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MODIFIED SQUARE RING SHAPED DGS EMBEDDED ON MICROSTRIP ANTENNA

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ABSTRACT

The requirement of large bandwidth and achievement of better performance is always being a challenge for microwave engineers.To overcome some of the disadvantages of the Microstrip antennamany approaches have been made, to achieve the better performances and bandwidth, from the review of literature it is found that there is a tremendous developments in the fields of Defected Ground Structure (DGS), on printed Microstrip antennas is been made, with a particular geometry and shape which is etched out as a single defect or periodic configuration to create a feature of stopping wave propagation through the substrate over a frequency range.

In this paper, an approach to improve the performance and bandwidth of square Microstrip antenna of frequency 2.4GHz is made by embedding the patch antenna with a modified square ring defect in the ground plane. The simulation process has been done through Finite Element Machine (FEM) based software High Frequency Structure Simulator (HFSS) software. The properties of the antenna designed for 2.4GHz lead to antenna virtual size miniaturization and better reflection coefficient with larger bandwidth and multi band operation. It is found that the antenna resonates at 1.6GHz for antenna-1 and 1.725GHz for antenna-2 with the band width of 1100MHz and the overall size reduction is found to be 48% in comparison with the conventional square antenna, and also its found that the because of the defected structure etched out of the ground plane the copper usage is reduced to 30%. Further it's also observed that proposed antenna finds its most of application in the lower band like IEEE 802.11 and ISM Bands.

Keyword: Antenna, Square MSA, DGS, Multiband operation, Bandwidth, HFSS.

I. INTRODUCTION

Microstrip antenna (MSA) technology has developed rapidly due to its numerous application and unique features in the field of microwave engineering, MSA has numerous advantages such as low volume, lesser cost, most importantly compatible with integrated circuits, which extends its application, In 1970's the first practical antenna [1] was designed. Since then, extensive research and development work in this field is taking place. Microstrip antennas also have their disadvantage which hinders the performance of the antenna, many research has been carried out to improve and overcome the disadvantages of the MSA.

Towards the achievement of the high data-rate and low signal power the microwave engineering is been focusing on the development to overcome the disadvantages, from the recent literature survey there is been a

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tremendous development in improving the performance using Defected Ground Structures (DGS), which is also known as Electronic Band Gap [1]. As the name suggest it's the intentionally created defect on the ground plane of the MSA under the printed transmission line and it perturbs the electromagnetic fields around the defect. Trapped electric fields give rise to the capacitive effect (C), while the surface currents around a defect cause an inductive effect (L). This, in turn, results in resonant characteristics of a DGS They have different shapes and size with different frequency responses and equivalent circuit parameters.

The DGS underneath the transmission line disturbs the current distribution in the ground plane and modifies the equivalent line parameter over the defected region. Which indirectly influence the wave characteristics and exhibits band gap properties as present in EBG structures and also produce a slow wave effect, which helps in compacting of printed antenna.

Design of DGS

With a proper modeling technique, we can obtain a basic mathematical model of the frequency based defect. A defect changes the current distribution in the ground plane of microstrip line, giving rise to equivalent inductance and capacitance. Thus, DGS behaves like L-C resonator circuit coupled to microstrip line. When an RF signal is transmitted through a DGS-integrated microstrip line, strong coupling occurs between the line and the DGS around the frequency where DGS resonates. If the transmitted signal covers the resonant frequency of DGS, and most of the signal is stored in its equivalent parallel LC resonator. Basically, modeling is classified into three main categories: (a) transmission line modeling [2]; (b) LC and RLC circuit modeling [3-4]; and (c) quasi-static modeling [5].

II. DESIGN OF PROPOSED ANTENNA

The proposed antenna is designed using the conventional design equations [6] and the conventional square antenna of frequency 2.4GHz was designed

Design consideration for required frequency i.e. 2.4GHz as given

Length L, usually $0.333\ \lambda_o < L\ 0.5\lambda_o$

$t \ll \ \lambda_o$Patch thickness

Height of substrate h, usually $0.003\ \lambda_o\ \leq h \leq 0.05\ \lambda_o$

The dielectric constant is considered $2.2\ \leq \epsilon_r \leq 12$

Based on the above design considerations and equation the conventional square MSA was designed with thickness of substrate as 1.6mm and its relative permittivity $\epsilon_r = 4.2$ from the calculation the length (L) and width (W) of patch is given as 3.01cm, and the length and width of substrate is calculated using 6h+ L, 6h+W, respectively. For the proposed antenna Microstrip line strip feed method was used to feed the signal. The top view of the conventional square MSA is as shown in Figure 1.

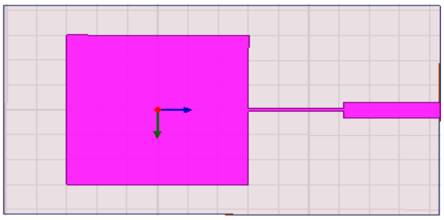

Figure 1: Top view of Square MSA

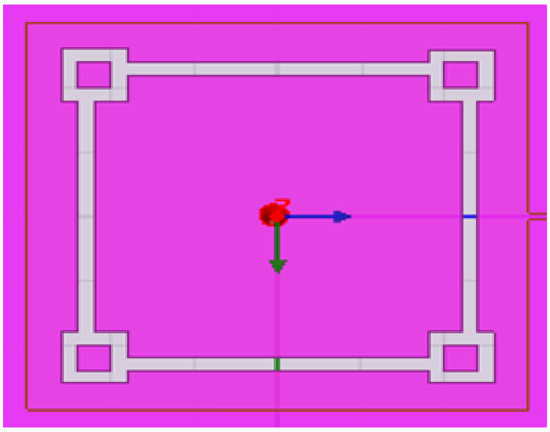

Figure 2: DGS of Antenna-1.

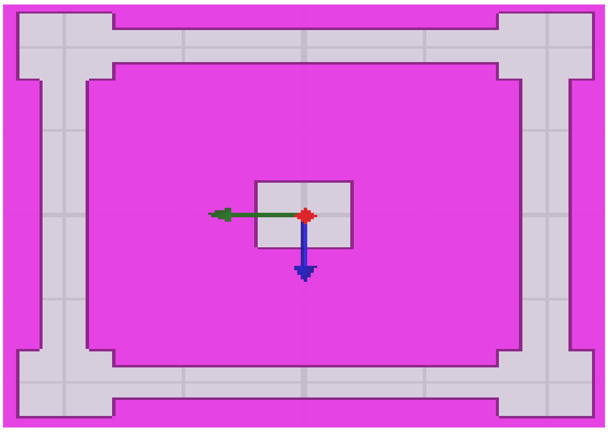

Figure 3: DGS of Antenna-2.

Simulated and desired results of conventional MSA were obtained as designed for the frequency. In order to improve the performance and to obtain improvement of bandwidth and other parameters of the antenna the DGS of following structure was introduced. Figure 2 shows the shape and the dimension of the defect structure for antenna-1 and Figure 3 for antenna-2. This is calculated using transmission line model. The designed structure is then embedded with the conventional square patch antenna on the ground plane, i.e. it's etched out from the ground plane.

III. RESULTS AND DISCUSSION

The Square ring shaped DGS as shown in the Figure 2 is been embedded with square MSA. The S11 parameter for the proposed antenna is calculated and the reflection coefficient of the antenna is obtained as shown in Figure 4. The results of reflection coefficient and other parameters are tabulated in Table-1

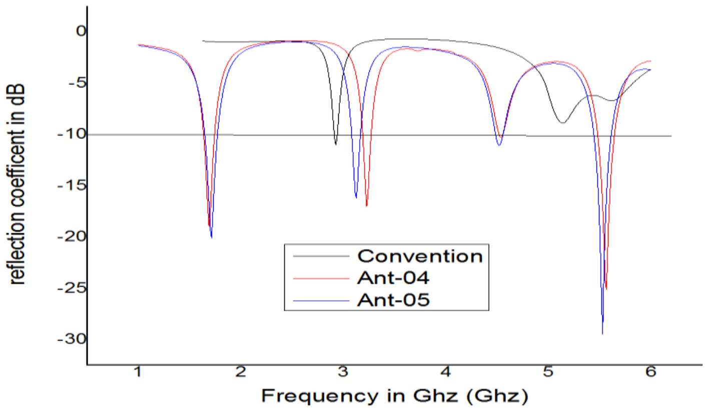

Figure 4: Reflection coefficient ofconventional and DGS embedded antennas.

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The results of reflection coefficient and the bandwidth of the proposed antenna embedded with modified DGS is given below as compared with conventional antenna of design 2.4GHz the antenna-1 is resonating in multiband frequency same with antenna-2, the bandwidth is less compared to that of conventional design but the reflection coefficient of multiple frequency is high due to with the impedance matching of single antenna for multiband operation is good as that compared with convention design.

Antenna	Resonating frequency in GHz	Reflection coefficient in dB	Bandwidth In MHz	Virtual Size reduction in %
Conventional	2.3	-11.030	145	-
Antenna-1	1.687 3.225 5.562	-18.92 -17.00 -25.10	100 75 150	42
Antenna-2	1.712 3.125 4.525 5.525	-20.07 -16.18 -11.01 -29.46	137 75 70 150	39

Table 1: reflection coefficient and bandwidth

Further we can see that proposed antenna is resonating is lower frequency than that of conventional design with leads to give us the virtual size reduction in the antenna up to 42% in compared with conventional size, and the same antenna is used for the higher frequency also.

The radiation pattern of the proposed antenna is shown in Figure 5from the figure it's observed the antenna radiation is Omni directional in azimuth plane, at resonant frequency of 1.68GHz and 1.725Ghz.

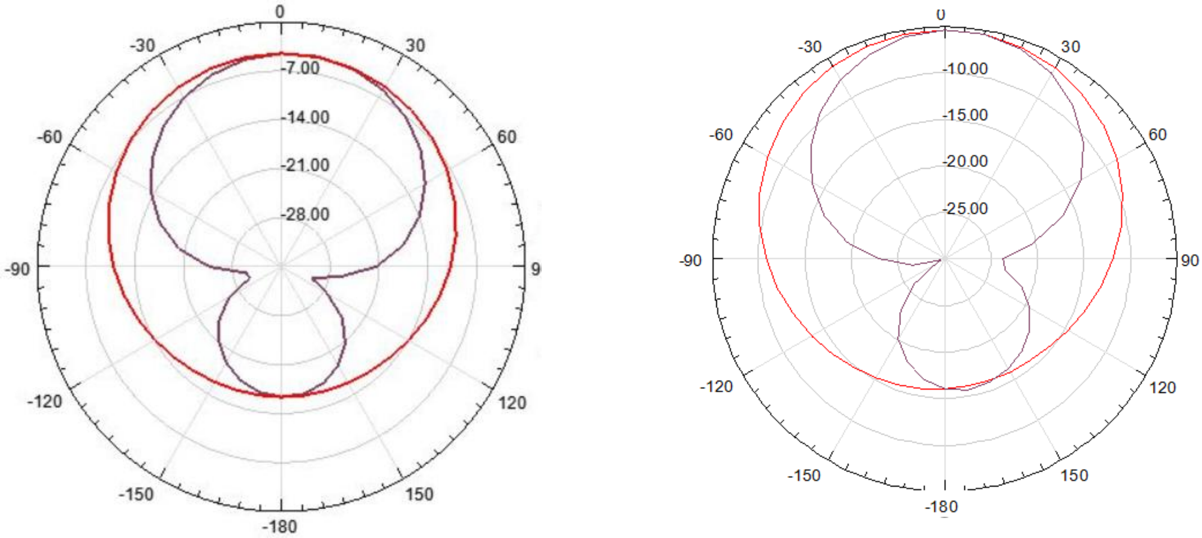

Figure 5: The Radiation pattern of the designed antenna-1 and antenna-2.

The gain of the antenna stands to be the most important factor among the parameters of the antenna; it is the ratio of radiated field intensity by test antenna to the radiated field intensity by reference antenna [7]. The gain of the antenna improves with DGS which is found to be 29.8dB and 25.10dB when compared with conventional square MSA (4.62dB).

From the smith chart Figure 6 given below can observe that the impedance match of the designed antenna is good.

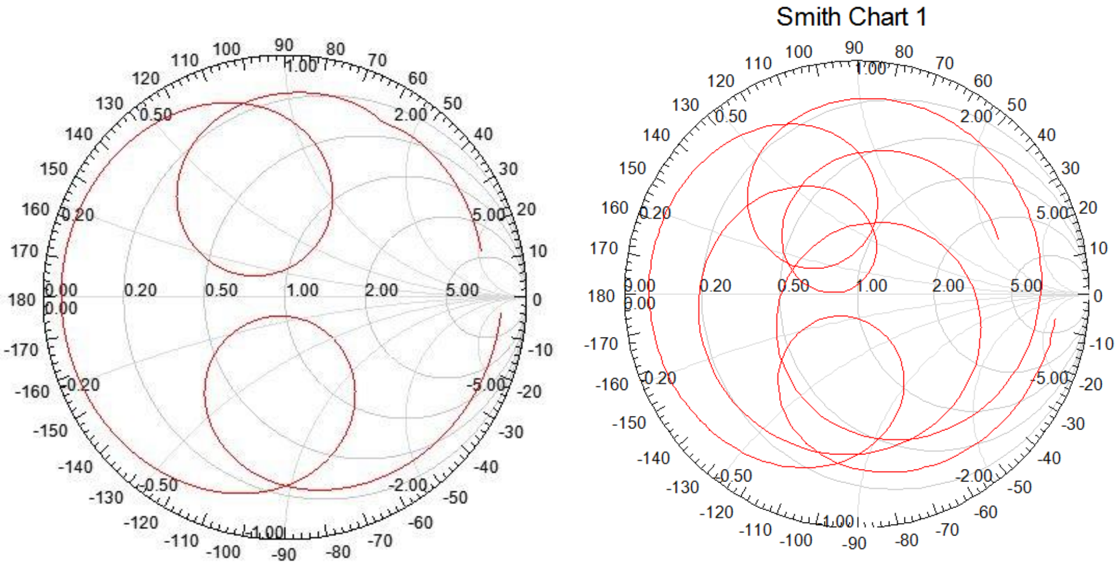

Figure 6: Smith chart of proposed antenna-1 and antenna-2

The important point to be observed in the following results and simulation is that the proposed antenna is resonating for the dual band operation in the lower frequency as well as in the higher frequency due to which the bandwidth improvement also can be claimed in the proposed antenna.

IV. CONCLUSION

From the detailed study, it is observed that the conventional antenna designed for 2.4GHz when embedded with the square ring shape defected ground structure exactly below the patch, because of which the antenna resonates both in lower band as well as in the higher band giving dual band operation of the antenna. From which size reduction of 42.8% as well as the bandwidth of 1100MHz is obtained. When a conventional antenna is embedded with DGS not only the parameters of the antenna is improved as well as without changing the shape of the antenna we are reducing the amount of copper used in the design of the antenna. In this proposed antenna approximately 30% copper is reduced in the ground plane, DGS plays an important role in modern printed antennas to improve the parameters and enhance the performance.

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