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Gain Enhancement Using Comb Shaped DGS Unit in a Rectangular Microstrip Patch Antenna for Wireless Application

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ABSTRACT: This article takes analysis on a unique design of multiband microstrip patch antenna and to accomplish gain enhancement, a comb shaped DGS unit are inserted within the ground plane of the patch antenna. The proposed microstrip patch antenna is designed using Rogers RT Duroid-5880 substrate with $\epsilon_r = 2.2$ and height $h = 1.6\text{mm}$. The projected multiband microstrip patch antenna will resonate at eight distinctive frequencies between 1.96 GHz to 7.2 GHz and it provide the return loss less than -10 dB. The performance of multiband antenna is validated and optimized using Ansys. HFSS based on method of moment.

KEYWORDS: Rectangular microstrip patch antenna, Wireless communication, HFSS, Defected Ground Structure.

I. INTRODUCTION

Microstrip patch antennas are mainly used in communication field and also, we can find many more applications in other fields too. Nowadays wireless communication systems are looking for reduced number of antennas for various applications within a system which is recommended due to physical limitations in installation space. Because of these limitations it is desirable to built a single antenna that serves various applications. The invent of the multiband system constitutes one of the important revolutions in the design of antennas. Multiband antennas find various applications because of its lower cost, smaller size and high data rate features. A separate antenna for each communication frequency band makes the entire mobile system bulky in terms of size and weight. This also effects the financial feasibility of the mobile system. In embedded systems antennas is to be integrated into small and portable system. The microstrip patch antennas are designed to resonate at single or multi resonating frequencies. Initially microstrip patch antenna configuration is designed for a particular application of interest and then by introducing Defected Ground Structure (DGS) unit enhances the gain and the number of resonating frequencies.

II. RELATED WORK

The study of multiband patch antennas is categorized into PIF antennas, wire antennas and defected patch antennas and defected ground antennas [1]. An antenna is designed with a compact size, which operates at four distinct bands where the shape of radiation unit is not changed [2]. A multiband resonator resonates at five distinct frequency band is designed using four rectangular DGS unit on Epoxy Woven Glass Material to enhance the gain [3]. In [4], a patch is defected by fractal shape slot for multiband operations and a microstrip line is used for feeding. This proposed makes the antenna to resonate at multiple frequencies which is in the range of 120 GHz. In [5], multiband operation is accomplished using a triangular patch. Here impedance of a triangular shape patch antenna is controlled through chip capacitors. In [6], an antenna is presented for multiband operations and it is achieved by a double sided comb shape on the ground plane. This technique helps in increasing the gain and the bandwidth. And it operates in seven distinct frequency bands.

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Even though above papers shows multiband operation antenna, those antennas are still suffering from limitations in terms of number of operating frequency bands and the antenna gain. The proposed antenna design consists of single sided comb shape DGS unit which operates at eight different frequency bands like 1.96 GHz, 2.31 GHz, 3.08 GHz, 3.90 GHz, 4.61 GHz, 5.88 GHz, 6.88 GHz and 7.23 GHz.

III. ANTENNA DESIGN

The Microstrip Patch Antenna is designed using Rogers RT Duroid-5880 as dielectric material having dielectric constant $\epsilon_r = 2.2$, thickness $h = 1.6\text{mm}$ and loss tangent $\tan \delta = 0.0009$. The geometry of the proposed rectangular patch antenna with modified ground plane is shown in Figure-1 (a). The total size of the MPA with DGS unit is $50.94\text{mm} \times 59.5\text{mm} \times 1.6\text{mm}$.

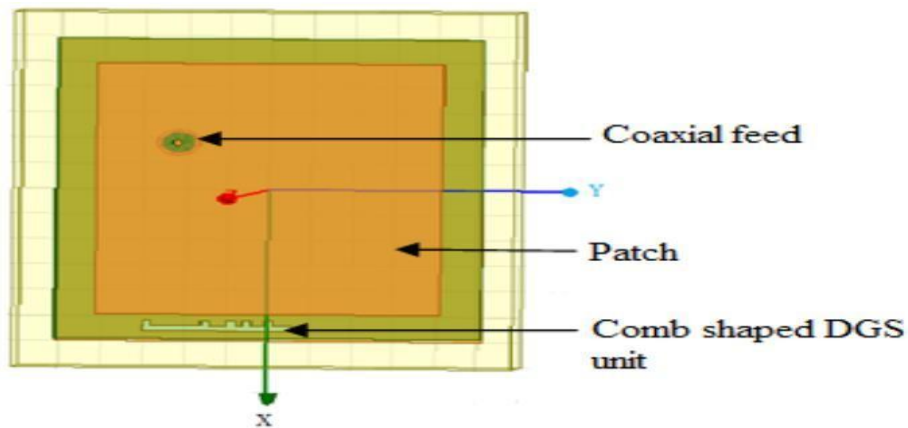


Figure-1: (a) Microstrip patch antenna with DGS unit on the ground plane

The conventional configuration is defected with six rectangular slots. The proposed defected ground structure (DGS) unit etched on the ground plane of a microstrip antenna is illustrated in Figure-1(b). It consists of six rectangular slots that are arranged in a comb structure, where five rectangular slots represent the teeth or strips of comb. In the Figure-1 (b), a and b represents the horizontal and vertical length of the slots/teeth/strips of comb, g_1, g_2, g_3, g_4 are the gap between the teeth or strips and f is the length of the comb DGS unit cell.

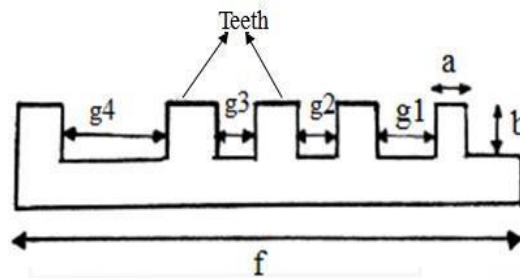


Figure-1: (b) Single side comb shaped DGS unit.

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IV. OPTIMIZATION

The no of teeth or strip, the comb length and the location of DGS unit in the ground plane were randomly varied to get improved return loss and the maximum gain.

A. Teeth Variation in Comb like DGS Unit.

Initially two rectangular slots that are arranged in 'L' shape is etched on the ground plane, whose dimensions are $a = 1\text{mm}$, $b = 1\text{mm}$, $f = 18\text{mm}$. And its S_{11} and radiation characteristics are observed. The L, C and R equivalent DGS circuit is determined by the dimensions of the DGS unit. The lumped capacitance C is provided by the gaps (g_1, g_2, g_3, g_4, g_5) between the teeth/strips. Later number of teeth are varied from one to six, observed the S_{11} and radiation characteristics.

As compared to the conventional antenna, number of resonating modes are increased when comb shaped DGS is introduced. The maximum return loss obtained when the comb shaped DGS has three teeth/strips that is at frequency 6.9 GHz, S_{11} is -36.06. Next highest return loss is -35.69 obtained at frequency 6.87 GHz when there are six numbers of teeth in the comb shaped DGS. When there are five numbers of teeth in DGS unit maximum return loss is -34.04 at frequency 6.88 GHz is obtained.

The simulated E-Plane and H-Plane Radiation Characteristics are observed and by parametric optimization, maximum gain of 11.91db is obtained for five teeth/strips comb shaped DGS unit.

B. Length of comb shaped DGS unit.

The five numbers of teeth in comb shaped DGS is considered because the gain and cross polarization are better when compared to all other DGS unit. For further investigation the length 'f' of DGS unit is varied. Initially the length 'f' of the comb DGS unit is $f = 16\text{mm}$ and observed maximum return loss and gain at frequency 6.87 GHz.

As compared to the conventional antenna, number of resonating modes are increased when comb shaped DGS is introduced. The maximum return loss obtained when the comb shaped DGS has three teeth/strips that is at frequency 6.9 GHz, S_{11} is -36.06. Next highest return loss is -35.69 obtained at frequency 6.87 GHz when there are six numbers of teeth in the comb shaped DGS. When there are five numbers of teeth in DGS unit maximum return loss is -34.04 at frequency 6.88 GHz is obtained

When the length of the DGS unit is increased from (1x16) mm to (1x30) mm there is a change in S_{11} and number of resonating modes. The number of resonating modes increases compared to the conventional configuration but gain and cross polarization is less. By parametric optimization better gain is obtained when the length of DGS unit is (1x18) mm.

When slots are (1x18) mm E-plane co-polarization gain is 11.91dB and cross polarization levels are at 2dB. And the H-plane radiation characteristics again show a co-polarization gain 11 dB.

C. DGS Unit Position Variation.

The comb shaped DGS unit are fixed at (1x18) mm with five teeth because the gain and cross-polarization are better when compared to all other dimension of the DGS unit. For further investigation the location of DGS unit is varied.

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Initially comb shaped DGS is etched at location (-27, -15, 0). At this location there is an increase in the number of resonating frequencies but there is no enhancement of gain. Later the comb shaped DGS unit is etched at location (5,15, 0) resulting in poor gain. Hence the comb shaped DGS unit is etched at the other edge of the MPA that is at location (27, -15, 0) resulting in good S11 and gain.

By observing the E-plane and H-plane radiation characteristic due to the variation in location of DGS unit, the maximum gain of 11.91 dB is obtained at DGS location (27, -15, 0) and cross polarization levels are at 2 dB.

V. SIMULATED RESULTS

The conventional MPA engraved comb shaped defect in the ground plane, which enhances the MPA gain and the return loss. In conventional MPA the maximum return loss -22.63 is obtained at frequency 1.96 GHz. The return loss characteristics of conventional and proposed MPA are illustrated in Figure-2.

By introducing comb shaped DGS unit the return loss is improved. For proposed MPA the maximum return loss -34.07 is obtained at frequency 1.96 GHz.

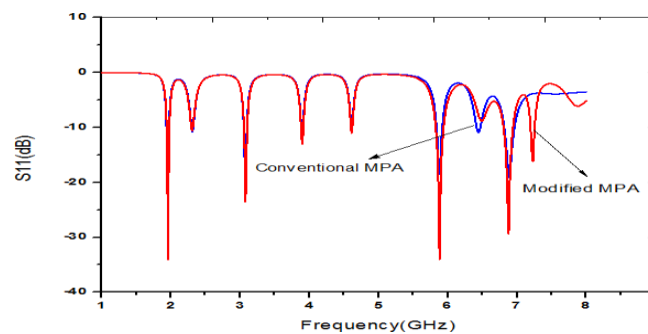


Figure- 2: S11 plot of conventional and proposed MPA

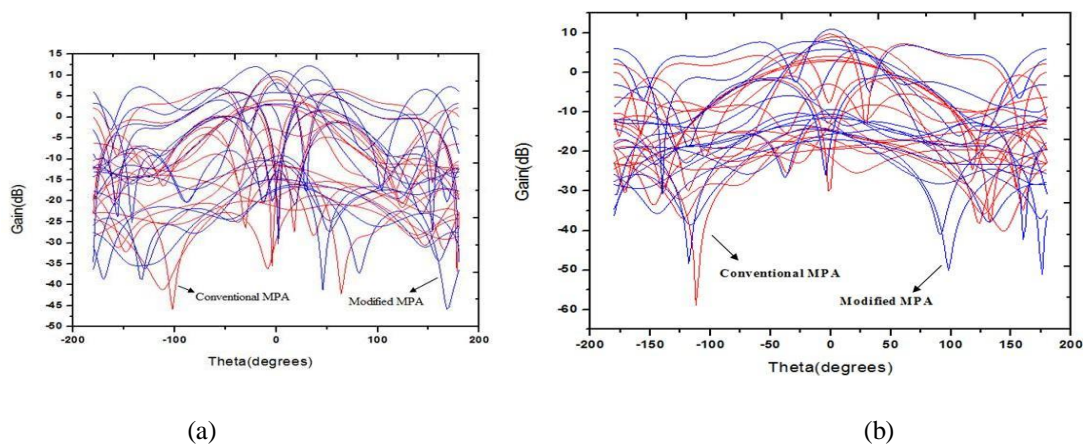


Figure-3: Radiation characteristics for conventional and proposed MPA, (a)E-plane, (b) H-plane.

The figure-3 (a) and figure-9 (b) shows the simulated result of E-Plane and H-Plane radiation characteristics for conventional and proposed MPA. The E-plane radiation characteristics of conventional MPA shows a maximum

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co-polarization gain 9.71 dB at resonating frequency 6.89 GHz and cross- polarization is well below -1.44 dB. The H-plane radiation characteristics of conventional MPA shows a maximum co-polarization gain 9.67 dB at resonating frequency 6.89 GHz.

The proposed microstrip patch antenna resonates at eight resonating frequencies. The E- Plane radiation characteristic shows a maximum co- polarization gain 11.91 dB at resonating frequency 7.23 GHz and cross-polarization is well below 2 dB. The H-plane radiation characteristics of proposed microstrip patch antenna shows a maximum co- polarization gain 10.92 dB at resonating frequency 6.88 GHz.

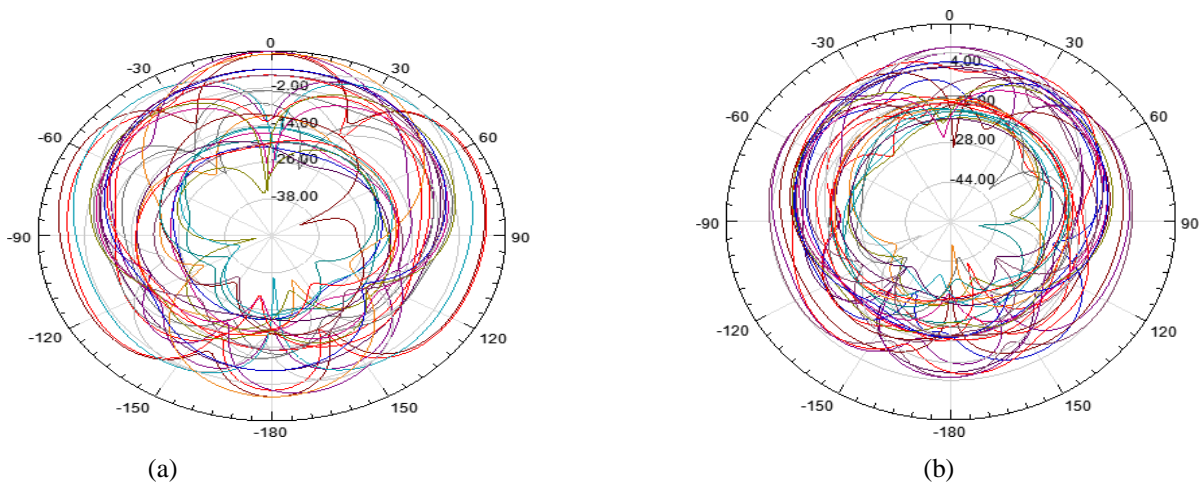


Figure-4: Radiation pattern (a) conventional and (b) proposed configuration.

Figure-4 (a) shows the radiation pattern of a conventional configuration and achieved a good radiation with co-polarization peak gain of 9.71 dB at resonating frequency 6.89 GHz. The Figure-4 (b) shows radiation pattern of proposed MPA, due to comb shaped DGS unit the modified MPA enhances the gain. The peak gain of 11.91 dB is obtained at frequency 7.23 GHz with angular coverage of -150 degrees to +75 degrees.

Table 1: Simulated Results for Conventional MPA.

Resonating frequency(GHz)	Return loss(S11)	Gain (dB)
1.96	-22.63	2.86
2.31	-10.79	4.03
3.08	-20.16	Non resonating mode
3.9	-11.24	Non resonating mode
5.88	-18.56	Non resonating mode
6.44	-10.94	8.02
6.89	-19.16	10.92

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Table 2 Simulated Results for Proposed MPA.

Resonating frequency(GHz)	Return loss(S11)	Gain (dB)
1.96	-34.07	3.15
2.31	-10.53	5.87
3.08	-23.56	Non resonating mode
3.9	-12.96	Non resonating mode
4.61	-11.06	Non resonating mode
5.88	-34.04	8.02
6.88	-29.35	10.92
7.23	-16.18	11.91

The conventional MPA resonates at seven different frequencies among those three are non resonating modes. The proposed MPA resonates at eight resonating frequencies among those three are non resonating modes. So by using comb shaped DGS unit we get an increased number of resonating frequencies. The proposed MPA gives better return loss as compared to conventional MPA. The plot shows that due to comb-shape etching the gain is increased, this is because of Cross-Polarization Suppression of Antenna using DGS unit. The obtained results are organized and correlated in Table-1 and Table-2.

VI. CONCLUSION

The Rectangular Microstrip Patch Antenna with co axial feed is designed to resonate at multiband using RT/ duroid 5880 substrate having dielectric constant $\epsilon_r = 2.2$ and thickness $h = 1.6$ mm. The conventional configuration resonates at 1.96 GHz, 2.31 GHz, 3.08 GHz, 3.90 GHz, 5.88 GHz, 6.44 GHz and 6.89 GHz. The better return loss is -22.63 obtained at 1.96 GHz. The MPA gives peak gain of 9.71 dB in E-plane and 9.67 dB in H-plane at frequency 6.89 GHz.

The conventional configuration is defected with comb shaped DGS element. The designed antenna efficiently resonates at 1.96 GHz, 2.31 GHz, 3.08 GHz, 3.90 GHz, 4.61 GHz, 5.88GHz, 6.88 GHz and 7.23 GHz. The improved return loss is -34.07 obtained at 1.96 GHz. The MPA maintains S11 for entire band well below -10 dB. The MPA gives peak gain of 11.91 dB in E-plane and H- plane at frequency 7.23 GHz. The proposed MPA operates in L band, S band and C band.

REFERENCES

1. Liao,Wen-Jiao,Shih-Hsun Chang, and Long-Kun Li."A compact planar multiband antenna for integrated mobile devices." Progress n Electromagnetics Research 109 (2010):1-16.
2. Chun-Xu Mao, Steven Gao et al., "A Novel Multiband Directional Antenna for Wireless Communications", OI 10.1109/LAWP.2016.2628715, EEE Antennas and Wireless Propagation Letters, 2016
3. M.S. Alam, M. Tariqul, H. Arshad, "Gain enhancement of a multiband resonator using defected ground surface on epoxy woven glass material", Sci. World J. 6 (2014), 159468 8, <http://dx.doi.org/10.1155/2014/159468>.



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4. Syed Ahsan Ali¹, Umair Rafique², Umair Ahmad³, M. Arif Khan⁴ “Multiband Microstrip Patch Antenna for Microwave Application” (IOSR-JECE) SSN: 2278-2834, SBN: 2278- 8735.
5. K.-M. Lee, Y.-J. Sung, J.-W. Baik and Y.-S. Kim, “A triangular microstrip patch antenna for multi-band applications,” *Asia Pacific Microwave Conf.*, pp. 1-4, 2008.
6. P. Muthili, P. Cherian, S. Mridula and D. Paul, “Design of a compact multi-band microstrip antenna,” *2009 Annual India Conf.*, pp. 1-4, 2009.