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Gain Enhancement in a Microstrip Rectangular Patch Antenna Using Alphabetical Slots

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ABSTRACT

The improvement in the radiation gain characteristic of a conventional RMPA upon the use of alphabetical slots has been investigated. The RMPA design has been built using a 58mm x 80 mm Flame Retardant-4 Epoxy substrate that is 1.6 mm thick and has a dielectric constant of 4.4. The employed feeding technique is coaxial feed. Simulation has been carried over HFSS-15. An improvement in the radiation characteristic of gain has been observed in each design iteration. The final design stage has been fabricated and experimentally verified. The measured results have been found to be in close approximation with the simulated ones.

Keywords: Improving performance, Circular Split Ring Resonator, HFSS-15, coaxial feeding technique

INTRODUCTION

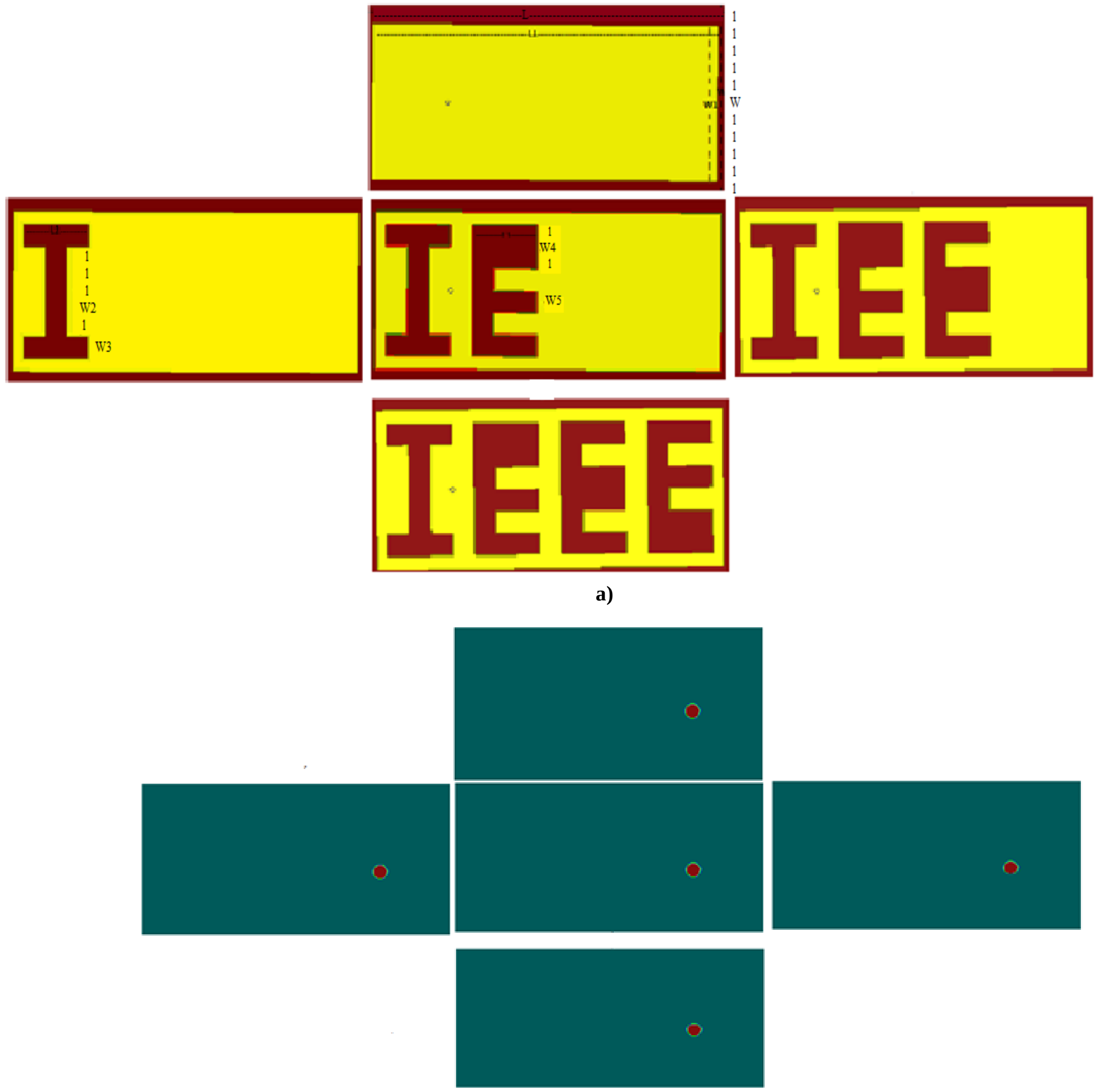
The modern trends in electronic circuit miniaturization has generated a lot of research interest in Microstrip patch antennas for their utilization in a wide variety of applications because of their supplementing characteristics of small size, light weight, low profile, compatibility with most MMIC designs, conformability to most non-planar structures etc. A study of the available literatures indicates that the rectangular shaped patches are the most fundamental consideration for Microstrip patch antenna design. Shanmuganantham in [1] initially designed a Microstrip rectangular patch structure for high frequency applications. The antenna structure had miniaturized substrate of dimensions of 10 mm x 8.7 mm x 1.6 mm and used a coaxial feeding mechanism. The designed prototype, however, offered a single band resonance with a limited gain. In another work, Kaushal in [2] initially designed a Microstrip rectangular patch antenna that exhibited limited gain performance at its single operation frequency. Most conventional patch structures have been found to be limited in values of the attained gain. The slotting of patch has often been argued as a useful technique for improving the gain characteristic. The CPW fed rectangular slot antenna for wideband applications proposed by Shanmuganantham in [3] offered a gain improved by a significant proportion over the conventional rectangular prototype. The equilateral triangular Microstrip patch antenna with spur lines embedded that was proposed by Malek in [4] offered dual band gains of 4.8 dBi and 4.40 dBi respectively. In [5], Kaushal proposed a slotted rectangular patch antenna to offer a triple band resonance with peak gains of 1.1 dBi, 3 dBi and 7.7 dBi respectively. In [6], Shanmuganantham has proposed a Microstrip rectangular patch antenna that was slotted to offer higher gains at its two band resonant frequencies. The Microstrip slotted rectangular shaped patch proposed by Kaushal in [7] offered a triple band resonance with significantly high gains. Yet another slotted rectangular patch antenna offers a triple band resonance with significantly higher gains.

The improvement in the radiation gain characteristic of a conventional RMPA upon the use of alphabetical slots has been investigated in this paper. The RMPA design has been built using a 58mm x 80 mm Flame Retardant-4 Epoxy substrate that is 1.6 mm thick and has a dielectric constant of 4.4. The employed feeding technique is coaxial feed. Simulation has been carried over HFSS-15. An improvement in the radiation characteristic of gain has been observed in each design iteration. The final design stage has been fabricated and experimentally verified. The fabricated prototype has been tested over Rhode & Schwarz ZVA 40 VNA of range 10 MHz-40 GHz for its reflection coefficient and in anechoic chamber for its radiation pattern & gain. The measured results have been found to be in close approximation with the simulated ones.A brief overview of the Microstrip patch antennas, the conventionally used rectangular type, its limitations and the slotting technique used for enhancement of gain has been discussed in first section and the section second describes the proposed antenna configuration the results of which are discussed in the final section.

GEOMETRY OF THE PROPOSED DESIGN

This section discusses the configuration of the different stages for improving the gain of an initially considered rectangular patch (yellow) built over a 58mm x 80 mm FR4 epoxy (silver) material that is 1.6 mm thick. Coaxial feeding technique has been employed. The rectangular patch antenna designed in stage 1 using the basic equations [8] listed in Table 2 has been slotted at every subsequent stage using different alphabets. The figure 1 shows the top view and the flipside view of the simulated basic rectangular patch antenna and the four subsequent slotting stages. The fabricated prototype of the final stage design has also been shown in Figure 2.

It should be noted that the choice of the slots introduced into the patch is purely arbitrary. The slots have been chosen based simple shapes of slots available in the reviewed literatures.



a)

b)

Fig.1Basic Rectangular Microstrip Patch Antenna and the subsequent slotting stages a) Top view b) Flipside view

Table -1Design Proportions of Stage 1

Dimension	Value (mm)	Dimension	Value (mm)
L	60	W2	7.5
W	80	L3	5
L1	40	W3	4.3
W1	35	W4	6
L2	20.6	W5	4.3

Fig. 2 Fabricated Prototype

Table -2 Design Equations

Parameter	Formula
W	$w = \left(\frac{c}{2\times f_r}\right)\left(\sqrt{\frac{\varepsilon_r+1}{2}}\right)$
ε_{reff}	$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2} \times \sqrt{\left(1+\left(\frac{12h}{w}\right)\right)}$
L	$L = \frac{c}{2\times f_r \times \varepsilon_{reff}} - 2\Delta l$
ΔL	$\Delta l = .412\times h\times\left[\left(\frac{\varepsilon_{reff}+0.03}{\varepsilon_{reff}-.258}\right)\times\left(\frac{w+0.264h}{w+.8h}\right)\right]$

RESULTS

The different stages in the design procedure have been designed and simulated over HFSS v-15. The final stage design has been fabricated and experimentally verified over Rhode & Schwarz ZVA 40 VNA [9] (10 MHz-40 GHz range) for its reflection coefficient and in anechoic chamber [10] for its gain. Using the received set of values, the experimental and the simulated results of the reflection coefficient [11]& gain [12] have been plotted in figures 3, 4, 5 and 4 respectively. The numerical values of the different resonant frequencies and the corresponding reflection coefficient and gain for the different design stages and the experimentally verified fabricated design have been listed in Table 3. The antennas upon testing yield varied results of reflection coefficient.

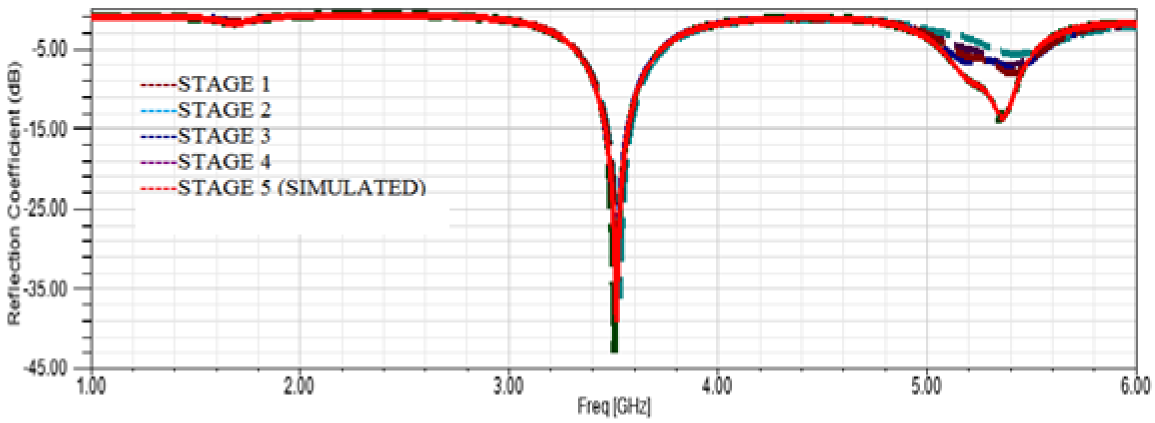


Fig.3 Comparative Reflection Coefficient Plot of Different Simulated Design Stages

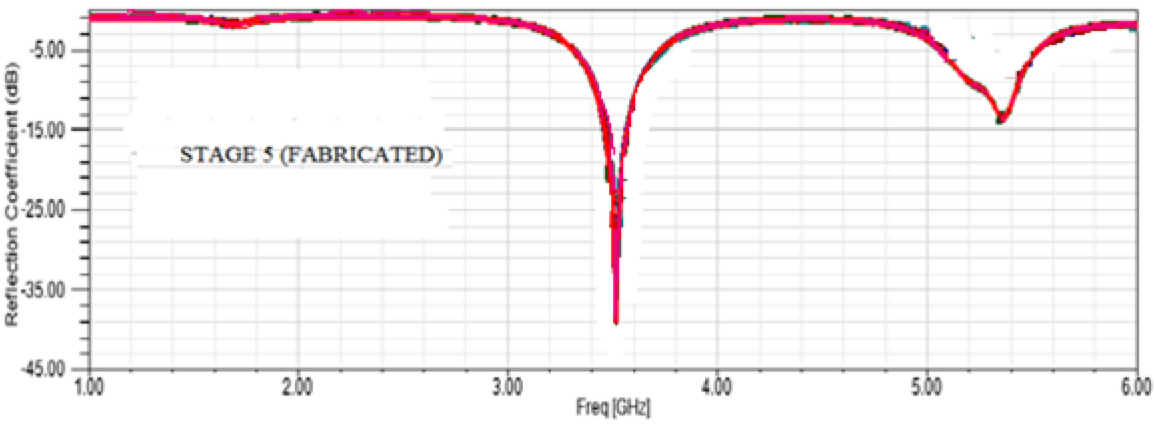


Fig.4 Reflection Coefficient Plot of Fabricated Design Stage

Table -3 Parametric Results of the Different Design Stages

Parameter	Simulated Stage 1 Iteration	Simulated Stage 2 Iteration	Simulated Stage 3 Iteration	Simulated Stage 4 Iteration	Simulated Stage 5 Iteration	Fabricated Proto-type
Number of Bands	Single (1)	Single (1)	Single (1)	Single (1)	Dual (2)	Dual (2)
Resonant Fre-quency (GHz)	3.49	3.52	3.53	3.54	3.5 (f1) 5.34 (f2)	3.51(f1') 5.37 (f2')
Reflection Coef-ficient (dB)	-28.88	-29.19	-31.22	-33.86	-42.88 (f1) -14.28 (f2)	-39.07 (f1') -13.36(f2')
Peak Gain (dBi)	1.9	4.45	7.12	9.51	18.56 (f1) 11.43 (f2)	12.63 (f1') 8.61 (f2')

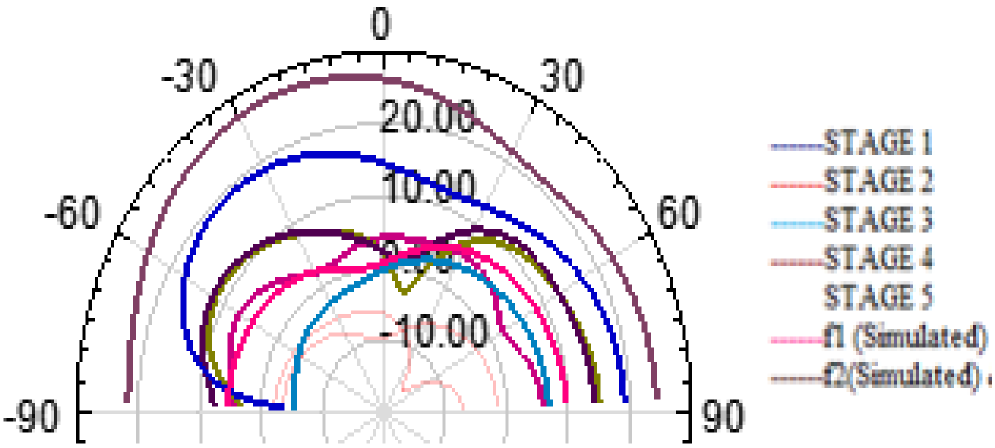


Fig. 5 Radiation Pattern Plot of Different Simulated Design Stages

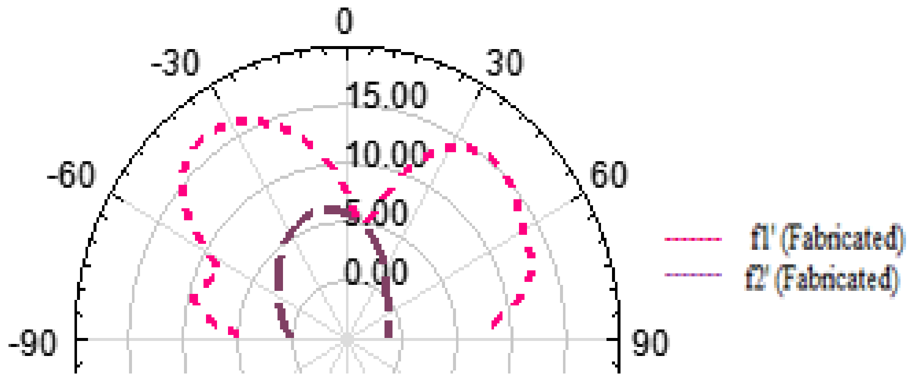


Fig. 6 Radiation Pattern Plot of Different Fabricated Design Stages

The recorded set of values clearly indicate an improvement in the gain at each stage of alphabetical slotting. The final stage is seen to exhibit a dual band resonance with significantly improved gain factor. It should be noted that though the patch is slotted several times, there is no addition of any sideband except for the final slotting stage where a second resonant frequency appears. However, a drastic change in the gain of the antenna can be observed upon its transition from initial to final stages i.e. the gain value shooting from 1.9 dBi to 18.56 dBi is extremely remarkable. Also, it should be noted that the three 'E' shaped slots do not contribute an equal increment in the gain values. The reason for this observation remains unaccounted. A closer look at the tabulated value leads to an inference that both the simulated & the fabricated results are in close agreement with the variation in results mainly accounted to the air gap in soldering the connectors and losses in connector cables.

CONCLUSION

The improvement in the radiation gain characteristic of a conventional RMPA upon the use of alphabetical slots has been investigated in this paper. The RMPA design has been built using a 58mm x 80 mm Flame Retardant-4 Epoxy substrate that is 1.6 mm thick and has a dielectric constant of 4.4. The employed feeding technique is coaxial feed. Simulation has been carried over HFSS-15. An improvement in the radiation characteristic of gain has been observed in each design iteration. The final design stage has been fabricated and experimentally verified. The fabricated prototype has been tested over Rhode & Schwarz ZVA 40 VNA of range 10 MHz-40 GHz for its reflection coefficient and in anechoic chamber for its radiation pattern & gain. The measured results have been found to be in close approximation with the simulated ones.

REFERENCES

[1] Deepanshu Kaushal, T Shanmuganantham and 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)*, **2017,** 1-5.
[2] Vijay Sharma, S Shekhawat, VK Saxena, JS Saini, KB Sharma, B Soni and D Bhatnagar, Right Isosceles Triangular Microstrip Antenna with Narrow L-Shaped Slot, *International Journal of Microwave and Optical Technology Letters*, **2009**, 51 (12), 3006-3010.
[3] T Shanmuganantham and G Rajender, Implementation of Spiral Planar Inverted-F Antenna for Multiband Applications, *International Journal of Computer Applications (IJCA)*, **2012**, 38(2), 06-09
[4] F Malek, M Md Shukor, MZA Abd Aziz, H Nornikman, MS Zulkefli, HM Mat, BH Ahmad, MF Abd Malek and MA Othman, Equilateral Triangular Microstrip Patch Antenna with Spur Lines Embedded, *IEEE Antennas & Propagation Conference*, Loughborough, UK, **2013**, 303-307.
[5] Vijay Sharma, VK Saxena, KB Sharma and D Bhatnagar, Radiation Performance of an Elliptical Patch Antenna with Three Orthogonal Sector Slots, *Romanian Journal of Information Science and Technology*, **2011**, 14 (2), 123–130.
[6] Deepanshu Kaushal and T Shanmuganantham, High Frequency Slotted Robot Patch Antenna for Multiple Space Applications, *International Conference on Antenna Test and Measurement Society (ATMS)*, Hyderabad, India, **2017**,364-371.
[7] Deepanshu Kaushal and T Shanmuganantham, Design of Multi Utility High Frequency Dual Band Slotted Android Logo Patch Antenna using Coaxial Feed, *International Conference on Antenna Test and Measurement Society (ATMS)*, Hyderabad, India, **2017**, 391-396.
[8] A Srilakshmi, NV Koteswararao and D Srinivasarao, X Band Printed Microstrip Compact Antenna with Slots in Ground plane andPatch, *IEEE Conference on Recent Advances in Intelligent Computational Systems (RAICS)*, **2011**, 851-855.
[9] AA Deshmukh and KP Ray, Analysis of Broadband Psi –Shaped Microstrip Antennas, *IEEE Antennas and Propagation Magazine*, **2013**, 55(2), 107-112.
[10] Can Ding, Y Jay Guo, Pei-Yuan Qin, Trevor S Bird and Yintang Yang, A Defected Microstrip Structure (DMS)-Based Phase Shifter and its Application to Beamforming Antennas *IEEE Transactions on Antennas and Propagation*, **2014**, 62(2), 1-5.
[11] Hanae Elftouh, Naima A Touhami and Mohamed Aghoutane, Miniaturized Microstrip Patch Antenna with 242 Defected Ground Structure, *Progress in Electromagnetic Research C*, **2014**, 55, 25–33.
[12] Sudhir Bhaskar and Sachin K Gupta, Bandwidth Improvement of Microstrip Patch Antenna using H- Shaped Patch, *International Journal of Engineering Research and Application*, **2012**, 2(1), 334- 338.