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Research Article

Rectangular Printed Antenna for 5G Mobile Communications With DGS

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Abstract. Mobile communication systems are becoming more and more developed and the demand for services and throughput is in increasing. In our work, we designed a rectangular planar antenna for 5G at 3.5 GHz between 3.4-3.8 GHz. FR4 ($\epsilon r = 4.3$, $h = 1.5$ mm) is used as material substrate. We used DGS to ameliorate the bandwidth of the rectangular antenna. Simulation results are very satisfactory in terms of S11, VSWR, Gain, and radiation pattern. The designed antenna is low-cost and easy for integrating to operate at 5G.

Keywords. Planar Antennas; Radiation pattern; Gain; Reflection coefficient; Defected Ground Structure (DGS); 5G

Mathematics Subject Classification (2020). 68M10; 68M15; 68Q06

1. Introduction

Printed antennas are very used in wireless and mobile communications which gives easy access for telecommunication devices. For this purpose frequency bandwidths are available to meet this need especially 5G [1, 4]. DGS technique has been required for many applications due to their advantages for printed antennas of bandwidth, gain and omnidirectional radiation pattern [7]. The design of printed antennas such as planar monopole (PIFAs), slotted printed antennas, aperture printed antennas and planetary antennas offers many techniques that play a major role or they are simple geometry, miniaturized and multiband/broad bandwidth form factor [8]. the best coverage offered by 5G is the frequency spectrum below than 6 GHz [6]. Many advantages are provided by Microstrip antennas such as the low cost, the light weight and low profile, etc. [2]. Among the techniques for enhancing the properties of printed antennas is the use of Defective Ground Structure (DGS). In this technology, the slots of antenna are placed on ground plane of the rectangular antenna so that they reduce its size and/or increase its bandwidth [5, 10]. In this work, a design of rectangular printed antenna with extended bandwidth is proposed which resonates at 3.4-3.8 GHz for 5G mobile communication using CST simulation software. FR4 ($\varepsilon r = 4.3$, $h = 1.5$ mm) is the substrate used. Its bandwidth has been extended by Defected Ground Structure DGS.

2. Rectangular Patch Antennas Geometry

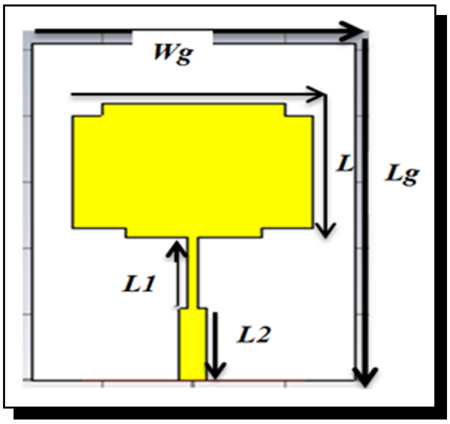

Figure 1. Rectangular patch antenna

Figure 1 show the antenna design which is fed by 50 ohms. The frequency chosen of 5G mobile systems is 3.5 GHz. FR4 is the simple substrate material used ($\varepsilon r = 4.3$, $h = 1.5$ mm). The parameters of the antenna are given in Table 1. There are calculated from the eqns. [3, 9]:

$$W = \frac{1}{2fr\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon rr+1}}, \tag{2.1}$$

$$\varepsilon e\frac{\varepsilon r+1}{2}+\frac{\varepsilon r-1}{2}\left[1+12\frac{h}{w}\right]^{-\frac{1}{2}}, \tag{2.2}$$

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon r_{\text{eff}}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon r_{\text{eff}}-0.258)\left(\frac{w}{h}+0.8\right)}, \tag{2.3}$$

$$L = \frac{1}{2fr\sqrt{\varepsilon r_{\text{eff}}}\sqrt{\mu_0\varepsilon_0}} - 2\Delta L, \tag{2.4}$$

$$Le = L + 2\Delta L. \tag{2.5}$$

The values of the parameters are given in Table 1:

Table 1. Dimensions of the initial patch antenna

Parameters	L	Lg	W	Wg	$L1$
Dimensions	20.25	50.89	26.32	35.32	10.82

3. Simulation Results

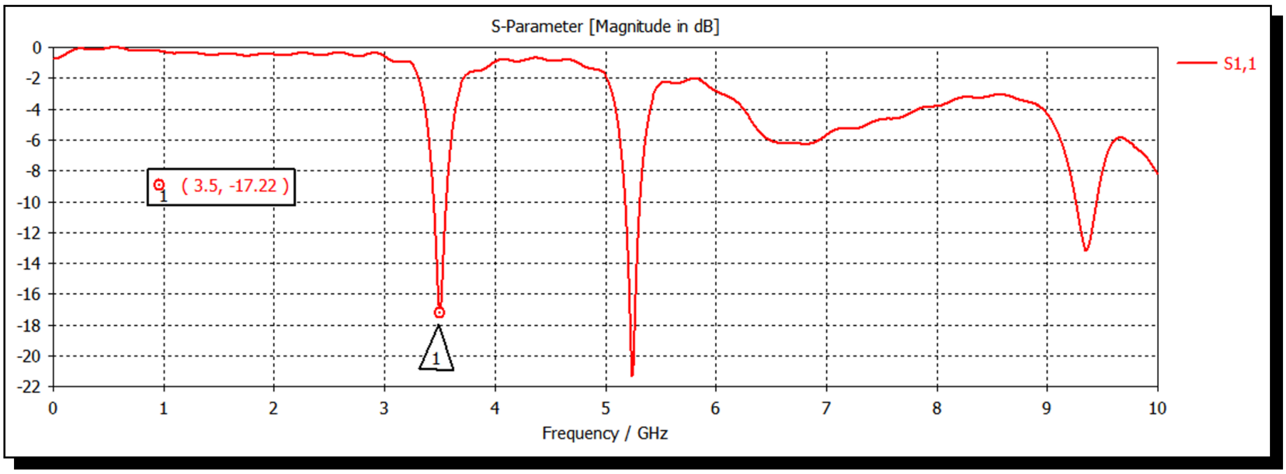

Figure 2. S11 parameter

Figure 2 shows that the return loss S11 is less than −10 dB. We obtained an S11 of −17.22 dB at 3.5 GHz.

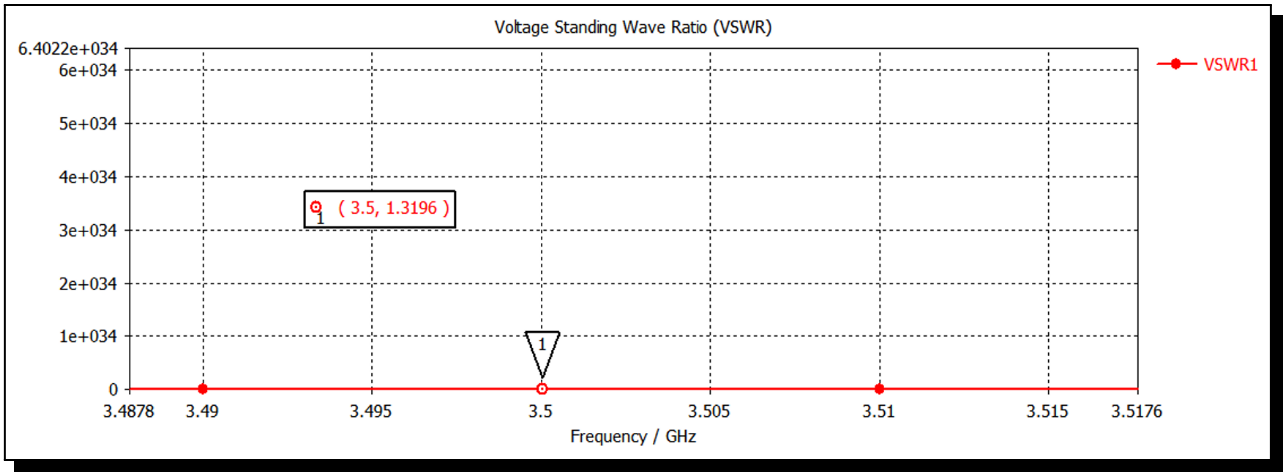

Figure 3. VSWR at 3.5 GHz

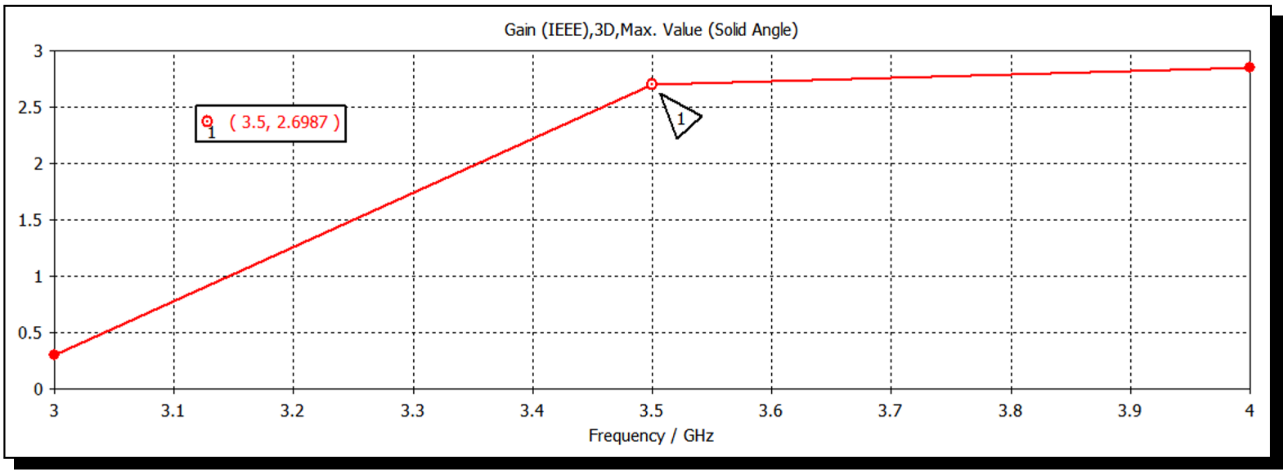

Figure 4. Gain at 3.5 GHz

From Figure 4, we obtained a gain of 2.6987 dB at 3.5 GHz.

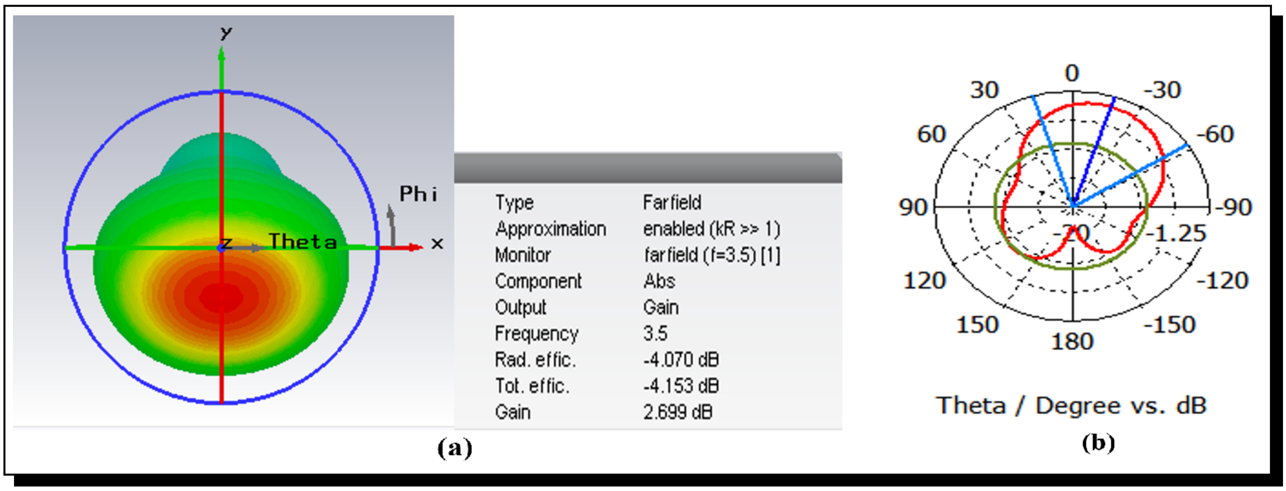

Figure 5. The radiation pattern of our rectangular patch antenna, (a) polar, (b) 3D

4. Bandwidth Enhancement of the Proposed Rectangular Printed Antenna

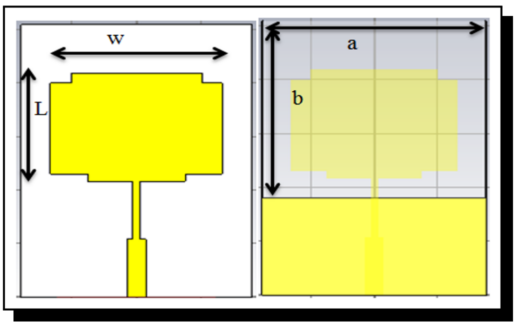

Figure 6. The proposed rectangular planar antenna

Table 2. Antenna parameters values

Parameters	L	W	a	b
Dimensions	20.25	26.32	35	33

(a) patch, (b) ground plan

5. Simulation Results

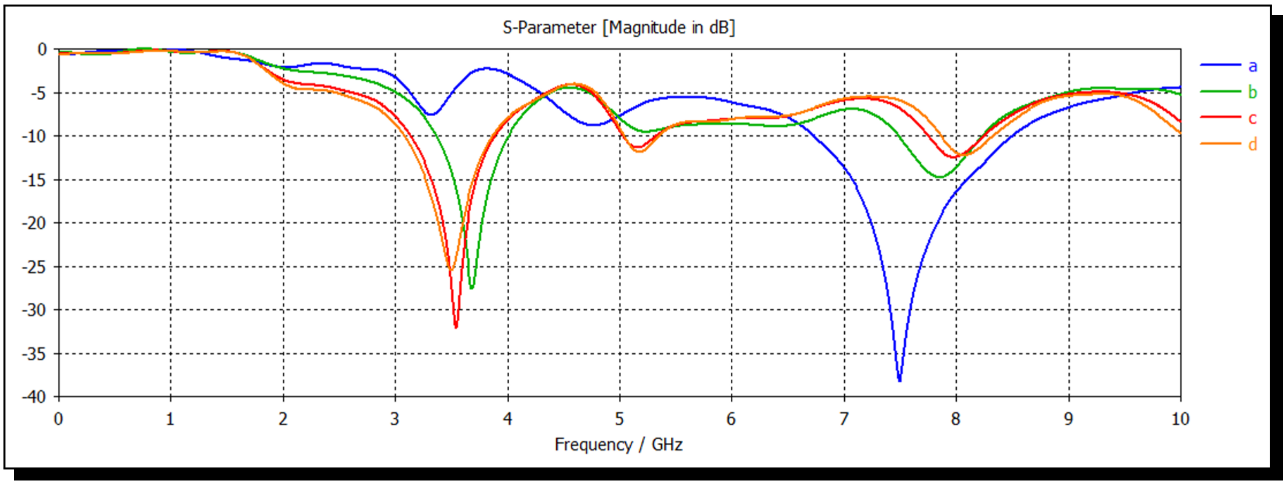

Figure 7. (a,b,c,d) Return loss of bandwidth enhancement

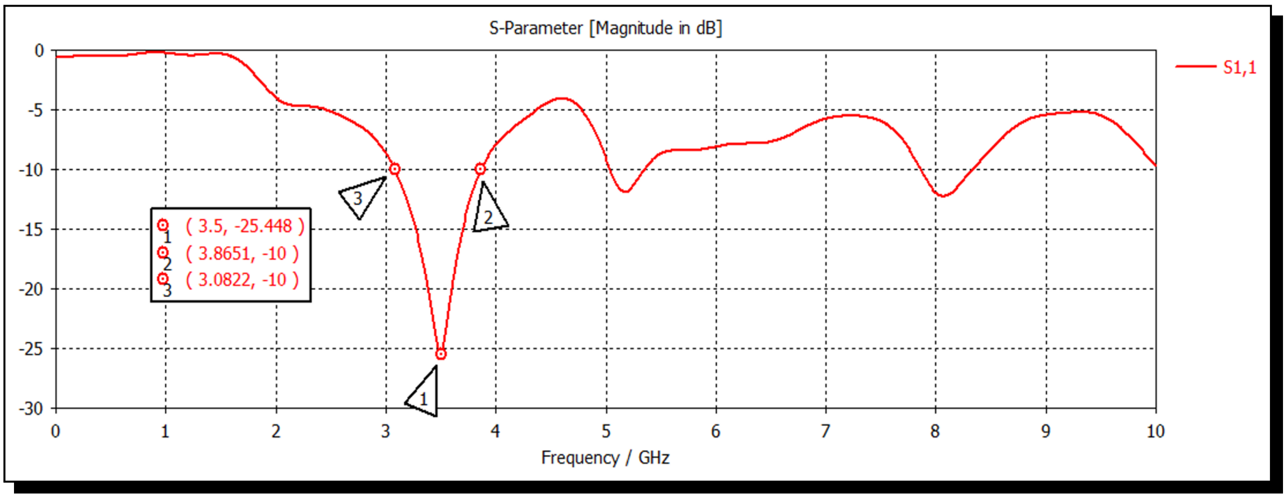

Figure 8. Final return loss obtained

From Figure 8, The reflection coefficient obtained is −25.448 at 3.5 GHz. The bandwidth is between 3.0822-3.8651 and equal to 780 MHz. The result is very satisfactory.

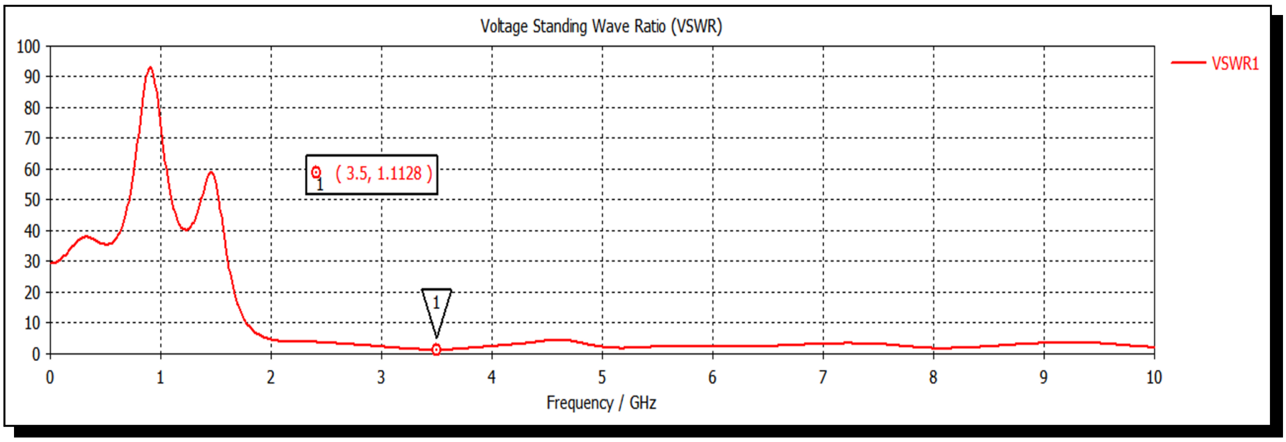

Figure 9. VSWR at 3.5 GHz

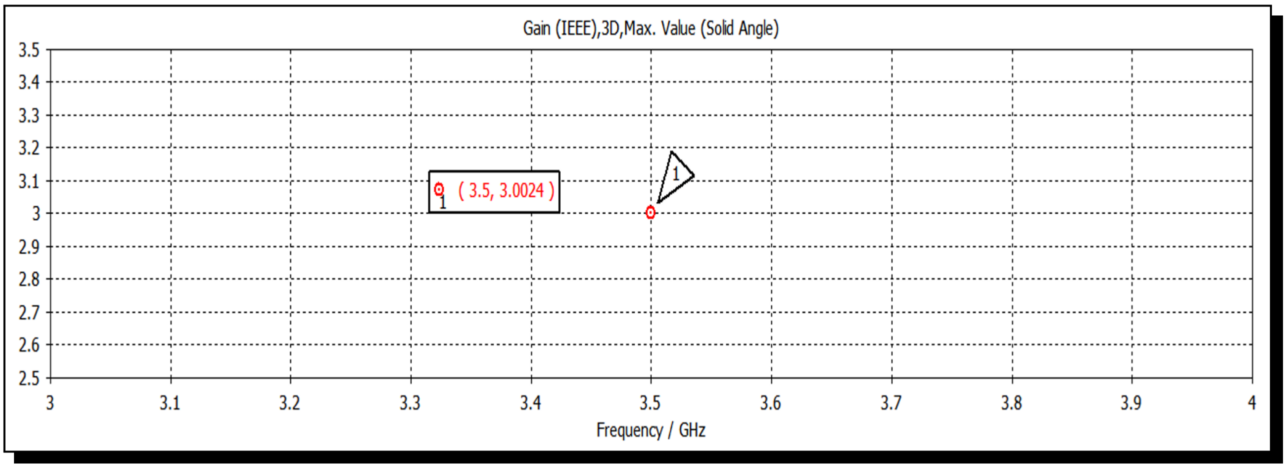

Figure 10. Gain at 3.5 GHz with large bandwidth

Figure 9 gives a VSWR of 1.1128 at 3.5 GHz witch is <2.
In Figure 10, the gain obtained is 3 dB at 3.5 GHz.

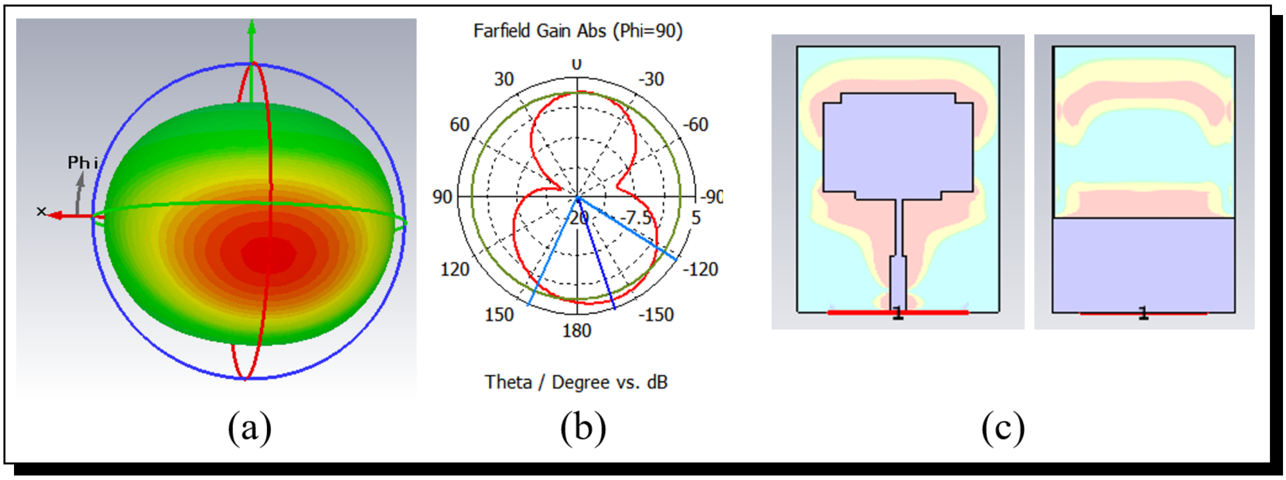

Figure 11. (a) 3D Radiation pattern, (b) Polar Radiation pattern, (c) current density

From Figure 11, we have an angular width of 81.4 deg. The radiation pattern of our proposed antenna is omnidirectional.

6. Conclusion

A new design of DGS rectangular planar antenna is designed in this paper. We have obtained a bandwidth of 780 MHz between 3.4-3.8 GHz with the use of DGS. The final reflection coefficient is −25.488 at 3.5 GHz and the gain is 2.99 which is very satisfactory for mobile communications systems. Our proposed antenna can be fabricated and integrated for 5G mobile communications.

Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

All the authors contributed significantly in writing this article. The authors read and approved the final manuscript.

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