Design of Compact Millimeter Wave Micro-Strip Antenna Using Defected Ground Structure for 5G Applications

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Abstract : This paper Presents the Millimeter-wave antenna design on the future 5G wireless systems In this paper create an L-slot on patch antenna at Millimeter-wave (MMW) frequency ranges of 5G Band at 41GHz to 42.5GHz. Partial Defected Ground Structure is used to improve the VSWR, Bandwidth, Return Loss, Compactness and Efficiency of an antenna. Defected ground structure (DGS) helps to absorb the waves which propagate through the ground plane. These waves are known as surface waves. This technique focuses on the compactness of antenna for Mobile Applications. Moreover, simulation evaluation of gain of the antenna is 3dBi, Theta gain is 5dBi, Phi gain is 4dBi and efficiency is higher than 85% in the complete range of operation.

***IndexTerms* - Defected ground structure (DGS); Millimeter-wave (MMW); Patch; Compact Size; 5G.**

I. INTRODUCTION

Wireless technology is one of the main areas of research in the world of communication systems today and a study of communication systems is incomplete without an understanding of the Operation and fabrication of antennas. Recently increase in growth of wireless for future that's the main reason for our selecting a project researching in this field.

In this trade of technology various demands of microwave and wireless communication systems in many types of applications resulting in an interest to improve antenna parameters performances. Therefore, the selection of micro-strip antenna is suitable and useful to apply in various fields such as medical application, telecommunication, satellite and, military system. (1)

There have been dynamic research activities round the world in advancing the next-generation 5G wireless systems. More than five billion dollars devices demand wireless contacts that working voice, data, and other applications in present day wireless networks. The amount of mobile data has expanded significantly throughout the years due to the availability of smart portable devices, which support high-speed wireless applications such as multimedia. The efficient deployment of the 5G systems requires the design of small yet efficient antennas. Presently there has been much interest within the antenna research community to develop effective antenna designs for the future 5G specifically designed to operate in 5G-frequency bands: 41GHz to 42.5 GHz band.(2)

One of the popular and large scales used antenna in the wireless field is micro-strip patch antennas. Micro-strip antennas are widely used for its low profile, easily manufactured, simple structure, Omni directional radiation patterns and low fabrication cost.(3)These types of features of patch antenna provide a great advantage over the traditional ones. But the drawback of this kind of antenna also sometimes confines their applications, especially the narrow bandwidth.(4)

DGS is realized by decoration off a simple shape in the ground plane, depending on the various shape/structure and dimensions of the defect, the shielded current distribution is disturbed in the ground plane, a manipulated, controlled fragmentation and propagation of the electromagnetic waves through the substrate layer. The structure or size of the defect may be changed from the simple structure to complicated structure for the better performance.(5)

II. 5G TECHNOLOGIES

Till now 5G requirements are not available for us. However, a few researchers have been to place the base the era to be able to offer these requirements. This generation normally includes Wi-Fi access systems, frequency utilization, electricity intake, antenna and propagation.(6)

(A) 5G Spectrum

Compared with 4G structures, one of the primary differences in 5G cell systems is the shift to better frequencies where is easier to reap wider bandwidths. As illustrated in Fig. 1, the centimeter/ Millimeter wave bands ought to offer bandwidths several times broader than 3G and 4G frequency bands.(7)

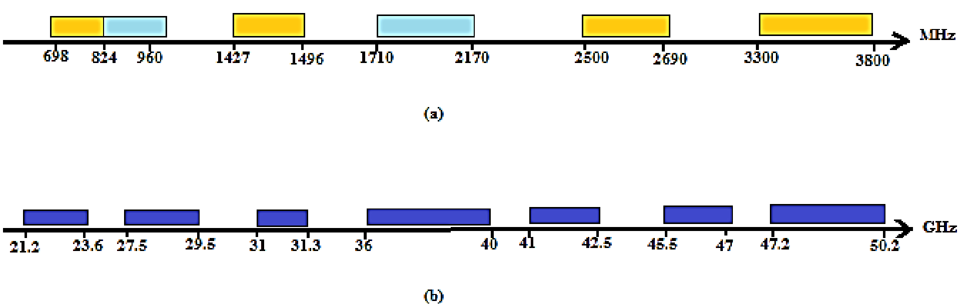

Figure 1 (a) Frequency bands of 3G and 4G, (b) candidates Bands for 5G in 20-50 GHz (8)

III. Material and Method

The proposed design for DGS patch antenna is shown in figure 1 and it is analysed using software CAD FEKO Suite 7.0 which is based on electromagnetic (EM) simulation. The proposed design is printed using the FR-4 substrate with loss tangent of 0.001. The antenna design is divided into four parts:

Firstly "T "shape Patch on a rectangular substrate.
Secondly L shape slot for the radiating patch.
Thirdly partial ground plane along with micro-strip feed line.
Fourth create the defected slot on Ground Plane.

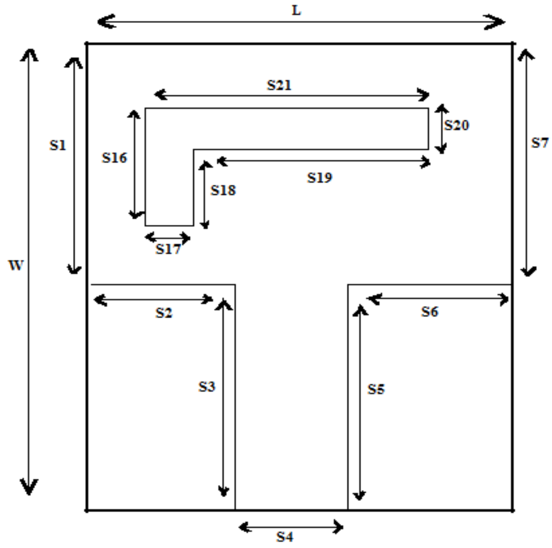

Figure 2 Proposed Antenna Design (Front View)

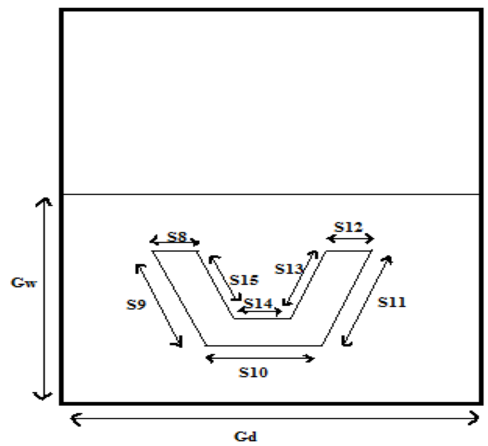

Figure 3 Proposed Antenna Design (Back View)

The dimensions for complete proposed DGS antenna design are tabulated in table 1.The proposed antenna has substrate dimensions of 3 * 2.5 mm^2. This proposed antenna has a partial ground of length width 0.92 mm and depth 2.5 mm as shown in figure 1. On partial ground we have create the U slot.

TABLE I OPTIMIZED DIMENSION OF PROPOSED ANTENNA

S. No.	PARAMETER	DIMENSION (mm)
1	W	3
2	L	2.5
3	S1	1.55
4	S2	1
5	S3	1.45
6	S4	0.5
7	S5	1.45
8	S6	1
9	S7	1.55
10	Gw	0.92
11	Gd	2.5
12	S8	0.1

13	S9	0.2
14	S10	0.35
15	S11	0.2
16	S12	0.05
17	S13	0.1
18	S14	0.3
19	S15	0.1
20	S16	1.1
21	S17	0.1
22	S18	1
23	S19	1.8
24	S20	0.1
25	S21	1.9

The figure - 4 shows the proposed software design of DGS antenna. In this figure on the front side T patch is created on rectangular substrate and L slot is created on the patch. On another side a U Slot, a defect is created on ground.

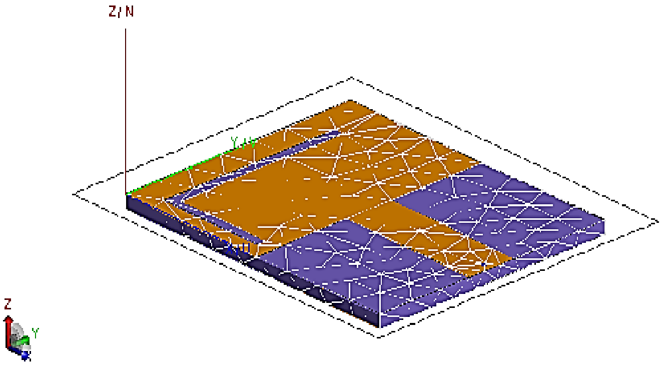

Figure 4 Proposed Software Design

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IV. Result and Discussion

The proposed MMW antenna is designed by EMSS FEKO v 7.0 software. In this section, simulated return loss results of the proposed T-shaped antenna with DGS are presented. As discussed, parametric analysis of the geometrical dimensions of proposed T-shaped patch antenna has been performed to achieve the desired impedance bandwidth. Simulated result of the proposed designed antenna has been shown in the figure. The return loss & VSWR of the antenna with rectangular slot is shown in figure-5 and figure-6 respectively.

1. Return Loss :

Below results gives the information about the variation of reflection parameters with respect to frequency. As we clearly shown in the above figure that at the 41 – 42.5GHz frequency we got Reflection coefficient is approximately equal to -14dB. It represents that antenna has a wide bandwidth that ranges from 40.78GHz to 42.57GHz and the bandwidth percentage is 4% of center frequency.

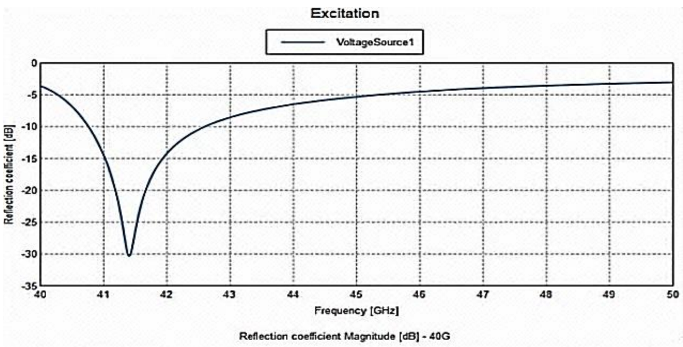

Figure 5 Plot between Reflection coefficient & frequency for DGS patch antenna

2. Voltage Standing Wave Ratio(VSWR):

VSWR is stands for voltage standing wave ratio. The VSWR is lies Between 1 – 2 shows in Figure 6. This is the VSWR and Frequency plot of proposed partial ground T-shaped antenna with L slot and DGS.

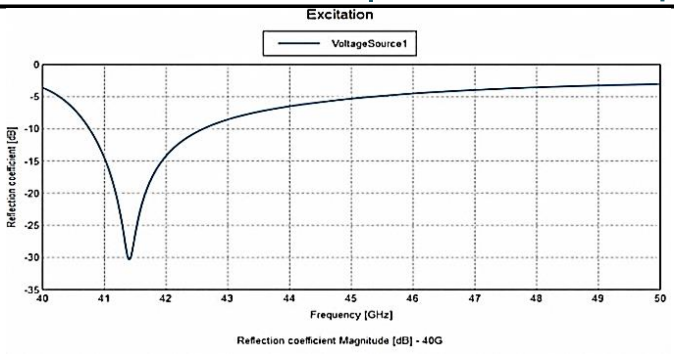

Figure 6 Plot between VSWR & frequency for DGS patch antenna

3. Current Distribution :

Figure 7 shows the simulated current density diagram of the proposed antenna. It is observed that the slots in the bottom ground plane depict a higher current distribution at the edges as compared to radiating patch.

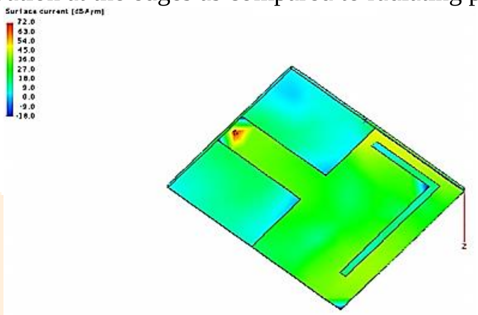

Figure 7 current distribution

4. Efficiency :

Fig 8 shows the graph between Power Efficiency and Frequency. The efficiency for DGS antenna in range of 41-42GHz is above 85-88% for proposed design.

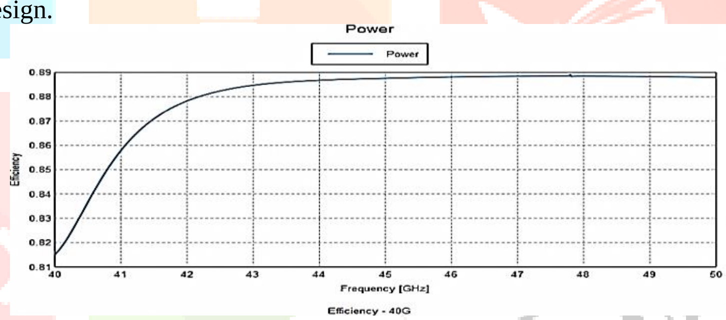

Figure 8 Plot between Power Efficiency & frequency for DGS patch antenna

5. Radiation Pattern :

Figure 9 shows the 3D omnidirectional pattern of the DGS antenna .In 3D pattern we obtained gain is 3dBi in range of frequency is 41-42.5GHz. In this design we obtain the Theta gain is 5dBi and the Phi gain is 4dBi in 41-42.5GHz range.

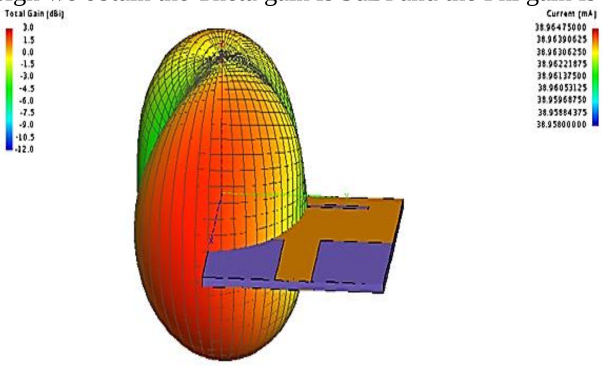

Figure 9 3D radiation pattern of DGS patch antenna

V. Conclusion

A very compact Defected Ground Structure Antenna is presented in this paper Proposed design covers the frequency range of 41 to 42.5GHz i.e. 5G Band. After going through simulations, return loss & VSWR is found to be satisfactory & the size of an antenna is also very compact and miniature which is added as biggest advantage. The overall performance of antenna finds it appropriate for use in future applications. The antenna has very vast applicability in different fields of communication with a very broad bandwidth.

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