Effect of Size and Location of the DGS on Characteristics of Rectangular Micro Strip Patch Antenna

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ABSTRACT
Microstrip antennas due to their small profile design take less area. Further they can be modified by two techniques that are introducing defect in ground plane and adding layers to the conducting surface in order to improve its gain, VSWR, bandwidth, return loss and directivity.[4] The most novel technique is modifying the ground plane known as Defected Ground Structure. This paper presents the effect of changing the location and size of the defect introduced in ground plane on the characteristics of the rectangular microstrip patch antenna. The antenna is simulated on Duroid substrate with dielectric constant of 2.2 and fed with 50 ohms microstrip line using HFSS software. By introducing the defect in the ground plane and changing its location and size the corresponding changes in the characteristics have been noted for 2.4GHz of resonant frequency.

Keywords
Microstrip Patch Antenna, Defected Ground Structure.

1. INTRODUCTION
Defected Ground structure or DGS has brought out the new technique for improving the bandwidth of the rectangular microstrip patch antenna by means of modifying the ground plane instead of changing the patch designs.[5] DGS employ modification in the ground structure which in general case found to be plane. Basically, DGS is achieved by etching process found in periodic or non-periodic cascaded structure. Defect in ground causes to disturb the shield current distribution, this disturbance in shield current distribution cause to change the characteristics of transmission line in sense of its equivalent capacitance and inductance.[1]

This paper will show the effect of location and size of the defect on the characteristics of the rectangular MSA.

2. DESIGN CALCULATIONS FOR MSA

2.1 Design Requirements
For a design of MSA we need to calculate the dimension of the patch layer taking consideration of following factors.

- Resonant frequency(fr) = 2.45Ghz
- Dielecrtric constant(er) =2.2
- Bandwidth(Bw) >120Mhz
- Return loss > -10dB
- 1 < VSWR > 2

2.2 Antenna Geometry
Width of patch

$$W = \frac{c}{2fr\sqrt{\frac{\varepsilon r+1}{2}}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

W = 43.29mm

Effective dielectric constant

$$\varepsilon reff = \frac{(\varepsilon r+1)}{2} + \frac{(\varepsilon r-1)}{2}\left(1+12\frac{h}{w}\right)^{\frac{-1}{2}} \quad \ldots\ldots (2)$$

$\varepsilon reff$ = 2.8388

Then calculate the effective length.

Effective length

$$Leff = \frac{c}{2*Fr*\sqrt{(\varepsilon reff)}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.... (3)$$

$Leff$ = 36.34mm

Delta length

$$\Delta L = 0.412h\frac{(\varepsilon reff+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon reff-0.258)\left(\frac{W}{h}+0.8\right)} \qquad \ldots\ldots\ldots\ldots.. (4)$$

ΔL = 747.7µm

Actual length

With the effective length and delta length now calculate the actual length patch:

L = Leff – (2*ΔL) …………………………… (5)

L= 34.84mm

Ground plane

The width and length ground plane can be calculated by the following equations:

Wg = 6*h +W = 52.41mm ……………………... (6)

Lg = 6*h + L = 43.96mm ……………………... (7)

3. SIMULATION TOOL
Now with having the dimensions it is required to model the design in the software based tool for example the software

from Ansoft called HFSS. It is found to be precise antenna simulation software available in the market with ease of user friendly interface. Building of the 3-D drawing in HFSS is far easy because of its dynamic selection of geometrical shapes. The three different ground planes are designed by using Boolean and subtraction operation available in the HFSS.

4. DESIGN MODELS

4.1 To study the Effect of changing the location of Defect

To study the effect on Bandwidth, Return loss, VSWR and radiation pattern of rectangular MSA due to changing the locality of the defect in ground plane, three different locations has been considered i.e. at left most part, at the centre and at the rightmost part of the ground plane. Following models in Fig.1, Fig.2 and Fig.3 respectively shows the locations of the defect

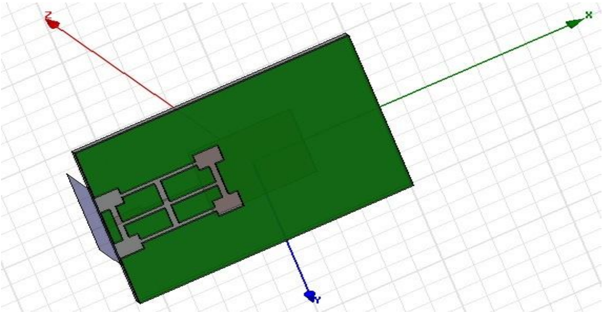

Fig 1: Defect introduced at left most part in ground plane

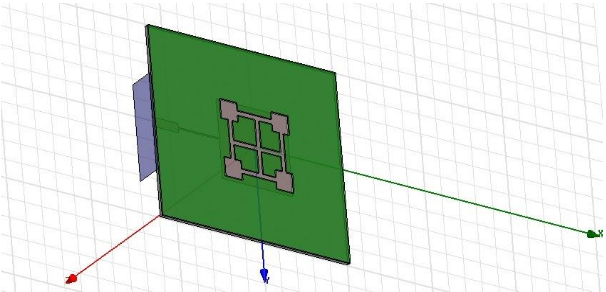

Fig 2: Defect introduced at center of the ground plane

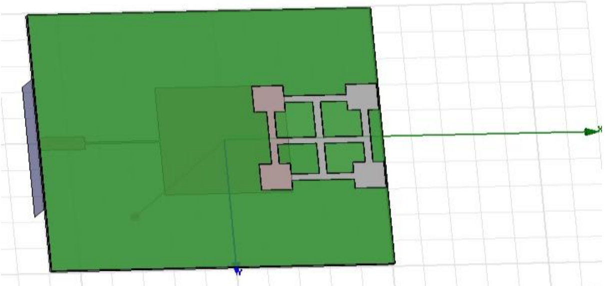

Fig 3: Defect introduced at right most part in ground plane

In the all three models the patch and substrate layer are kept same and they are simulated to obtain the results for the mentioned parameters shown in the Table.1.

4.2 To study the Effect of changing the Size of Defect

For analyzing the behavioral changes in the above mentioned characteristics of the rectangular MSA due to change in the size of the defect a model shown in fig.4 is designed. The size of the defect is reduced to 50% than it is used in fig.3. Corresponding changes and its comparison with the original is listed in the Table.2

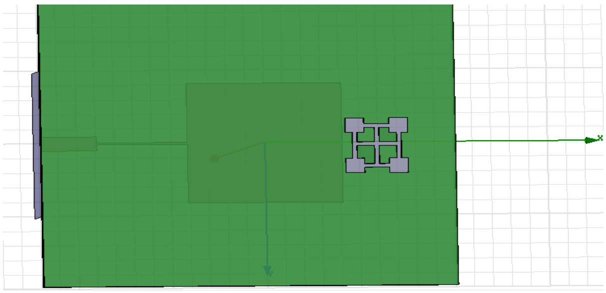

Fig 5: 50% Reduction in size of the defect

5. RESULTS OF THE SIMULATION

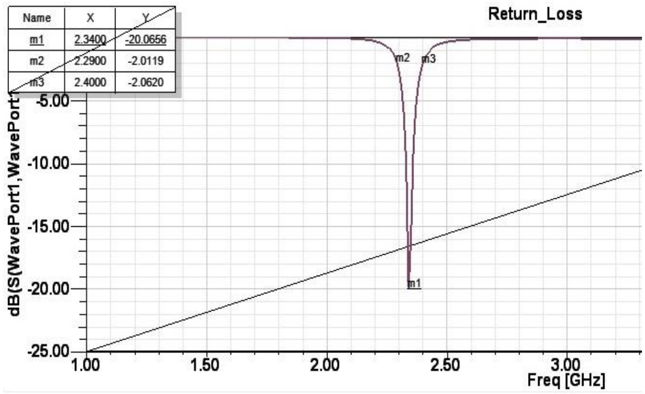

Fig 6: BW and Return loss in leftmost located DGS

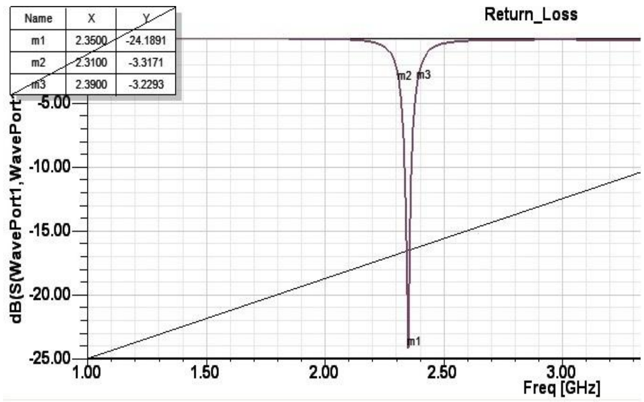

Fig 7: BW and Return loss in Center located DGS

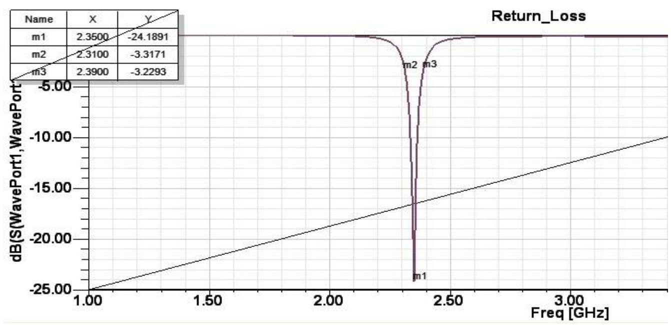

Fig 8: BW and Return loss in right most located DGS

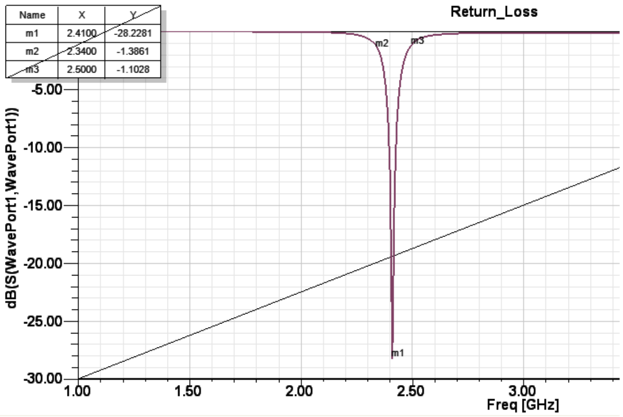

Fig 9: BW and Return loss of Reduced Size DGS

Fig.6 to Fig.9 shows the bandwidth and return loss variations due to various locations and sizes of the defect. The variation in return loss is observed in the range of -19.4961dB to -28.2281 and variation in the bandwidth is in the range of 90Mhz to 160Mhz.

Similarly the variation in the VSWR is observed as shown in the fig.10 to fig.13

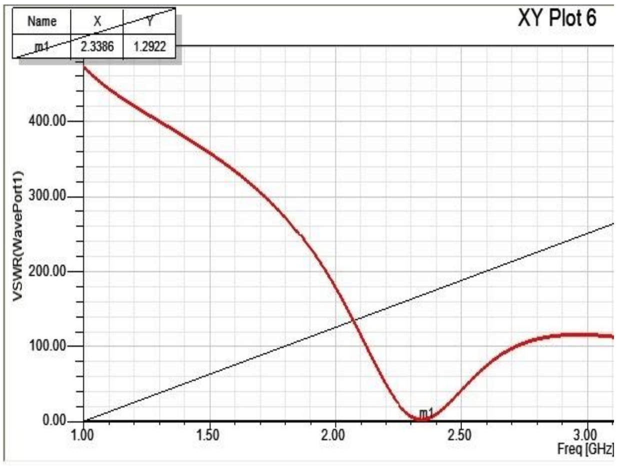

Fig 10: VSWR of the leftmost located DGS

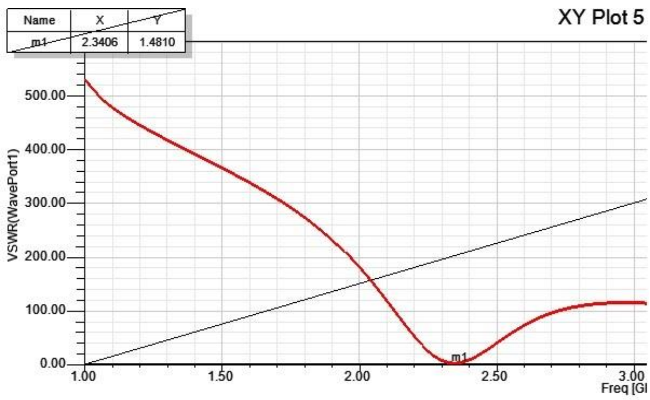

Fig 11: VSWR of the centre located DGS

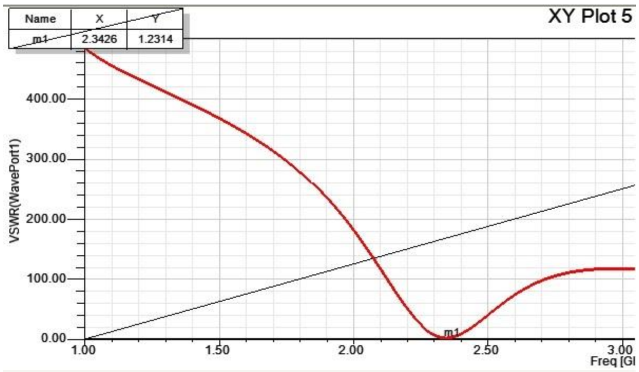

Fig 12: VSWR of the right most located DGS

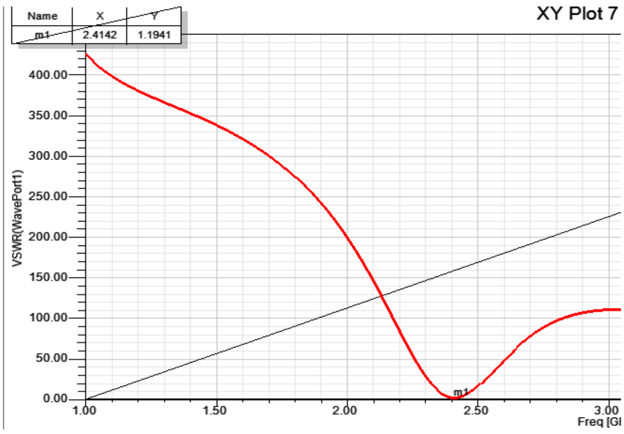

Fig 13: VSWR of the Reduced Size DGS

Fig.10 to Fig.13 shows the variation in the VSWR caused due to various locations and sizes of the defect. The variation in VSWR is observed in the range of 1.1941 to 1.4810.

Similarly the variation ii gain is from 7.45 to 7.48dB is observed

6. CONCLUSION AND RESULT ANALYSIS

It would have been a big advantage to know the HFSS simulation software beforehand as a lot of measurements could have been applied. Microstrip antennas and their theory get much more complex as you want to create more efficiency and wider bandwidth. Table.1 lists the parameters for various located defected structures. Defect in the centre of the ground plane brings down the bandwidth to the lowest value amongst the all while defect in the right most side increases the bandwidth up to 30% that of the centre. Return loss in dB is observed at the lowest in the centre located DGS structure. VSWR is ideal and lowest in the right most located Defect. While there is not significant variation is observed in the gain.

Table 1. Effect of changing the location of the Defect

Location of the Defect	Bandwidth	Return loss dB	VSWR	Gain
At Left most	90 Mhz	-20.06	1.29	7.48
At Centre	80 Mhz	-24.18	1.48	7.46
At Right most	110 Mhz	-19.49	1.23	7.25

Table.2 shows the changes in the antenna parameters due to the reduction in the size of the defect. For comparison purpose the rightmost defect model is taken and size of the defect is reduced to the 50% than its original.

Table 2. Effect of changing the size of the Defect

Size of the Defect	Bandwidth	Return loss dB	VSWR	Gain
Size1	110 Mhz	-19.49	1.23	7.25
Size2	160 Mhz	-28.22	1.19	7.25

All the dimensions of Size2 are half than that of the size1.

The 45% improvement has been observed in the bandwidth of rectangular MSA due to reduction in the Defected structure. All the results lead to the conclusion that the location and the size of the defect changed the parameters of the antenna. The smaller and right shifted defect improves bandwidth and bring down the VSWR near to unity.

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