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MULTIBAND OPERATION OF CONVENTIONAL SQMSA EMBEDDED WITH DGS

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ABSTRACT

In this paper a modified square Microstrip antenna is proposed to increase multiband operation and return loss. The operating frequency of the antenna designed is 2.4 GHz ISM band. To enhance the performance of the antennaDefected Ground Structure (DGS) has been introduced on the ground plane of the Microstrip antenna with slight modification in the dimensions of the DGS introduced and change of performance is studied. The DGS has been optimized to provide a multiband resonance. The stop band of the DGS added with stop band of the square antenna which is responsible for enhancement of return loss. The DGS on the ground plane increases fringing field which introduces parasitic capacitance. This parasitic capacitance increases the coupling between theconducting patch and the ground plane which is responsible for the enhancement of the bandwidth. The performance of the antenna is depends on the physical dimension of the antenna as well as location and shape of the DGS. The simulation process has been done through Finite Element Machine (FEM) based software High Frequency Structure Simulator (HFSS) software. The properties of antenna such as reflection co-efficient, bandwidth and gain are determined and compared with the properties of single element square patch antenna and dimension of DGS. 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: DGS, Bandwidth, HFSS,Square MSA,.

I. INTRODUCTION

The Microstrip patch antenna is one of the most useful antennas for low cost and compact design for RF applications and wireless systems. In wireless mobile communication and satellite applications, Microstrip antenna has attracted much interest because of their small size, low cost on mass production, light weight, low profile and easy integration with the other components [1-2]. Although Microstrip patch antennas have many very desirable features, they generally suffer from limited bandwidth. So the most important disadvantage of Microstrip resonator antenna is their narrow bandwidth. To overcome this problem without disturbing their principal advantage (such as simple printed circuit structure, planar profile, light weight and cheapness), a number of methods and structures have recently been investigated.

An individual Microstrip patch antenna has a typical gain of about 6 dBseveral approaches have been used to enhance the bandwidth by perturbing the higher order mode by interpolating surface modification into patch geometry. The most unique technique to reduce the size of patch is to defect the ground. While comparing the antenna with the defected ground structure and the antenna without the defected ground, the antenna having defected ground structure reduces the size of antenna [7]. The percentage of reduction of size depends upon the ground area that is defected. Defected Ground Structure disturbs the shielded current distribution that depends on the dimension and shape of the defect. The current flow and the input impedance of antenna are then influenced by the disturbance at shielded current distribution due to the DGS structure. The DGS structure can also be used to control the excitation and the electromagnetic waves propagating through the substrate layer [6]. A defect in the ground plane causes to increase in effective capacitance and inductance. In this paper, Microstrip antenna for low frequency at 2.4 GHz is designed and simulated using the HFSS software.

II. ANTENNA DESIGN PARAMETERS

For the designing of square Microstrip patch antenna, the following equations are used to calculate the dimensions of the square Microstrip patch antenna [7].

Design consideration for required frequency.

Length L, usually 0.333 λ_0< L < 0.5 λ_0

t<<λ_0 patch thickness

Height of substrate h, usually 0.003 $\lambda_0 \leq$ h $\leq$ 0.05 λ_0

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

An effective dielectric constant ε_{reff} must be obtained in order to account for the fringing and the wave propagation in the line. The value of ε_{reff} is little less than ε_r because the fringing fields around the edge of the patch are not confined in the dielectric substrate but are also spread in the

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{\frac{1}{2}}$$

air. The expression for ε_{reff} can be given as:

The dimensions of the patch along its length have now been extended on each end by a distance ΔL, which is given empirically as:

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

The effective length of the patch L_{eff} now becomes:

$$L_{eff} = L + 2\Delta L$$

For a given resonance frequency f_0 the effective length is given by as:

$$L_{eff} = \frac{C}{2f_0\sqrt{\varepsilon_{reff}}}$$

For a rectangular Microstrip patch antenna, the resonance frequency for any TM_{mn} mode is givenby as:

$$f_0 = \frac{C}{2\sqrt{\varepsilon_{reff}}}\left[\left(\frac{m}{L}\right)^2 + \left(\frac{n}{W}\right)^2\right]^{\frac{1}{2}}$$

Where m and n are modes along L and W respectively

For efficient radiation, the width W is given as:

$$W = \frac{C}{2f_0\sqrt{\frac{(\varepsilon_r+1)}{2}}}$$

Substrate dimensions given as:

$$L_g = 6h + L\& \qquad W_g = 6h + W$$

Where,

h = substrate thickness

L = length of patch

L_{eff} = effective length

W = width of patch

c = speed of light

f_0 = resonant frequency

ε_r = relative permittivity

ε_{reff} = effective permittivity

L_g = Length of ground plane

W_g = Width of ground plane

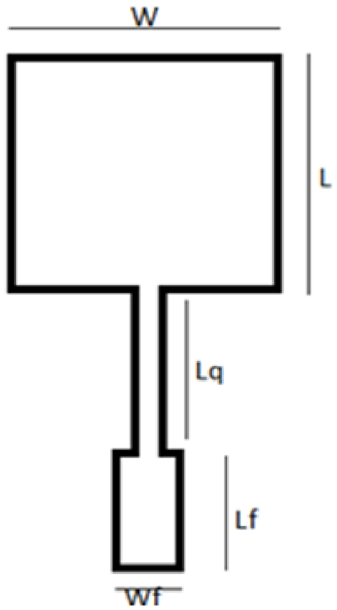

Figure 1: Top view of conventional square MSA

Based on the above formulae a conventional square patch antenna has been designed with thickness of substrate as h=0.16cm and relative permittivity$\varepsilon_r = 4.2$. From the analysis the length and width of patch are 3.01 cm and 3.01 cm respectively and length and width of substrate are 7.2cm and 4.2cm respectively.The proposed antenna is fed by using Microstrip line feed method. Figure 1 shows the top view of conventional square MSA [7].

III. PROPOSED ANTENNA DESIGN

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].

In the proposed antenna the defect in the ground structure is introduced as the square ring shaped defect which is spread across the edges of the Square Microstrip antenna (SQMSA)as shown in the Figure 2 the defect

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introduced in the conventional SQMSA has made the antenna not only to resonate in the lower frequency but also as a multiband antenna which finds its application in various ISM band frequency.

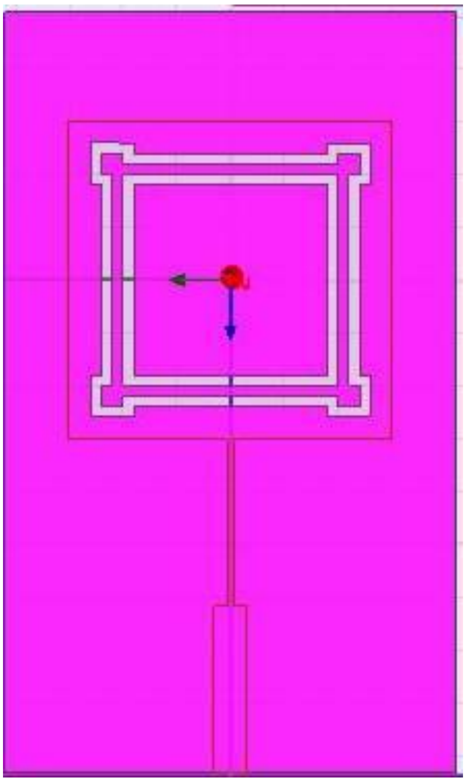

Figure 2: Defected Ground Structure Introduced on SQMSA

The defect introduced is modified to find out the various variations in the antenna parameters Table 1 gives the comparison of reflection coefficient vs. Frequency from the conventional SQMSA and DGS embedded SQMSA.

Table 1: Comparison Table for Reflection Coefficient with Different Modifications in the DGS

Antenna Deigns	Resonating Frequency in GHz with reflection coefficient	BW MHz	Size reduction in %
Conventional SQMSA	2.36 at -16.50dB	1.27	0
Antenna-4	1.71 at -18.34 3.23 at -14.23 4.52 at -13.82 5.55 at -33.45	125 to 155	40.35

The Modification introduced on conventional SQMSA with DGS as shown in Figure 2 has effect of change in the reflection coefficient and also gives the multiband operation of the antenna, we can also observe the change in the radiation patterns and input impedance change as discussed in the results.

IV. 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 antennas is calculated and the reflection coefficient of the antennas is obtained as shown in Figure 3. From the figure we can say that antenna-1 to antenna-4 is resonating with larger reflection coefficient of -18.34dB at 1.715GHz to -33.45dB at 5.5750GHz with impedance bandwidth as shown in the Table 1 Which is much larger than that obtained for conventional square MSA.

Other parameters such as the overall size reduction of the designed antennas with respect to conventional square MSA is up to 43.78%. Also it is observed that the antenna resonates both in lower as well as in higher band of frequencies that is at 1.68GHz and 5.5GHz. Which gives the proposed antenna has multi band of operation and large bandwidth.

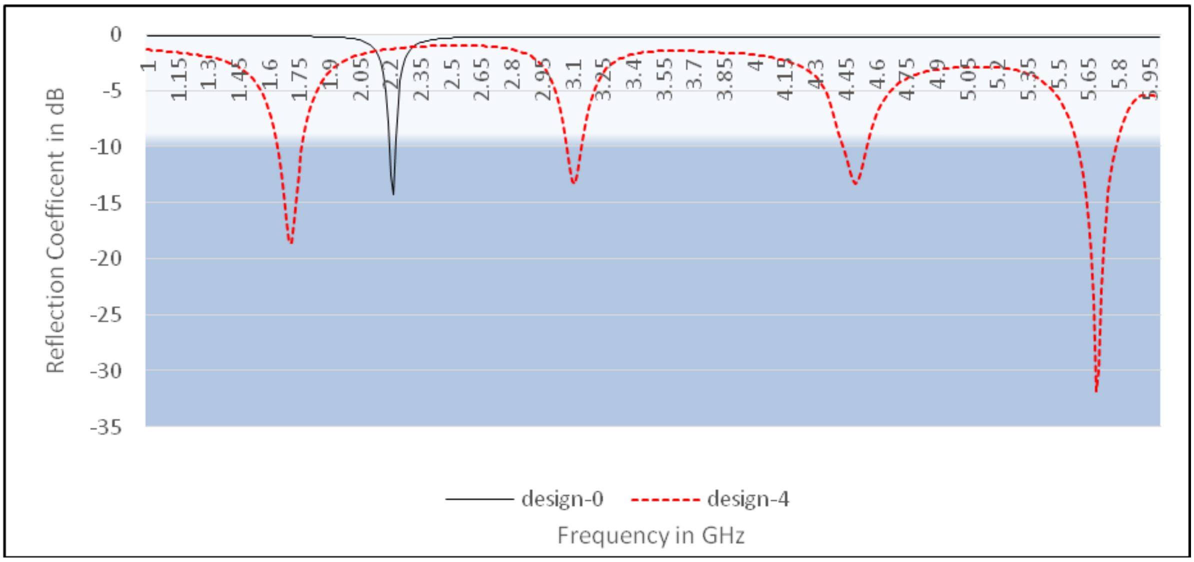

Figure 3: Reflection Coefficient vs. Frequency of Designed Antennas.

The radiation pattern of the proposed antennasare shown in Figure 4 from the figure it's observed the antenna radiation is Omni directional in azimuth plane, at resonant frequency of 1.68GHz.

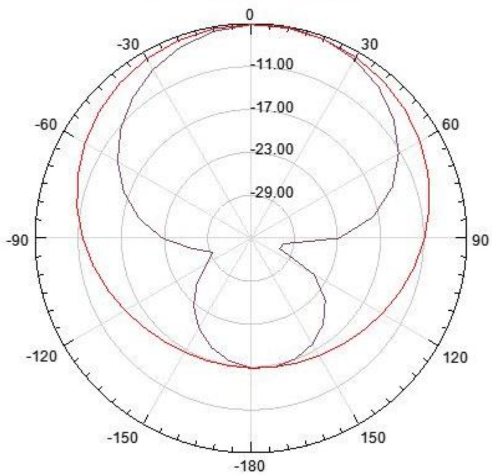

Figure 4: Radiation Pattern of Proposed Antenna

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 29.0dB when compared with conventional SQMSA (4.62dB).

From the smith chart Figure 5given below can observe that the impedance match of the designed antenna is good as shown in the below figure multiband frequency having good impedance match.

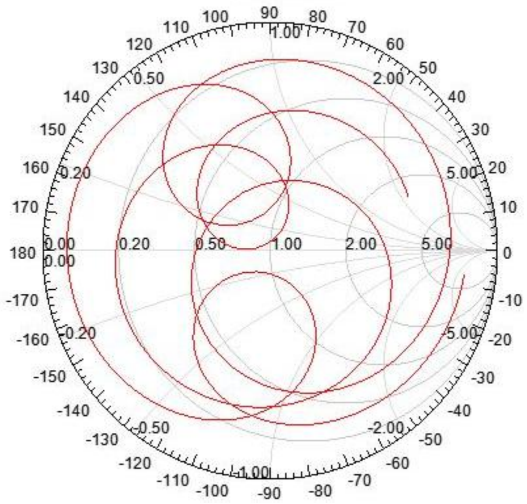

Figure 5: Smith Chart of Proposed Antennas

The important point to be observed in the following results and simulation is that the proposed antenna is resonating for the multi 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.

V. CONCLUSION

From the above study it is observed that the conventional antenna designed for 2.4GHz when embedded with the square ring shape defected ground structure and different modifications over it which is placed exactly below the patch, because of which the antenna resonates both in lower band as well as in the higher band giving multiband operation of the antenna. From which size reduction of 43.78%. 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 which can be claimed as size reduction. 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, enhance the performance and have multiband operation.

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