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Grid Shape Defected Ground Structure for Multiband Operation and Parameter Enhancement of Microstrip Patch Antenna

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Abstract: Many technologies have been introduced to provide improvement in parameters of microstrip patch antenna also introduce multiband operation in a single antenna due to the increasing need for compact and low power applications, in this paper defected ground structure (DGS) method is used to employ the multiband operation and enhance the parameter of the antenna, simple grid structure of DGS is embedded on the ground plane of conventional design. It is observed that the undesired performance of microstrip patch antenna in terms of parameter enhancement and multiband operation is obtained. The proposed structure has improved the parameter performance and also provided a size reduction of 67.9 % w.r.t. conventional design. The proposed antennas are found to match with simulation and measured reading using vector network analyzer. Antenna find application in various ISM and WIFI applications.
Keywords: Defected ground structure (DGS), Performance of antenna, Size reduction,

I. INTRODUCTION

Emerging trends of communication has demanded for antenna with high performance and compactness with respect to size, recently years, various wireless communication services have been developed, which use many frequency spectrum allocations, e.g., WIMAX, BWA and WIFI. For these applications, microstrip antennas are preferred because of their advantages of easy fabrication low cost and low power and these antennae have found to operate with multi frequency bands. However, a common disadvantage of microstrip antennas is surface wave, which is excited whenever the substrate has dielectric permittivity greater than one (ε_r>1) [1]. To suppress surface waves, several studies are conducted including defected ground structure (DGS). DGS is realized by etching the ground plane with a certain lattice shape which disturbs the current distribution of the antenna on ground plane. Many shapes of DGS have been studied such as concentric ring, circle, spiral, dumbbells [2-4], H-shaped [5], modified square ring [6] square [7] rectangle [8]. DGS provides a feature of stopping wave propagation through the substrate over a frequency range [2].

A. Design structure

The paper presents an experimental investigation of a microstrip slot antenna that has a DGS embedded in ground plane of conventional patch antenna, shape of the DGS used here is a grid structure created by slots of 1 mm thickness and same experiment is repeated with respect to reduction in the slot thickness to 0.5 mm. both the antenna with and without DGS is simulated and measured using Vector network analyzer, and is found to give a perfect match between both simulated and measured. Furthermore, parameters are discussed later in the paper. The conventional square microstrip patch antenna designed at C band i.e. 5 GHz, it's found to resonates at 4.48 GHz. Antenna is designed by using modified epoxy substrate material with thickness h = 1.6 mm, dielectric permittivity (ε_r= 4.2) and tangent loss (tan δ = 0.02). The extracted parameters for the conventional antenna is illustrated in Table 1 and the simulating result is shown in Fig. 1, respectively. Looking at the results of conventional design it's found that antenna has a return loss of -21.9 dB, and is having a narrow band of 150 MHz and gain of 1.9 dBi. Conventional antenna is found to have less application since it has limited bandwidth and single resonating frequency.

Table 1: Results conventional antenna

Antennas	Resonating frequency in GHz	Reflection Coefficient in dB	Bandwidth in MHz
Conventional	4.485	-21.9	150

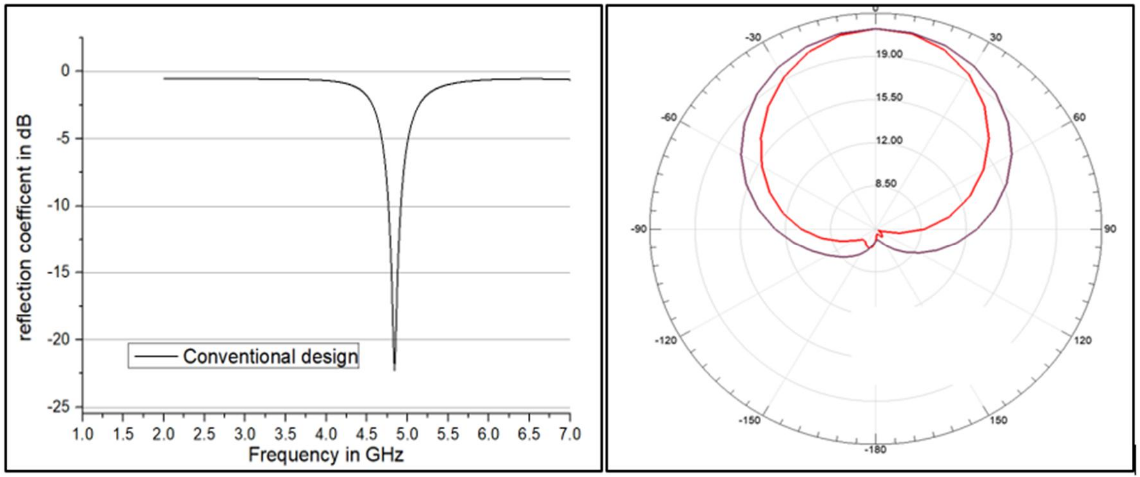
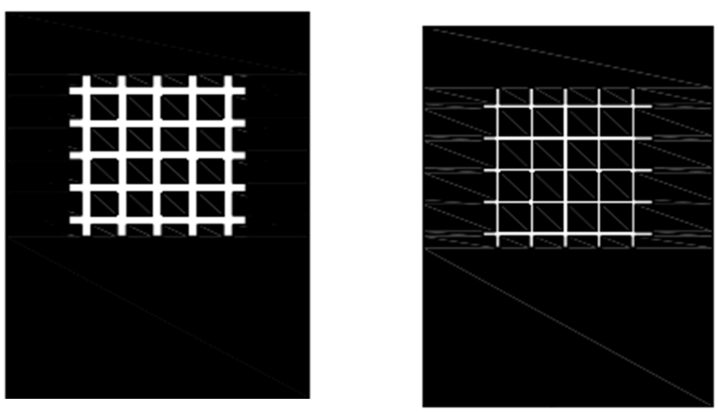


Fig 1: Return loss and the radiation pattern of conventional antenna

In order to enhance its parameters and improve its performance, conventional antenna is embedding with defect in ground plane, DGS effect is observed by shift in the resonance frequency from C band to S band keeping the physical volume of the antenna constant and making it shift its resonating frequencies, and hence the size reduction about more than 45% compared with the conventional one is carried out.

B. Proposed novel structure of DGS

Here we propose two novel design structures (grid) theses proposed structure are arranged in formation of slots to form grid structure as shown in the Fig 2, the design is place below the patch to obtain maximum performance. [7] proposed structure is created using slot of thickness of 1 mm taking 5 slots to form a grid structure in antenna-1 and the slots are created using thickness of 0.5 mm in antenna-2, results of antennas are discussed in section 4.



(a) (b)

Fig 2: Proposed Structure of defect on the ground plane

C. Measured Results And Discussions

The measurement of return loss response of antenna without DGS shown in Fig 2, is embedded with DGS of proposed structure antenna-1 is found to give a multiband operation it's found that antenna has trip band operation with higher bandwidth as shown in Table 2, there are three dips at 2.8 GHz, 5.1 GHz, 7.1 GHz. It can be referred that grid structure defect provide an improvement in the performance of antenna and also provide a multiband operation, with wide bandwidth when compared to conventional design. The simulation result of first proposed antenna is shown in Fig 3, S_{11} parameter is ploted both comparative result of simulation and the measured is given in the figure.

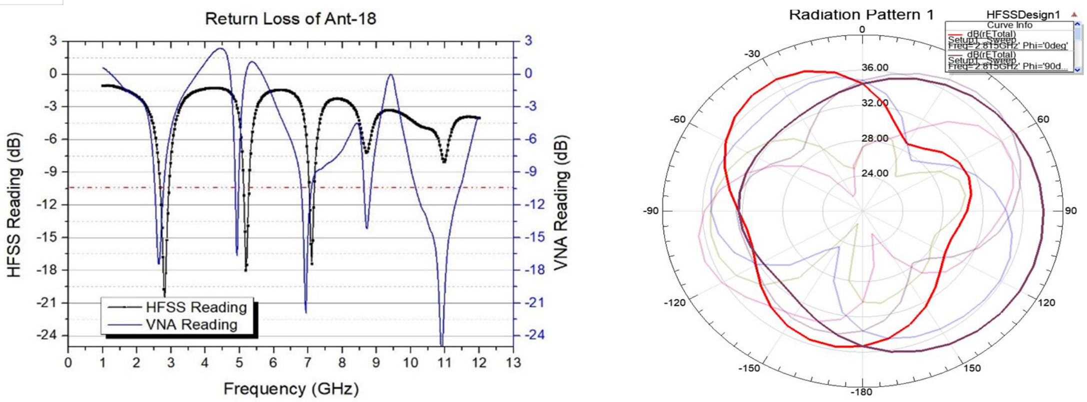


Fig 3: Return loss and radiation pattern of proposed antenna-1 VNA and Simulated.

Fig 3, gives polar radiation plots simulated at $\phi = 90^0$ and $\phi = 0^0$ gain of the proposed antenna is measured to be 6 dBi which is comparatively more than conventional antenna.

Table 2: Proposed antenna -1

	ANT-01					
	fc in Ghz	rl in db	fh in Ghz	fl in Ghz	I BW in %	BW in Mhz
1	2.815	-20.685	2.953	2.678	9.769	275.000
2	5.180	-17.993	5.290	5.098	3.716	192.500
3	7.105	-17.355	7.188	7.023	2.322	165.000

It is observed that first proposed structure provides a multiband operation and the overall size reduction of 43.37 % since the antenna after embedding the defect is resonating at 2.81 GHz with bandwidth of 275 MHz multiband frequencies with the return loss and bandwidth is given in Table 2. Similarly, efforts are made to further improve the performance by making the current distribution across the ground plane by reducing the size of the slot introduced in ground plane, antenna-2 is proposed with the slot size of 0.5 mm to form a grid and provide more surface area for the antenna ground plane to resonated which adds to the performance of antenna and improve its gain and other parameters. Fig 5 shows the S_{11} of antenna-2, we can observe that the proposed structure embedded on ground plane provide a same trip band operation with almost same size reduction of 67.9%.

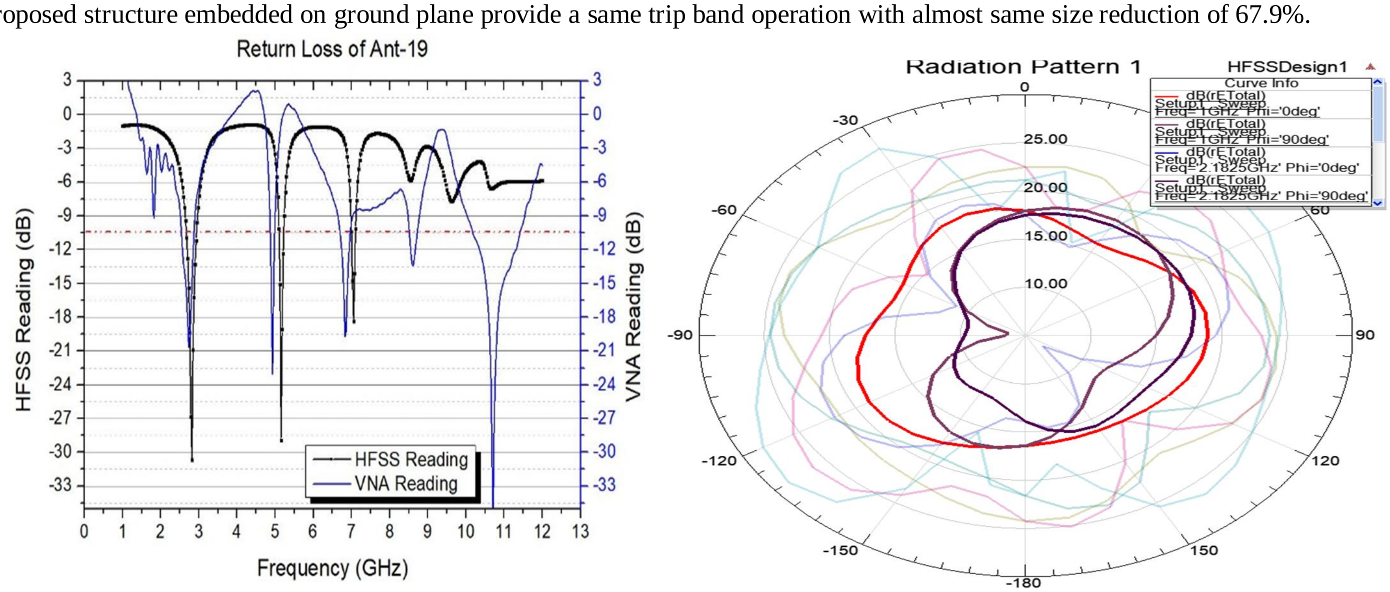


Fig 4: Return loss and radiation pattern of proposed antenna-2 measured and simulated.

From the Fig 4 we have a radiation pattern similar to that of the omni directional, with gain of 7 dBi. Table 3 provides a detail analysis of proposed antenna 2.

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Table 3: Detailed analysis proposed antenna-2

	ANT-02					
	fc in Ghz	rl in db	fh in Ghz	fl in Ghz	I BW in %	BW in Mhz
1	2.815	-30.694	2.953	2.650	10.746	302.500
2	5.153	-28.911	5.235	5.098	2.669	137.500
3	7.050	-18.353	7.105	6.995	1.560	110.000

The antenna-2 is found to have larger bandwidth at same resonating frequency as that of antenna-1. By comparison of Table-1 and Table-2, proposed antennas resonate at multiband frequency. Antenna-2 is found to have larger bandwidth and better radiation pattern than that of antenna-1. Objective of multiband operation and gain enhancement and multiband operation from a conventional antenna with grid shaped defected ground structure. The simulation and measurement results of the proposed structure is performed on the vector network analyzer, antennas are fabricated using photolithographic process. Fig 5 shows conventional design of proposed antenna. Table 4 gives a size reduction of both proposed antenna with respect to conventional design [10] [11].

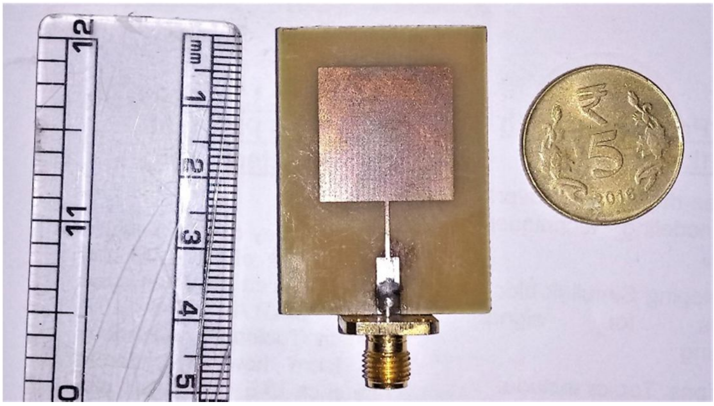

Fig 8: Fabricated antenna conventional of 5 GHz.

Table 4: Size comparison table with conventional design

Antenna	Convectional patch size without DGS at f= 5GHz	Patch size needed for at resonating frequency with DGS	Size reduction in %
Antenna-1	3.461 cm^2	10.81	67.9
Antenna-2	3.461 cm^2	10.81	67.9

II. CONCLUSION

This work has provided a platform for applying grid structure for conventional microstrip as defected ground structure which results in making the antenna resonate in lower band of frequency providing virtual size reduction of 67.9%, in comparison with conventional parameters the gain and other parameters have increased to more of higher values gain is measured as 7dbi for antenna-2. It is reported that simulated and measured values of antenna are matching. These antennas can find their application in both higher as well as lower band of application, since antennas resonate from 2.851 GHz to 7.505 GHz.

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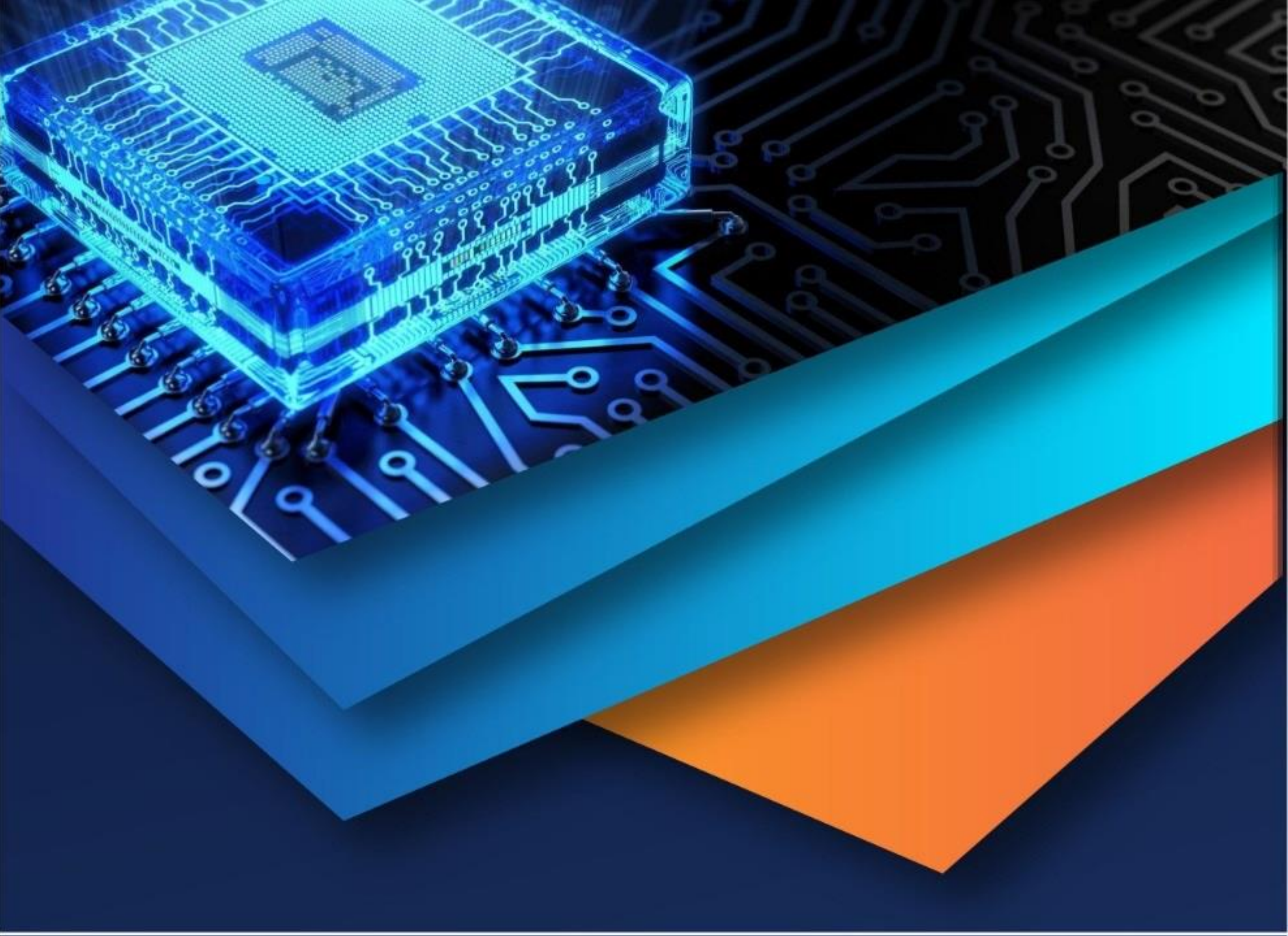

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