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DGS Inspired Microstrip Antenna Array for Improved Radiation Properties

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Abstract:

A simple, easy and flexible Defected Ground Structure (DGS) is proposed for rectangular arrays and demonstrated theoretically in here with the aim of achieving suppression of cross polarization resulting improved polarization purity in radiated fields. The employed DGS appears to be highly efficient in terms of suppressing Cross Polarization especially in H-plane. A [2×2] array has been designed having aspect ratio of 1.3 and showing 14 dB enhancement in the segregation between the co-polarization to cross-polarization dissemination with improved impedance Bandwidth.

Keywords: **Defected Ground Structure, Aspect Ratio, Antenna Array, Rectangular Patch Antenna**

I. INTRODUCTION

Due to low profile, low cost, light weight and ease of integration with RF devices, microstrip patch antenna is widely used in various applications. The most important drawback is the randomness of work top signals that occur in the substrate layer. work top signals are unwanted as when a patch antenna emits, a portion of entire available radiated energy become trapped along the work top of the substrate, resulting reduction in the antenna efficiency, gain and bandwidth. For arrays, work top signals have a significant impact on the mutual coupling between array elements [1]. One of the best solutions to reduce surface waves and to improve performance of antenna is using Defected Ground Structure (DGS). Since 2005, DGS has been applied in microstrip antennas to improve radiation properties [2] and several designs have been enquired for different configurations [3]-[7]. Those designs suppress the cross-polarization level up to 10-15 dB, especially in H-plane. As a result 25 dB or more segregation seen in the principal planes between co- polarizations to cross-polarization. Earlier researches focused on single element antenna, to decrease cross polarization radiations but we concentrated on antenna array for mutual coupling as well as the surface cross polarization radiation because of surface wave among the elements.

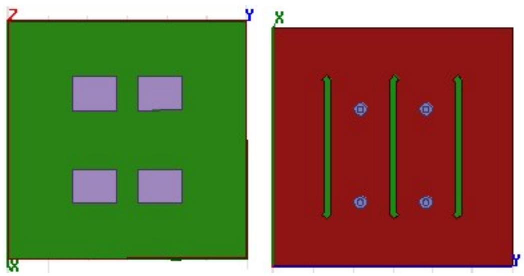
Thus, this paper, focused on application of DGS, directly to suppress cross polarization in the planar array. Here the idea is to configure an uncomplicated also physically viable Defected Ground Structure (DGS) shape resulting enhancement in cross polarization characteristics. By considering to the previous shapes such as linear [7] or folded [5] DGS, the present design seems to be combination of both. The up to dated design seems further flexible, easier and involves only a single DGS between two elements in row. In this way, DGSs can be easily placed between the array elements resulting minimum in number of DGS unit used.

A set of 2×2 array has been studied theoretically using HFSS 13.1, by introduction of proposed flexible arm DGS. From the design and based on the simulated result, it can be sought that there will be 14 dB of improvement in co- to cross-polarization isolation with promising suppression of cross polarization.

II. THE PROPOSED CONFIGURATION

The proposed configuration is shown in Fig. 1. From the configuration, each DGS unit having a pair of flexible arm having length $l_f =$

1.525 mm . The arm length should vary as $l_f < 0.3l$ to obtain the maximum suppression in cross polarization without affecting the adjacent ones and l is the length of the unfolded slot having value 34mm. Now the total length of the DGS can be considered as $(l + 2l_f)$ with thickness of 1.5mm. Each DGS unit maintains a distance of 1.975mm from the patch boundary, in Y-plane. The flexibility can be achieved by the bending angle and can be determined by θ_1 or θ_2 (=180^0-θ_1).



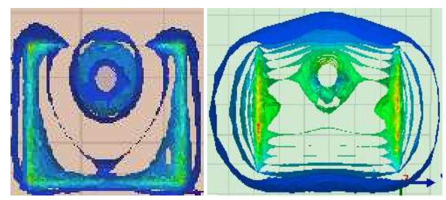
(i) (ii)

Fig.1. Proposed 2×2 array of Rectangular Patch Inspired with Flexible DGS (i) Top View (ii) Bottom View

The peak cross polarization value can be suppressed consistently, if θ_1 varies from 90^0 to 180^0. So this indicates the design is flexible and can be integrated with array elements. This, in turn provides uniform substrate field achieved by DGS can be visualized from Fig. 2. Changeable θ helps in fulfilling to occupy little space in size maintaining its length and other electrical properties.

The distance between the patch boundary and bending angle is about 0.75mm, in X-plane. The dimensions of the patch can be determined from the relation [12]. As the resonant length L is the primary factor in determining the resonant frequency, we have changed W to generate different aspect ratios (W/L). Present configuration is made with aspect ratio (W/L) of 1.3 having L=8.5 and array spacing is of $0.5\lambda_0$. This is realized on RT8570 substrate having h=1.575mm and ε_r=2.33.

Earlier investigations require three DGS units, for two patches in a row, i.e. it require (*n*+1) DGSs, for *n* number of patches in a row and total of six DGS units for a 2×2 array elements. As per previous researches [3]-[7] may demand 2*n* DGSs i.e. nearly double. The present configuration requires total of three DGS units for 2×2 array elements, this in turn half the total number DGSs. This may be written as with increase in row elements the number of DGS unit increases without taking into consideration of column elements. It may be taken as an superior feature of flexibly shaped DGSs. So for this, 2×2 array, we require three DGS units, while viewing horizontally or only three DGS units, while viewing vertically. It shows, a DGS folded, making a θ angle on one side with respect to other side seems as a mirror image.



(i) (ii)

Fig. 2.Simulated Substrate (i) Electric Field (ii) Magnetic Field at $\theta=135^0$

III. ANALYSIS OF SIMULATED RESULTS

The present analysis is made with rectangular patches with aspect ratio of 1/3, operating near 10.2 GHz with return loss about -20dB, as shown in Fig. 3.

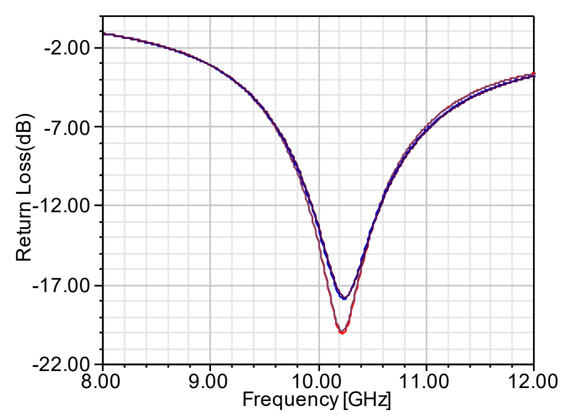
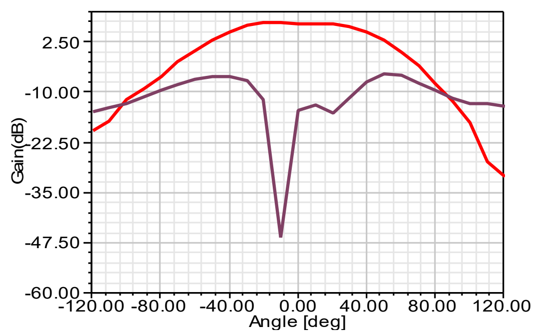
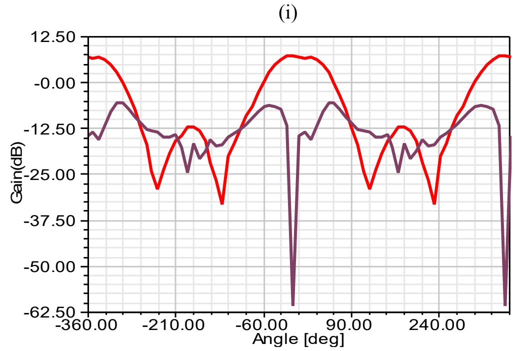


Fig. 3.Simulated Frequency versus Return loss plot for the Propose Antenna Array

To get the required data, the patches are fed with equal amplitude using coaxial probe feed. In earlier investigations, H-plane radiation pattern shows 5-7 dB of suppression cross polarization from without DGS to DGS array antenna. Present configuration realizes 14 dB suppression of cross polarization in H-plane, as shown in Fig. 4.



(i)



(ii)

Fig.4. Simulated H-Plane Radiation pattern of proposed Antenna Array at centre frequency (i) with DGS (ii) without DGS

This in turn, showing 14 dB enhancement in the segregation between the co-polarization to cross –polarization radiations. This may be considered as an advantageous feature.

It is required to note that, any suitable set of angles θ_1 and θ_2 the cross polarization values remain steady and they do rarely affect the co-polarized radiations. In this proposed configuration, the bending angle of one DGS unit is 135^0 and for the next one is 45^0 and this process continues with increase in the number of array elements, especially in row. The cross polarized radiation is minimal for E-plane at $\phi=0^0$ but maximizes somewhere in between E ($\phi=0^0$) and H ($\phi=90^0$) planes at centre frequency, as shown in Fig. 5

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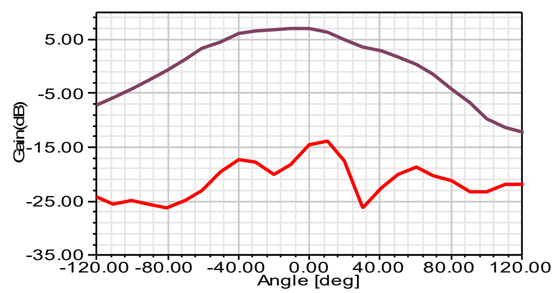

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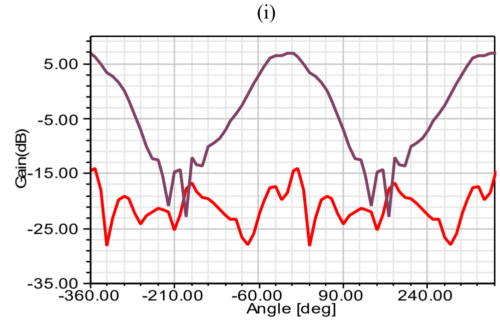


(ii)

Fig.5. Simulated E-Plane Radiation pattern of proposed Antenna Array at center frequency (i) with DGS (ii) without DGS

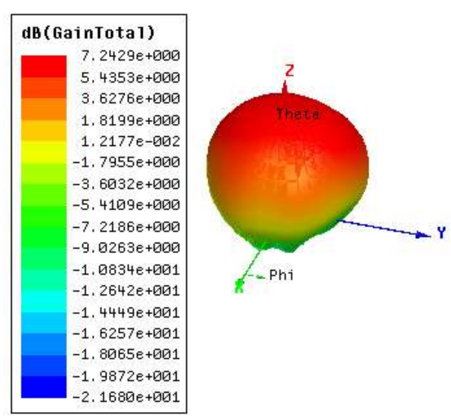
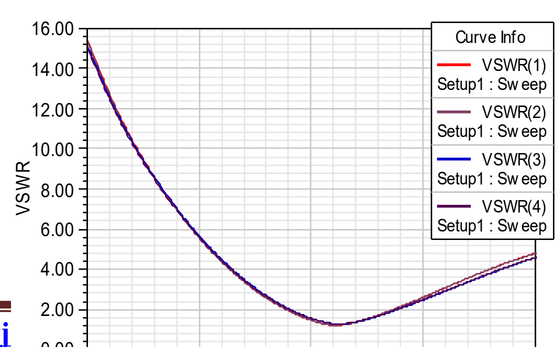


Fig. 6.Simulated 3D polar Radiation pattern of proposed antenna



Simulated, frequency versus Return loss plot, as from Fig. 3, there is minimal fluctuation of resonance only due to DGS approaching lower frequency, as compared to earlier researches [3]-[7].Another representative result is furnished in Fig. 8 with complete information for further study. The mutual coupling between antenna array elements with DGS, shown in Fig. 9. A minimum of 2 dB of reduction in mutual coupling is achieved even for furthest apart elements. The radiation pattern, shown in Fig. 6, it can be considered as an Omni-directional antenna array. As the VSWR is greater than one and less than two, at the centre frequency, can be applied to the practical fields and can be visualized from fig. 7.

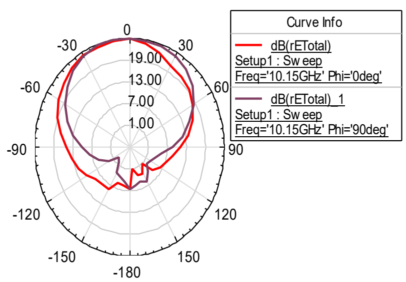


Fig.8. Simulated plot showing comparison of co and cross polarization total radiated power for proposed antenna

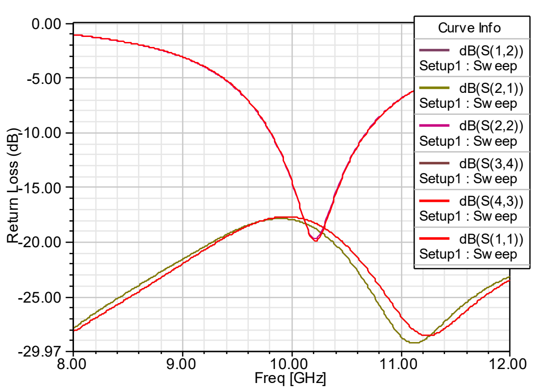


Fig. 9.Simulated Frequency versus S-parameter plot of the elements in array

IV. CONCLUSION

Defected Ground Structure to attend cross-polarization issue of microstrip array antenna revealed here, seems superior for some reasons as linear in configuration, flexible and easy to design and fabricate and reduces etched out area over 50% without degrading the performance. It was observed that, the undesired cross-polarization has been reduced in H-plane at center frequency with impedance bandwidth broadening and can be used in practical field.

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