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Novel DGS Integrated High Performance Microstrip Antenna with Frequency Tuning Characteristics

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Abstract :- An angular spiral defective ground structure (DGS) is integrated in the ground plane and the length of the DGS is modified accordingly to achieve the GSM frequency band, Bluetooth frequency band and Wimax frequency band respectively. Moreover to enhance the performance of the proposed micorstrip antenna at the GSM frequency band and the Wimax frequency band, dual DGS is integrated in the ground plane. As a consequence, appreciable bandwidth and gain is observed in the GSM frequency band and the Wimax frequency band for proposed antenna.

Keywords :-Defected Ground Structure, Frequency tuning, High performance, Microstrip antenna ,Miniaturization,

1. INTRODUCTION

Researchers developed and designed microstrip antennas with light weight, low profile, portable, with minimum cost and ease of fabrication which can be used for practical wireless communications. Rigorous efforts in the field of microstrip antenna are being made to design extremely compact antennas which give a higher percentage of miniaturization. In this effort several papers are reported in which compactness of microstrip antenna is implemented by cutting regular geometric slots, slits, defective ground structure etc[1,2,3]. With the above modifications, a perturbation effect results in the microstrip antenna. Therefore the antenna can be operated at a lower application frequency band[4,5]. In the proposed work, an angular DGS is integrated in the ground plane to compact the microstripcircular shaped antenna. The implementation of the DGS in the ground plane modifies the shielded current distribution. Previously the proposed antenna is found to be resonating at 5.2GHz i.eWLAN frequency band. Then by the integrating the novel angular spiral DGS, the resonant frequency is reduced down to 1.8GHz i.e. GSM frequency band. So a higher degree of compactness in size of the microstripcircular antenna is obtained.Then the length of the angular DGS is modified to make the microstrip antenna resonant at the Bluetooth frequency band and Wimax frequency band respectively. Moreover a high performance of the microstrip antenna, resonant at the GSM frequency band and the Wimax frequency band, are obtained by the inclusion of the double DGS in the ground plane, which results in enhanced bandwidth and enhanced gain characteristics.

2. DESIGN OF SINGLE DGS INTEGRATED CIRCULAR MICROSTRIP ANTENNA WITH FREQUENCY CHARACTERISTICS

2.1 DESIGN PRINCIPLES

The detailed structural geometry of the proposed antenna is given in Fig.1. The substrate FR4_epoxy of dielectric constant 4.4 and dielectric loss tangent of 0.002 is taken to design the proposed antenna and ZelandIE3D software tool is used to simulate the microstrip antenna.
Previously the microstrip antenna is designed to resonate at the WLAN band i.e. 5.2GHz. When DGS is integrated in the ground plane, a shift of frequency from the WLAN band i.e. 5.2GHz to the GSM band i.e.

1.8GHz is observed. The radius of the circular patch is 7.65mm and the feed point is placed at (0,2.55). For the given dimensions, the proposed antenna is resonant at the WLAN band i.e. 5.2 GHz. The angular spiral shaped DGS,integrated in the ground plane is given in Fig. 2. The total length of the angular spiral DGS is almost 28.6mm with the width of 0.5mm which is positioned at a length of 2.8mmfrom the feed position. Due to implementation of the DGS at the ground plane, the proposed antenna is found to be resonant at the GSM band i.e. 1.8GHz. Furthermore the length of the angular spiral DGS is modified accordingly so that the resonant frequency is gradually increased from 1.8GHz to 2.4GHz and 3.5GHz respectively. From Fig. 3 it can be observed that the length of the angular spiral DGS is 20.3mm, for which the antenna becomes resonant at the Bluetooth frequency band i.e. 2.4GHz. Similarly from Fig. 4 it can be seen that when the length of the DGS is modified to 12.2mm, the antenna becomes resonant at the Wimax frequency band, i.e. 3.5GHz. Thus it can be observed that as the length of the angular spiral DGS is reduced, the microstrip antenna is found to be resonant at a higher frequency band, which justifies the tunability of the microstrip antenna.

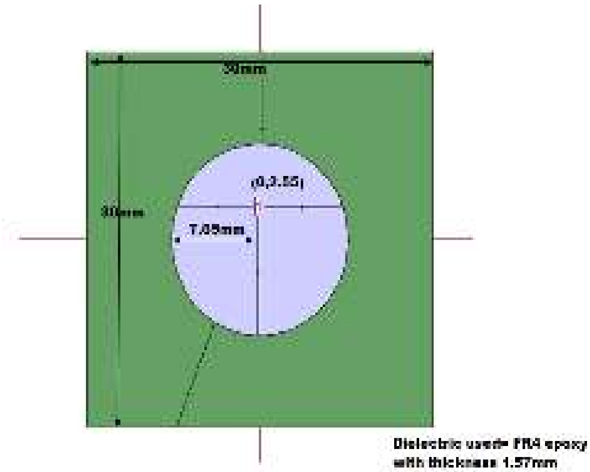


Fig. 1. Front view of the proposed circular microstrip antenna, resonant at 5.2GHz

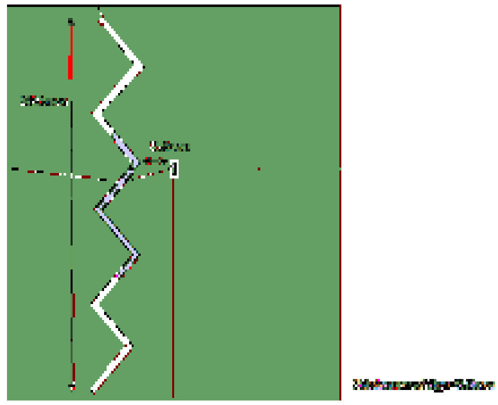


Fig. 2. Back view of the proposed circular microstrip antenna, resonant at 1.8GHz

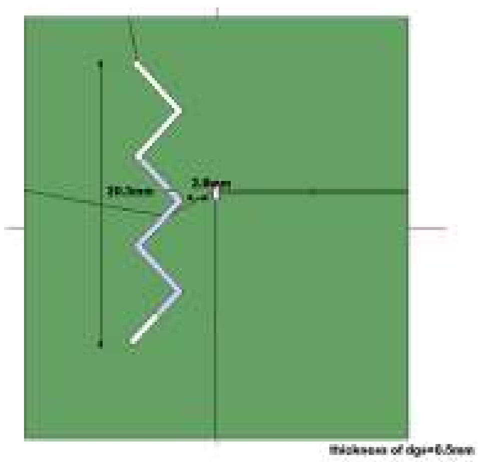


Fig. 3. Back view of the proposed circular microstrip antenna, resonant at 2.4GH

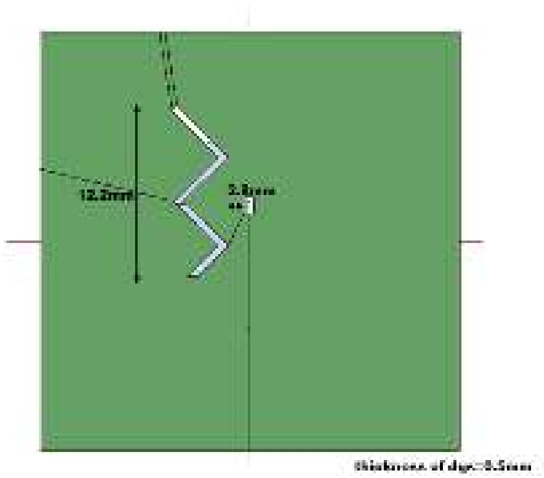


Fig. 4. Back view of the proposed circular microstrip antenna, resonant at 3.5GHz

2.2 RESULTS

2.2.1 S_{11} versus frequency graph

The return loss versus frequency graph of the microstrip antenna with DGS and without DGS is shown in Fig.5 and Fig. 6respectively.From the figures it is seen that in absence of DGS at the ground plane return loss at 5.2 GHz is -30dB and for the DGS integrated antenna the resonance is at 1.8Ghz with -24dB return loss. Fig. 7 shows the variation of return loss versus frequency for the microstrip antenna with modified length of the DGS and it is seen that the antenna is resonant at the Bluetooth frequency band i.e. 2.4GHz with -31dB return loss. Furthermore Fig. 8 shows the variation of return loss versus frequency plot for the microstrip antenna, resonant at the Wimax frequency band, i.e. 3.5GHz. The return loss at the resonating frequency is found to be -26dB.

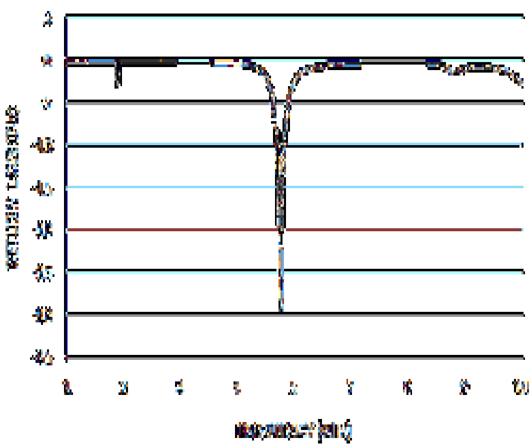


Fig. 5. Simulated Return Loss of the proposed antenna without DGS

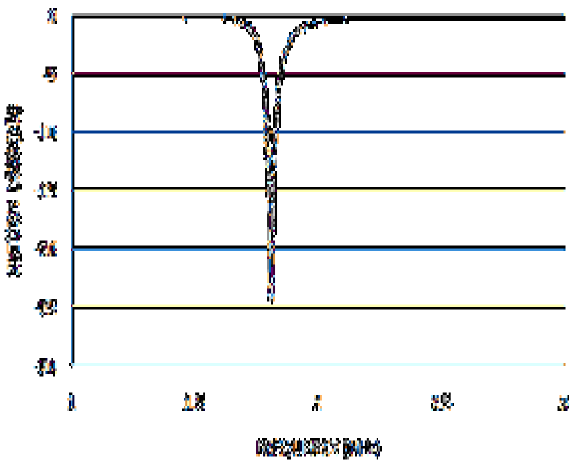


Fig. 6. Simulated Return Loss of the proposed antenna with DGS, resonant at 1.8Ghz

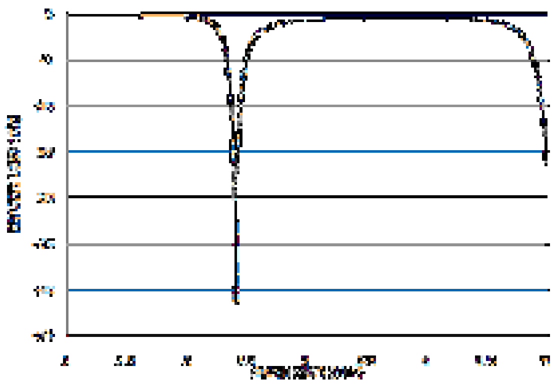


Fig. 7. Simulated Return Loss of the proposed antenna with DGS, resonant at 2.4Ghz

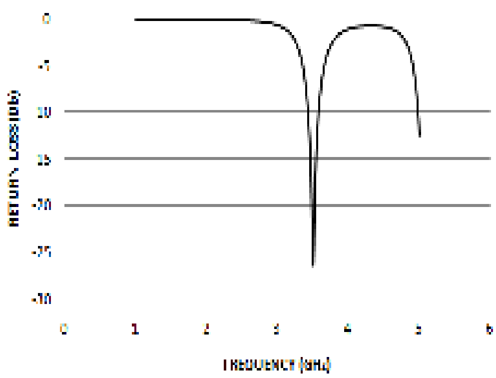


Fig. 8. Simulated Return Loss of the proposed antenna with DGS, resonant at 3.5Ghz

2.2.2. Impedance versus frequency graph

At the resonant frequency the real part of impedance in the impedance versus frequency graph for the microstrip antenna has to be close to the characteristics impedance of 50ohms. Similarly the imaginary part of impedance in the impedance versus frequency graph has to be close to 0ohm for a perfect match. Fig.9 shows the impedance versus frequency graph for the microstrip antenna without DGS and Fig.10 gives the same graph for DGS integrated microstrip antenna, resonant at 1.8Ghz. Similarly Fig.11 and Fig. 12.shows the impedance versus frequency plot for the microstrip antenna, resonant at 2.4GHz and 3.5GHz respectively. It can be observed from the figures that the real part of impedance and the imaginary part of impedance at the resonance is almost equal to 50ohms and 0ohm respectively. Therefore at the resonating frequency the compact microstrip antenna is perfectly matched for optimum performance.

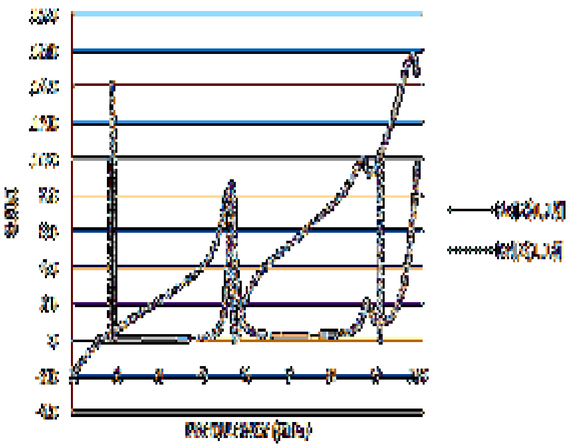


Fig.9. Simulated impedance versus frequency plot for the microstrip antenna without DGS

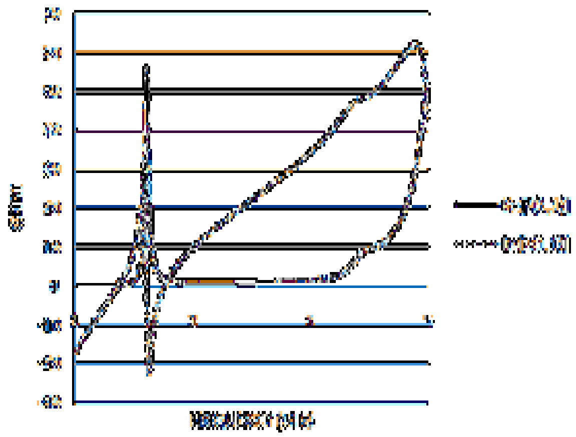


Fig.10. Simulated impedance versus frequency plot for the microstrip antenna with DGS, resonant at 1.8GHz

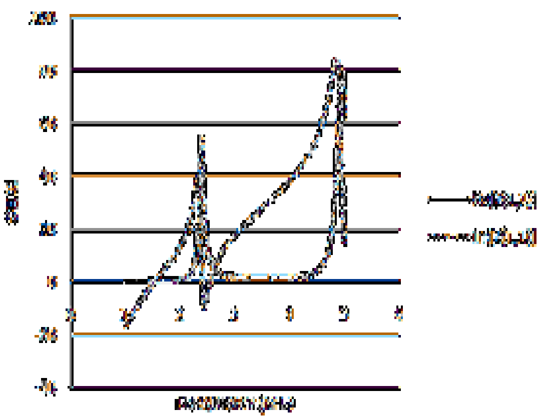


Fig.11. Simulated impedance versus frequency plot for the microstrip antenna with DGS, resonant at 2.4GHz

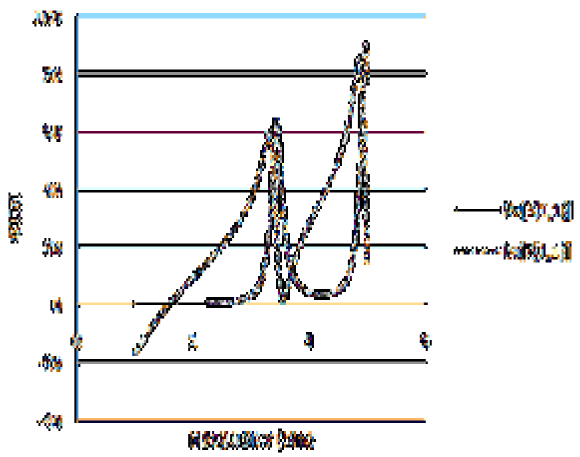


Fig.12. Simulated impedance versus frequency plot for the microstrip antenna with DGS,resonant at 3.5GHz

2.2.3 Radiation Pattern

Generally the radiation pattern of the microstrip patch antenna is orthogonal to its patch surface and so the elevation pattern for φ= 0 and φ= 90 degrees are measured. The E-plane and H plane radiation pattern at WLAN frequency band (i.e. 5.2GHz) is shown in Fig.13and it can be observed that the gain is obtained at resonant frequency is 5.6dBi. Fig.14 shows the E-plane and H plane radiation pattern at GSM band (i.e. 1.8 GHz) and the gain at 1.8GHz is obtained as 1.68dBi.Similarly Fig. 15 and Fig. 16.shows the radiation pattern of the microstrip antenna resonant at 2.4GHz and 3.5GHz respectively. From the figures it can be observed that the maximum gain as obtained at 2.4GHz and 3.5GHz frequencies are 2.41dBi and 3.39dBi respectively.

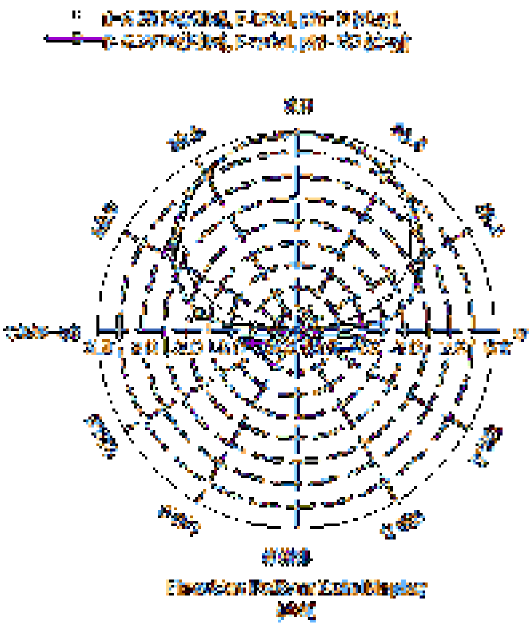


Fig. 13. Radiation Pattern of the antenna without DGS , resonant at 5.2GHz

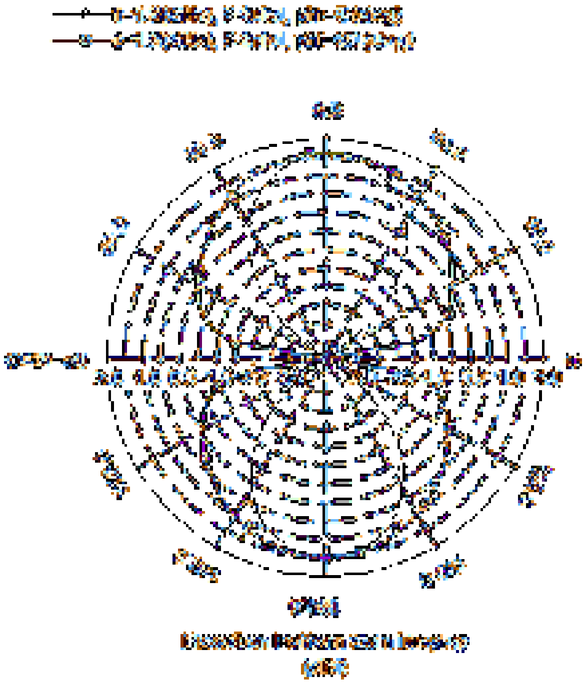


Fig. 14. Radiation Pattern of the antenna with DGS, resonant at 1.8 GHz

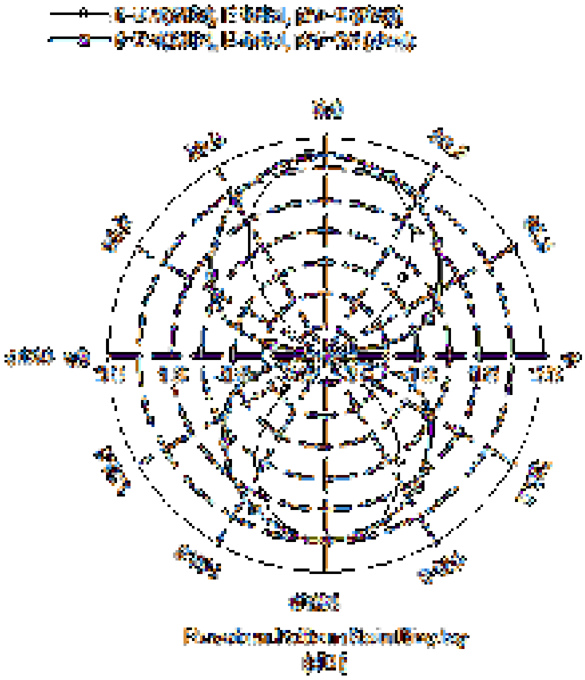


Fig. 15. Radiation Pattern of the antenna with DGS, resonant at 2.4 GHz

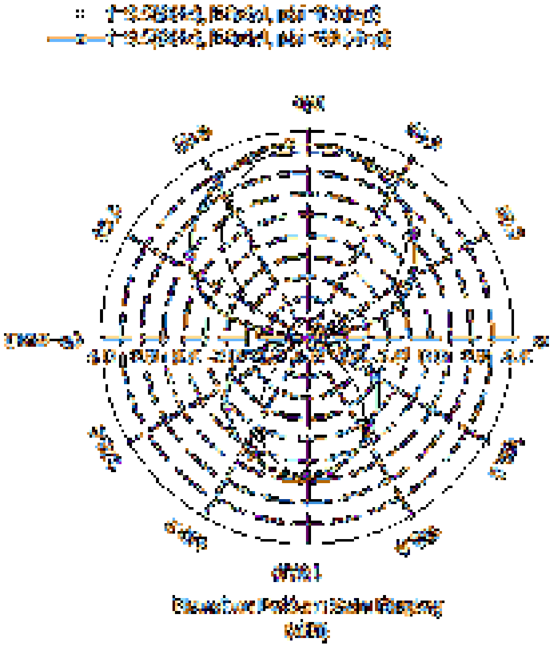


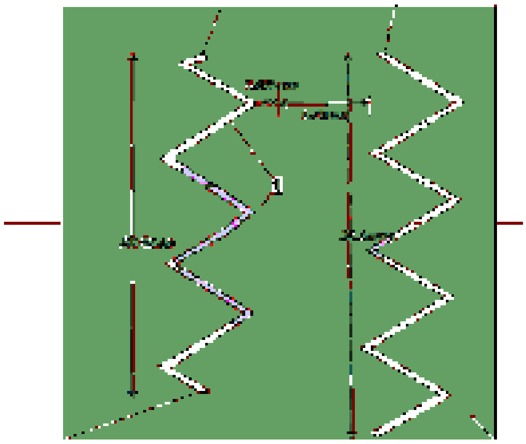
Fig. 16. Radiation Pattern of the antenna with DGS, resonant at 3.5 GHz

3. DESIGN OF DOUBLE DGS INTEGRATED MICROSTRIPANTENNAFOR PERFORMANCE ENHANCEMENT

3.1 DESIGN PRINCIPLES

In the proposed microstrip antenna dual DGS is integrated in the ground plane as given in the Fig.17. The lengths of the two DGS are adjusted to 23.4mm and 26.6mm respectively. With the given dual DGS integrated in the ground plane, it is found that the antenna is resonating at 1.8GHz.To minimize the effect of coupling the distance between the two DGS are optimized with respect to the feed position.

The length of the dual DGS in the proposed microstrip antenna is further reduced as shown in the Fig.18. The lengths of the two DGS are modified to 12.32mm and 14mm respectively and the position of the DGS is optimised so as to minimize the effect of coupling. Thus the microstrip antenna with modified length of dual DGS is found to be resonant at 3.42GHz.



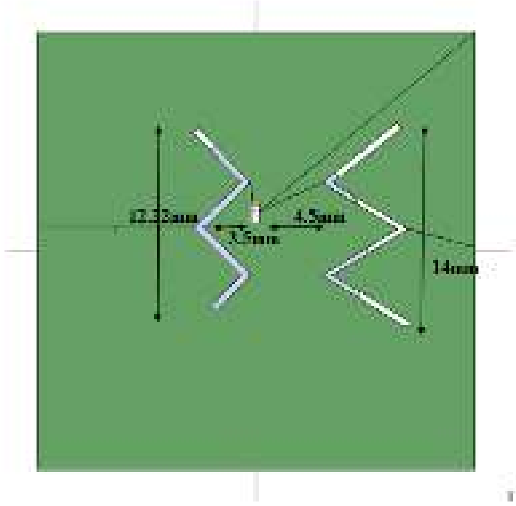


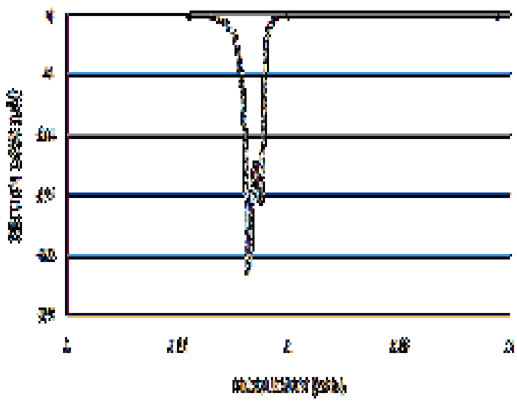
Fig. 17. Back view of the proposed circular microstrip with dual DGS , resonant at 1.8GHz

Fig. 18. Back view of the proposed circular antenna microstrip antenna with dual DGS , resonant at 3.5GHz

3.2 RESULTS

3.2.1 S_{11} versus frequency graph

Fig. 19 and Fig. 20 shows the variation of S11 versus frequency graph of the dual DGS integrated microstrip antenna. It is observed that the proposed antennas are resonant at 1.83GHz with -21dB return loss and at 3.4Ghz with -24dB return loss respectively. As the return loss due to the first DGS tries to increase, the second DGS tries to pull back the return loss which results in the increased bandwidth due to the dual effect of the two DGS.



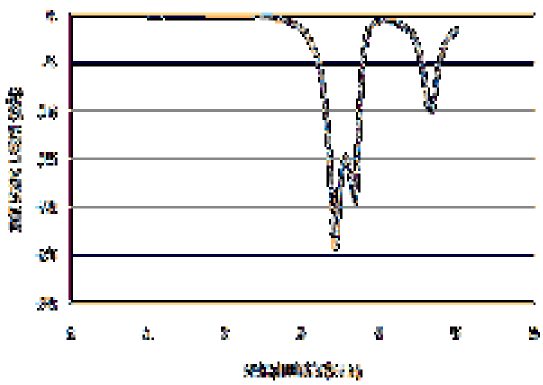


Fig. 19. Simulated Return Loss of the proposed antenna with dual DGS, resonant at 1.8GHz

Fig. 20. Simulated Return Loss of the proposed antenna with dual DGS, resonant at 3.5GHz

3.2.2 Impedance versus frequency graph

Fig. 21 and Fig. 22 shows the impedance versus frequency plot for the microstrip antenna with dual DGS implemented in the ground plane,resonant at 1.8Ghz and 3.42Ghz respectively. From the figures it can be observed that real part of impedance is 50ohms and imaginary part of impedance is 0ohm at the resonant frequency.

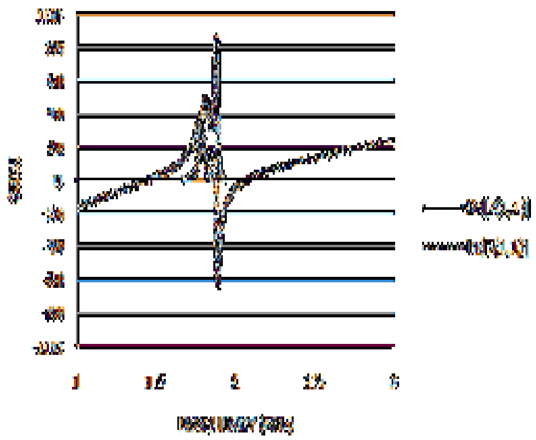


Fig.21. Simulated Impedance versus frequency plot for thedual DGS integrated microstrip antenna, resonant at 1.8Ghz

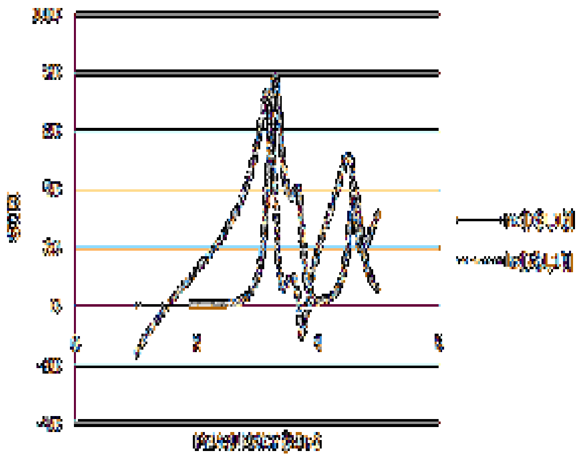


Fig.22. Simulated Impedance versus frequency plot for the dual DGS integrated microstrip antenna, resonant at 3.5Ghz

3.2.3 Radiation Pattern

The radiation pattern of the dual DGS integrated micorstrip antenna, resonant at 1.8Ghzis shown in Fig. 23 and the maximum gain obtained from radiation pattern is about 2dBi.Likewise Fig.24 shows the radiation pattern of the microstrip patch antenna, resonant at 3.42Ghz and it is seen that the maximum gain obtained at resonance is 3.2dBi.

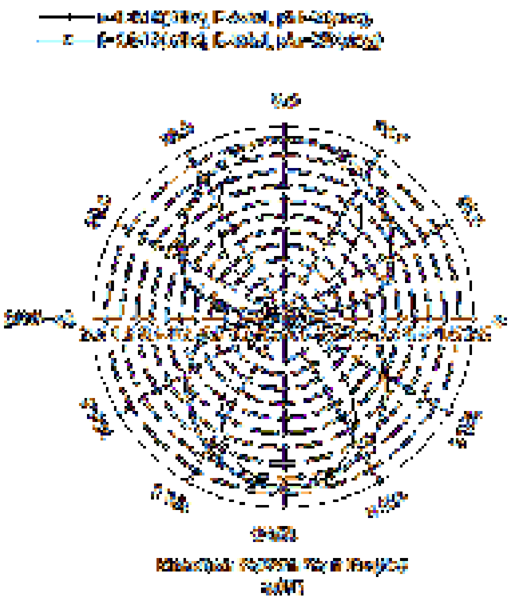


Fig. 23. Radiation Pattern of the antenna with dual DGS, resonant at 1.8 GHz

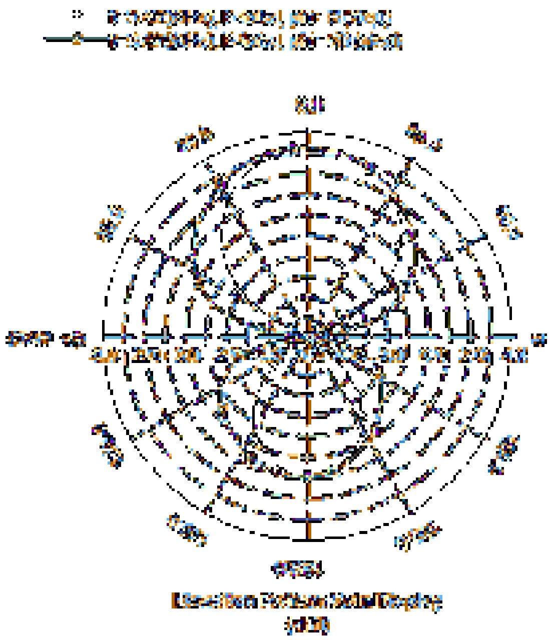


Fig. 24. Radiation Pattern of the antenna with dual DGS, resonant at 3.5 GHz

4. CONCLUSION

An novel angular spiral DGS implemented in microstrip antenna results in appreciable compactness of about 88.9% and the shift of resonant frequency from the WLAN band, 5.2GHz to the GSM band, 1.8GHz,theBluetooth frequency band i.e. 2.4GHz and the Wimax frequency band i.e. 3.5GHz respectively. This proves the tunability of the proposed circular microstrip antenna. Extremely high compactness, enhanced bandwidth and appreciable gain in every application band justify the high performance of the circular microstrip antenna, making it suitable used for practical wireless communications.

5. ACKNOWLEDGEMENTS

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