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Compact Microstrip Defected Ground Structured Antenna for Reduction of Harmonics and Cross Polarized Radiations

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Abstract
A novel Inset fed microstrip patch antenna is designed on defected ground structure (DGS) to reduce the higher order harmonics and cross polarized radiations. Square rings, and square shaped slots are placed on the ground plane of the microstrip patch antenna to get the desired operation. These annular ring and arc DGS appears to be highly efficient in terms of suppressing the cross polarization. Relative suppression of radiated field is observed by placing and without placing the defected ground structures. The stop band property exhibited by the DGS is used to filter out the harmonics. The current model successfully reduced the DGS size and by comparing with the well known design, size reduction of 20% is achieved. Instead of normal square patch, a slotted aperture patch model is considered in the current design to reduce the overall size of the antenna.

Keywords: Defected Ground Structure (DGS), Cross Polarized Radiations, Reduction of Harmonics, Microstrip Patch Antenna.

Introduction

Photonic band gap structures (PBG) is one of the promising technique to reduce the harmonic radiations from the microstrip patch antennas. An array of different types of slots will be etched on the ground plane beneath the antenna and the feed line. The stop band property exhibited by the PBG was used to filter out the harmonics. It was one of the simple technique which involved no additional circuitry and complexity [1].

In recent years defected ground structures became popular to suppress higher harmonics, which are constructed from PBG's etched on grounded substrates. As per the design is concerned physical part of the defect appears to be an important aspect, especially in the microwave integrated circuits. Square-headed dumbbell shaped DGS will suppress up to the second harmonic and a pair of dumbbell shaped DGS will suppress up to the third harmonic [2-7]. Harmonics in a microstrip patch indicate the multiples of the fundamental frequency and they belong to the category of higher order modes, excited in the radiating patch depending on its geometry. In between the harmonics and the fundamental resonance, few other higher order modes may exist [8].

In this paper harmonic control of antennas in terms of quantitative suppression of radiated fields has been presented. This investigation is also successful to reduce the DGS size significantly and by compared to the known compact design, 20% reduction in size is attained.

Antenna Design and Specifications

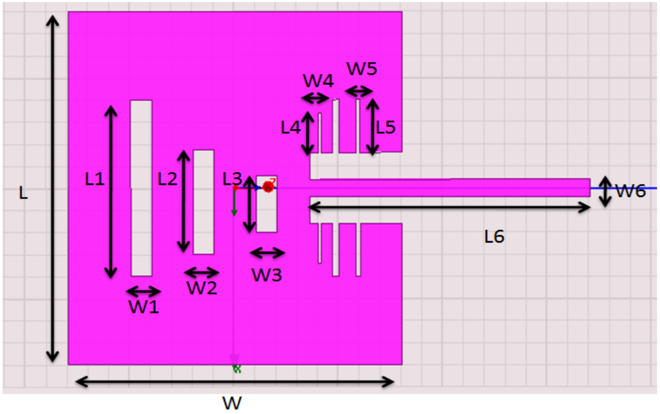

Fig 1 Slotted Square patch antenna

A square patch fed by conventional microstrip line is shown in fig 1. Instead of normal square patch, a slotted aperture square patch is taken in this design to reduce the overall size of the antenna. The modes have been identified primarily by resonating Frequencies. To control the harmonics, a compact DGS on the ground plane with square rings and beneath the feed line with annular square ring has been examined to achieve the aim. Fig 2 shows this arrangement.

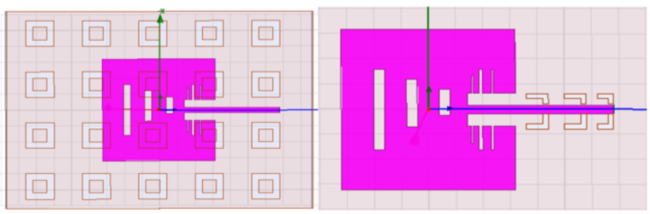

Fig 2a. Square Slotted DGS on ground plane, Fig 2b. Annular Square ring DGS beneath feed line

Table 1. Patch Dimensions

L = 30 mm	L1 = 18 mm	L2 = 12 mm	L3 = 8 mm	L4 = 6 mm	L5 = 7 mm	L6 = 28 mm
W = 30 mm	W1 = 2 mm	W2 = 2 mm	W3 = 2 mm	W4 = 0. 8 mm	W5 = 0. 8 mm	W6 =2 mm

Results and Discussion:

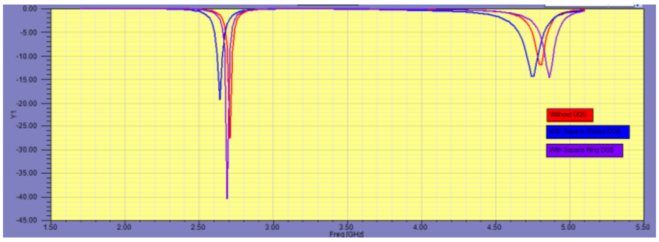

Fig 3. Return loss Vs Frequency

Schematic view of antenna is shown in fig 1 and DGS models are shown in fig 2. RT-Duroid substrate with permittivity 2. 2 and height of 1. 6 mm is taken in this work. Fig 3 shows the S11 characteristics of the conventional ground plane and DGS ground plane based antenna. Results showing the excellent agreement with the computed parameters of the antenna. The radiation characteristics are examined at resonant frequencies 2. 6 GHz and 4. 8 GHz. Fig 3 indicating the mismatch in the input impedance over the target frequency range covering the 2-6 GHz. This ensures suppression of all higher order modes up to the second harmonic of the fundamental. This will significantly reduce radiations at those frequencies. This has been addressed extensively.

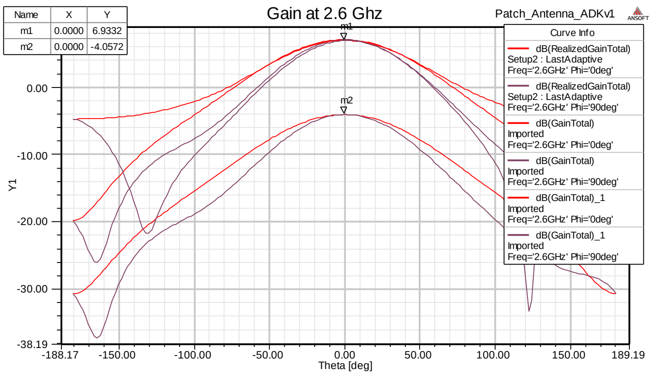

Fig 4. Gain curve for three models

The three dimensional radiation patterns caused by the higher order modes can be visualized by observing the model fields as shown in fig 7 and 8. Figure 5 and 6 shows the radiation pattern of cross polarization and co-polarization with and without DGS.

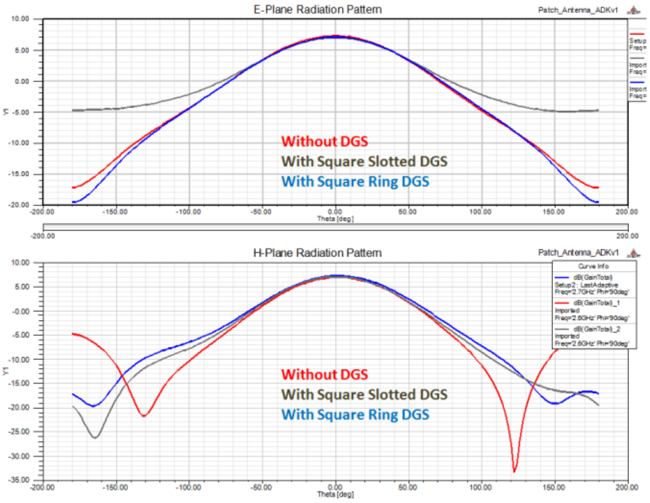

Fig 5. E-Plane and H-Plane Radiation patterns with and without DGS. Frequency 2. 6 GHz

Presence of DGS shows no significant effect on the radiation, considering both co-polarized and cross polarized fields. Gain is obtained up to 4. 9 dB for all the configurations.

Table 2 Antenna Parameters

S. No	Antenna Parameter	Without DGS		Square Slotted DGS on ground plane		Annular Square ring DGS beneath feed line	
		At 2. 6	At 4. 8	At 2. 6	At 4. 8	At 2. 6	At 4. 8
1	Max U	0. 0021455	0. 002538	0. 002541	0. 002855	0. 000325	0. 002593
2	Peak Directivity	5. 57	5. 72	5. 11	4. 11	5. 49	5. 89
3	Peak gain	5. 30	5. 29	4. 94	3. 99	5. 05	5. 45
4	Peak realized gain	2. 69	3. 18	3. 19	3. 58	0. 408	3. 25
5	Radiated Power	0. 00483	0. 00557	0. 00624	0. 00872	0. 000744	0. 00553
6	Accepted Power	0. 00507	0. 00602	0. 00645	0. 008978	0. 000808	0. 00597
7	Incident Power	0. 01	0. 01	0. 01	0. 01	0. 01	0. 01
8	Radiation efficiency	0. 9515	0. 9252	0. 9668	0. 9723	0. 9199	0. 9259
9	Front to back Ratio	293. 96	86. 92	15. 06	9. 071	452. 22	85. 57

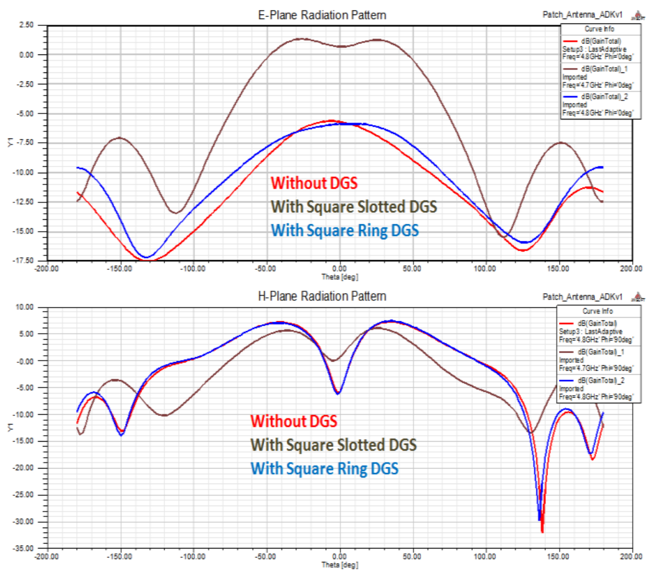

Fig 6. E-Plane and H-Plane Radiation patterns with and without DGS. Frequency 4. 8 GHz

We compared our present designs with the earlier ones in terms of area required to implement the defected ground plane. However the size of the present design is reduced almost by 20% compared to nearest early design

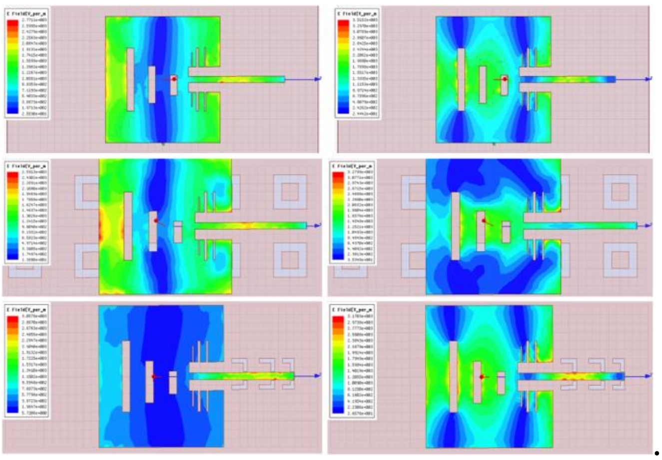

Fig 7. E-Field Distribution of Three models at 2. 6 and 4. 8 GHz

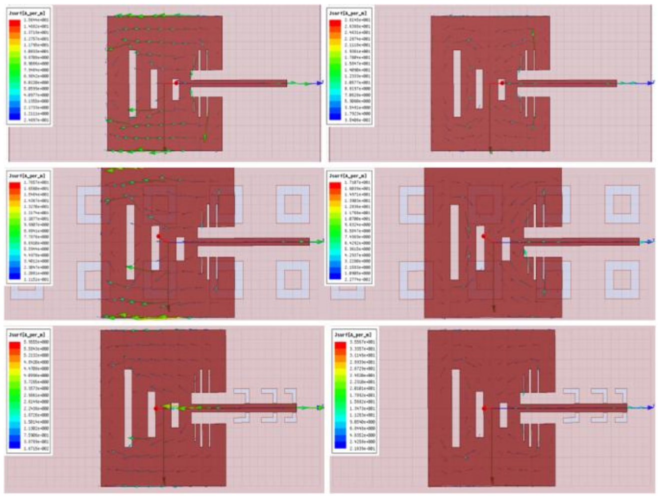

Fig 8 Current distribution at 2. 6 and 4. 8 GHz

Conclusion

In this paper Control of higher modes up to second harmonic has been successfully achieved by placing square rings on ground plane and square annular ring beneath the feed line. The DGS used in the design is compact in size, easy to implement and no compromise in the performance compared to earlier ones. The performance of the DGSs has been verified in two different frequency bands and hence they are expected to be equally effective for all rectangular patches. The DGS will find different applications where polarization purity of antenna is an important aspect.

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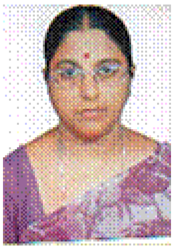

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