IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 08, Issue 6 (June. 2018), ||V (V) || PP 52-57

Micro Strip Patch Antenna with Multi-Split Ring Resonator Using DGS for Multi Band Applications

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Abstract- An Innovative Micro strip patch antenna is designed to resonate at multi band using double split ring resonator (SRR) with center conducting patch. By inserting elliptical shaped ground along semi arc Defected Ground Structure (DGS) provides a good improvement in the return loss and impedance bandwidth. The antenna is simulated by using CST MW studio andis fabricated on FR4 substrate of size 30×30 mm^2 with relative permittivity 4.3 and height 1.6 mm. The antenna parameters are measured using Vector Network Analyzer and the return loss values are -13.049dB, -20.436dB and -14.145dBat 3.26 GHz, 6.48 GHz, and 8.05GHz for S-band, C-bandand X-band applications respectively.

Keywords: Defected Ground Structure-DGS, FR4, Multi Split-ring resonator, Elliptical shaped ground, Impedance Bandwidth

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Date of Submission: 07-06-2018 Date of acceptance: 23-06-2018

I. INTRODUCTION

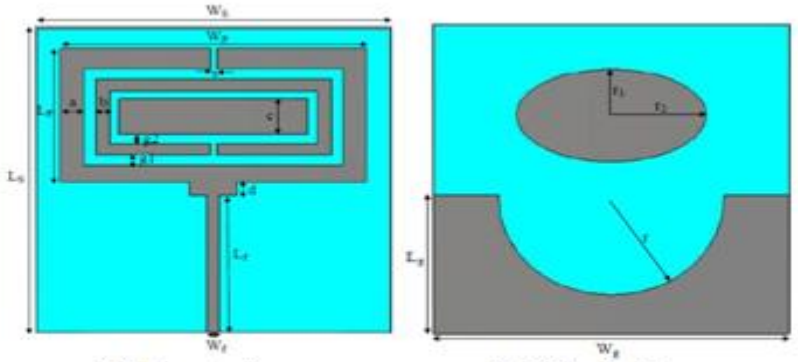
In the present scenario demand of multiband wireless communications which supports more than one service, having different frequencies of operation simultaneously, gathers attention of many researchers. Simple in geometry to assure reliability and mobility characteristics Microstrip Patch Antenna (MPA) play a vital role due to its innate qualities like light weight, high gain, low profile, high efficiency, easy in fabrication and are easily well-suited for opto-electronic integrated circuits(OEICs) and microwave monolithic integrated circuits (MMICs) [1,2] due to its compact and elementary feeding techniques. This key feature of the microstrip patch antenna makes them applicable in many wireless communications such as Radio location, Space Research, Satellite communications, Radar and medical applications.

Many designs having a single conducting patch in different way to obtain multiband applications are investigated such as Circular ring with Y-shaped strip MPA[3], E-Shaped slot on fractal patch with H-Shaped and L-Shaped slots on the ground plane [4-6]. Square slot, triangular slot DGS [7]. Fan shaped patch with circular ring slot DGS [8], Inverted L-shaped slot patch [9], Dual Inverted L-shaped strip fed by cross-shaped strip line[10],[11], Fork shaped monopole antenna [12], Hexagonal MPA [13], Rectangular shaped DGS [14]. U-Shaped patch antenna with U-slot DGS [15], I-slot loaded MPA [16],

In this work, a compact MPA for Multiband frequency of operation is proposed. The conducting patch isetched to protrudent Split Ring Resonator (SRR) shape and fed with 50 ohm inline feeding technique. In addition, to this infinite ground plane was cut out semi arc shaped slot and by introducing elliptical shaped finite ground beneath the radiating element gives three resonant frequencies along with excellent impedance matching and directivity over the operating frequencies.

II. ANTENNA DESIGN

The proposed MPA is designed on FR4 substrate with dielectric constant 4.3and loss tangent of 0.025 of height 1.6mm is sandwiched between the radiating element and the ground. The overall size of the MPA is 30×30 mm^2. The schematic diagram of the proposed MPA is depicted in the figure 1 and the fabricated antenna is depicted in figure 1.1.



(a) Front view (b) Back view

Figure.1: The schematic diagram of the proposed MPA

(a) (b)

Figure 1.1: (a) Front View (b) Back View of the fabricated MPA

The design parameter values of the schematic configuration of the antenna are listed in the table-1. Table-1 depicts the proposed antenna dimensions.

Dimensions	Values (mm)	Dimensions	Values (mm)
L_S	30	b	1.2
W_S	30	c	3.5
L_P	13.5	d	1
W_P	26	s	0.5
L_f	13.5	g_1	1
W_f	1	g_2	0.8
L_g	13.4	r	9.5
W_g	30	r_1	4.5
a	2	r_2	8

Initially the proposed multiband MPA was first designed with rectangular patch of size $L_P \times W_P$ and the ground plane is partially taken with $L_g \times W_g$ is fed with Microstrip line feeding technique.

In the second step, rectangular patch was etched to form dual split ring resonator and it is filled with rectangular strip inside it to generate dualband resonance.

In the third step, the return loss and the impedance bandwidth obtained in the step-2 was improved by introducingelliptical strip of radii 'r_1, r_2' and cut out semi arc slot from the Partial Ground Plane (PGP) of radius 'r' and also dual band resonance is extended to triple band by optimizing. The designed antenna with step by step development was depicted in the figure 2.

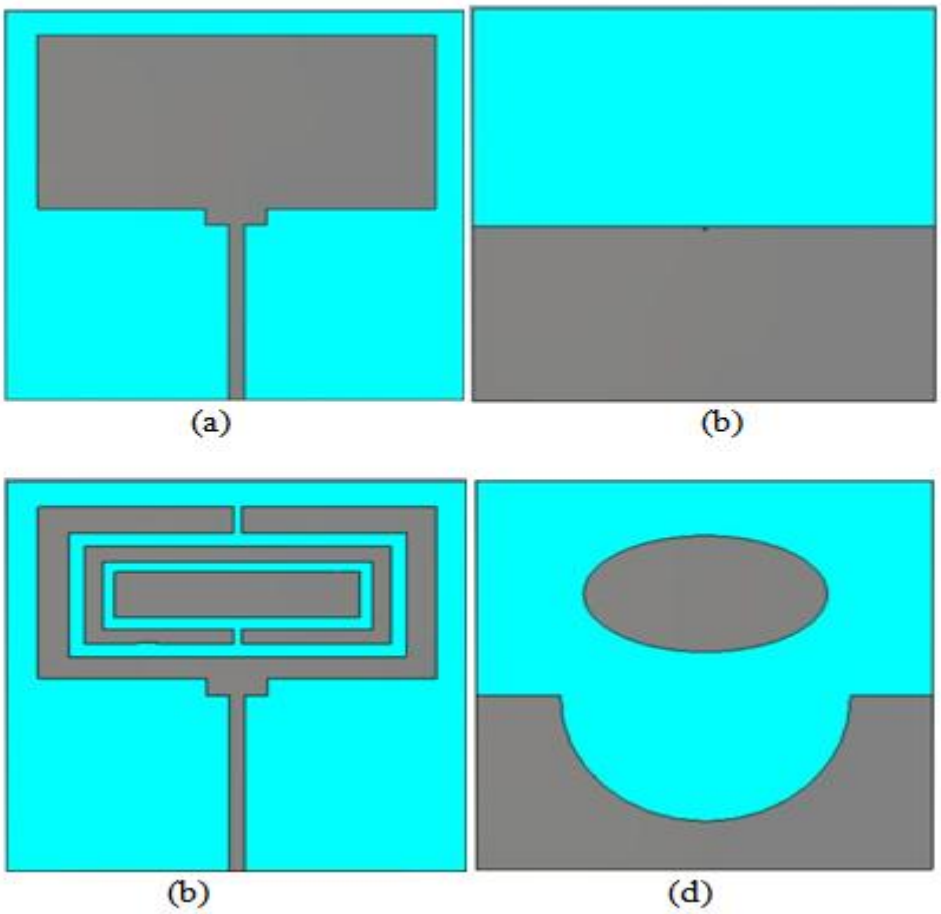


Figure.2: Design steps of the proposed antenna (a),(b) simple rectangular patch with partial ground plane in step-1 and (c),(d) are the front and back view of the optimized steps-2,3

All the above steps are optimized carefully to provide good impedance matching, S_{11} and directivity.

III. RESULTS AND DISCUSSION

The simulation results of the proposed antenna are analyzed with the characteristic parameters of the MPA like S_{11}, VSWR, gain and directivity.

Figure.3 depicts the $|S_{11}|$ vs frequency comparison of the step by step optimized design of the proposed antenna with and without elliptical strip and semi arc in the ground plane. The simulation results shows that the introduction of elliptical strip and semi arc slot in the partial ground plane provides a uniform current distribution which leads to triple band resonant characteristics. The return loss at the frequencies 3.12 GHz, 6.38 GHz and 7.89 GHz with -18.72dB, -18.88dBand -14.53dBrespectively are depicted.

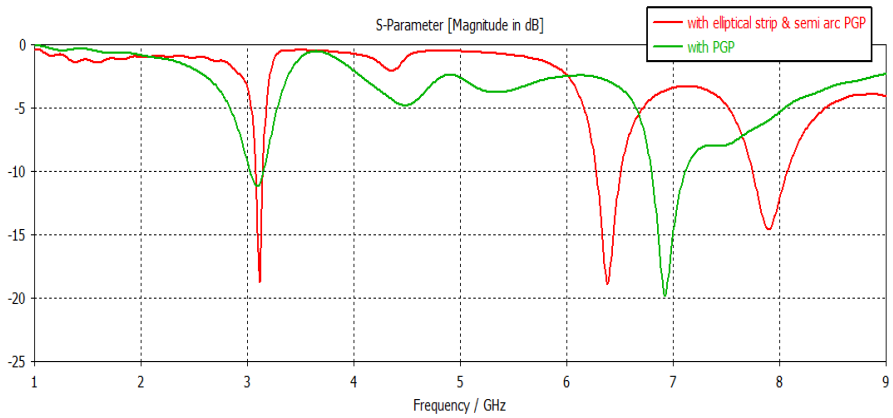


Figure.3:lS_{11}l comparison plot of optimized design steps-2 and 3.

The figure.4 describes the VSWR of the MPA with Semi arc slot and elliptical strip DGS which depicts that the VSWR is less than 2 in all the three resonant frequencies at 3.12 GHz, 6.38 GHzand 7.89 GHz with 1.26, 1.25 and 1.46 respectively. This antenna is well suited for S-bandand C-bandin Radio location, satellite communication and Space research applications.

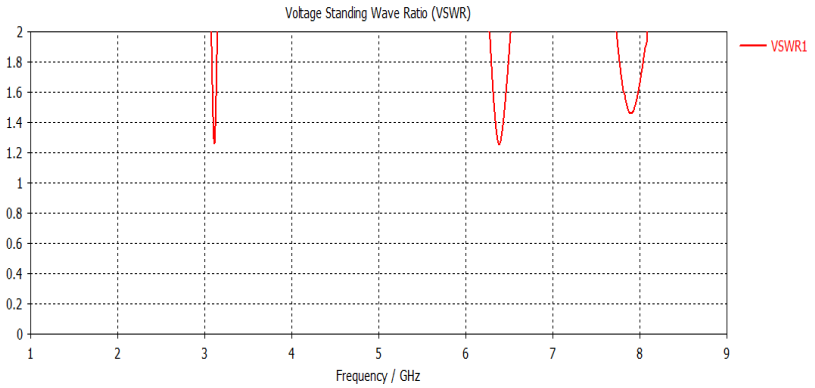


Figure.4: VSWR plot of the proposed MPA.

Table 2 depicts the simulation results of the proposed MPA with and without elliptical strip and semi arc slot DGS. It has been analyzed that there is a satisfactory improvement in the antenna parameters such as impedance bandwidth, gain and directivity.

Table-2 Simulation results comparison of the MPA with and without elliptical strip and semi arc slot DGS.

Design Type	Frequency (GHz)	S_{11} (dB)	VSWR	Directivity (dBi)	Bandwidth (MHz)
MPA without elliptical and semi arc DGS	3.12 6.38 7.89	-18.72 -18.88 -14.55	1.26 1.25 1.46	4.46 4.39 5.38	67.17 232 328.2
MPA with elliptical and semi arc DGS	3.10 6.92	-11.07 -19.84	1.77 1.22	3.42 4.70	123 314

2-D radiation pattern of the proposed antenna was depicted in figure 5 and Directivity is monitored for frequencies at 3.12 GHz of S-band, 6.38 GHz, 7.89 GHz for C-band and 8 GHz for X-band.

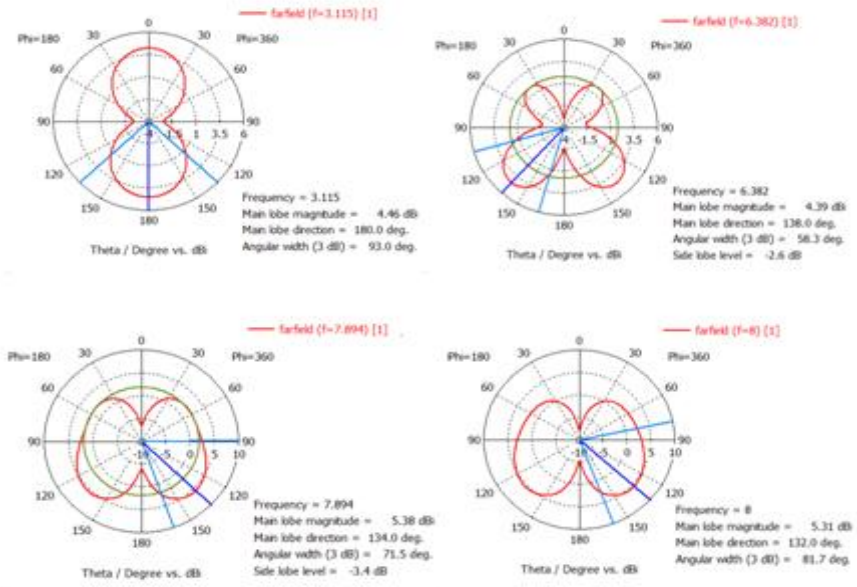


Figure.5: 2-D radiation pattern (directivity) of the proposed MPA.

The fabricated antenna is tested and measured by using Vector Network Analyzer (VNA) is depicted in the figure 6 and the measured results are in good correlation with the simulated results is depicted in table 3.

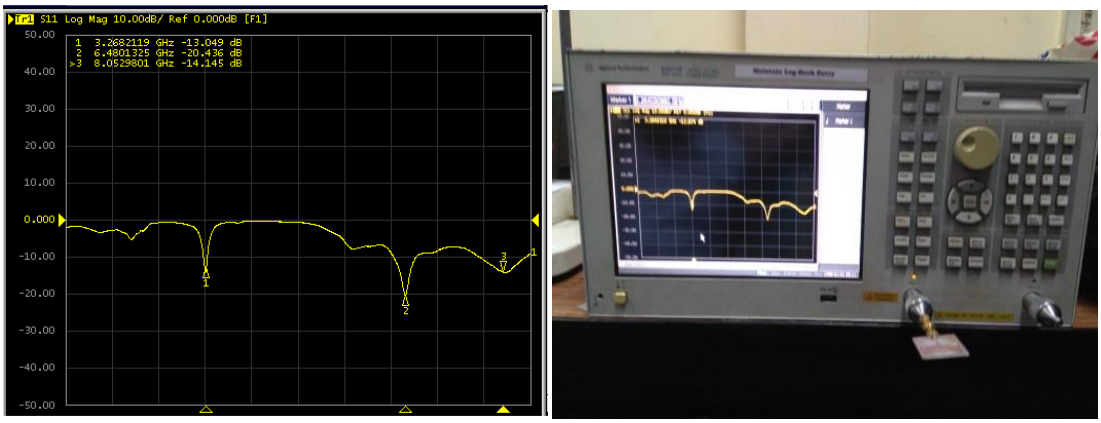


Figure.6: Measured results of the fabricated antenna using VNA

Table 3 depicts the comparison between the simulation results and measured results

Antenna Parameters	Simulation Results	Measured Results
Frequency (GHz)	3.12 GHz, 6.38 GHz, and 7.89 GHz	3.26 GHz, 6.48 GHz, and 8.05GHz
Return Loss $\lvert S_{11}\rvert$ (dB)	-18.72 dB, -18.88 dB and -14.55 dB	-13.049dB, -20.436dB and -14.145dB
VSWR	1.26, 1.25 and 1.46	1.56, 1.20 and 1.48

IV. CONCLUSION

In this novel work, MPA with dual SRR is designed with elliptical strip and semi arc DGS in the ground plane. The simulation results depicts that the antenna resonant at three frequency bands with $\lvert S_{11}\rvert$ are -18.72 dB, -18.88 dB and -14.55 dB at 3.12 GHz, 6.38 GHz, and 7.89 GHzfrequencies respectively. By optimizing the radius of the semi arc slot and elliptical strip in the ground plane excellent improvement in the frequency resonance band is obtained near the X-band region. The fabricated results with $\lvert S_{11}\rvert$ are -13.049dB, -20.436dB and -14.145dB at 3.26 GHz, 6.48 GHz, and 8.05GHzshow a good correlation with simulated results. The developed antenna can be used to operate at S-band, C-bandand X-band for satellite communication, Radio location and Space research applications.

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IOSR Journal of Engineering (IOSRJEN) is UGC approved Journal with Sl. No. 3240, Journal no. 48995.

Dr.K.P.Vinay "Micro Strip Patch Antenna with Multi-Split Ring Resonator Using DGS for Multi Band Applications." IOSR Journal of Engineering (IOSRJEN), vol. 08, no. 6, 2018, pp. 52-57.