International Journal of Research in Engineering, Science and Management
Volume-2, Issue-4, April-2019
www.ijresm.com | ISSN (Online): 2581-5792

Development of Tunable Defected Ground Structure for Multiband Application

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***Abstract*: Introduction of DGS structure in ground plane is capable to influence the bandwidth of the MS line. Introduction of short along with the DGS changes the upper frequency of MS line. It is observed that by varying locations of short along the DGS upper frequency changes to 2.5 GHz, 7 GHz and 10 GHz.**

***Keywords*: bandwidth, short**

1. Introduction

A defected ground structure helps in the design of compact microstrip product such as antennas and filters. This structure is etched in metallic ground plane to have resonant property therefore many of them have been applied to filter circuits.

Many etched shapes for the microstrip could be used as a unit DGS. The etched defect in ground plane changes the current distribution in the ground plane and this change in the current disturbance changes the characteristics of the microstrip transmission line by modifying the line capacitance and inductance. Therefore, to represent the DG unit an LC equivalent circuit can be used. The physical dimensions of the DGS unit affect the equivalent circuit parameters. It is one the purposes of this thesis to study different DGS slots and the effect of its shape on the equivalent circuit parameters and the response of the circuits. To design a circuit with DGS section, the equivalent circuit and parameters of the DGS section should be extracted. The equivalent circuit parameters are extracted from the response of the EM Simulator. The etched DGS in a transmission line section can be used as a series element. The shunt capacitance can be implemented either by stub or low-characteristic impedance section.

Following are the advantages of using DGS slot in the ground plane in a low-pass filter:

- The structure is very compact and simple.
- DGS introduces a very wide and the rejection is better than that of a conventional low-pass filter.
- It introduces a very low insertion loss in the product.

2. Literature Survey

Defected ground structures (DGS) have been developed to improve characteristics of many microwave devices. Although the DGS has advantages in the area of the microwave filter design, microwave oscillators, microwave couplers to increase the coupling, microwave amplifiers. DGS is also used in the microstrip antenna design for different applications such as antenna size reduction, cross polarization reduction, mutual coupling reduction in antenna arrays, harmonic suppression and many more. The DGS is derived from the concept of Photonic/Electromagnetic Band gap structures. The etching of one or more PBG element creates defect in the ground plane and used for the same purpose. An equivalent L-C resonator circuit is the representation of DGS. The value of the inductance and capacitance depends on the area and size of the defect. By varying the various dimensions of the defect, the desired resonance frequency can be achieved. In this paper the effect of DGS, to the different antenna parameter enhancement is studied.

3. Scope of Project

A DGS, depending on the size of it, is capable of rejecting a particular band and passing the remaining. It is well understood that the LC circuit is the equivalent representation of the DGS. It is known that the resonant frequency of the LC circuit is dependent on the L and C component. Any change in the value of the L or C, changes the resonant frequency of the LC circuit. Therefore, if the dimension of the DGS can be reconfigured then multiple stop bands can be created as per the requirement. This structure can be used in a wide band antenna to design multiband antenna.

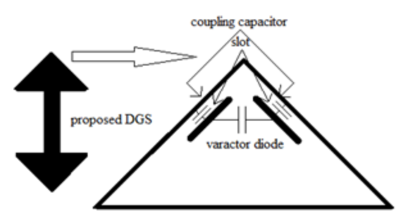

Fig. 1. Proposed reconfigurable DGS

4. Designing Method

A DGS is created in the ground plane. DGS structure is dumbbell in shape with rectangular ends. It can be of any shape line circular triangle or spiral. Fig. 1 shows the orientation of the DGS and Fig. 2, shows the dimensional details of the DGS.

The Fig. 3, shows the S-parameters of the MS line for the introduced DGS. It can be observed that the DGS brings a huge change in the behaviour of the line. The MS line still behaves like low pass filter but the upper frequency is much less than 10 GHz. It can be observed that the upper frequency is not more than 2.45 GHz with insertion loss less than -3 dB. As the frequency increases the insertion loss increases and the deflection coefficient degrades and is much less than -10 dB.

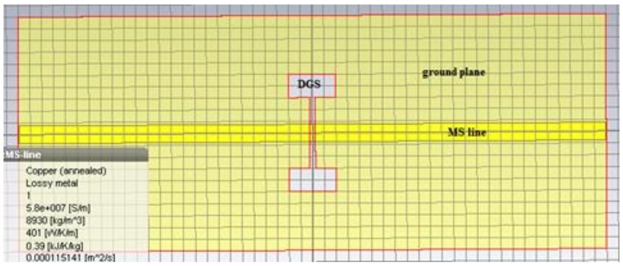

Fig. 2. DGS introduced in ground plane of MS line

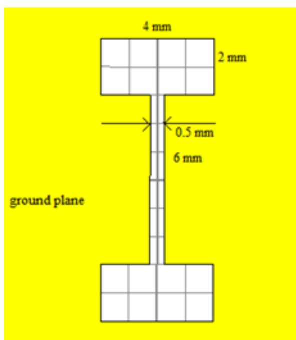

Fig. 3. Dimensional details of DGS

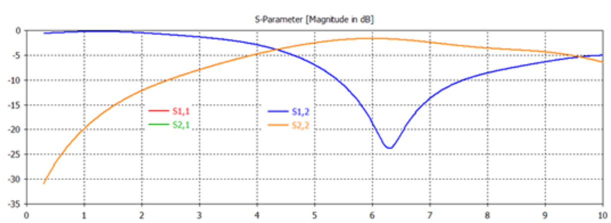

Fig. 4. Reflection coefficient v/s frequency

It is found in literature that a DGS is introduced with a varactor diode and the electrical property of the DGS is changed to change the characteristics of the MS line and a single line with single DGS can be used for various frequencies. We are proposing a different approach of using PIN diode at different locations of the DGS and by turning ON and OFF the diodes different bands can be generated.

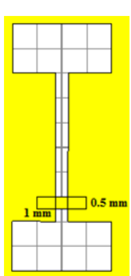

Fig. 5. Location of the Short along DGS

PIN diode is realized with the help of short and open as shown in figure. Figure 3 shows the location and dimension of the DGS with a diode in ON state. If the diode is ON then it behaves like a short circuit therefore that it is realized with the help of short circuit. The width of the height of the short is 0.5 mm and is at a height of 1 mm from the lower end of DGS as shown in Fig. 3.

The Fig. 4 shows impact of short introduced in DGS. It can be observed that the upper frequency of MS line is now shifted to 7 GHz. Now the MS line still behaves as LPF with upper frequency of 7 GHz. This upper frequency is larger than band of the MS line with DGS not having a short.

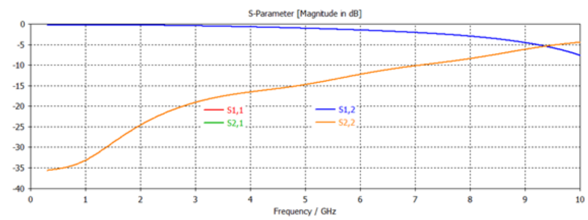

Fig. 6. S-parameters of MS line with DGS and short

The Fig. 5 shows the new location of short which is 1.5 mm above DGS.

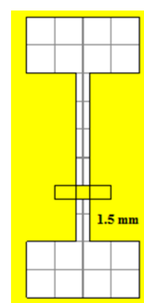

Fig. 7. Location of the Short along DGS and at a height of 1.5 mm

The Fig. 6 shows the impact of new location of short along DGS. It can be observed that the upper frequency is shifted to 10 GHz. Insertion loss is better than -3 dB. Therefore, MS line is still a LPF with upper frequency of 10 GHz.

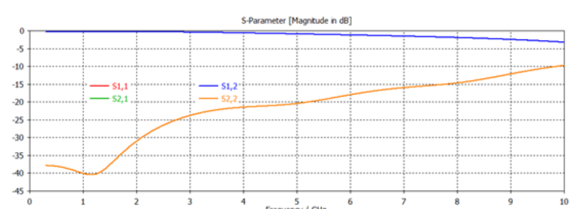

Fig. 8. S-parameters of MS line

Short circuit is shifted to new location. The short is shifted to 2.5 mm above DGS line. This is shown in Fig. 7.

The Fig. 9 shows that the impact of shift in short at a height of 2.5 mm from DGS. It can be observed that the upper frequency is more than 10 GHz.

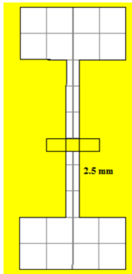

Fig. 9. Short circuit at a height of 2.5 mm from DGS

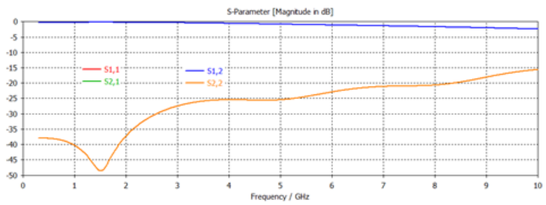

Fig. 10. S-parameters of MS line with DGS with short

The Fig. 11 shows the final location of short from DGS.

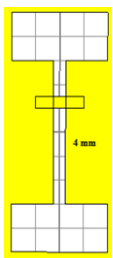

Fig. 11. New location of short in DGS line

Now the short is shifted further to a height of 4 mm, it does not give any fruitful change in the S-parameters. The upper frequency is 10 GHz.

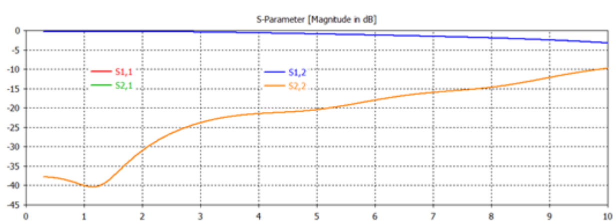

Fig. 12. S-parameters of MS line with DGS with short

It can be observed that by varying the location of short along the DGS, upper frequency of MS line changes to 2.45 GHz, 7 GHz, 10 GHz and upper frequency.

Table 1
DGS and Upper frequency

Short along DGS	Upper frequency
Plane MS line	No upper limit
DGS with no short	2.45 GHz
Short 1	7 GHz
Short 2	10 GHz
Short 3	More than 10 GHz
Short 4	10 GHz

5. Conclusion

MS line with DGS influences the S-parameters of MS line. Introduced DGS brings the upper frequency to a very small frequency which depends on the dimension of DGS. Introduction of short along with DGS further changes the upper frequency and using PIN diodes at different locations can generate different bands.

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