Khwaja Yunus Ali University Journal

Publisher homepage: www.kyau.edu.bd

OPEN ACCESS
ISSN: 2791-3759 (Online), 2521-3121 (Print)

Journal homepage:www.journal.kyau.edu.bd

Research Article

Design and Performance Enhancement of a Wireless Microstrip Patch Antenna at 2.4 GHz

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Abstract

This study provides an outline of a compact, highly directional microstrip patch antenna. The typical patch antenna is simulated using FR4 dielectric and has an entire size of 40 × 40 × 1.6 mm^3. The defected ground structure (DGS) of different array is designed on the back side of the typical antenna to enhance performance. The designed antenna works at a 2.4 GHz frequency. The return loss of the designed antenna was reduced by 25.85% after the addition of DGS, and the gain was enhanced from 4 dB to 4.2 dB at 2.4 GHz. With CST software, the entire antenna has been constructed, as well as its performance has been observed. The suggested antenna may be used for Wi-Fi, wireless LANs (WLANs), Bluetooth, and Zig-Bee communications since it has a high directivity of 4.96 dBi.

Keywords: Microstrip Patch antenna, Wireless communications, Return loss, VSWR, Gain, Directivity.

1. Introduction

The importance of Microstrip Patch Antenna in today's world is immense [1]. Wireless communications have been playing an important role for communication in the world. Small, low-cost, and low-profile antennas are required for wireless communication systems [2-4]. All of these requirements are met by a microstrip patch antenna. Conventional microstrip antennas' principal limitations are their limited bandwidth and low gain [5-6]. As a result, patch antenna reconfiguration is essential for present technology [7-8].

DGS is made possible by etching a basic form onto the ground plane. DGS increases useful capacitance and inductance. Defected Ground Structure (DGS) can be used for electromagnetic excitation and propagation control that enhance the performance of the antenna [5]. In recent years the designs with DGS are very beautiful, simple and also affordable [9-10]. Also, the DGS application focuses on improving the return loss and directivity to enhance its performance [11-12]. In this work, a simple microstrip patch antenna that can work at 2.4 GHz is designed and its performance has been increased using DGS.

2. Antenna Design and Configuration

A rectangular microstrip patch antenna is constructed, with a patch length (L_p) of 26.6 mm and a patch width (W_p) of 17.6 mm. The simulated antenna operates at 2.4 GHz. The 3D view and the geometry of the proposed antenna have been shown in Fig. 1 and Fig. 2 respectively.Different arrays of circular holes are created in ground of the antenna to increase the performance of conventional antenna. Fig. 3 shows the structure of DGS. Various optimized parameters of the designed antenna are listed in Table I.The dimensions used for Defected Ground Structure are summarized in Table II.

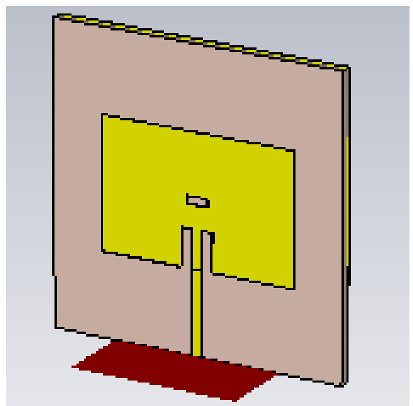


Fig. 1. 3D view of the proposed antenna.

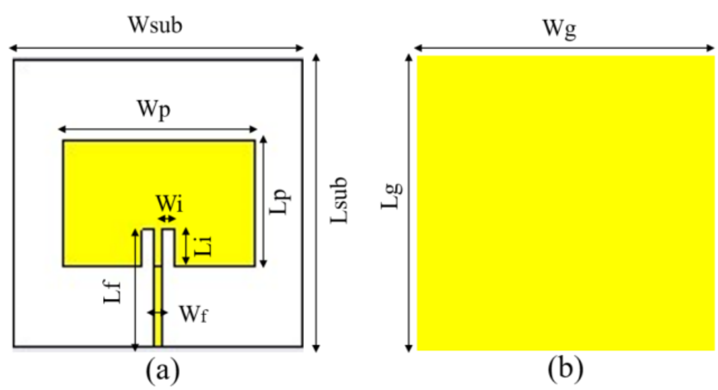


Fig. 2. Geometry of the proposed antenna (a) front view and (b) back view.

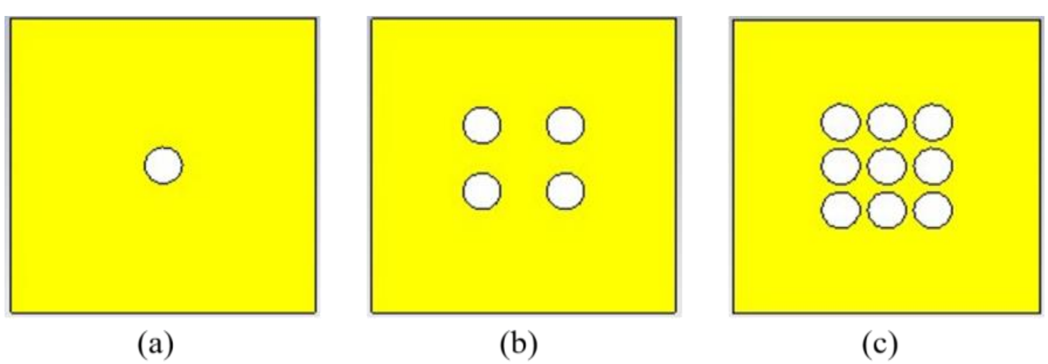


Fig. 3. Structure of circular holes designed on the ground (a) single array, (b) 2×2 array and 3×3 array

Table I. Design Parameters of the Proposed Antenna

Sl. No.	Parameter	Value (mm)
1.	Width of Substrate (W_{sub})	40
2.	Length of Substrate (L_{sub})	40
3.	Thickness of Substrate (T_{sub})	1.6
4.	Width of Patch (W_p)	26.6
5.	Length of Patch (L_p)	17.6
6.	Thickness of Patch (T_p)	0.035
7.	Width of Inset (W_i)	1.5
8.	Length of Inset (L_i)	5.16
9.	Width of Feed line (W_f)	1.13
10.	Length of Feed line (L_f)	11.2
11.	Width of Ground (W_g)	40
12.	Length of Ground (L_g)	40

Table II. Geometry of the Proposed Defected Ground Structure

Circular hole structure			
Hole diameter	2.5 mm	Gap width	1.0 mm

3. Result and Discussion

The simulated return loss with the effects of DGS on the ground are shown in Fig. 4. From the figure it is observed that the 3×3 array DGS has the better performance than the others. Hence it is our proposed design. The simulated return loss with and without DGS is shown in Fig. 5. It has been observed that the return losses of the proposed antenna without DGS is -25.06 dB and with DGS are -38.65 dB. So, after incorporate the DGS the return loss improved significantly at 54.23% at 2.4 GHz. The VSWR of the proposed antenna with and without DGS has also been compared and shown in Fig. 6. The lowest value of VSWR at 2.4 GHz is 1.02. The inclusion of DGS also improves its gain and directivity listed in Table III and Table IV. Fig. 7 (a) demonstrates the 3D gain and Fig. 7(b) shows the directivity of the proposed antenna. From the patterns it has been observed that the proposed antenna is operating at nearly all directions at 2.4 GHz. In the broadside direction of the proposedantenna, the gain and directivity values with and without DGS are compared in Fig. 8 and Fig. 9 respectively. It is observed that there is an improvement of gain 5% and directivity 7.59%at desired frequency band of 2.4 GHzdue to the presence of DGS. It can be shown that the antenna with defected ground structure is more directive than the conventional antenna. The current distribution on the surface of the proposed antenna is shown in Fig. 10. It is observed from the figure that the higher level of current isdistributed through the microstrip feeding line. The maximum simulated E-current at the frequency of 2.4 GHz is 208(A/m).

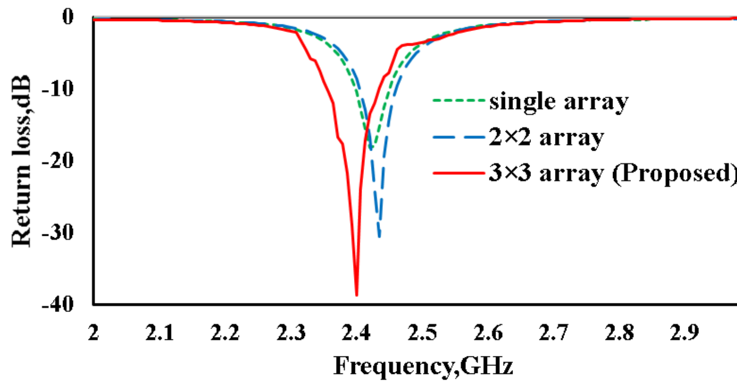


Fig. 4. Simulated return loss with the effects of DGS on the ground.

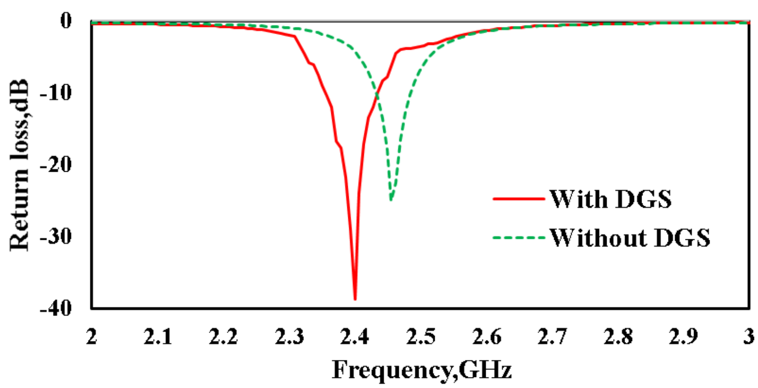


Fig. 5. Simulated return loss of the proposed antenna with and without DGS.

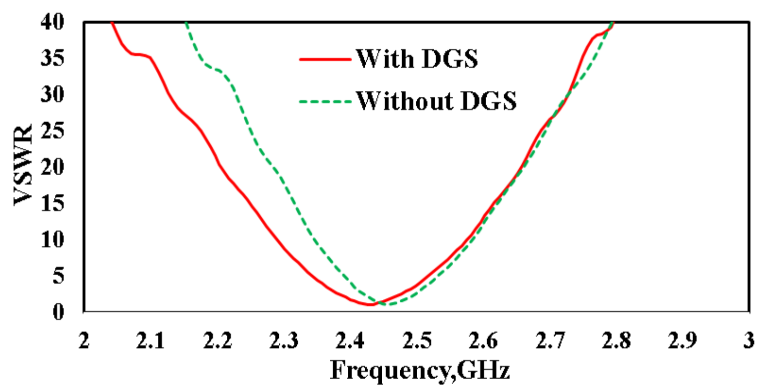


Fig. 6. VSWR of the proposed antenna with and without DGS.

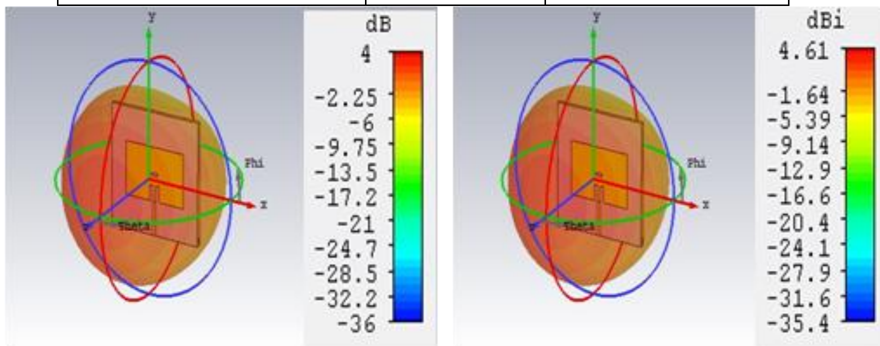
Table III. Obtained Parameters of the Proposed Antenna with and without DGS

Antenna Model	Return loss	Gain (dB)	Directivity (dBi)
Antenna without DGS	-25.06	4	4.61
Antenna with DGS	-38.65	4.2	4.96

Table IV. Improved in Parameters using DGS

Return loss (%)	Gain (%)	Directivity (%)

54.23	5	7.59



(a) (b)

Fig. 7. 3D antenna Gain and Directivity at 2.4 GHz (a)Gain, (b) Directivity.

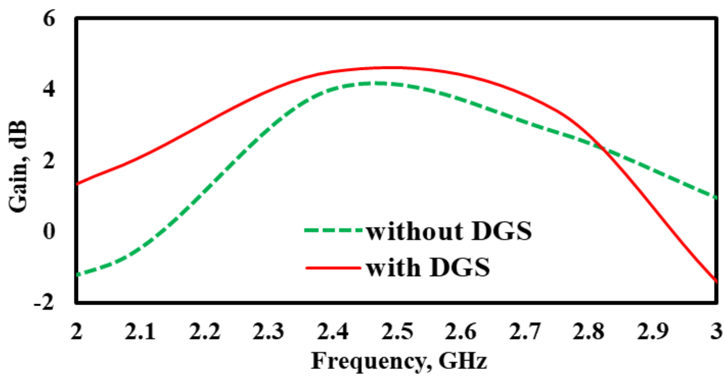


Fig. 8. Effects of DGS on antenna gain.

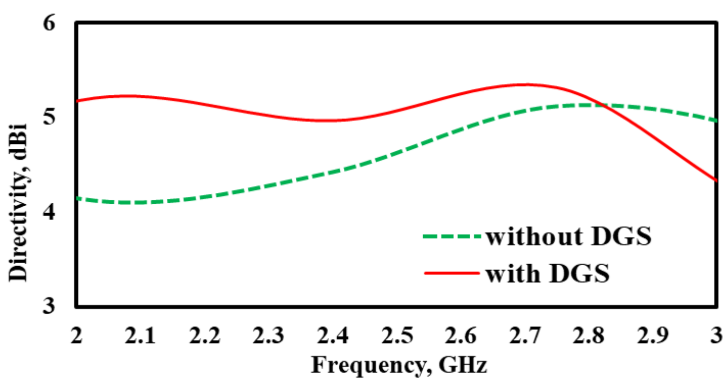


Fig. 9. Effects of DGS on antenna directivity.

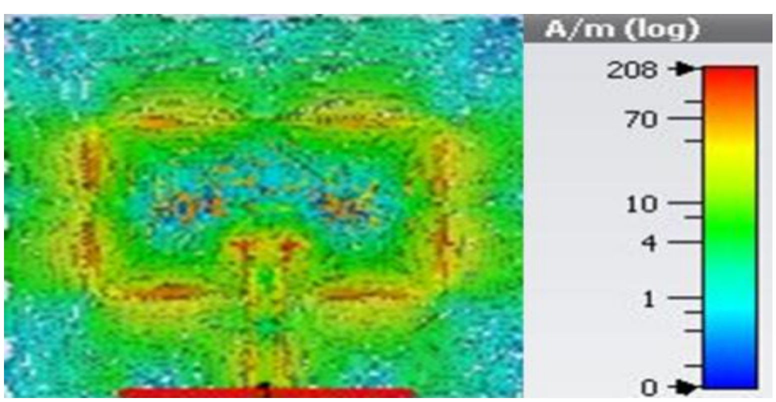


Fig.10. Simulated current distribution of the designed antenna at the frequency of 2.4 GHz.

4. Conclusion

A DGS based microstrip patch antenna was developed and analyzed for the improvement of gain, bandwidth, directivity and return losses. The proposed antenna operates at 2.4 GHz with improved return loss of 25.85%. Moreover, the significantly enhanced maximum gain of 4.2 dB and maximum directivity of 4.96dBi at the desired frequency band. This antenna can be used for a variety of purposes, including Wi-Fi, ISM band for medical application, WLAN and Bluetooth communications.

5. Conflicts of Interest: This research is done for scientific purposes only without any conflict with other parties.

6. Acknowledgement: Authors would like to acknowledge the Research Grand Committee of Khwaja Yunus Ali University for their funding the present work.

7. Author's Contribution: The overall antenna design as well as the simulation of the proposed antenna was performed by the corresponding author Md. Biplob Hossain. Other author Md. Roni Islam contributed to write the paper and to draw some output figures

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Citation: Hossain MB, and Islam MR. (2022).Design and Performance Enhancement of a Wireless Microstrip Patch Antenna at 2.4 GHz. *KYAU Journal.* 5(1):54-59