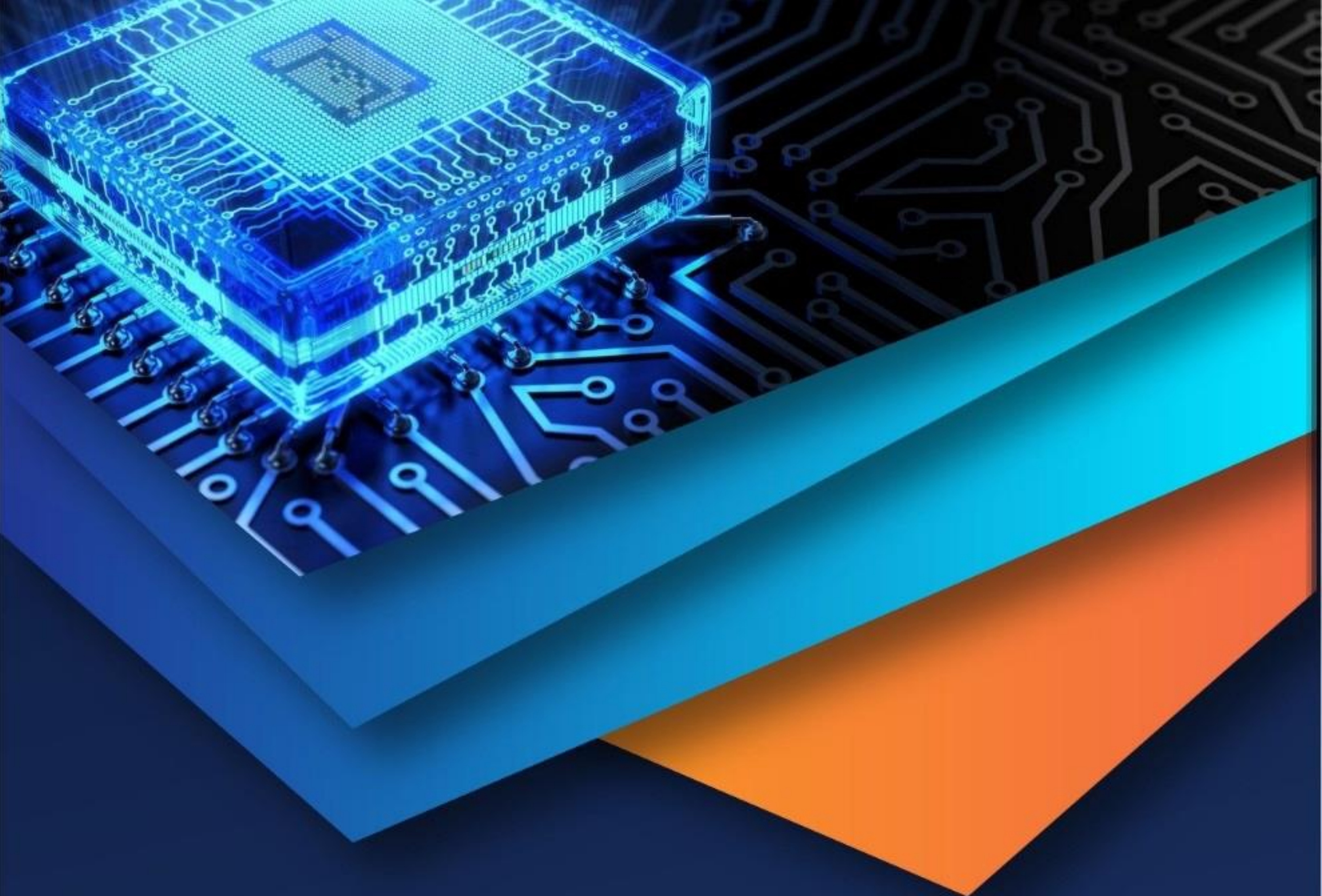

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