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DESIGN & SIMULATION OF DGS INTEGRATED COMPACT MICROSTRIP PATCH ANTENNA

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***Abstract*— In this paper, the aim is to design four microstrip antennas with different patch shapes, rectangular, hexagonal, circular and triangular. These antennas are made to resonate in the WLAN band, i.e. 5.8GHz. After this, an L-shaped defective ground structure (DGS) is introduced in the ground plane. Now, it is observed that the same antennas start resonating at the WiMax band, i.e. 3.3-3.5GHz. Changing the dimension of the DGS makes the antenna resonate in the other bands as well and thus it is concluded that wide bandwidth and low power handling capacity can be overcome by introducing a slotted patch in the ground structure of any antenna. The proposed microstrip antennas can be used in the various wireless applications.**

Keywords— Defective Ground Structure, WLAN, WiMax

I. INTRODUCTION

Microstrip patch antennas have been designed and implemented on a large scale in recent times because of its use in various practical and research purposes. [1] The main reason behind using these antennas is due to its light weight, compact and small size, and also it is very easy to fabricate. It can perform excellently with both planar and non-planar circuits and surfaces. [2],[3] It has been observed that introduction of a defect in the ground plane of the microstrip antenna, disturbs the current distribution and thus the antenna is found to resonate at a lower frequency band.[4][7] In this paper, four different antennas are designed with rectangular, hexagonal, circular and triangular patch shapes. Then, a DGS is introduced in the ground plane. Without the DGS, the antenna was resonating at the WLAN band (5.8GHz), but after the introduction of DGS, it is seen that the same antenna starts resonating at the WiMax band.[8]

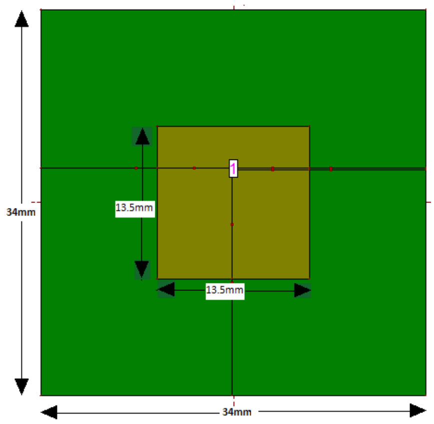

Fig. 1. Front view of Microstrip Antenna with Rectangular patch resonant at 5.8 GHz

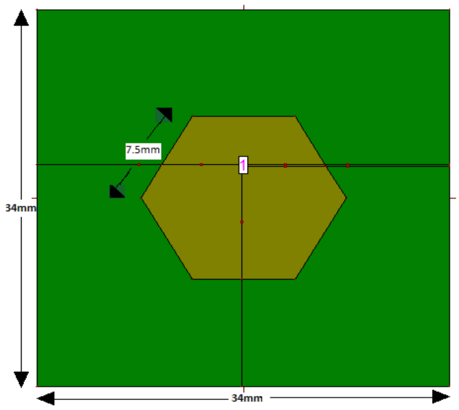

Fig. 2. Front view of Microstrip Antenna with Hexagonal patch resonant at 5.8GHz

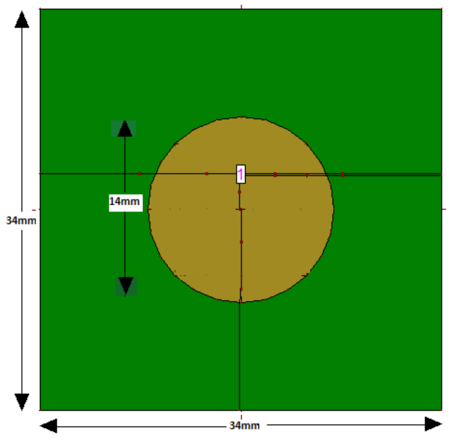

Fig. 3. Front view of Microstrip Antenna with Circular patch resonant at 5.8GHz

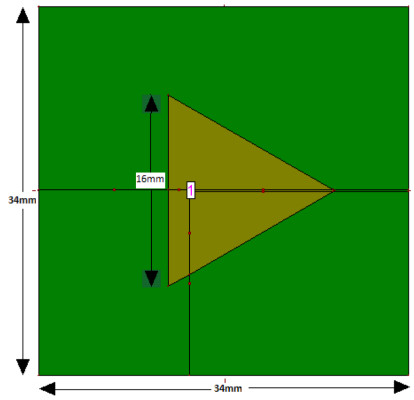

Fig. 4. Front view of Microstrip Antenna with Triangular patch resonant at 5.8 GHz

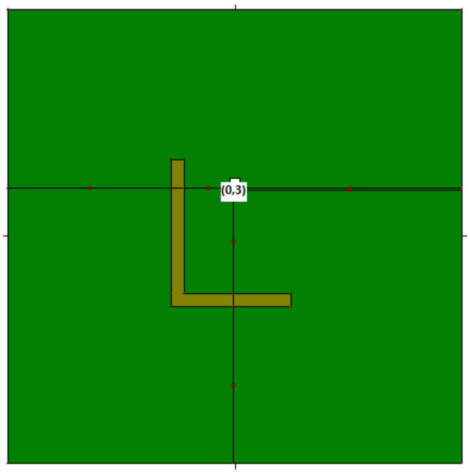

Fig. 5. Rear view of Microstrip antenna with Rectangular patch resonant at 3.5GHz

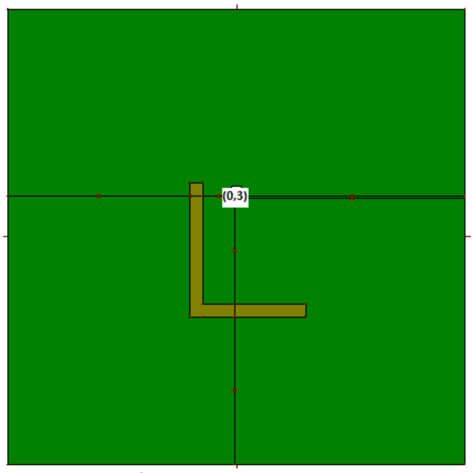

Fig. 6. Rear view of Microstrip antenna with Hexagonal patch resonant at 3.5GHz

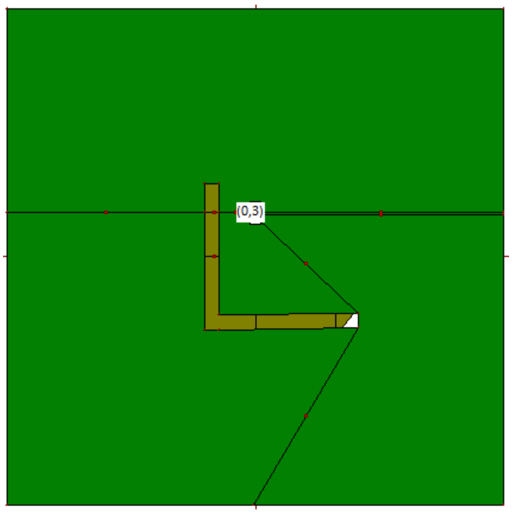

Fig. 7. Rear view of Microstrip antenna with Circular patch resonant at 3.5GHz

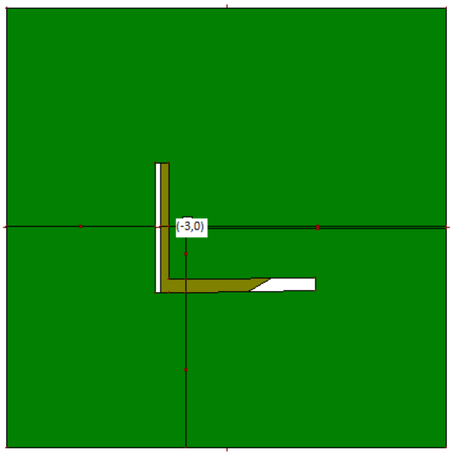

Fig. 8. Rear view of Microstrip antenna with Triangular patch resonant at 3.5GHz

II. Design Principles

In the beginning, four microchip patch antennas are designed and are made to resonate at the WLAN band 5.8 GHz without any DGS. With the introduction of DGS, the antenna is found to resonate at a much lower frequency, i.e. 3.5GHz. For all the patch antennas the ground plane is taken 34mm*34mm. FR4_epoxy is used as the dielectric substrate and the dielectric constant is taken 4.4 with loss tangent equal to 0.002.

For the circular patch antenna, the coaxial feed is approximated at (0,3). For the antenna to resonate at 5.8GHz the radius of the circular patch is taken 7mm. For DGS, the thickness of the L-strip is taken to be 1mm approximately.

For the rectangular patch antenna, the coaxial feed is taken at (0, 3). For the antenna to resonate at 5.8GHz the dimension of the patch taken is 13.5mm*13.5mm. For DGS, the thickness of the L-strip is taken to be 1mm approximately.

For the hexagonal patch antenna, the coaxial feed is taken at (0,3). For the antenna to resonate at 5.8GHz the length of each side of the patch is 7.5mm approximately. For DGS, the thickness of the L-strip is 1mm approximately.

For the triangular patch antenna, the coaxial feed is taken at (-3,0). For the antenna to resonate at 5.8GHz the side of the triangular patch is 16mm.

III. Results

A. S11 v frequency (without DGS)

The return loss characteristics of the four microstrip patch antennas are shown in figures 9, 10, 11 and 12. It is observed that the rectangular microstrip patch antenna resonates at 5.8GHz with -45dB return loss, whereas at the same resonating frequency the hexagonal microstrip patch antenna has a return loss of -32dB, the circular microstrip patch antenna has a return loss of -28dB and the triangular microstrip patch antenna has a return loss of -23dB.

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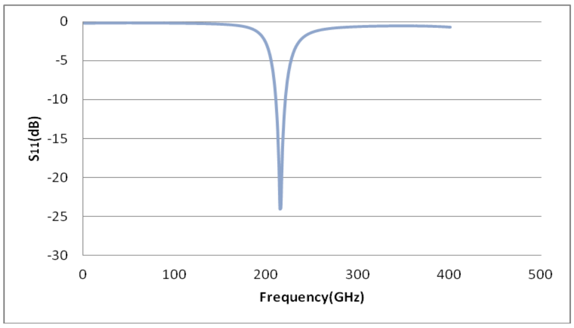

Fig. 9. S_{11}(dB) vs Frequency(GHz) plot of Microstrip antenna with Rectangular patch resonant at 5.8GHz

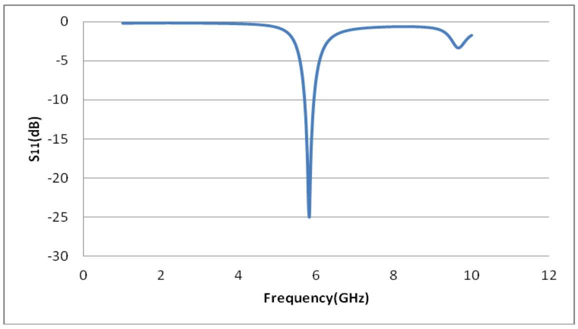

Fig. 10. S_{11}(dB) vs Frequency(GHz) plot of Microstrip antenna with Hexagonal patch resonant at 5.8GHz

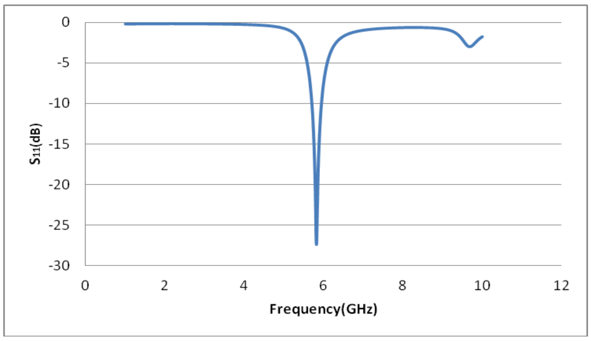

Fig. 11. S_{11}(dB) vs Frequency(GHz) plot of Microstrip antenna with Circular patch resonant at 5.8GHz

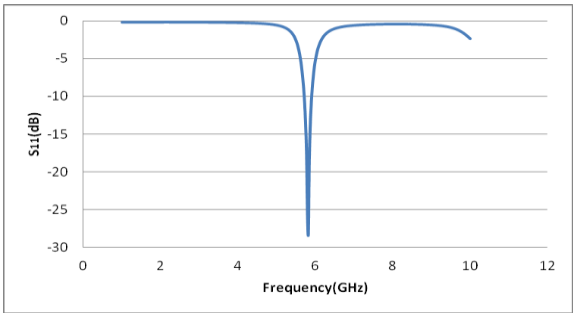

Fig. 12. S_{11}(dB) vs Frequency(GHz) plot of Microstrip antenna with Triangular patch resonant at 5.8GHz

B. S_{11} vs frequency (with DGS)

The return loss characteristics of the four microstrip patch antennas with defective ground structures are shown in figures 13, 14, 15 and 16. It is observed that with the introduction of DGS the same antenna, which was resonating at 5.8GHz, now resonates with a much lower return loss at a frequency of 3.5GHz. The return losses of the rectangular, hexagonal, circular and triangular microstrip antennas are -17dB, -14 dB, -18dB and -12dB respectively.

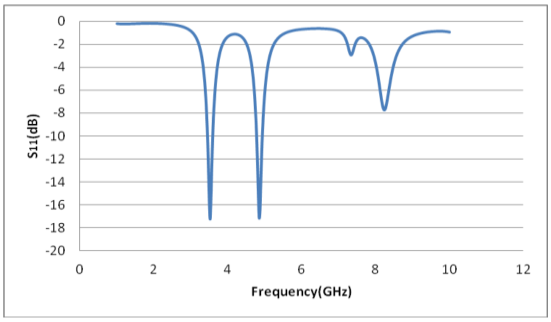

Fig. 13. S_{11}(dB) vs Frequency(GHz) plot of Rectangular Microstrip patch antenna with DGS resonant at 3.5GHz

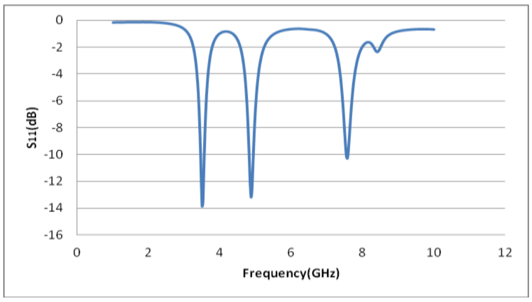

Fig. 14. S_{11}(dB) vs Frequency(GHz) plot of Hexagonal Microstrip patch antenna with DGS resonant at 3.5GHz

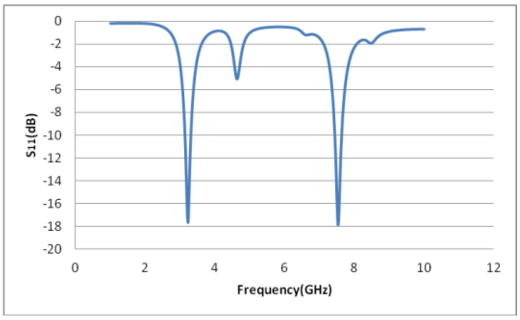

Fig. 15. S_{11}(dB) vs Frequency(GHz) plot of Circular Microstrip patch antenna with DGS resonant at 3.5GHz

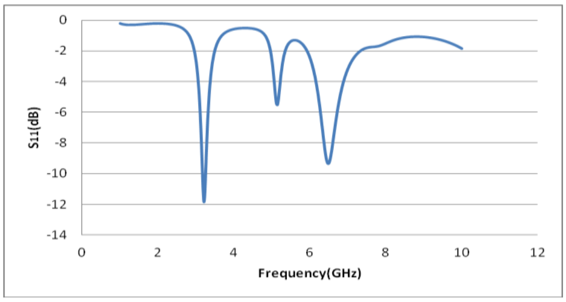

Fig. 16. S_{11}(dB) vs Frequency(GHz) plot of Triangular Microstrip patch antenna with DGS resonant at 3.5GHz

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C. Gain vs frequency (without DGS)

The gain vs frequency curves of the microstrip antennas with four different patch shapes, i.e. rectangular, hexagonal, circular and triangular are given below in figures 17, 18, 19 and 20 respectively. It is observed that gain is 5dB for rectangular, hexagonal and circular patch antennas resonating at 5.8GHz, but for triangular patch antenna the gain is around 2dB at the same resonating frequency.

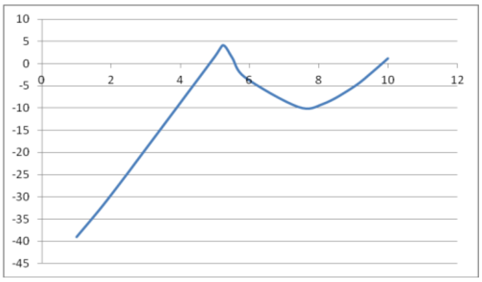

Fig. 17. Gain(dB) vs Frequency(GHz) plot of Rectangular Microstrip patch antenna resonant at 5.8GHz

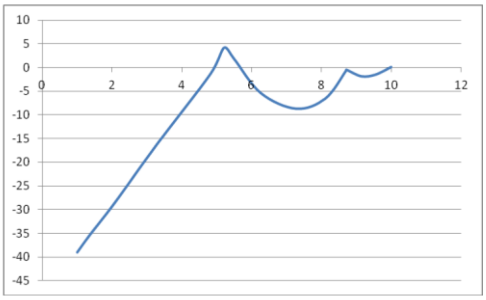

Fig. 18. Gain(dB) vs Frequency(GHz) plot of Hexagonal Microstrip patch antenna resonant at 5.8GHz

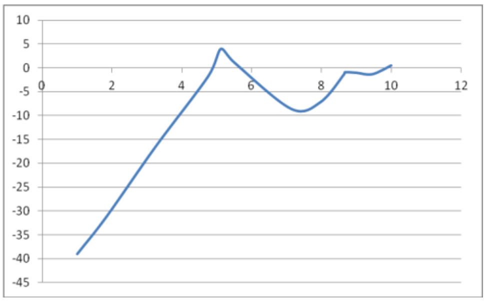

Fig. 19. Gain(dB) vs Frequency(GHz) plot of Circular Microstrip patch antenna resonant at 5.8GHz

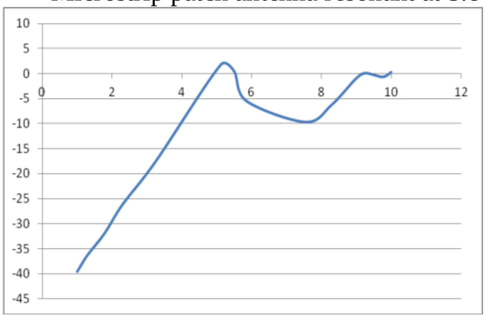

Fig. 20. Gain(dB) vs Frequency(GHz) plot of Triangular Microstrip patch antenna resonant at 5.8GHz

D. Gain vs frequency (with DGS)

The introduction of DGS lowers the amount of gain for all the four antennas. The antenna which was resonating at 5.8 GHz with a gain of 5dB now starts resonating at 3.5GHz with a gain of only 1dB. With the introduction of DGS, it is observed that the hexagonal and circular patch antennas have a gain of 3dB, but rectangular and triangular patch antennas have gain around 1dB.

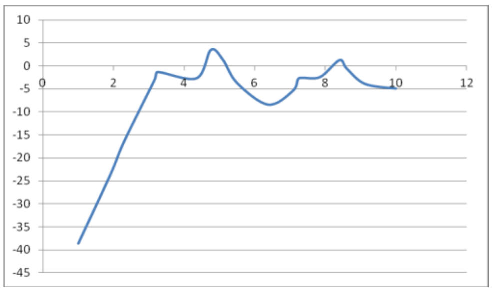

Fig. 21. Gain(dB) vs Frequency(GHz) plot of Rectangular Microstrip patch antenna resonant at 5.8GHz

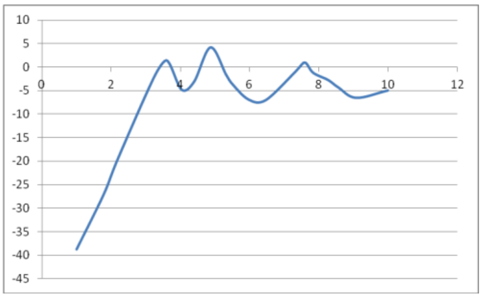

Fig. 22. Gain(dB) vs Frequency(GHz) plot of Hexagonal Microstrip patch antenna resonant at 5.8GHz

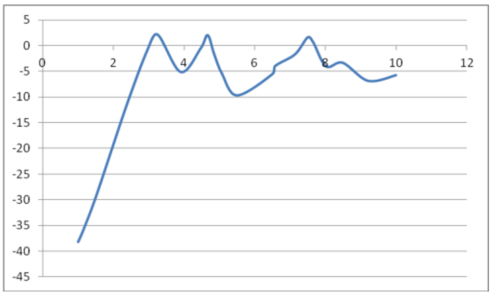

Fig. 23. Gain(dB) vs Frequency(GHz) plot of Circular Microstrip patch antenna resonant at 5.8GHz

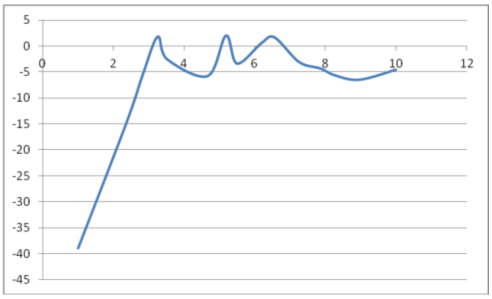

Fig. 24. Gain(dB) vs Frequency(GHz) plot of Triangular Microstrip patch antenna resonant at 5.8GHz

IV. CONCLUSION

A theoretical survey on microstrip patch antenna is presented in this paper. An observation made on the return loss characteristics of the microstrip antenna gives two results:
i) Return loss is maximum for the rectangular microstrip patch antenna at the same resonating frequency when there is no DGS.
ii) After the introduction of DGS, the circular microstrip patch antenna has a slightly higher return loss than rectangular microstrip patch antenna.
An observation made on the gain vs frequency curves of the microstrip antennas gives two results:
i) When there is no DGS, the triangular microstrip patch antenna has the least gain while resonating at 5.8GHz, whereas the remaining three have same amount of gain.
ii) With DGS, the hexagonal and circular microstrip patch antennas have more gain than the rectangular and triangular patch antennas.
After study of different patch shapes and sizes, it is concluded that wide bandwidth and low power handling capacity can be overcome by introducing a slotted patch in the ground structure of any antenna. Some antenna parameters are discussed, like return loss and gain. Microstrip patch antenna can be designed by implementing various parameters, generating trial and error method application to make the antenna resonate in a particular frequency and different merits are compared with conventional microwave antenna.

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