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Modified E-Shape Rectangular Microstrip Patch Antenna with DGS for Wireless Communication

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ABSTRACT- A modified E-shape dual bands rectangular microstrip patch antenna for wireless applications is presented in this paper. An E-slot Microstrip patch antenna with a defective ground structure method has been proposed and getting two bands at 1.9 GHz and 2.89 GHz with S11<-10dB. Defective ground structures provide a maximum gain and low insertion loss *i.e.*, a gain of 3.16 dB, voltage standing wave ratio less than 2, and insertion loss less than -10 dB for both bands. The size of the antenna is 46.83mm x 38.41mm x 1.676mm, which is compact in term of size. The dual band microstrip patch antenna exhibits low cost. The simulation's outcome closely resembles the actual printed antenna and applicable for WiMAX application. The antenna was designed using the Computer Simulation Technology (CST) software and printed on FR-4 substrate.

Keywords: E-RMPA; DGS; Gain; VSWR; Return Loss; WiMAX.

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1. INTRODUCTION

The rectangular microstrip planar patch E-shape slot antenna design is reported for lower frequencies applications [1]. Comparative characterization of a microstrip patch antenna array with a defective ground structure for a biomedical application suggests in [2]. Compared to conventional antennas, various antennas have advantages in term of smaller dimensions, lower volume, lighter weight, and ease of manufacture, as well as fewer interference and superior performance [3]. The concept of radiator with the alphabet letter E-shape can be created using a variety of slot antenna techniques for WLAN and Wi-Max application. The frequency range of the E-shape microstrip patch antenna for wireless communication is between 1.9 GHz and 2.8 GHz [4]. Low-Profile Single- and Dual-Band Antenna Design for Internet of Things Applications offer a wide bandwidth, feedline endurance, frequency flexibility, and beam inspection [6]. Mobile, satellite, adjusting remote controls, various computer linkages, and radar systems are only a few of the communication systems that make use of RMPAs. Narrow bandwidth is one of these types of antenna's drawbacks. Its performance is enhanced by the employment of numerous antenna methods. It is a straightforward microstrip patch antenna that is manufactured directly on the printed circuit board (PCB) with a radiated patch component and a defective ground structure.[7] To produce multi- and dual-frequency band response, slots are etched into the defective ground structure [8]. To accomplish the intended results, the rectangular microstrip planar patch E-shape antenna has been designed, manufactured, and simulated at 2.8 frequency band [9]. Varieties of antenna are proposed by using circular, triangular, and square methods for the purpose of reducing size and improving operational parameters [12]. [10] Reported Butterfly shaped patch antenna with improve gain for 5G applications. Metamaterial also one of the best methods for improves directivity and bandwidth of patch antenna for S-band application [11].

1.1 Antenna Design

The suggested modified [1] E shaped rectangular microstrip patch antenna with the defected ground structure (DGS) embedded in the ground is shown in Figures 1 (Front view) and 2 (Back view). For multi-frequency responses, an E-shaped patch is designed. A slot in the Centre of the ground plane is introduced in the rear view of the antenna, and a modified E-shaped slot is etched into the rectangular patch in the front view. For increased band responsiveness, the ground architecture additionally contains four rectangular slot corners. The dimensions of the patch are W_p*L_p*H_P = 37.23mm* 28.81mm*1.676mm, while the specifications of the ground plane are Wg*Lg = 46.83mm * 38.41mm. For modeling antennas that operate at 1.9 GHz and 2.8 GHz, the CST studio suite is a helpful resource. The modified E-shape slot for 1.9 GHz and 2.8 GHz transmission and reception is where the suggested design begins. A ground plane is made of copper because of its high conductivity. The antenna's resonant frequency is 1.9 and 2.89 GHz, and an E-shape slot is cut on a patch with dimensions of 1.86mm in width by 1.4mm in length on a FR-4 substrate with a 4.4 dielectric and 1.6mm in thickness. *Figure 1* shows the proposed antenna's front view, *figure 2* shows the proposed antenna's back view, and *table 1* shows the proposed antenna's dimensions as listed below –

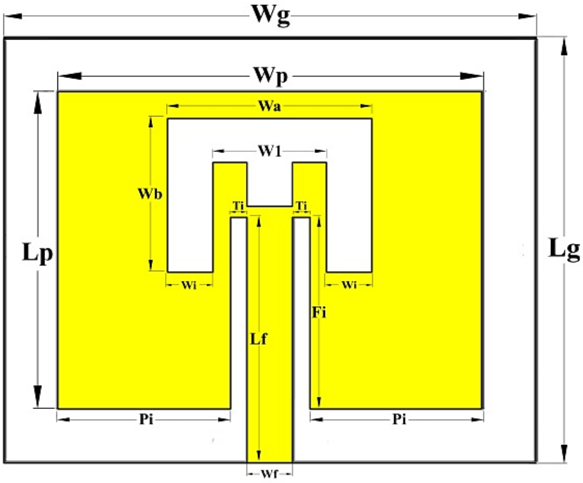


Figure 1: Front view of proposed structure

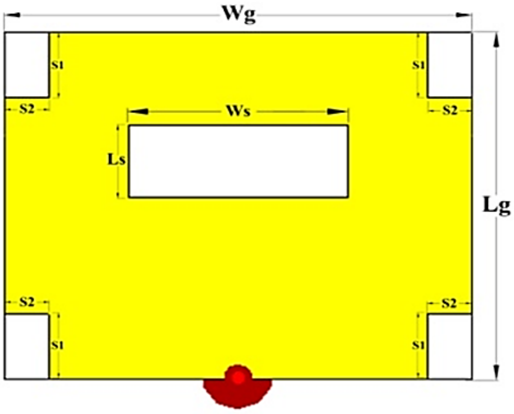


Figure 2: Back view of proposed structure

Table 1. Dimensions of Proposed Antenna

Parameters	Numerical values (mm)	Parameters	Numerical values (mm)
Wg	46.83	W1	10
Lg	38.41	Wi	4
Wp	37.23	Pi	15.12
Lp	28.81	Fi	17
Wf	4	Ti	1.50
Lf	22.21	Ws	22
Ti	1.50	Ls	8
Wa	18	S1	7.2
Wb	14	S2	4.4

2. MATHEMATICAL MODEL

2.1 Equations for calculating dimensions of patch

$$W=\frac{\upsilon_0}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}} \qquad (1)$$

Where, $f_r =$ Resonance Frequency
υ_0 = Free space velocity of light

To calculate effective dielectric constant,

For $\frac{W}{h} \leq 1$:

$$\epsilon_{reff}=\frac{\epsilon_{r+1}}{2}+\frac{\epsilon_{r-1}}{2}\left\{\left(1+12\frac{h}{W}\right)^{-0.5}+0.04\left(1-\frac{W}{h}\right)^{2}\right\} \qquad (2)$$

$$Z_c = \frac{\eta}{2\pi\sqrt{\epsilon_{reff}}}\ln\left(\frac{8h}{W}+0.25\frac{W}{h}\right) \qquad (3)$$

For $\frac{W}{h} \geq 1$:

$$\epsilon_{reff}=\frac{\epsilon_{r+1}}{2}+\frac{\epsilon_{r-1}}{2}\left(1+12\frac{h}{W}\right)^{-0.5} \qquad (4)$$

$$Z_c = \frac{\eta}{\sqrt{\varepsilon_{reff}}}\left\{\frac{W}{h}+1.393+0.677\ln\left(\frac{W}{h}+1.444\right)\right\}^{-1} \qquad (5)$$

Where, W = Width of the Patch
h = Height of the substrate
$\epsilon_{reff} =$ Effective dielectric constant
ϵ_r = Dielectric constant of substrate

Thus, effective length of patch,

$$L_{eff} = L+2\Delta L \qquad (6)$$

To calculate length of patch,

$$L = \frac{v0}{2fr\sqrt{\epsilon reff}} -2\Delta L \qquad (7)$$

To calculate ΔL

$$\Delta L = h\ 0.412\frac{(\epsilon_{reff+0.3)}\,(\frac{W}{h}+0.264)}{(\epsilon_{reff-0.258)}\,(\frac{W}{h}+0.8)} \qquad (8)$$

To calculate Length of patch,

$$L = \frac{\upsilon_0}{2f_r\sqrt{\epsilon_{reff}}} - 2\Delta L \qquad (9)$$

To calculate the width of Microstrip Feed Line,

$$W= h\frac{8e^{A}}{e^{2A}-2} \qquad (10)$$

$$A = \frac{z_0}{60}\sqrt{\frac{\epsilon_{r+1}}{2}}+\frac{\epsilon_r-1}{\epsilon_r+1}\left(0.23+\frac{0.11}{\epsilon_r}\right) \qquad (11)$$

2.2 Simulation Results

Figures 3, 4, and 5 display the computation outcomes for the design using CST Studio Suite (2018).

In the 1.9 and 2.8 GHz frequency ranges, an E-shaped slotted rectangular microstrip patch antenna is constructed and simulated using CST. The S11 properties of dual band MPAs show the frequency at 1.9 and 2.89 GHz. The return losses for lower band are -22 dB and for upper band its -25 dB, as shown in *figure 3*. The bandwidths are 56.5 MHz and 140 MHz as *figure 4*, the VSWR are 1 and 2.6. The modified RMPA produces a maximum gain of 3.16 dB shown in *figure 5*. The obtained frequency range is used for Bluetooth and Wi-Fi applications.

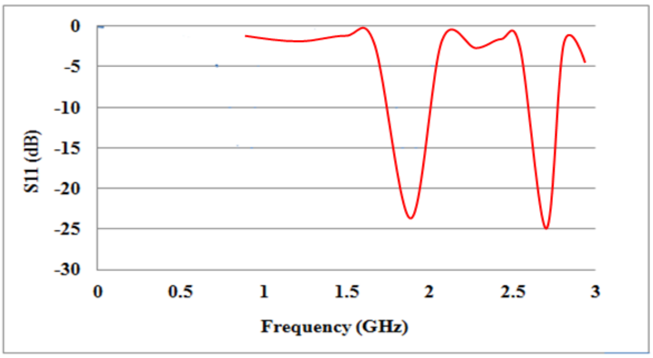


Figure 3: Simulated S11 of the proposed MPA

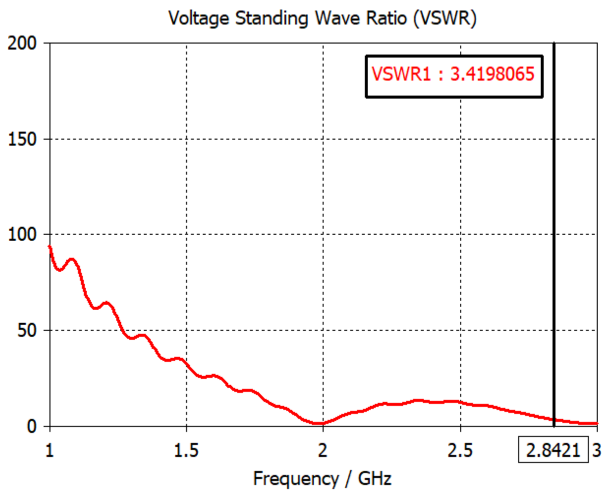


Figure 4: VSWR of the proposed antenna

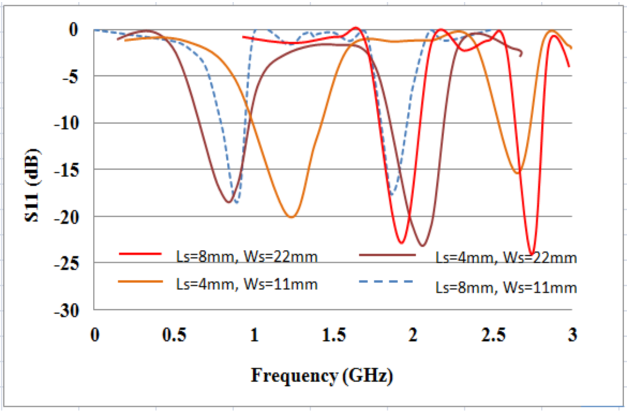


Figure 5: Variation in DGS length and width

Figure 5 represent the effect of DGS slot. Variation in length L_s along with W_s the bands are shifting from lower frequency to upper frequency. At L_s =8mm and W_s=22 mm, found that the lower band shifted at 1.9 GHz and upper band shifted from 2 to 2.89 GHz.

░ Table 2. Results Comparison with published previous reports

Reference (Year)	Size (mm)	Frequency (GHz)	R.L (dB)	BW (MHz)	Gain (dB)
[9] (2018)	28.5*21.9	2.8	-18.1	323	2.51
[8] (2018)	30*24	2.8	-15.4	52	1.89
[7] (2018)	41*50	2.8	-20.6	100	1.09
[6] (2019)	40*16	2.8	-7.9	220	1.9
[5] (2021)	21.4*36.4	2.8	-29.5	220	2.45
[4] (2021)	100*28.5	2.8	-34	NA	1.3
[3] (2022)	60*50	1.9	-14	140	1.42
[2] (2022)	30*70	1.94	-20	170	1.4
[1] (2022)	37.23*28.8	1.9 & 2.8	-20.2, -13.12	110	3
This Paper	37.23*28.8	1.9 & 2.89	-18 & -13.7	140	3.164

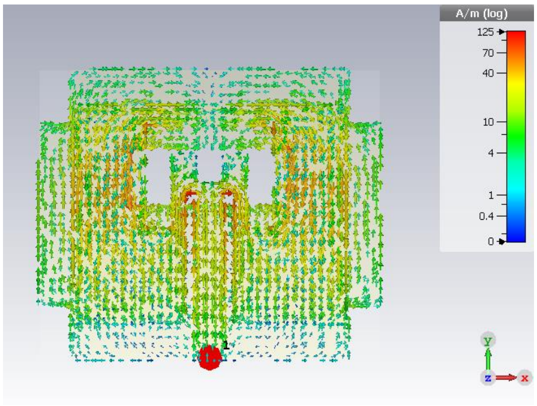


Figure 6: Surface current density

The antenna dimensions are compared to meet the required standards. *Table 2* shows various parameters comparisons with published antenna results–

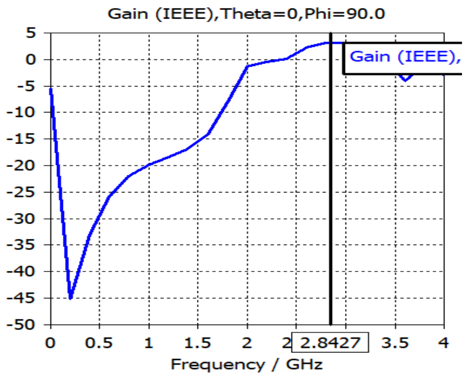
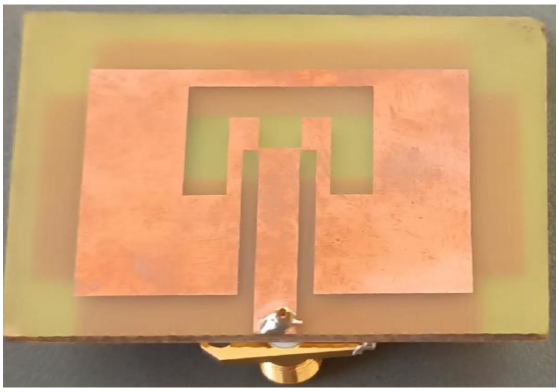


Figure 7: Gain of the proposed antenna

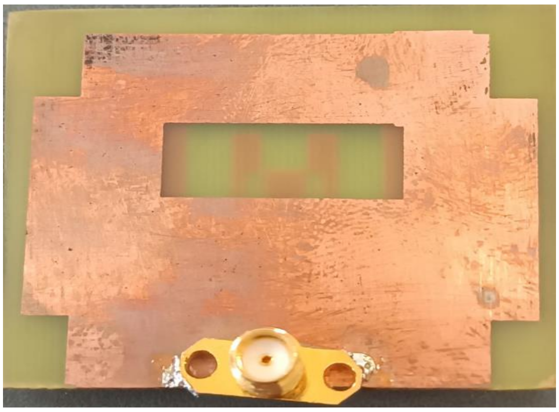
Figure 6 showing the current density on antenna surface. The arrows on surface indicate the direction of current flow on surface of the antenna.

2.3 Fabricated Antenna and Measurements Results

Figures 8 represent the fabricated antenna. The antenna is built on a printed circuit board (PCB) using a FR-4 substrate. A connector is attached to the feed line. The front and back views of an erected antenna. According to the results of the antenna measurement, the S11 is -22 dB for lower band and -25.7 dB for upper band. The bandwidth is therefore 140 MHz additionally, a printed circuit board (PCB) is typically plated to create the manufactured antenna. The antenna's VSWR is less than 2.



Front View



Back View

Figure 8: Front and Back view of fabricated antenna

Ref: -20.0 dBm
Att: 14 dB
RBW: 3 MHz
SWT: 200.0 ms
M1: -21.9 dB 1.98 GHz
TG Level: -20.0 dBm
TG Offs: 0 Hz
TG Cal: ON
Center: 1.5GHz Span: 3GHz

Figure 9: Measured result at Spectrum Analyzer

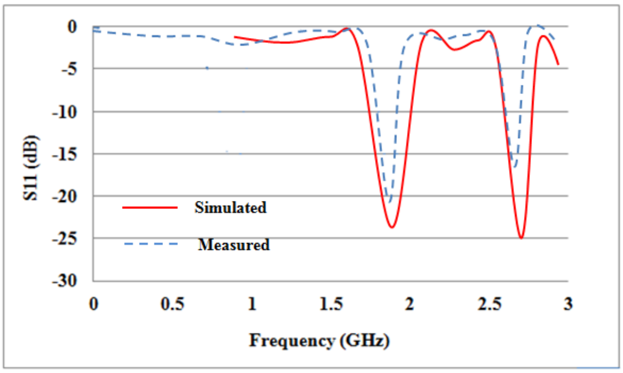


Figure 9: S11 Comparisons of measured and simulated results

The gain of this antenna is 3.16 dB. Figure 8 and Figure 9 shows the measured result at 1.9 and 2.89 GHz with the help of spectrum analyzer (9 KHz to 3GHz). Figure 9 exhibit the comparison between simulated and measured results shown in the graph. Figure 10 shows the radiation pattern with respect to directivity.

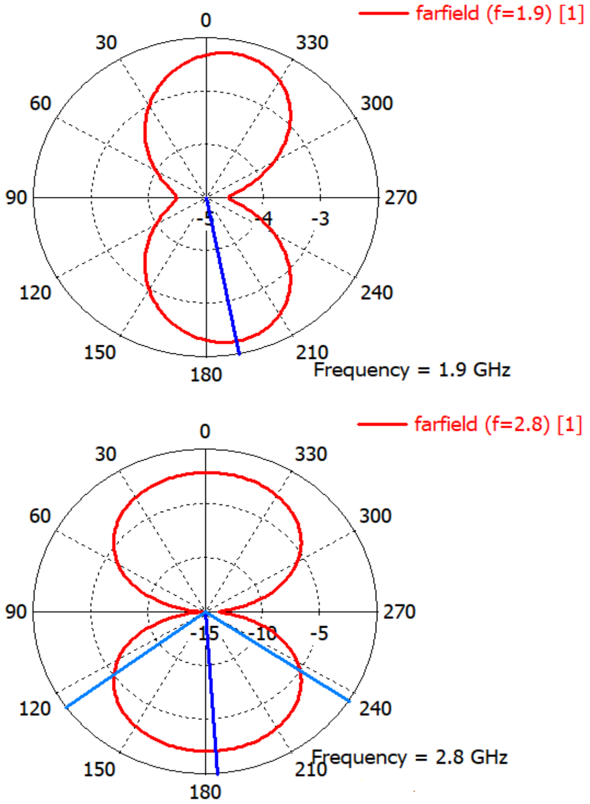


Figure 10: Radiation Pattern at 1.9 GHz and 2.8 GHz

3. CONCLUSION

In the current research, the antenna is developed, simulated, and built on a FR-4 substrate. The antenna parameters are modeled using CST software. According to the results antenna resonates at 1.9 (1.9546 to 2.0113) GHz and 2.89 (2.5 to 3.0632) GHz. Modified E-shaped antenna is used with DGS method. Slot on ground plane playing a crucial role in regulating resonance frequencies. In comparison to earlier works, a low bandwidth but improved gain is achieved by this technique. The antenna's providing low profile and high gain *i.e.,* 3.16dB. In order to prevent enemy detection in radar and communication systems, it is essential to significantly increase the impedance bandwidth of microstrip patch antennas by using a multilayer dielectric configuration. The future holds tiny patch antennas.

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REFERENCES

[1] Prachi Goyal, P.K. Singhal, Pooja Sahoo, and D.K. Parsediya , "Dual Band U Shape Slot Rectangular Microstrip Patch Antenna with Defected Ground Structure" International Journal of All Research Education and Scientific Methods (IJARESM), ISSN: 2455-6211 Volume 10, Issue 7, July 2022.

[2] Suganthi Santhanam, Thiruvalar Selvan Palavesam Comparative characterization of a microstrip patch antenna array with a defective ground structure for a biomedical application, Bulletin of Electrical Engineering and Informatics, Vol. 11, No. 1, February 2022, pp. 346–353, ISSN: 2302-9285, DOI: 10.11591/eei.v11i1.3549

[3] Elkorany, A.S.; Mousa, A.N.; Ahmad; Ghaffar; Soruri; Dalarsson; Alibakhshi kenari; Limiti E. Adoption of a Miniaturised Planar Tri-Band Microstrip Patch Antenna for Mobile Applications. 2022.

[4] Asmaa E. Ammar, Nessim M. Mahmoud, Mahmoud A. Attia, and Amr H. Hussein "Efficient Diplexer with High Selectivity and Low Insertion Loss Based on SOLR and DGS for WIMAX", Progress In Electromagnetics Research C, Vol. 116, 171-180, 2021

[5] W.M.; Sheta, A.F.A.; Alkanhal, M.A.; Elshafiey, "Low-Profile Single- and Dual-Band Antenna Design for Internet of Things Applications". https://doi.org/10.3390/ electronics10222766, 2021; Electronics, 10,2766

[6] A. Amir Anton Jone, John Paul. J., Shajin Prince, K. Martin Sagayam, and Samson Immanuel, Folded shorted patch antenna with slots for wireless applications, International Journal of Engineering and Advanced Technology (IJEAT), Volume 9 Issue 1, October 2019.

[7] Khraisat, Y.S.H. Increased Microstrip Patch Antenna Bandwidth by Ground Slot Insertion, (2018). 10, 1-11 of the Journal of Electromagnetic Analysis and Applications, https://doi.org/10.4236/jemaa.2018.101001

[8] Narinder Sharma, Vipul Sharma, A design of Microstrip Patch Antenna using hybrid fractal slot for wide band applications, http://dx.doi.org/10.1016/j.asej.2018.05.008

[9] Gloria Russi, Andrés Piedrahita, Angel Lozada, Design and research of a 2.8/3.1/3.6/4.7/5.4 GHz microstrip slot antenna, DOI:0.1051/matecconf/20171250.

[10] Ribhu Abhusan Panda, Debasish Mishra, Pawan Kumar Nayak, Mihir Panda, "Butterfly Shaped Patch Antenna for 5G Applications" International journal of Electrical and Electronics Researcch (IJEER), Volume 8 issue 3, page 32-35, December 2020.

[11] Ranjeet Pratap Singh Bhadoriya, "Directivity and Bandwidth Enhancement of Patch Antenna using Metamaterial", International journal of Electrical and Electronics Researcch (IJEER), Volume 9 issue 2, page 6-9, June 2021.

[12] Mahesh Shankar Pandey and Dr. Virendra Singh Chaudhary, "REULEAUX Triangle Shaped MSPA for 5G and WLAN Applications", International journal of Electrical and Electronics Researcch (IJEER), Volume 9 issue 4, page 107-113, September 2021.