ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 6, Issue 11, November 2017

Parametric Enhancement in a Modified Miniaturized Rectangular Patch Antenna for Dual Band Operation

Dr. T. Shanmuganantham[1], Deepanshu Kaushal[2]
[1, 2]Dept. of Electronics Engineering, Pondicherry Central University, Pondicherry-605014

***Abstract*— This paper presents an enhancement of performance parameters in a miniaturized rectangular patch antenna that has been achieved through a stage wise modification of the basic rectangular patch geometry. The modifications introduced include an extension in the length of the basic patch followed by its multiple slotting. A 1.6 mm FR4 epoxy substrate and a coaxial feeding technique have been used. The different design stages have been simulated over HFSS-15 for the major antenna parameters including the reflection coefficient, bandwidth, radiation pattern, gain and VSWR. Experimental verification of the final stage fabricated prototype has been found to yield results in close approximation to the corresponding simulated one. The designed structure may be used for the C-band fixed meteorological satellite applications and for the X-band applications of aeronautical radio navigation and radio location.**

***Index Terms*—Microstrip Patch, Slot, Dual Band, VSWR.**

I. Introduction

Ever since the time of their inception, the MPAs have continued to dominate the field of antenna engineering and have served numerous applications including the satellite applications and the aviation communication applications of radio location and radio navigation. These MPAs have inherent advantages of small size, light weight, low profile, compatibility with most MMIC designs and conformability to the host satellite structures. The basic rectangular patch antenna that was initially designed by T. Shanmuganantham in [1] exhibited a single band resonance at 6.29 GHz offering a bandwidth of 110 MHz. Another rectangular patch antenna geometry that was designed by Deepanshu Kaushal in [2] at the initial stage achieved a reflection coefficient of -13.46 dB and a bandwidth of 300 MHz. Most conventional rectangular patches have been recorded to exhibit a single band resonance with performance indicators of limited values. Techniques including the modification of the basic patch by introduction of slots has often been suggested for an improved parametric performance. The introduction of slots into the initially designed rectangular patch antennas by T. Shanmuganantham in [3]- [5] has resulted into not only an increased number of sidebands along with the resonance at the solution frequency but also into significantly improved performance indices of reflection coefficient, gain and bandwidth.

Manuscript received November, 2017
Dr.T.Shanmuganantham, Assistant Professor, Dept. of Electronics Engineering, Pondicherry University, India
(e-mail: shanmugananthamster@gmail.com).
***Deepanshu Kaushal**, Pondicherry University, Pondicherry, India*

The proposed design achieves an improved parametric performance of a basic rectangular patch through a two stage modification process. The substrate used is a 22 mm x 20 mm x 1.6 mm FR4 epoxy material that has a relative permittivity 4.4 and a dielectric loss tangent of 0.02. The feeding technique used is coaxial/ probe feeding mechanism. The three design stages have been simulated over HFSS-15 [6] for the reflection coefficient, bandwidth, radiation pattern and VSWR characteristics. An extension of length of the patch results into the lowering of resonant frequency. The slots introduced into the patch geometry in the third stage results into multiple resonance of the designed antenna at different frequencies that offer significant parametric values. The final stage structure was fabricated and the experimentally verified for its standard parameters including the reflection coefficient and VSWR which were found to closely approximate the simulated ones.

The proposed final stage prototype may be used for C- band and X-band applications including the fixed meteorological satellites (space to earth) and for aeronautical radio navigation and radio location.

An introduction to the microstrip patch antennas and the existing literature works over the transitions from conventionally used rectangular patches to modified slotted structures has been given in the section 1. The geometry of the proposed antenna and its specifications are discussed in the section 2. The comparative results of the three design stages and the fabricated counterpart have been included in the section**.**

II. DESIGN Procedure

The proposed antenna design has been developed through a three stage iteration process of a basic rectangular patch, extended rectangular patch geometry and finally the slotting of the modified patch in the end stage.

A. Iteration1: Basic RMPA Design

The figure 1 shows a 10 mm x 8 mm rectangular patch built over a 22 mm x 20 mm FR4 epoxy substrate. The table 1 lists the specifications of the basic RMPA whose design equations have been listed in table 2 while the utilized design equations are listed in table 2.

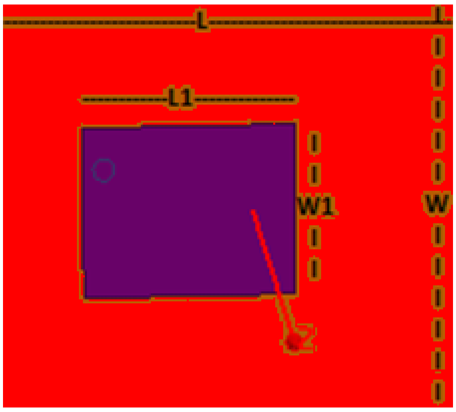


Figure 1: Basic RMPA Design

Table 1: Specifications of RMPA

Dimensions	Value (mm)
L	22
W	20
L1	10
W1	8

Table 2: Design Equations

Parameter	Formula
Width of the radiating patch (W)	$w = \left(\frac{c}{2\times f_r}\right)\left(\sqrt{\frac{\varepsilon_r+1}{2}}\right)$
Effective dielectric constant of the substrate ε_{reff}	$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2} \times \sqrt{\left(1+\left(\frac{12h}{w}\right)\right)}$
Effective length of the radiating patch (L)	$L = \frac{c}{2\times f_r \times \varepsilon_{reff}} - 2\Delta l$
Extension Length for patch (ΔL)	$\Delta l = .412\times h \times \left[\left(\frac{\varepsilon_{reff}+0.03}{\varepsilon_{reff}-.258}\right)\times\left(\frac{w+0.264h}{w+.8h}\right)\right]$

B. Iteration 2: Modification of Length of Basic RMPA Design

The increase in the length of the basic RMPA results into the lowering of resonant frequency. Most specifications of this stage design are similar to those of the first stage design and the additional ones have been tabulated below.

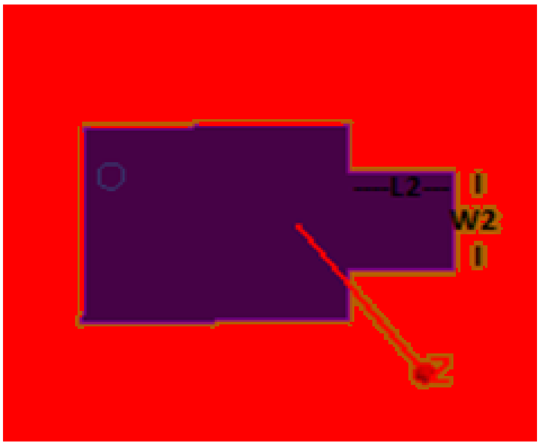


Figure 2: Modified RMPA Design

Table 3: Specifications of Modified RMPA

Dimensions	Value (mm)
L2	4
W2	4

C. Iteration 3: Slotting the modified RMPA Design

As shown in the figure 3 below, the final stage witnesses a 0.41 mm x 6 mm rectangular and a 0.5 mm radii twin circular slots introduced into an extended microstrip rectangular patch antenna of stage 2.

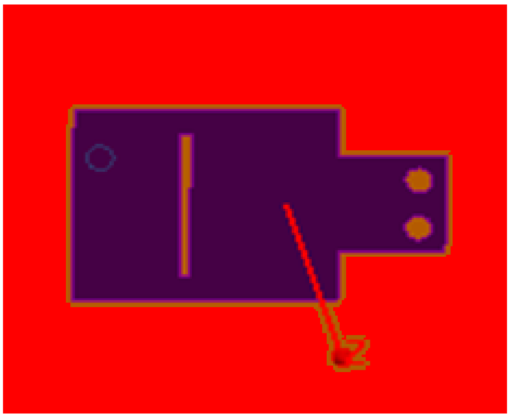
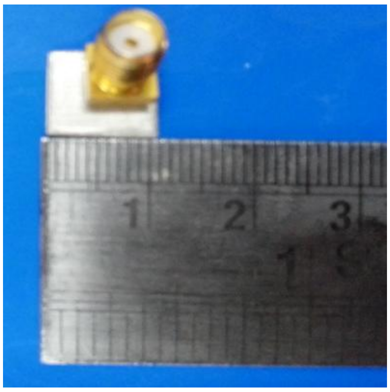


Figure 3: Final Stage Design

The following figure shows the top side and the flipside view of the fabricated prototype.



(a)

(b)

Figure 4: Fabricated Prototype a) Top side view and b) Flip side view

Table 4: Comparison Results

III. RESULTS AND DISCUSSION

The three design stages were simulated over HFSS-15 and analyzed for their standard parameters including the reflection coefficient [6], bandwidth [7], gain [8] and VSWR. The final stage design was fabricated and tested over 10 MHz-40 GHz Rhode & Schwarz ZVA VNA [9] for its reflection coefficient, bandwidth and VSWR and in anechoic chamber [10] for its radiation pattern and gain

The simulations over HFSS-15 revealed that the initially designed RMPA exhibited a single band resonance. The modification of length in the second stage resulted into not only the lowering of the resonant frequency but also the design offered an improvement of characteristics of reflection coefficient, bandwidth, gain and VSWR. The introduction of slots at the final stage resulted into dual band performance with significantly improved characteristics.

The fabricated design exhibited results close to those of the simulated stage design. The variations in the results may be accounted to the faults in fabrication. The figures 4-6 show the comparative plot of the standard parameters of the three design stages and the fabricated prototype. A tabulated comparison of the different stages and the fabricated structure in terms of their standard parameters has been provided towards the end of this section.

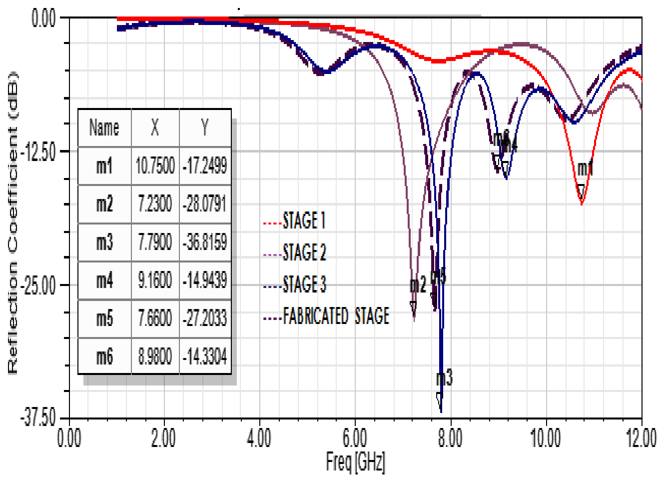


Figure 5: Comparative Reflection Coefficient Plot

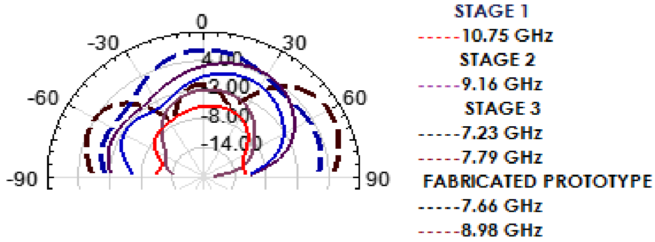


Figure 6: Comparative Radiation Pattern Plot

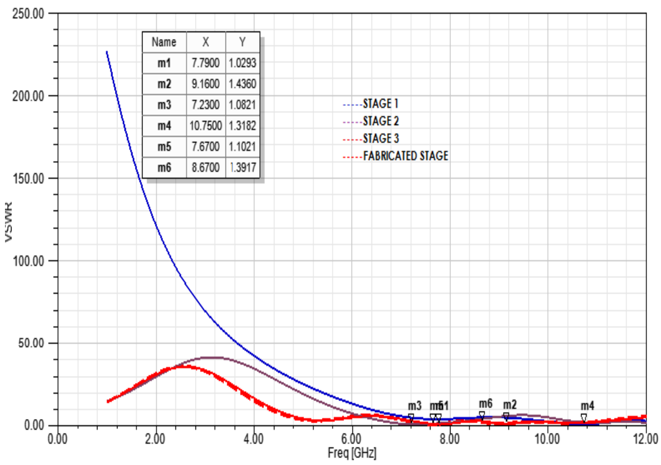


Figure 5: Comparative VSWR Plot

The comparison of the three design iterations in terms of number of bands, resonant frequency, reflection coefficient, VSWR, bandwidth, and gain has been tabulated as under.

Parameters	**Iteration 1**	**Iteration 2**	**Iteration 3**	**Fabricated Design**
Number of Bands	Single (1)	Single (1)	Double (2)	Double (2)
Operating Frequency (GHz)	10.75	9.16	f1=7.23 f2=7.79	f1'=7.66 f2'=8.98
Reflection Coefficient (dB)	-17.24	-28.07	-36.81 (f1) -14.94 (f2)	-27.2 (f1') -14.3 (f2')
VSWR	1.31	1.08	1.02(f1) 1.43(f2)	1.01(f1') 1.39 (f2')
Bandwidth (MHz)	730	1000	580 (f1) 390(f2)	575 (f1') 388 (f2')
Gain (dBi)	-5.21	-1.95	2.02(f1) 4.47 (f2)	4.2 (f1') 2.5 (f2')

IV. Conclusion

An enhancement of performance parameters in a miniaturized rectangular patch antenna has been achieved through a stage wise modification of the basic rectangular patch geometry. The modifications introduced include an extension in the length of the basic patch followed by its multiple slotting. A 1.6 mm FR4 epoxy substrate and a coaxial feeding technique have been used. The different design stages have been simulated over HFSS-15 for the major antenna parameters including the reflection coefficient, bandwidth, radiation pattern, gain and VSWR. Experimental verification of the final stage fabricated prototype has been found to yield results in close approximation to the corresponding simulated one. The designed structure may be used for the C-band fixed meteorological satellite applications and for the X-band applications of aeronautical radio navigation and radio location.

REFERENCES

1] Deepanshu Kaushal, T. Shanmuganantham, Sajith K. Dual Band Characteristics in a Microstrip Rectangular Patch Antenna using Novel Slotting Technique. *IEEE International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT)*, Kerala, 2017.

[2] Deepanshu Kaushal, T. Shanmuganantham, C. Elavarasi. A Miniaturized Pen Drive Shaped Extended Rectangular Slotted Patch Antenna Design for C and X Band Operation. *IEEE International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT),* Kerala, 2017.

[3] Deepanshu Kaushal, T. Shanmuganantham. A Vinayak Slotted Rectangular Microstrip Patch Antenna Design for C-Band Applications. *John Wiley-Microwave and Optical Technology Letters*, Vol. 59, No.8, pp. 1833-1837, August, 2017. (Indexed by SCI.

[4] Deepanshu Kaushal, T. Shanmuganantham. Microstrip Slotted Caterpillar Patch Antenna for S, Ku and K Band Applications. *Journal of Materials Today: Elsevier*. In Press (Indexed by SCI)

[5] Deepanshu Kaushal, T. Shanmuganantham. A Novel Microstrip Flower Patch Antenna Design for Multiband Operation. *Journal of Materials Today: Elsevier*. In Press (Indexed by SCI).

[6] Deepanshu Kaushal, T. Shanmuganantham. Design of a Compact and Novel Microstrip Patch Antenna for Multiband Satellite Applications. *Journal of Materials Today: Elsevier*. In Press (Indexed by SCI)

[7] Deepanshu Kaushal, T. Shanmuganantham. Triple Band Microstrip Delete Patch Antenna for Satellite Related Applications. *Indian Journal of Innovations and Development*. Vol.5, No. 12, pp.1-5, December 2016.

[8] Ghriti Khanna, Narinder Sharma. Design of Stair cased Square Fractal Antenna for Multiband Applications. *International Journal of Microwaves Applications*. Vol.6, No.1, pp. 10-13, January-Feburary,2017.

[9] Navpreet Kaur, Narinder Sharma, Navdeep Singh. A Study of Different Feeding Mechanisms in Microstrip Patch Antenna. *International Journal of Microwaves Applications*. Vol.6, No.1, pp. 10-13, January-Feburary,2017.

[10] Deepanshu Kaushal, T. Shanmuganantham. Single Band High Gain Microstrip Shivling Patch Antenna for Aviation Communication. *Indian Journal of Innovations and Development*, Vol. 5, No.11, pp.1-6, November 2016.

.

.

T. Shanmuganantham received B.E. degree in Electronics and Communication Engineering from University of Madras, M.E. degree in Communication Systems from Madurai Kamaraj University and Ph.D. (Gold Medal) in the area of Antennas from National Institute of Technology, Tiruchirappalli, India under the guidance of Dr. S. Raghavan, Professor/ECE, NITT. He has 21 years of teaching experience in various reputed Engineering colleges such as PKIET, SSN College of Engineering, National Institute of Technology and Science. He is currently working as Assistant Professor in the Department of Electronics Engineering, School of Engineering & Technology, Pondicherry Central University, Pondicherry. His research interest includes Antennas, Microwave/Millimeter-Wave Circuits and Devices, MEMS/NEMS. He has published 350 research papers in various National and International level Journals and Conferences. His biography was included in Marquis who is who in the world, USA in the year 2010. He received Fellow in ATMS and a member in IEEE, Life Member in ISSS, IETE, IE (India), CSI (India), Society of EMC, OSI, ILA, ISI and ISTE.

Deepanshu Kaushal completed his B.Tech.in Electronics & Communication from Punjab Technical University in 2014. He is currently a second year M. Tech (E.C.E.) student of Pondicherry University and is doing his project on 'Microstrip Slotted Patch Antennas for Multiband Operation' under the guidance of Dr. T. Shanmuganantham (Assistant Professor, Department of Electronics Engineering, Pondicherry University, Pondicherry). His area of interest includes Antennas, Fractals and Metamaterials. He has 19 conference papers and 7 journals till date.