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Mono band microstrip slotted power button antenna for aviation communication

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

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

Abstract

Background/Objectives: To design a mono band microstrip slotted power button antenna intended to serve aviation communication involving 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 tries to approximate boundary value problem solutions for the case of partial differential equations. It subdivides a larger problem into small and simple finite elements which are represented by simple equations that are finally assembled into a larger system of equations representing the entire problem. Different methods from the calculus of variations are used to approximate a solution by minimizing the associated error function. 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 hexagonal shaped MSA that has been used as a reference, the proposed structure has an improved gain by a factor of 3.72 dBi and a reflection coefficient reduced by a factor of 1.91.
Application/Improvements: The structure is fit to be used for aviation communication/ radio determination including radio location and aeronautical radio navigation.

Keywords: Slotted power button, aviation, radio determination, radio location, radio navigation.

1. Introduction

The 2.65 GHz to 2.85 GHz band may be used for radio determination purpose that involves determining the movement characteristics (position, velocity or others) and further includes radio location and radio navigation. Figure 1 shows that the microstrip patch antennas used for such an application have a radiating patch of metallic nature at one side of a dielectric substrate that has a grounded support at its other side.

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 concentric circles. Further, a vertical rectangular slot is introduced into the structure. The vertical inclusion of circular slots with extremely small radius gives the structure an appearance like that of power button on keyboard of laptops.

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In [1] discussed CPW fed tapered slot antenna at 5.5 GHz for wireless applications. The basic results of the antenna including bandwidth, reflection coefficient, gain, radiation pattern and polarization are obtained. Each of these confirm to acceptable antenna standards.

In [2] proposed a suspended microstrip patch antenna using an inverted V- shaped ground for wireless applications. Again, the obtained bandwidth, reflection coefficient, gain, radiation pattern and polarization are found to confirm to acceptable antenna standards.

In [3] proposed a rectangular microstrip patch antenna (RMPA) with circular slot applicable for S band and X band applications. Comparative observations are noted for different feed positions and slotted structures of proposed antenna with conventional RMPA. Rogers RT/Duroid material with 2.2 dielectric constant is used for substrate. Simulation results shows the frequency shift towards lower side for slotted structures and improved parameters such as return loss, gain, VSWR and radiation pattern as compare to simple RMPA.

In [4] proposed a simple microstrip patch antenna suited for wireless local area Network (WLAN) applications. The structure uses a FR-4 substrate with the proposed patch antenna design covering 2.4GHz frequency range with a reflection coefficient of -39dB**.**

The section II of the paper describes the antenna geometry and specifications. The section III includes results. The final sections of the paper include conclusion and references.

2. Geometry and specifications of the proposed antenna

The design idea for the proposed antenna geometry has been taken from the shape of the power button normally available on keyboard of laptops and keypads of the mobile phone devices as shown in figure 2 and thus the proposed structure has been named after it.
The proposed antenna geometry is shown in figure 3.
The geometrical specifications of the proposed antenna are listed in table 1.

Figure 2. Power button

Figure 3.Proposed antenna geometry

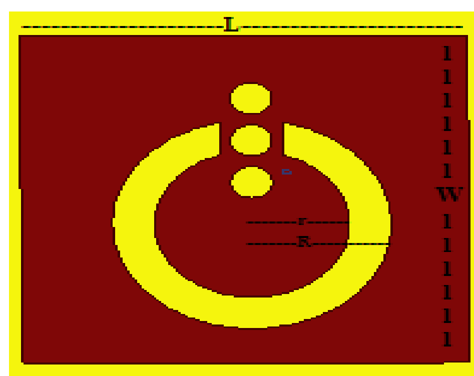

Table 1. Geometric specifications of proposed antenna (mm)

Parameters	Dimensions (mm)
L	64
W	62.5
R	20
r	14

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Table 2. Design equations for the proposed antenna

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

2.1. Design considerations

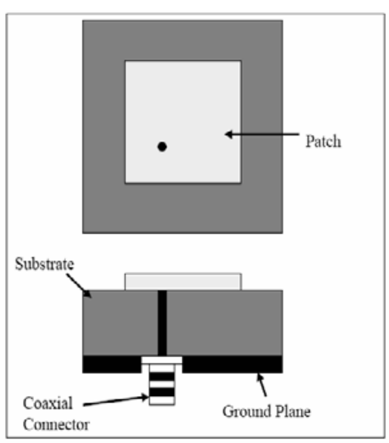
The design uses a 1.6 mm FR4 epoxy substrate. The basic calculations involved in the designing of a rectangular patch antenna (RPA) include:

Step 1: Width (w) of the radiating patch
Step 2: Effective dielectric constant of the substrate.
Step 3: Extension length of the radiating patch.
Step 4: Length of metallic patch.

The equations [5] for the parameters under calculation in the four steps above have been listed in table 2.

The design incorporates coaxial feed technique as shown in figure 4 on account of the several offered benefits including easy fabrication, low spurious radiation and simple matching techniques.

Figure 4. Coaxial feeding technique



3. Results and discussion

3.1. Reflection Coefficient and Bandwidth

Figure 5 shows a minimum reflection coefficient [6] of -12.7 dB achieved at 2.83 GHz. The bandwidth attained is 50 MHz.

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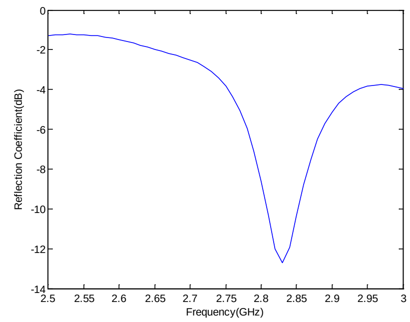
Figure 5. Reflection coefficient curve for the proposed geometry



3.2. Radiation pattern

Figures 6-8 shows the plots of the overall radiation pattern and the respective patterns in the azimuthal plane and the elevation plane for the proposed geometry.

Figure 6. Overall radiation pattern

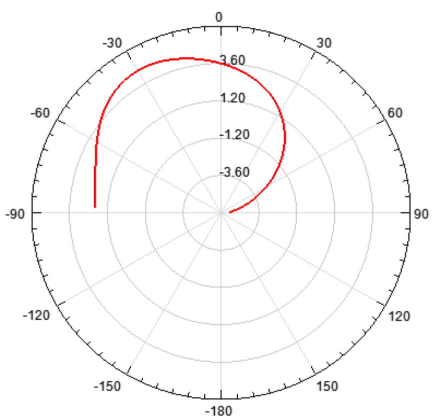


Figure 7. Radiation Pattern in Azimuthal plane

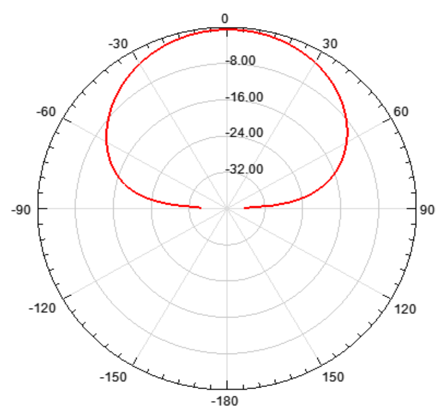
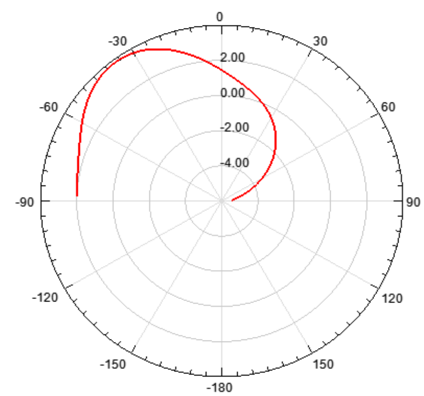


Figure 8. Radiation pattern in elevation plane

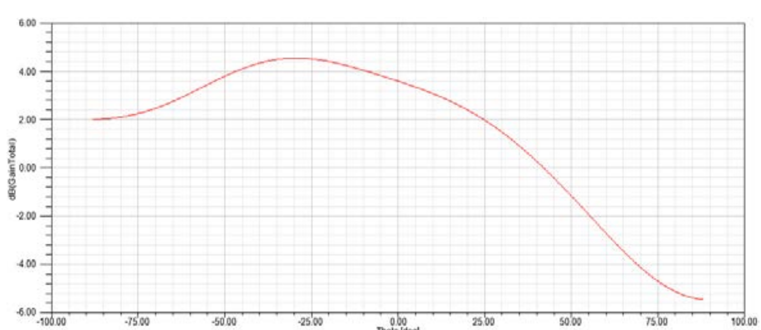


3.3. Gain

The variations in the gain [7] specify the changes in ratio of the energy propagated by the antenna in different directions to that would propagate for a non directional antenna.

As shown in figure 9, the design achieves a peak gain of 4.5 dBi at 2.83 GHz.

Figure 9. Gain variations for the proposed antenna at 2.83 GHz



3.4. Directivity

The angular variations of directivity [8] as depicted in figure 10 shows that the parameter achieves a maximum value of 7.3 dB at 2.83 GHz

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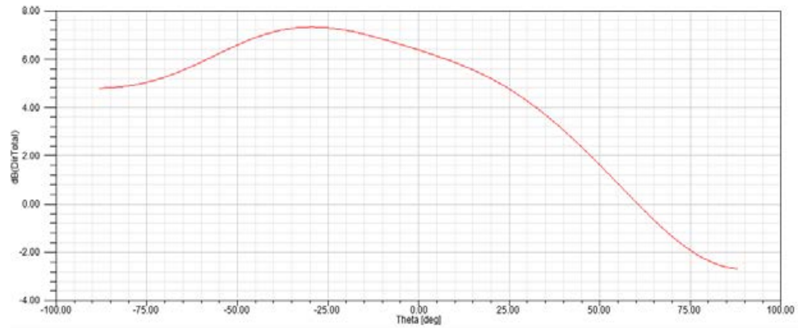
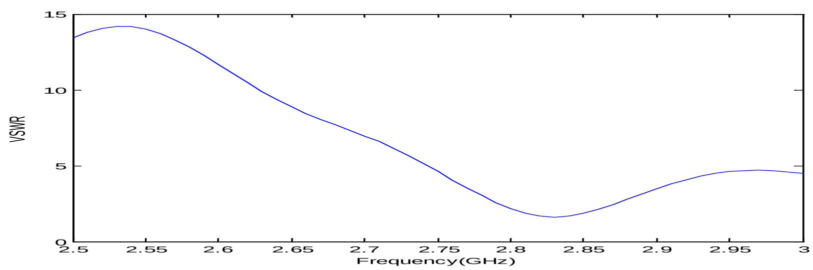
Figure 10. Directivity variations for the proposed antenna at 2.83 GHz



3.5. VSWR

The VSWR [9] expressing the matching extent between the impedance and the transmission line has a value of 1.6 for the proposed geometry as in figure 11. The attained value is less than 2 and satisfies the required condition [10].

Figure 11. Variations of VSWR with frequency



3.6. Distribution of fields

Figures 12-14 shows the E, H field and surface current distribution [11] at 2.83GHz.

Figure 12. E-Field Distribution for the proposed structure at 2.83 GHz

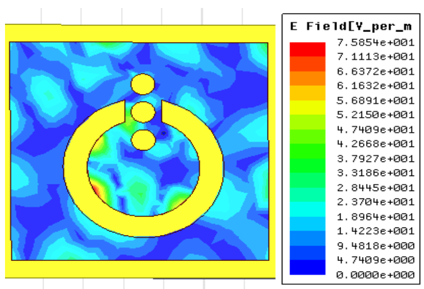


Figure 13. H-Field Distribution for the proposed structure at 2.83 GHz

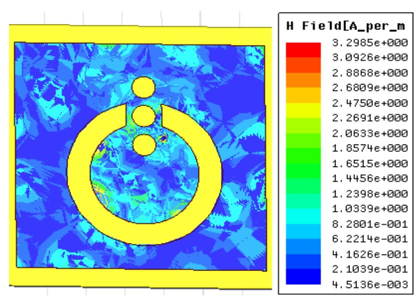
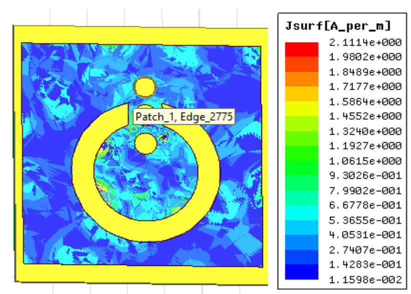


Figure 14. Surface Current Distribution for the proposed structure at 15.4 GHz



The tabulated result is as shown in table 3

Table 3. Tabulated results

Resonating Freq(GHz)	Reflection Coefficient(dB)	Gain(dBi)	BW (MHz)
2.83	-12.7	4.5	50

4. Conclusion

Mono band microstrip slotted power button antenna using FR4 epoxy substrate and coaxial feed technique was designed and found to offer a gain of 4.5 dBi with a 50 MHz bandwidth.

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