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A new defected ground structure for proximity coupled antenna

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ABSTRACT

The main aim of recent antenna research has been on reducing the size of the antenna and increasing the rejection of unwanted frequencies. The lesser the antenna size, the more area that can be saved, which can be used for other constructive improvements. The higher the stop band attenuation, the better the transmission and reception efficiency. A new Defected Ground Structure (DGS) is proposed in this paper which increases the stop band attenuation. In this paper the proposed DGS is compared with cross shaped, dumbbell shaped and E shaped DGS and shown to have improved performance when compared to the three.

Keywords: Microstrip antenna, stop band attenuation, polarization

INTRODUCTION

As frequency of operation of the antenna increases, it becomes increasingly difficult to design the antenna because the size of the antenna is directly related to the wavelength of the signal at the resonant frequency. In such cases, antennas which are relatively easier to design and manufacture called the microstrip antennas. Much effort has been directed towards reducing the size of the microstrip antenna which include methods such as making slots on the patch, using a stacked patch or using a substrate with high permittivity. Also, an etching of a particular shape and pattern can be made on the antenna to reduce its size and improve its performance. This sort of etching is called Defected Ground Structure (DGS). The DGS element tends to improve the stop band characteristics of the antenna and also reduces its size. Many DGS patterns have been proposed for these purposes. Recent modified patterns like the U-shaped and the H-shaped DGS have been proposed for achieving high Q-factor. In order to get the maximum gain, the transmitter and receiver antennas have to be polarized similarly. Reconfigurable antennas can be used to get different polarizations at one frequency. In this paper, a new DGS structure is proposed which improves stop band performance of the proximity coupled antenna.

Resonance behavior of DGS: Self resonance is a phenomenon exhibited by the DGS unit cells. At microwave frequencies, the change of the characteristic impedance of the transmission line is used to define the unit cell. Therefore the effects of self-resonance is expected to be proximal or even overlapping over the same frequency range. A unique cell of a periodic structure has a response that is wider and smoother compared to the resonator's frequency response.

Design and modelling of DGS: A cross shaped DGS is generally used in the design of a compact antenna but a cross shaped DGS has the disadvantage of a small unloaded Q-factor and high transmission loss. Its performance can be improved by a dumbbell shaped DGS. A layout diagram of a proposed DGS resonator and existing DGS resonators are shown in Fig. 1. Proposed DGS resonator consists of one unit of the proposed DGS cell with 50 ohms input/output ports as shown in Fig. 1. (d). The dumbbell shaped DGS has a higher stop band attenuation of about - 21dB when compared to the cross shaped DGS which has a stop band attenuation of about -19dB as seen in fig. 2 (a). The third E-shape DGS has a higher stop band attenuation of about -25dB than the first two types also seen in fig 2(a). Now the proposed DGS has the highest stop band attenuation of -32 dB when compared to the other three shown in fig.2.

(b). The proposed DGS has a wide stop band from 5Ghz to 12Ghz which indicates better rejection of unwanted frequencies.

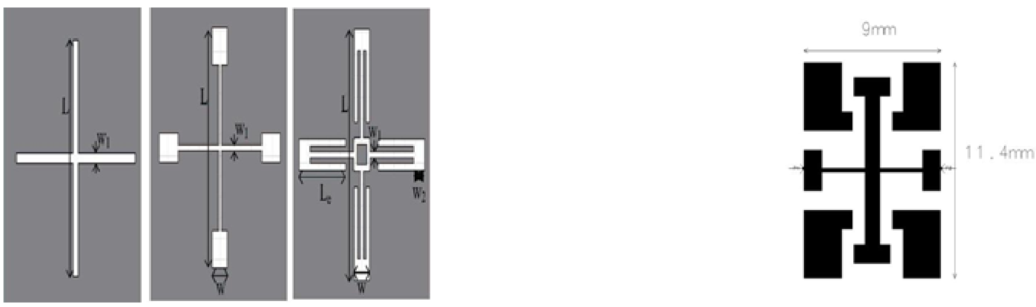
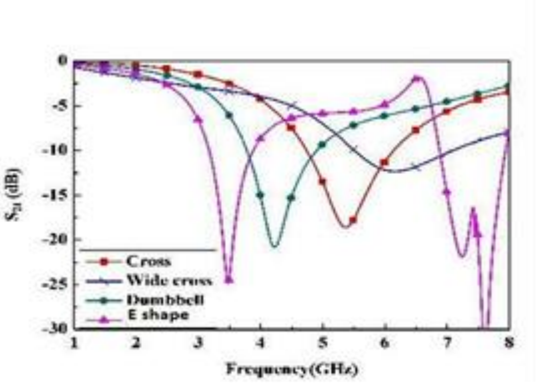


Figure 1. Geometries of 4 types of DGS : (a) Cross (b) Dumbbell (c) E-shape (d) Proposed shape



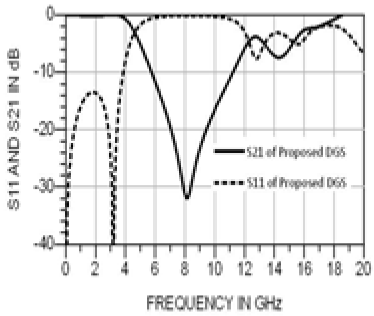


Figure 2. (a) .Transfer characteristic of Various DGS **2. (b) .Transfer characteristic of Proposed** DGS

Where, c is the velocity of light and is the effective permittivity of the DGS cell. A full-wave EM-simulator based on the Method of Moment has been used to simulate the S-parameters of the proposed DGS. The proposed DGS is constructed on characteristic impedance of Z_0= 50 Ω microstrip waveguides based on the FR4-expoxy substrates of = 4.6 with metal layer thickness of 1.6 mm and conductivity Sigma = 5.8 X 10^7 S/m, while the corresponding signal strip width $2w_2+w_3$= 4.2 mm, slot width g = 0.2 mm and ground width w_1+w_4=3.5mm.

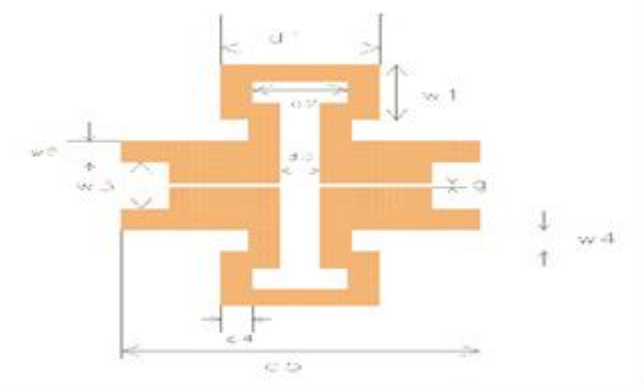


Figure.3.Etched parameters of the DGS prototype (g=0.2mm, W1=2.6mm, W2=1mm, W3=2.2mm, W4=0.9mm, d1=4mm, d2=2.4mm, d3=1mm, d4=0.4 mm ,d5=9 mm)

Equivalent circuit for DGS: The proposed DGS equivalent circuit and its simulated S-Parameter results are illustrated in Fig.4.(a) and (b). Each element in the circuit model has a definite connection with the physical connection of the EBG structure such that the stop band and pass band characteristics are easier to control. According to the results, the equivalent lumped L-C values are extracted, where L_3=0.05nH, L_5=6nH, L_6=1.575nH, L_7=1.05nH, C_3=0.05pF, C_4=0.99pF.

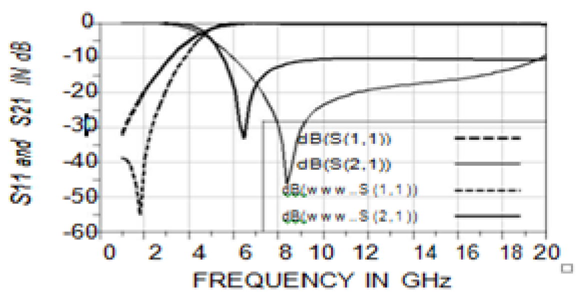


Figure.4.(a) Equivalent circuit of the DGS **Figure.4.(b):S-parameters of the proposed DGS equivalent circuit**

In the proposed DGS equivalent ciruit Fig.4(a) a sharp attenuation of -32dB is achieved but with further tuning of the L and C values, the circuit provides a deep attenuation of -48dB with a higher resonant frequency of4.7Ghz.

Proximity coupled microstrip antenna: Micro strip antennas prove to be excellent candidates For wireless communication due to their low cost, light weight and easy printing on the circuit board. But the major drawback is their narrow bandwidth and a smaller stop band attenuation. This has been overcome in the present DGS which provides a wide stop band with deep attenuation of about -32 dB. Proximity (electromagnetically) coupled antenna uses a two layer substrate with micro strip line on the lower layer and patch antenna on the upperlayer.The feedline terminates in an open end urideneath the patch. The configuration of this type of feed is planar with good reliability and easy impedance matching. The bandwidth achieved is comparatively more than other types of microstrip feeds. Bandwidths of the order of 13 percent is achieved using this feed. By introducing the proposed DGS in this proximity coupled antenna the patch size can be reduced when compared with the conventional ones with a wider stop band. It can provide switchable polarization with minimum DC interference on the patch. Fig.5 shows the proposed Proximity coupled antenna.

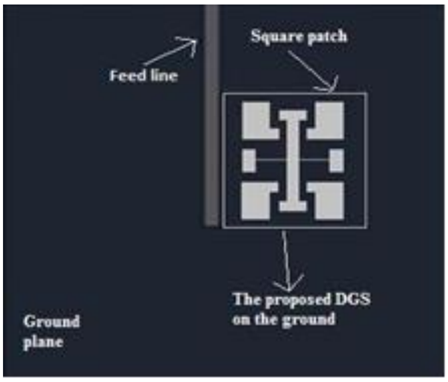


Fig.5.Proposed Proximity coupled antenna.

Table 1 : Parameters of different DGS

DGS	Size (mm x mm)	(GHz)
Cross	35.74 x 0.615	2.342
Dumbbell	28.66 x 2.87	2.495
E-shaped	23.165 x 2.87	2.5789
Proposed	11.44 x 9	4.8

CONCLUSION

A table comparing the parameters of the different DGS is show in Table 1. The size and resonanct frequency of the proposed DGS are compared. The proposed DGS has a length of 11.44 mm which is very less compared to cross DGS, dumbbell DGS and E-shaped DGS. It has a wide stop band, with higher resonant frequency. By introducing the proposed DGS in proximity coupled antenna the patch size can be reduced.

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