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Design of 1X2 Triangular Shaped Microstrip Patch Antenna Array for WLAN Applications with DGS Structures

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ABSTRACT: In this paper we have discussed and analyzed the performance of triangular shaped patch antenna for WLAN (Worldwide Local Area Network) application. Operating range of WLAN is 2.4GHz to 5GHz.The presented design operates at resonant frequency of Fr=3.5GHz. Later DGS structure is incorporated and various parameters such as Return Loss, VSWR and Gain are analyzed. Antennas are designed and simulated using CST Software version-14.Microstrip line feeding technique is used.

KEYWORDS: WLAN, DGS, Microstrip line feeding, Return Loss, VSWR.

I. INTRODUCTION

As an interface between transmitter/receiver and free space, antennas are essential part of any communication system (satellites, radars, aviation, medical applications etc.). Microstrip patch antenna is formed when a substrate material is placed between two metal plates. The dimension of microstrip patch are very less i.e., in the order of few mm to cm, Moreover microstrip patch antennas can be easily integrated with the VLSI circuit boards. This indirectly increases the package density and reduces the power consumption. The key features of a Microstrip patch antenna are ease of fabrication, light weight, low cost [1]. These advantages of Microstrip antennas make them popular in many wireless communication applications such as telemetry and communications, aviation, naval communications, automatic guidance of intelligent weaponry, radar, GPS systems. The most serious problem of patch antenna is its narrow bandwidth [2]. Therefore there is a need to enhance the bandwidth of microstrip antenna for WLAN application.

Microstrip patch antennas are designed based on type of substrate, dimensions of the patch, resonating frequency and substrate thickness. WLAN (Worldwide Local Area Network) operates in the range of 2.4GHz to 5GHz. To produce WLAN operating frequency, many complex designs are proposed earlier. These complex designs increase the fabrication cost. In order to reduce the fabrication cost, we propose simple triangular shaped patch (1X2) arrays resonating at 5.1-5.9 GHz to operate at WLAN frequencies. Later DGS structure is implemented for the design to improve the operating characteristics.

The DGS is a deliberately etched periodic or non-periodic cascaded configuration defect in the ground plane of a planar transmission line [5]. It disturbs the shield current distribution in the ground plane which eventually changes the characteristics of a transmission line such as line capacitance and line inductance [4]. The proposed antenna consists of a 1×2 patch arrays using microstrip line feed for WLAN applications. First the patch antenna array is designed with triangular shape and E-shaped DGS structure is used to get the better performance.

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II. RELATED WORK

In [3] author explained Rectangular Microstrip Patch antenna with Frequency Selective Surfaces (FSS) and Slotted Patch to enhance Bandwidth at 2.4 GHz for WLAN Applications. Further, by providing air gap between patch and substrate bandwidth improved. In [4] author used microstrip line feed and power dividers for 4X1 and 8X1 microstrip patch antenna, dielectric material FR4 with dielectric constant 4.28, tangent loss of 0.002 and height of 1.6mm. antenna designs are simulated using IE3D software. From the simulated results, it is observed that the antenna can operate at 2.4GHz frequency. But it doesn't cover the entire range of WLAN frequency ranging from 2.4GHz-5.6 GHz. In [5] author presented the paper with advanced techniques like Defected Ground Structure (DGS) is implemented on the ground plane to improve bandwidth by filtering surfaces at the edges of the substrate. In [6] author explained the use of DGS by increasing the coupling power and by reducing the reflected power. In addition to that bandwidth is also improved considerably. From the above literature survey DGS improves the bandwidth without increasing the size of the antenna. But, in above designs the design complexity is also increasing with bandwidth. We proposed a microstrip antenna with DGS to cover the entire WLAN frequency range by reducing the design complexity.

III. ANTENNA DESIGN

A. Design of 1X2 triangular shaped antenna array for WLAN applications

The proposed antenna is designed using FR4 substrate with dielectric constant ε_r=4.4, loss tangent tanδ= 0.02 and thickness of the substrate is h=1.4mm. Microstrip line feeding technique is used for the antenna to get desired performance. The patch arrays are fed with 50-Ω microstrip line which is terminated with a SMA connector for measurement purpose. The width of the feed line W_f and length of the line L_f are 3mm and 15.6mm respectively. The ground plane is trimmed in the dimension (24X48mm) to operate at WLAN frequency range

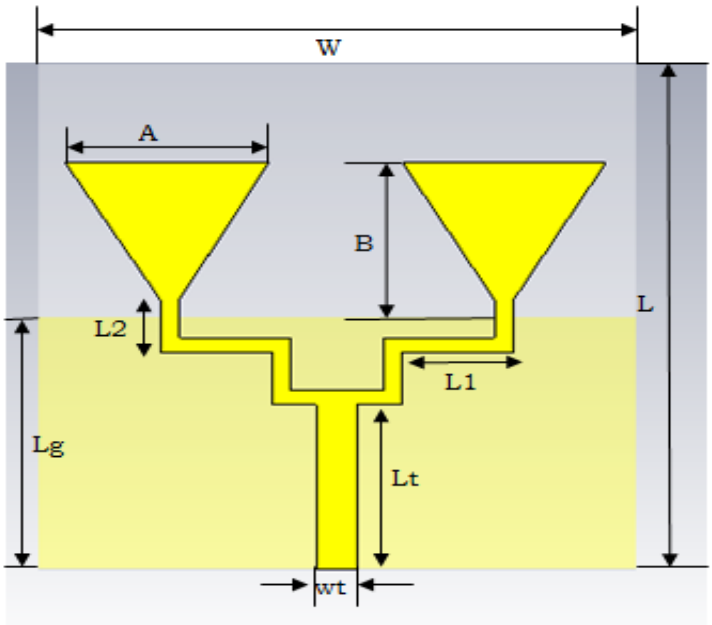

Fig.1 GEOMETRY OF PROPOSED ANTENNA

Fig.1 shows the general configuration of proposed triangular shaped patch array. Where 1×2 triangular shaped patch array is placed over the FR4 substrate and dimensions of triangular shaped patch antenna are tabulated in a tabular form.

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Table 1 shows the dimensions of the designed antenna

Design parameter	Length in mm
L	48
W	44
L1	8.2
L2	5
Lg	24
Lt	15.6
Wt	3
A	15
B	13
h	1.4

B. **Design of triangular shaped patch antenna with DGS structure**

For this triangular shaped patch antenna with DGS structure, further attached E-shaped slot on the ground plane and dielectric constant of the substrate is optimized to $\epsilon_r = 2.65$, with loss tangent $\tan\delta = 0.012$. The radiation properties such as VSWR, Return Loss and Gain plots observed. The proposed design is shown in Fig.2 with various dimensions of the antenna and are tabulated in Table.2

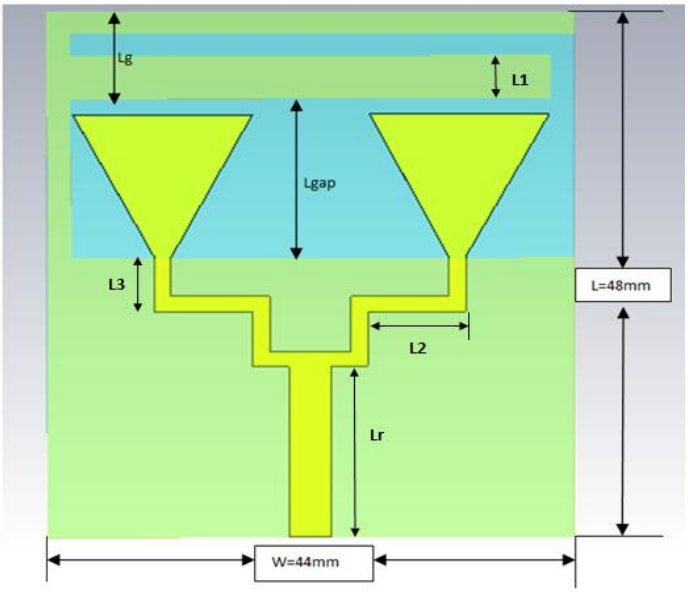

Fig.2 GEOMETRY OF ANTENNA WITH E-SHAPED DGS

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Design parameter	Length in mm
L	48
W	44
L1	4
L2	8.2
L3	5
Lr	15.6
Lgap	14.2
Lg	8

TABLE -2 Dimensions of antenna.

IV. RESULTS & DISCUSSION

Various parameters such as Return loss, VSWR and Gain are analyzed. The comparative analysis of both the antennas i.e triangular shaped patch antenna array design with rectangular DGS structure, the triangular shaped patch antenna array design with E-shaped DGS structure are presented.

a) VSWR vs. Frequency plot

Fig.3 shows the VSWR plot of triangular shaped patch antenna array using E-shaped DGS and without using E-shaped DGS. Voltage standing wave ratio can be evaluated by dividing maximum voltage with minimum voltage or we can find by using reflection coefficient. In the Fig.3 it is clear that for the operating frequency is 2.5-5.5GHz. After introducing E-shaped DGS the operating frequency is improved to 2.56GHz to 6.3 GHz. The bandwidth is improved from 3GHz to 3.796 GHz.

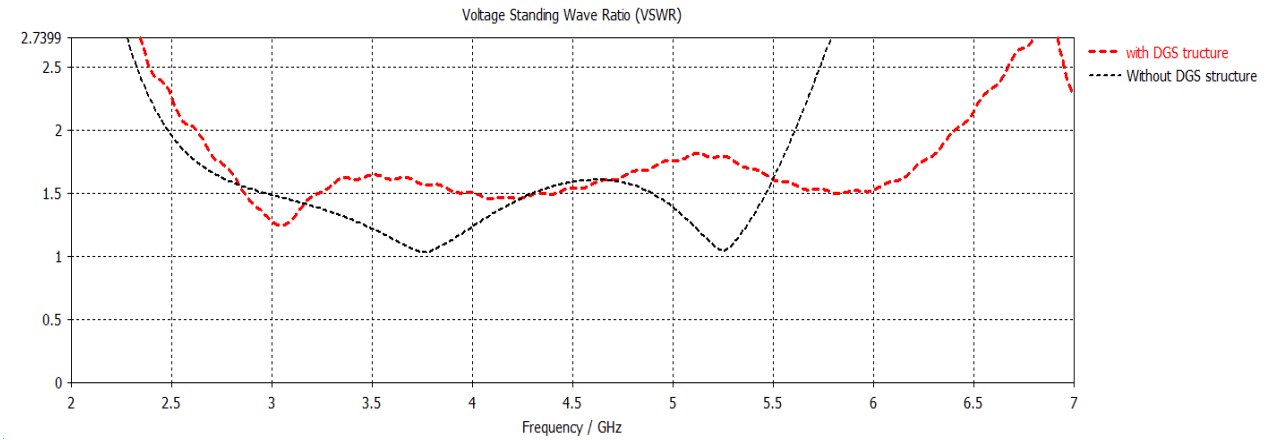

Fig.3 VSWR vs. FREQUENCY PLOT

b) Return loss vs. frequency plot

Fig.4 shows the plot of return loss vs. Frequency for triangular shaped patch antenna. $\mathbf{S_{11}}$ is a measure of the effectiveness of power delivery from a transmission line to load such as antenna. The return loss plots for antennas using E-shaped DGS and without using E-shaped DGS is shown in the Fig.4 It is obvious that S_{11}< -10dB for the frequencies from 2.5 GHz to 5.5 GHz in the absence of DGS and bandwidth of 3GHZ is achieved. When DGS is incorporated the bandwidth of 3.796GHz is obtained and operating frequency ranges from 2.5GHz - 6.3GHz. This operating frequency well suits for WLAN applications.

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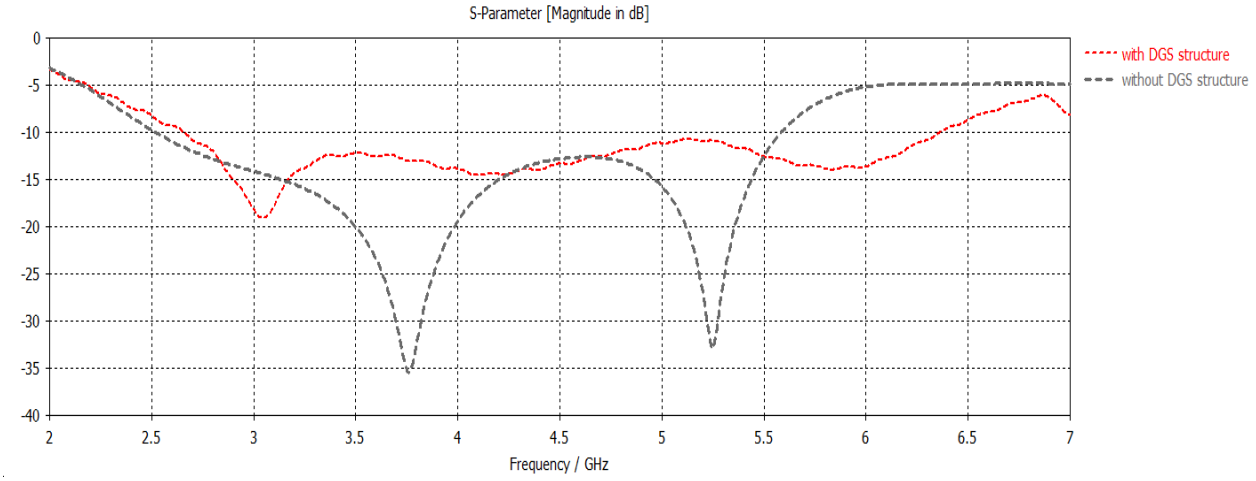

Fig.4 RETURN LOSS vs. FREQUENCY PLOT

c) **Gain Vs. frequency plot**

The simulated Gain versus frequency plot of proposed triangular shaped patch array with and without E-shaped DGS are shown in the fig.5. For triangular shaped patch antenna without DGS shows stable radiation patterns with increase in operating frequencies i.e 2.7dB, 4dB and 4.55dB at the frequencies 2.5GHz, 3.5GHz and 5GHz respectively.

When E-shaped DGS is incorporated, the gain is 2.42dB at 2.5GHz, 3.88dB at 3.5GHz, 5.16dB at 4GHz and 5.5dB at 5GHz. From which it can be observed that the antenna can provide stable gains over the entire operating frequency range. From the fig.5 it is clear that the proposed antenna is a good compact antenna for the WLAN and Wi MAX applications in the wireless communication systems.

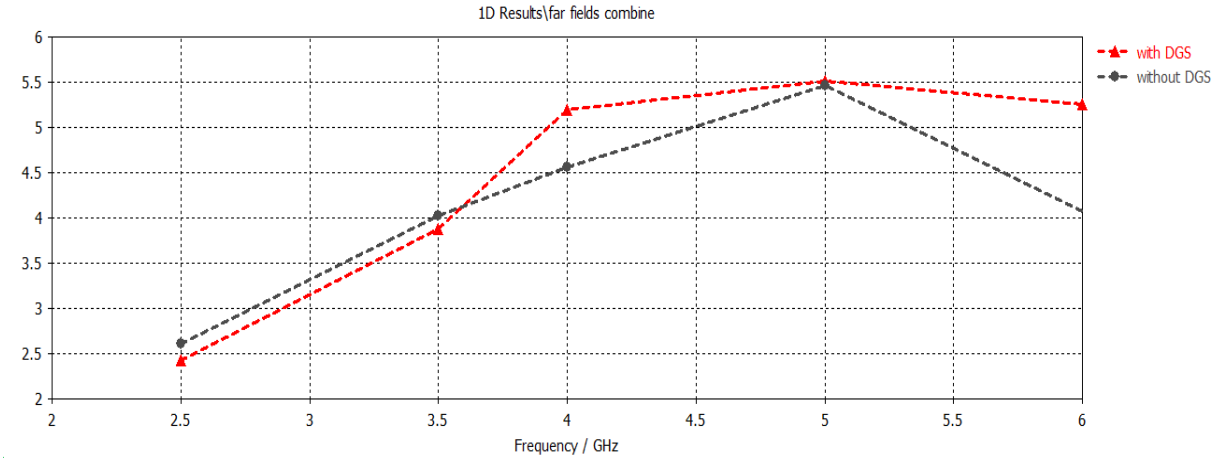

Fig.5 GAIN vs. FREQUENCY PLOT

V. CONCLUSION

The 1×2 triangular shaped patch microstrip antenna array is designed for WLAN applications. This antenna covers the several WLAN bands in wireless communications such as Bluetooth, Wi-Fi and Wi-MAX. The maximum peak gain achieved with this antenna is 5.4dB at 5GHz. Here the bandwidth of 3GHz is achieved. After DGS structure

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is incorporated it is observed that bandwidth is increased to 3.78 GHz. The maximum peak gain achieved is 5.5dB at 5GHz.

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