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# The Effect of Defective Ground Plane on a Wide Band Dual Frequency Circular Patch Antenna

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***Abstract-*** ***In this paper a novel design of a slotted circular Microstrip patch antenna with two tuning arms and a defective ground plane is proposed. In this paper it is also emphasized with proper simulation result that Defective Ground Structure(DGS) is successfully implemented for bandwidth enhancement, for this purpose a comparative study is held between two antenna with identical radiating element , one with a DGS and another without a DGS .The result shows almost 200 MHz bandwidth enhancement with the use of a DGS in a circular patch antenna. The proposed antenna operates at both S-band (2.1 GHz) and C Band (4.3 GHz) with a bandwidth of 19.4 % and 5.75 % respectively. The proposed antenna can be used for S band and C band wireless communication applications. The simulations were done using Ansoft HFSS 13.0.***

***Keywords – Defective Ground Structure (DGS), Dual Frequency, Wideband antenna, S band, C band***

## I. INTRODUCTION

In the recent past there has been significant advancement in the field of Microstrip patch antenna design. Various novel approaches and techniques have been discussed by researchers to achieve multiband operation, multi frequency operation, Bandwidth enhancement , size reduction etc.

In this paper a new technique called the Defective Ground Structure(DGS) is discussed and its effect on a circular patch antenna is observed through simulation. First C. S. Kim, J. S. Park, D. Ahn, and J. B. Lim have proposed and discussed this Defected Ground Structure in their research paper [1]. Then a detailed discussion can be found in a literature by D. Guha, S. Biswas, and Y. M. M. Antar [2] . A more thorough discussion along with simulation results can be found in another literature by Debatosh Guha, Sujoy Biswas, and Chandrakanta Kumar [3].Though DGS was first used to analyse filters for improving microwave circuit performances specially but after conducting different investigations by researchers it was observed that DGS can well be used to improve the radiation characteristics of Microstrip antenna.

Here in this article the effect of DGS is shown emphasizing its use in bandwidth enhancement. A comparative study is been conducted between two identical radiating patch with and without a defected ground. Two slots have been cut out from the ground plane of the antenna one with a shape of "I" and another with "L" shape.as we know from the conventional theory of DGS due to the surface current that are present around the defect an inductive effect is seen also because of trapped electric field a capacitive effect can be seen which gives rise to the resonating characteristics to the DGS [3] which in return interfere with the main radiating patch performance.

## II. DESIGN AND ANALYSIS

### *A. An microstrip patch antenna without a defective ground*

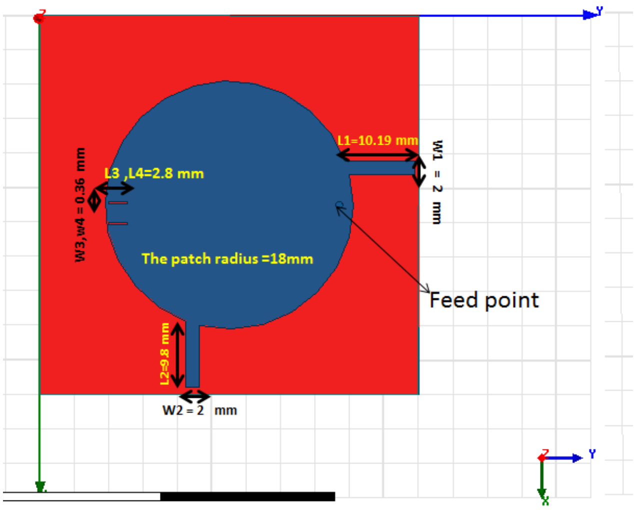



Fig 1: Antenna 1: A Microstrip circular patch antenna with two tuning arms and two slots on the patch (without a DGS)

Table 1: Dimensions of Circular patch antenna without a DGS

| **Dimensions of** | **Length** | **Width** |
|---|---|---|
| Tuning arm 1 | L1 = 10.19mm | W1 = 2 mm |
| Tuning arm 2 | L2 = 9.8 mm | W2 = 2mm |
| Slot 1 | L3=2.8mm | W3=0.36 mm |
| Slot 2 | L4=2.8mm | W4=0.36 mm |
| **The patch radius** | **18 mm** | |

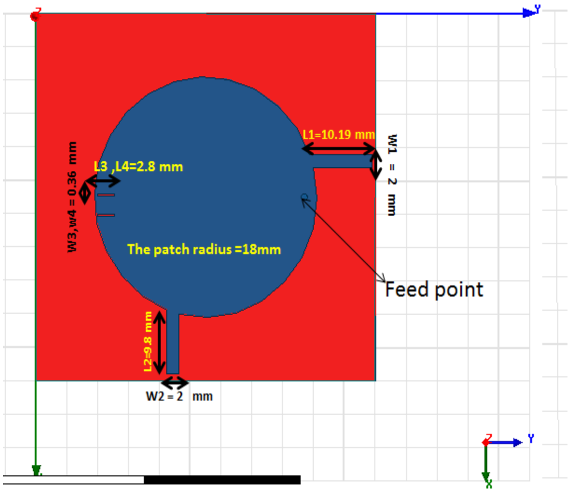



Fig 2: Antenna 2 : the patch is made identical to antenna 1

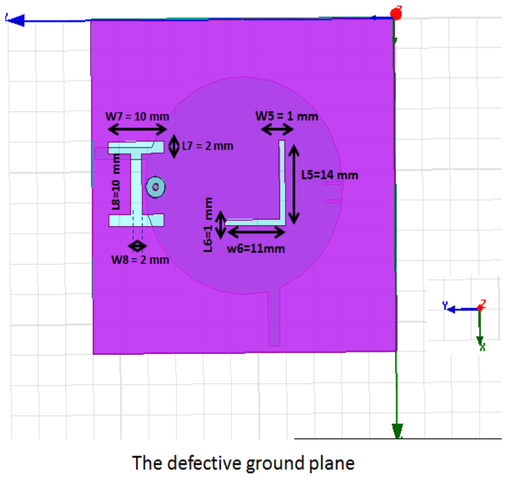



Fig 3: Antenna 2 : the ground plane of antenna 2 with two defects of "I" and "L" shape

Table 2 : Dimensions of radiating Circular patch antenna with a DGS (Antenna 2)

| **Dimensions of** | **Length** | **Width** |
|---|---|---|
| Tuning arm 1 on patch | L1 = 10.19mm | W1 = 2 mm |
| Tuning arm 2 on patch | L2 = 9.8 mm | W2 = 2mm |
| Slot 1 on patch | L3=2.8mm | W3=0.36 mm |
| Slot 2 on patch | L4=2.8mm | W4=0.36 mm |
| **The patch radius** | **18 mm** | |
| **Detailed dimensions of DEFECTED GROUND PLANE** | | |
| **Dimensions of** | **Length** | **Width** |
| "L" shape | L5 = 14 mm<br>L6 = 1mm | W5 = 1mm<br>W6 = 11 mm |
| "I" shape | L7 = 2 mm*<br>L8 = 10 mm | W7 = 10 mm**<br>W8 = 2 mm |
| *Dimensions of Upper portion of I is same as the lower portion<br>** Dimensions of Upper portion of I is same as the lower portion | | |

## III. EXPERIMENT AND RESULT

### *A. Comparative result between antenna 1 and antenna 2 with respect to S [1 1]*

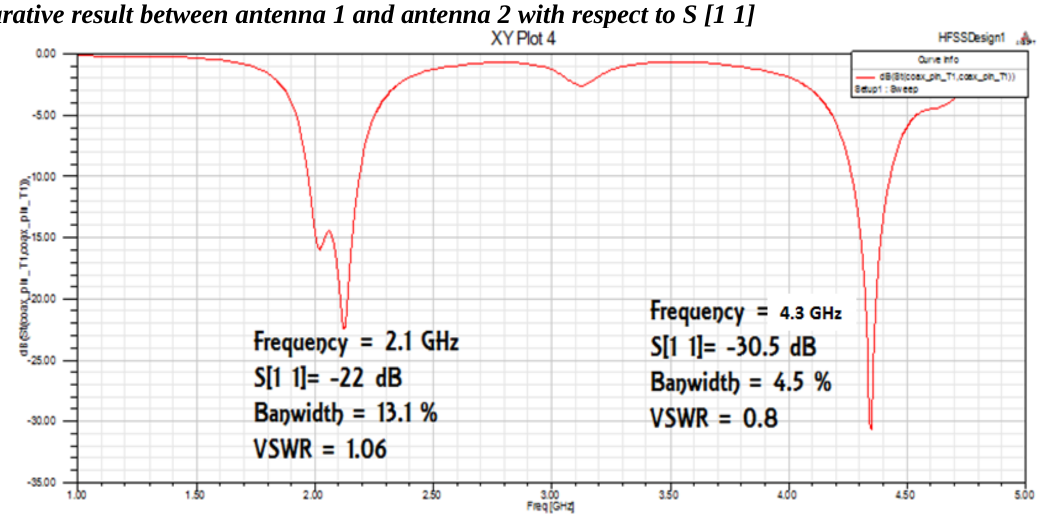



Fig 4 : S [1 1] in dB vs Frequency in GHz result for antenna 1 (without DGS)

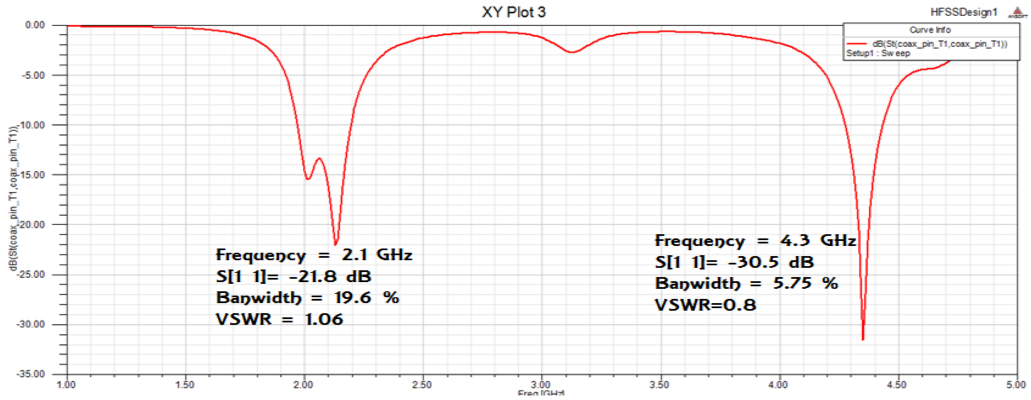



Fig 5 : S [1 1] in dB vs Frequency in GHz result for antenna 2(with DGS)

*Report : almost 200 MHz increment in Bandwidth is seen after using DGS though other parameters are almost identical*

### *B. Comparative result between antenna 1 and antenna 2 with respect to VSWR*

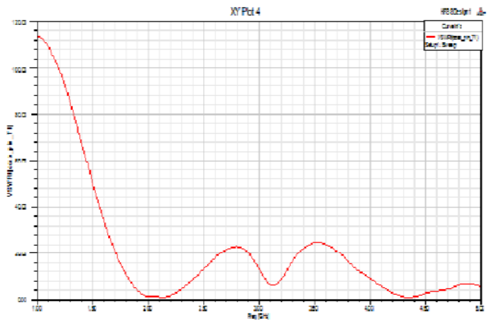



Fig 6 : Frequency vs VSWR plot for antenna 1(without DGS)

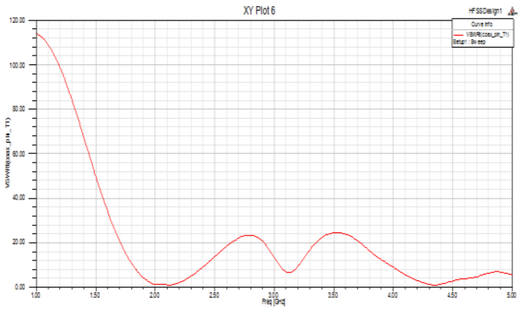
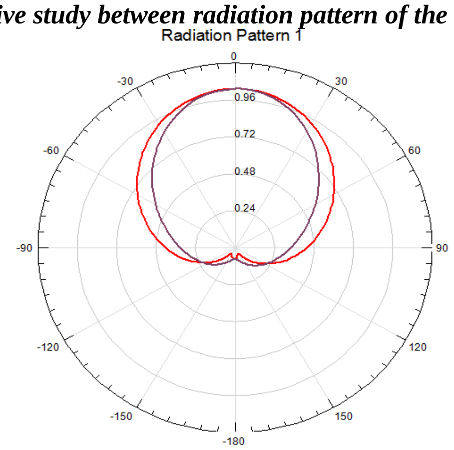



Fig 7: Frequency vs VSWR plot for antenna 2(with DGS)

*Report : identical response*

### *C. Compaative study between radiation pattern of the two antenna*



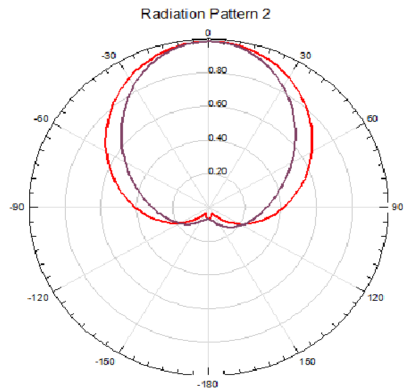
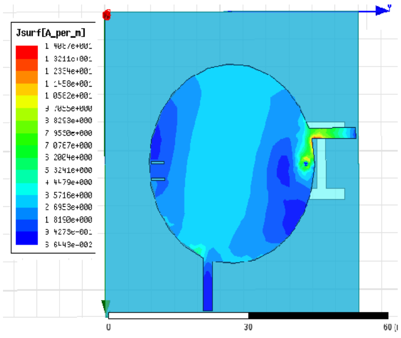




Fig 8 : Radiation Pattern of antenna 2 ( with DGS)

Fig 9 : radiation pattern of antenna 1 ( without DGS)

*Report : as we can see the radiation pattern is almost identical*

### *D. Surface Current and Electric Field distribution on the patch*



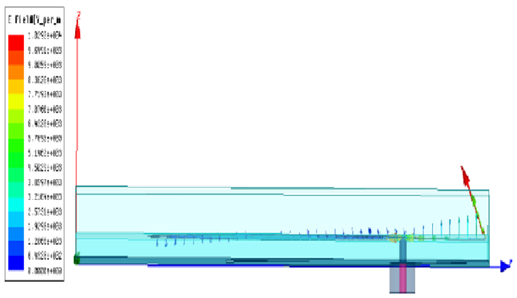



Fig 10 : a ) Surface Current distribution ( magnitude) on antenna 2 ( with DGS) b) E field distribution ( vector) on antenna 2

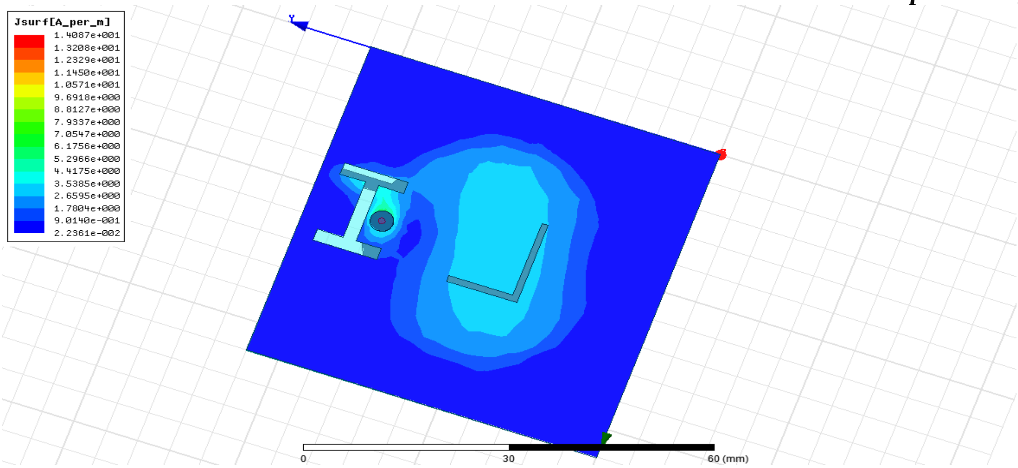



Fig 11 : Surface current distribution on the Defective Ground Plane

Table 3 : Comparison between the performance of antenna 1 (without DGS) and antenna 2 (with DGS)

| | ***Antenna 1*** | ***Antenna 2*** | ***Remarks*** |
|---|---|---|---|
| **Resonant frequencies** | f1 = 2.1 GHz (S Band) f2 = 4.3 Ghz (C Band) | f1 = 2.1 GHz (S Band) f2 = 4.3 Ghz (C Band) | No shifting in frequency occurred |
| **VSWR** | At f1 VSWR = 1.06 AT f2 VSWR = 0.8 | At f1 VSWR = 1.06 AT f2 VSWR = 0.8 | No change in VSWR |
| **S[1 1]** | At f1 S[1 1] = -22 dB At f2 S[1 1]= - 30.5 dB | At f1 S[1 1] = -21.8 dB At f2 S[1 1]= - 30.5 dB | Almost identical response |
| **Bandwidth** | At f1 = 13.1 % AT f2 = 4.5 % | At f1 VSWR = 19.6 % AT f2 VSWR = 5.75 % | More than 200 MHz increased bandwidth is achieved with the implement of DGS |

### *E. Hardware Simulation:*


Fig 12 : The hardware of the proposed antenna and Simulation reading of the hardware using R&S Antenna analyser

## IV. CONCLUSION

As the study concludes that DGS can successfully be used to increase bandwidth at the same time the other parameters like gain , directivity also can be effected by this method. Here the proposed antenna simulation and measured results are in good agreement. The hardware simulation gives us a good result.The readings were taken using Rohde & Schwartz Antenna Analyser Kit. The little discrepancies are due to the losses in the hardware design which were during the manufacturing of the antenna. The hardware simulation is shown in Fig 12. It shows an acceptable comparison between the software and hardware simulation The proposed antenna can be used for the communication applications in C band(4.3 GHz) and S Band(2.1 GHz).

## ACKNOWLEDGEMENT

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