A Single band E-Shaped Patch Antenna with Defective Ground Structures for ISM Band Applications

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***Abstract*—This paper presents a single band E-shaped micro strip patch antenna with Defective Ground Structures (DGS). The overall dimension of the antenna is (32*31.5*1.64) mm. The antenna produces bandwidth ranges from (2.3 to 2.5) GHz, which supports ISM band application. It provides reflection coefficient about -32dB. The antenna is designed using FR4 substrate with dielectric constant of 4.4. The various parameters like Reflection coefficient, VSWR, Directivity, and radiation pattern are obtained. The antenna is simulated using EM simulator.**

***Keywords*— DGS (Defected Ground Structure), Antenna, ISM band.**

I. INTRODUCTION

A defect introduced in the ground is called Defective Ground Structure. When DGS integrated on the ground plane improves performance like Bandwidth, return loss, VSWR. Conventional micro strip patch antennas have limitations like lower bandwidth, polarization problems. There have been several techniques applied to enhance their operating range.One such techniques is defected ground structure (DGS) which is derived to enhance the performance of an antenna and other techniques are also used to improve the performance such as Frequency selective surfaces, Electromagnetic Band Gap Structures (EBG), Photonic Band Gap structures, different feeding structures, stacking many layers etc. Antenna with defect in the ground plane has provided more useful parameters and hence it enhances the performance.

This minimizes the higher mode harmonics and mutual coupling in case of array antennas [1].To increase the performance, Defected Ground Structure (DGS) are proposed [2] .The term DGS is also describing a partial ground plane. The DGS can be treated as a simplified form of EBG structure; it exhibits a band stop property [3]. DGS is used for a wide range of applications. Various DGSs have been presented and are used in applications of microwave circuits. Thoroughly the development of DGS is discussed in [4]. DGS has many advantages when compared to EBG due to its low cost and simplicity. The DGS disturbs the shield current distribution in the ground, which varies the capacitance and inductance characteristics of a transmission line. In other words, depend on the slot or defect etched in the ground plane, changes the effect of capacitance and inductance of micro strip line. There are many different alphabets shapes are used in ground plane of micro strip line. These shapes include circular dumbbell, rectangular dumbbell, spiral, “A to Z”, cross, and concentric rings. Some complex and different shapes also have been studied which include meander lines, split ring resonators, and fractals [5].

The repetition of slots is called periodic structures. Distance between the cells, no of cells placed, are the main parameters which will decide the main parameters which will decide the performance of micro strip antenna. Multiband also can be achieved by using DGS [6]. Dual broadband antenna with rectangular slot has been analyzed for wireless applications [7]. Effective capacitance and effective inductance of the model are changed by embedding the slots on the ground plane, resulting in shifting of resonance frequency to its lower side. Thus, compactness is achieved by using DGS [8].

A compactness of 30% is achieved by using meandering slots in the ground plane [9]. A “T” shaped slot integrated in the ground plane to achieve the compactness and miniaturization of 80% has been achieved [10].

A dual-band asymmetric slits loaded micro strip patch antenna has been proposed and Circular Polarization (CP) was achieved using DGS in both bands of operation [11]. In order to achieve multiband performance, a compact DGS monopole antenna has been presented [12], which introduce a single L-shaped slot in the ground plane of a conventional circular disc monopole antenna.

This paper is organized with antenna design and analysis, results and discussion, conclusion.

II. ANTENNA DESIGN AND ANALYSIS

The antenna is designed with three layers, like defective ground structure, substrate and patch. The proposed E-shaped patch is placed above the substrate. The substrate used here is FR4, which is suitable for ISM band applications. The dimension of the ground plane is (32*31.5) mm and made of copper with thickness 0.035mm. The substrate is with dimension (32*40) mm, with thickness 1.57 mm.

The design of patch and ground is shown in the figures 1 and 2 respectively

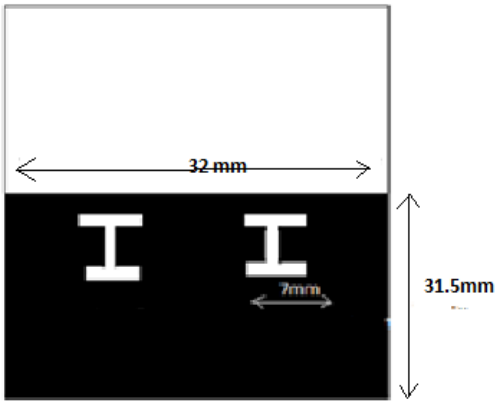

Figure 1. Defected Ground Structure with I-Shaped slots.

The distance between each and every I-Shaped slot is12mm horizontally and vertically.

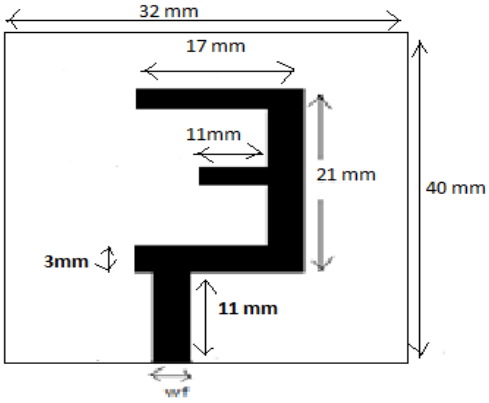

Figure 2. E-Shaped patch with inset feed line

The dimension of the patch is 17 mm. The E-shaped patch provides miniaturization and when integrated with DGS produces dual response.

The periodic arrangement of cells in ground will introduce changes in inductance and capacitance which contribute changes in resonance behavior.

III. Results And Discuission

The antenna is designed and analyzed for various parameters like reflection coefficient, VSWR, directivity, and surface current distribution.

Figure 3 shows the reflection coefficient of without defective ground structure. The dimension of the ground plane is (32*40) mm and made of copper with thickness 0.035mm. The substrate is with dimension (32*40) mm, with thickness 1.57 mm. It shows the reflection coefficient (dB) vs. frequency (GHz) graph providing single band resonance

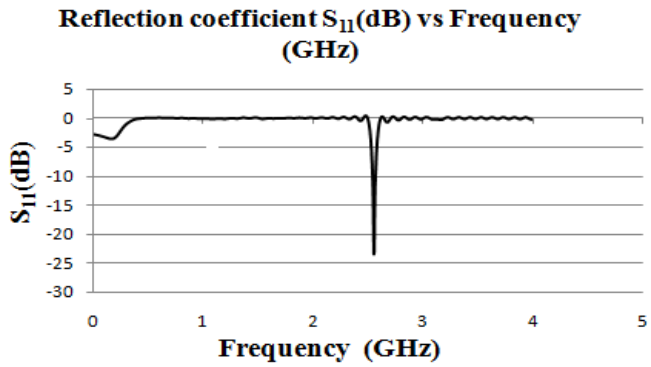

Figure 3. Reflection coefficient (dB) vs frequency (GHz) for without DGS

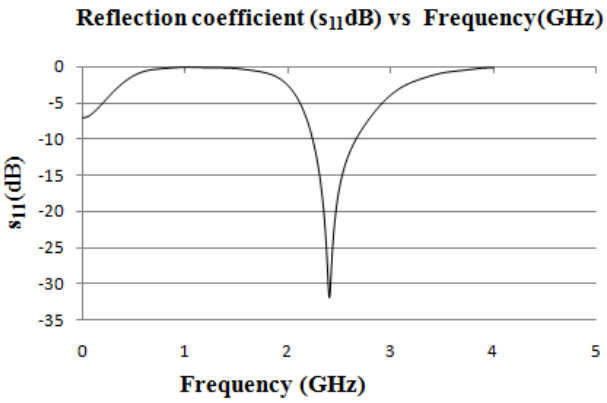

Figure 4. Reflection coefficient (dB) vs. Frequency (GHz) for with DGS.

Figure 4 Shows that by reducing the ground plane from (32*40) mm to (32*31.5) mm and introducing (2) cells on the ground plane single response with reasonable reflection coefficient is obtained. The return loss (S_{11}) in decibels for frequency 2.4 GHz is found to be -32 dB respectively.

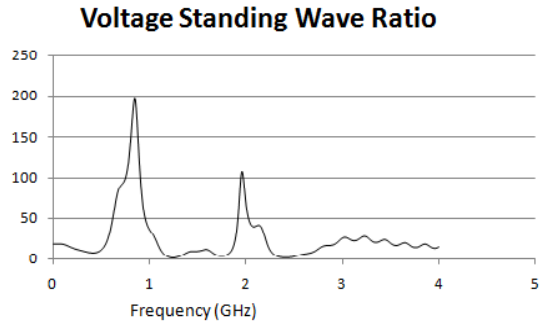

Figure 5. VSWR Vs Frequency

The VSWR is found to be 1.425, which tells us that reflection is minimum and forward propagation is enhanced.

Figure 5 shows the graph drawn between VSWR Vs frequency (GHz). The VSWR value is found to be 1.425 which is less than 2. This explains that backward radiation is minimized.

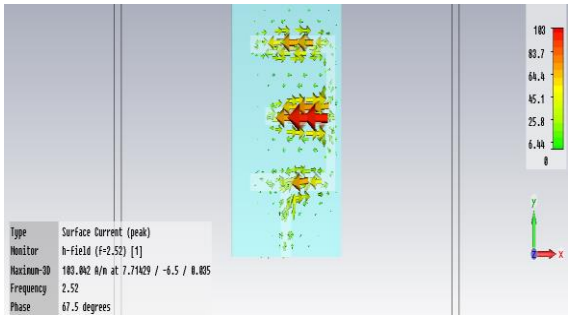

Figure 6. surface current at 2.5 GHz

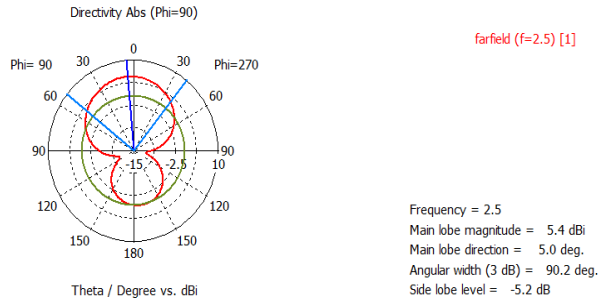

Figure 7. Directivity at 2.5 GHz

Figure 6 and 7 shows the graph of surface current and directivity of without defective groung structure at 2.5 GHz

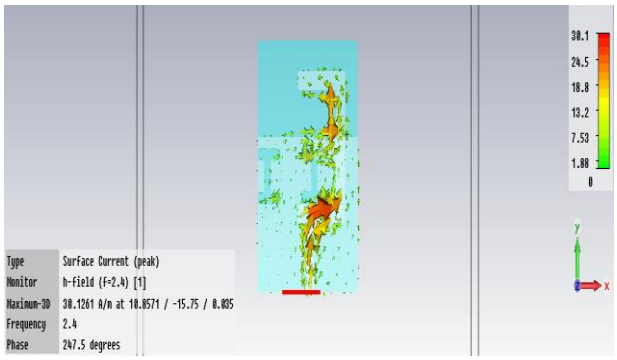

Figure 8. surface current at 2.4GHz

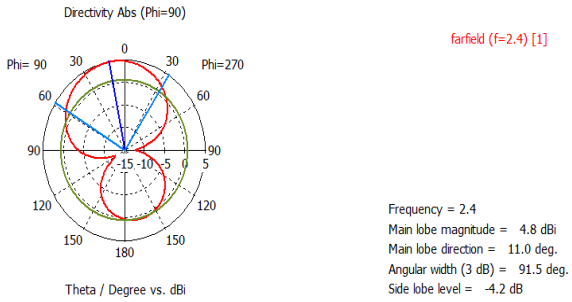

Figure 9. Directivity at 2.4 GHz

Figure 8 and 9 shows graph of surface current and directivity of defective ground structure at frequency of 2.4GHz .The Defected Ground Structures produces single band for ISM band applications.

Table 1 shows Comparison of various parameters of an antenna with and without DGS structure without defective ground structure ,with defective ground structure performance is better because it produce the bandwidth of 450MHz. Many number of slot structures can be introduced and by changing the dimensions which can enhance the performance of an antenna.

TABLE 1 COMPARISON OF VARIOUS PARAMETERS

Parameters	Proposed model	
	Without DGS	With DGS
Frequency	2.5GHz	2.4GHz
Reflection coefficient	-24 dB	-32 dB
Directivity	4.3dBi	4.8dBi
Bandwidth	56MHz	456MHz

IV. CONCLUSION

The proposed E- Shaped patch antenna is designed with Defective Ground Structures using I-slots. The antenna's performance is enhanced without stacking up many layers. Using three layers the antenna has achieved miniaturization and single band resonance operation. The dimension of the Defective Ground Structures and the patch can be altered such that performance is improved. The extension of this work can be done by placing the Defective Ground Structures above the patch also and this will provide better performance. The reflection of the antenna is minimum hence this can be used for ISM band application.

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