ISSN (online) : 2277-5390
ISSN (Print): 2277-5382

Single band high gain microstrip shivling patch antenna for aviation communication

Deepanshu Kaushal*[1], T. Shanmuganantham[2]

*[1]PG Student, [2]Assistant Professor, Department of Electronics Engineering, Pondicherry University, Pondicherry, India
*[1]deepanshu_kaushal@yahoo.com, shanmuga.dee2pondiuni.edu.in

Abstract

Background/Objectives: To design a single band microstrip shivling patch antenna intended to serve aviation communication including radio location and aeronautical radio navigation.
Methods/Statistical analysis: The proposed geometry uses numerical Finite Element Method (also called the finite element analysis) technique that attempts to find approximate solutions to boundary value problems for partial differential equations. The proposed antenna geometry uses a FR4 epoxy substrate with a coaxial/probe feeding technique. The design has been analysed in terms of reflection coefficient, bandwidth, radiation pattern, gain, directivity, VSWR and field overlays.
Findings: Using HFSS based on FEM, the design has been analysed in several aspects. Compared to a conventional rectangular MSA, the proposed structure has a gain higher by a factor of 13.36 dBi and a bandwidth improvement of 39.07%. The design is thus ahead in terms of its functionality and results compared to the rectangular counterpart.
Application/Improvements: The novel structure may be used for aviation communication including radio location and aeronautical radio navigation.

Keywords: Shivling patch, aviation, radio location, radio navigation.

1. Introduction

The aviation communication involves conversing of two or more aircrafts. The manner in which the aircrafts are constructed makes it problematic to view beyond what directly confronts it. Safety being the priority in aviation, communication methods including wireless radio is effective for aircraft to communicate with the necessary personnel. The aviation communication including the radio location and radio navigation make use of microstrip patch antennas as shown in figure 1 with a radiating patch at one side of a dielectric substrate that has a grounded support at the other side [1].

Figure 1. Three layer structure of microstrip patch antenna

The proposed prototype uses a FR4 epoxy substrate with a thickness of 1.6 mm, relative permittivity of 4.4 and a dielectric loss tangent of 0.02. The structure is formed by the combination of a rectangle and a semicircle at its top. A further insertion of narrow horizontal rectangular slots in the design so formed gives it a resemblance close to the holy Shivling.

In [1] and [2], the comparative study of a rectangular MPA in multi band is discussed. The designed rectangular patch achieves a peak gain of 7.7 dBi and a bandwidth of 453 MHz. The circular counterpart, on the other hand, achieves a gain of 7.52 dBi with a 488 MHz bandwidth.

ISSN (online) : 2277-5390
ISSN (Print): 2277-5382

In [3], the design of a rectangular spiral microstrip patch antenna integrated with LED for Wifi application is proposed. The designed antenna achieved an appreciable reflection coefficient of -26.49 dB but offered a very narrow bandwidth of 35.4 MHz.

In [4], a novel miniaturized microstrip patch antenna based on metamaterial unit is proposed. The designed structure achieves a 4.97 dBi gain with a 122 MHz bandwidth.

In [5], a novel MPA using SIW technique for WLAN/Wi-Fi applications in C-band is discussed. An effective reflection coefficient of -34 dB and a peak gain of 7.1 dBi is achieved by the single element.

In [6], the performance analysis of MPA using CSRR and PSRR techniques for WLAN, WiMAX, Wi-Fi and IMT applications are discussed. The MPA using circular CSRR achieves a -31.64 reflection coefficient with a maximum gain of 5.64 dBi and a 494 MHz bandwidth. Another MPA using rectangular CSRR achieves a 5.72 dBi gain with a 592 MHz bandwidth.

An insight into the antenna geometry and specifications has been given in section II. The section III includes results. The final sections of the paper include conclusion and references.

2. Geometry and specifications of the proposed antenna

The proposed antenna geometry has a structural resemblance to the mythological shivling as shown in Figure 2 and thus the proposed structure has been named after it.

Figure 2. Shivling

Figure 3 shows geometry of the proposed antenna with its specifications as tabulated in Table 1.

Figure 3. Proposed Antenna Geometry

Table 1. Geometric Specifications of Proposed Antenna (mm)

Parameters	Dimension (mm)
L	40
W	50
L1	30

2.1. Design considerations

The design uses a 75 mm x 60 mm x 1.6 mm FR4 epoxy substrate. The design criteria of a rectangular patch antenna (RPA) is based on the equations as mentioned under [7]:

Step 1: Calculation of the Substrate Thickness

ISSN (online) : 2277-5390
ISSN (Print): 2277-5382

$$h \le 0.3 \times \frac{c}{2 \times \pi \times f_r} \times \sqrt{\varepsilon_r} \quad (1)$$

Step 2: Calculating the width of the radiating patch

$$w = \left(\frac{c}{2 \times f_r}\right)\left(\sqrt{\frac{\varepsilon_r + 1}{2}}\right) \quad (2)$$

Step 3:The length of metallic patch is calculated as under:

$$L = \frac{c}{2 \times f_r \times \varepsilon_{reff}} - 2\Delta l \quad (3)$$

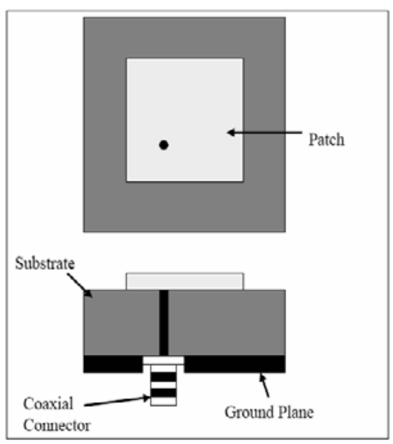
$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \times \sqrt{\left(1 + \left(\frac{12h}{w}\right)\right)} \quad (4)$$

Step 4: Extension length of the radiating patch is computed with this equation:

$$\Delta l = .412 \times h \times \left[\left(\frac{\varepsilon_{reff} + 0.03}{\varepsilon_{reff} - .258}\right) \times \left(\frac{w + 0.264h}{w + .8h}\right)\right] \quad (5)$$

The design incorporates coaxial feed technique [8] as shown in Figure 4 on account of the offered easy fabrication, low spurious radiation and simple matching techniques.

Figure 4. Coaxial feeding technique

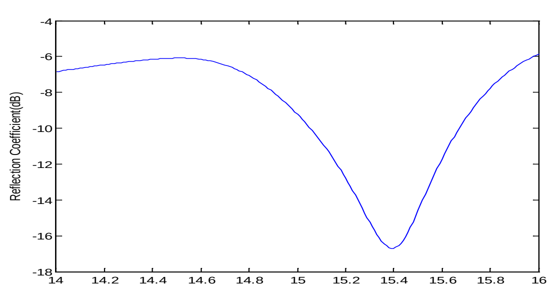


3. Results and discussion

3.1. Reflection coefficient

Figure 5 shows the variations that occur in the reflection coefficient [9] upon the frequency variation. The value of reflection coefficient at 15.4 GHz is -16.7 dB. The designed structure thus offers a single band resonance with a bandwidth of 630 MHz.

Figure 5. Plot of reflection coefficient versus frequency



ISSN (online) : 2277-5390
ISSN (Print): 2277-5382

3.2. Radiation pattern

Figures 6-8 shows the plots of the overall radiation pattern [10], radiation pattern in azimuthal plane and that in the elevation plane.

Figure 6. Overall Radiation Pattern

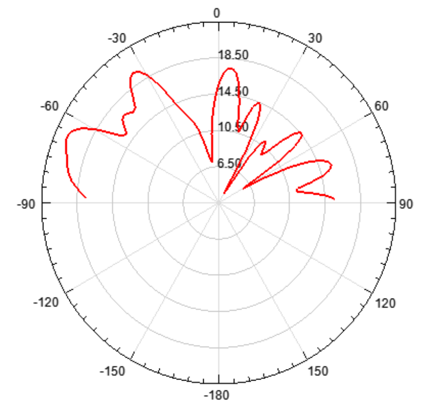


Figure 7. Radiation Pattern in Azimuthal plane

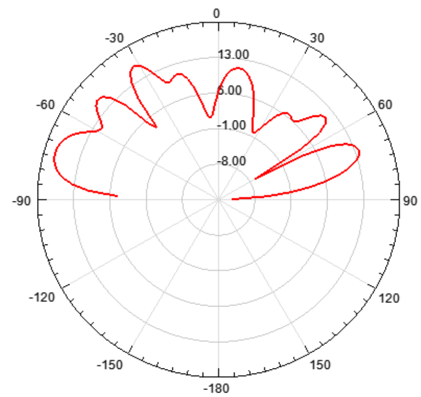
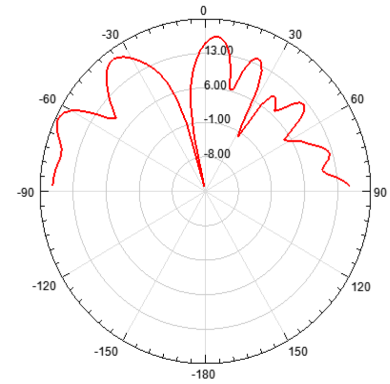


Figure 8. Radiation Pattern in Elevation plane

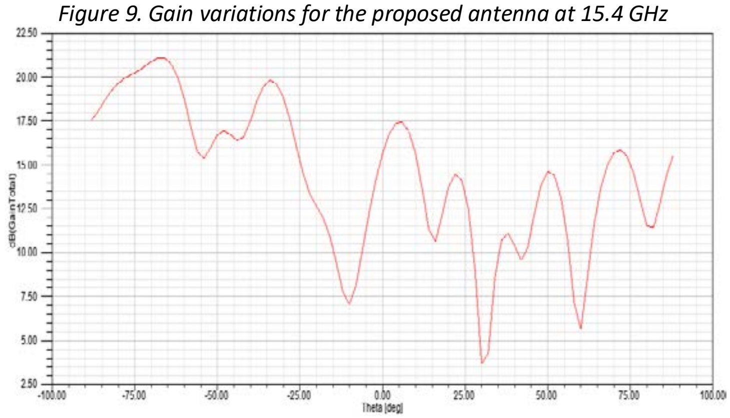


3.3. Gain

The variations in gain [11] mathematically express the changes in ratio of measure of the amount of energy propagated by the antenna in different directions to the energy that would be propagated if the antenna were not directional.

The gain as in Figure 9 is found to attain a maximum value of 21.1 dBi at 15.4 GHz.

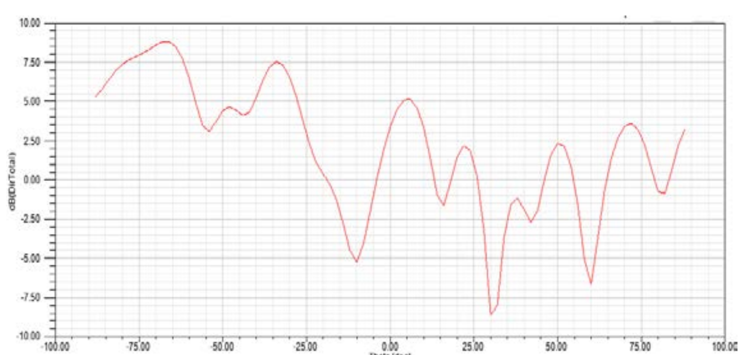
Figure 9. Gain variations for the proposed antenna at 15.4 GHz



3.4. Directivity

Figure 10 shows the angular variations of directivity that has a maximum value of 8.8 dB at the single resonant frequency of 15.4 GHz.

Figure 10. Directivity variations for the proposed antenna at 15.4 GHz

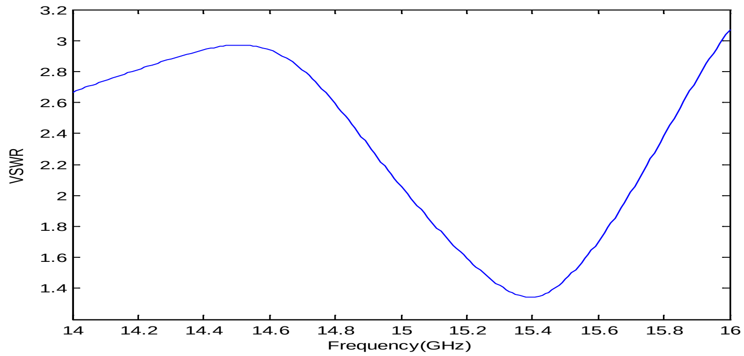


 ISSN (online) : 2277-5390
ISSN (Print): 2277-5382

3.5. VSWR

The VSWR expressing the degree of matching between the impedance and the transmission line has a value of 1.3 as shown in Figure 11 for the proposed antenna. The attained value is less than 2 and the result is thus satisfactory.

Figure 11. Variations of VSWR with frequency



3.6. Distribution of fields

Figures 12-14 shows the E, H field and surface current distribution at 15.4 GHz.

Figure 12. E-Field Distribution for the proposed structure at 15.4 GHz

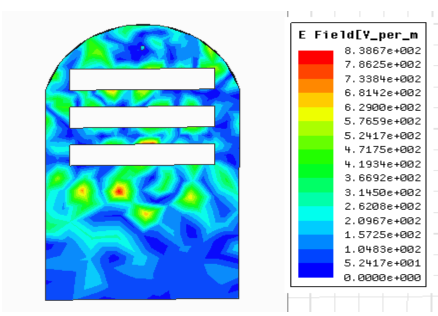


Figure 13. H-Field Distribution for the proposed structure at 15.4 GHz

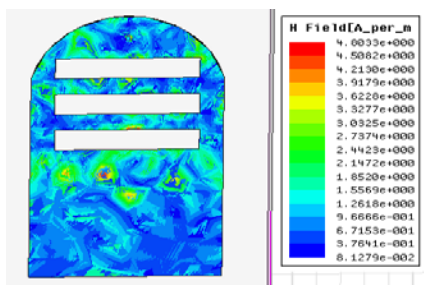
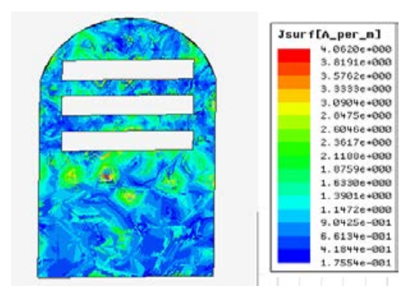


Figure 14. Surface Current Distribution for the proposed structure at 15.4 GHz



The tabulated result is shown in Table 2.

Table 2. Tabulated results

Resonating Freq(GHz)	Reflection Coefficient(dB)	Gain(dB)	BW (MHz)
15.4	-16.7	21.1	630

4. Conclusion

Microstrip Shivling patch antenna using FR4 epoxy substrate and coaxial feed technique was designed and found to offer considerable gain of 21.1 dBi and significant bandwidth of 630 MHz.

5. References

1. Deepanshu Kaushal, T. Shanmuganantham. Danger microstrip patch antenna for fixed satellite applications. *IEEE International Conference on Emerging Trends in Technology.* 2016, 213-219.
2. C. Elavarasi, T. Shanmuganantham. Parametric analysis of water lily shaped split ring resonator loaded fractal monopole antenna for multiband applications*. International Journal of Electronics and Communication Engineering.* 2016;3(9), 1221-1224.

3. K.A. Ansal, T. Shanmuganantham. ACS- Fed Wideband Antenna with L-Shaped Ground Plane for 5.5 GHz WLAN Applications. *Progress in Electromagnetic Research Letters (PIERL).*2014, 49, 59-64.
4. S. Ashok Kumar, T. Shanmuganantham. Implantable CPW fed double crossed type triangular slot antenna for ISM Band. *Intelligent Computing, Networking, and Informatics, Springer.*2014; 243, 503-509.
5. DeepanshuKaushal,T. Shanmuganantham. Design of compact microstrip apple patch antenna for space applications*. IEEE Antenna and Propagation Symposium.*2016; 305-310.
6. K.A. Ansal, T. Shanmuganantham. Planar ACS fed dual band antenna with DGS for wireless applications. *International Journal of Antennas.* 2015;1(1),85-97.
7. K.A. Ansal, T. Shanmuganantham. A novel CB ACS fed dual band antenna with truncated ground plane for 2.4/5 GHz WLAN applications. *AEU: International Journal of Electronics and Communications (Elsevier).* 2015; 10, 1506-1513.
8. Deepanshu Kaushal, T. Shanmuganantham. Mono band microstrip slotted power button antenna for aviation communication*. National Conference on Recent Advances in Wireless Communication for the Design of Smart Antennas.*2016*;* 27-32.
9. Deepanshu Kaushal, T. Shanmuganantham. Triple band microstrip delete patch antenna for satellite related applications*. National Conference on Recent Advances in Wireless Communication for the Design of Smart Antennas.*2016*.* 21-26.
10. E. Sarva, P.V. Sridevi. A novel triple band planar microstrip patch antenna with defected ground structure. *Indian Journal of Science and Technology.* 2016; 9(3), 1-5*.*
11. S.V. Devika, Sarat K. Kotamraju, K. Ch. Sri Kavya, V. Sudheer Kumar, K. Suhas, K. Vinu, B. Anudeep. A circularly polarized Ka-band antenna for continuous link reception from GSAT-14. *Indian Journal of Science and Technology.* 2016; 9(38), 1-6.

The Publication fee is defrayed by Indian Society for Education and Environment (iSee). www.iseeadyar.org

Citation:

Deepanshu Kaushal, T. Shanmuganatham. Single band high gain microstrip shivling patch antenna for aviation communication. *Indian Journal of Innovations and Developments.* 2016; 5 (11), November.