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Hex band microstrip envelope patch antenna for multiple space applications

Deepanshu Kaushal*[1], T. Shanmuganatham[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

Objectives: To design a hex band microstrip envelope patch antenna that would serve multiple space applications including radio astronomy, space research, aviation communication, RF devices, ISM equipment, amateur radio, satellite communications, mobile except aeronautical mobile and fixed microwave.
Methods/Statistical analysis: The proposed geometry utilizes numerical Finite Element Method that would subdivide a large problem into smaller, simple parts, called finite elements. The simple equations modelling these finite elements are finally grouped into a system of larger equations that would model the entire problem. FEM next uses various methods from the calculus of variations to approximate a solution by minimizing an associated error function. The proposed antenna geometry uses a FR4 epoxy substrate with aprobe feeding technique. The design has been analysed in terms of reflection coefficient, bandwidth, radiation pattern, gain, directivity, and VSWR and field patterns.
Findings: Using HFSS based on FEM, the design has been analysed in several aspects. Compared to both single band rectangular and circular reference MSA's, the proposed multi band design offers highly improved characteristics as listed in Table
Application/Improvements: The structure is suited for multi band applications. The 110 MHz bandwidth extending from 4.99 GHz to 5.1 GHz may be used for radio astronomy, space research and aviation communication (radio location and radio navigation), 160 MHz bandwidth of 5.66 GHz to 5.82 GHz may be utilised for RF devices, ISM equipment and amateur radio. The 300 MHz bandwidth extending from 7.47 GHz to 7.77 GHz may be used for satellite communication, the 900 MHz bandwidth extending from 9.02 GHz to 9.92 GHz can be put forth to radio location and aeronautical radio navigation applications and finally the 260 MHz bandwidth of 11.29 GHz to 11.55 GHz can be used for mobile except aeronautical mobiles and fixed microwave.

***Keywords*:** Mailbox patch, radio astronomy, ISM equipment, amateur radio and fixed microwave.

1. Introduction

Most space applications including radio astronomy, space research, aviation communication, RF devices, ISM equipment, amateur radio, fixed microwave etc. make use of microstrip patch antennas as shown in figure 1with radiating patch as the topmost layer that has a dielectric substrate with a grounded support beneath it.

Figure1.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 two rectangles. Further, a M- shaped slot is introduced inside the inner rectangle. The structure finally resembles an envelope. Also, it looks more or less similar to symbol of the email application available the mobile phones and other devices.

In [1] proposed the design of a multiband square microstrip patch antenna that has circular polarization (CP) and can be used for WLAN applications. The single square patch is excited using microstrip feed. The proposed antenna exhibits multiband operation at band of frequencies including 2.31 GHz to 2.48 GHz, 3.88 GHz to 3.94 GHz and 4.41 GHz to 4.53 GHz with respective impedance bandwidths 3.5%, 2.9% and 10.6%.

In [2] proposed a CPW fed octagonal patch antenna with hexagonal slot suiting the UWB applications. The proposed antenna uses a FR4 epoxy substrate with a 4.4 dielectric constant and an ultra-wide bandlying between 3.1GHz - 10.6 GHz for a less than 2 VSWR. The most significant antenna parameters which include the reflection coefficient, VSWR, radiation patterns, gain and 3 dB bandwidth are obtained and each of them confirms to the acceptable standards of antenna.

In [3] proposed an equilateral triangle shaped microstrip patch antenna having spur lines. The proposed antenna has a triangular planar patch element with two spur line slots. The centre frequencies of this antenna include the first resonant frequency being 0.90 GHz and the second resonant frequency being 1.80 GHz. The designed antenna proposes a GSM 1800 bandwidth improvement of up to 100 MHz. It exhibits a reflection coefficient of – 16.2 dB, bandwidth of 33 MHz (0.919 GHz to 0.952 GHz) and a gain of 3.5dBiat the first resonant frequency. The second resonant frequency has a reflection coefficient of – 28.2 dB with a bandwidth of 115 MHz (1.714 GHz to 1.829 GHz) and gain of 3.4dBi.

In [4] discussed the design and performance analysis of an inverted L shape slotted micro strip patch antenna. The FR4 substrate with a relative permittivity of 4.4 and a thickness of 1.57mm was used. The proposed antenna design had impedance bandwidth of 3.13GHz.The antenna had resonant at frequencies including 3.05GHz, 4.15GHz and 5.80GHz within the operating frequency range of 2.91GHz - 6.04 GHz and the reflection coefficients of -18.32 dB,-34.56 dB and -32.08 dB, respectively.

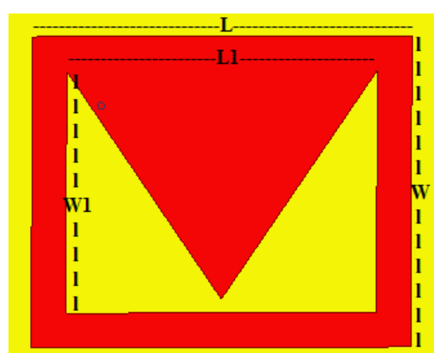
The section II of the paper describes the antenna geometry and specifications. The section III includes results. The final sections of the paper include conclusion and references.

2. Antenna geometry and its specifications

The antenna design resembles envelope as well as the email application symbol as shown in figure 2.The proposed antenna geometry is shown in figure 3.

Figure 2. Envelope symbol

Figure 3. Proposed antenna geometry



The geometric specifications of the proposed antenna have been listed in Table 1.

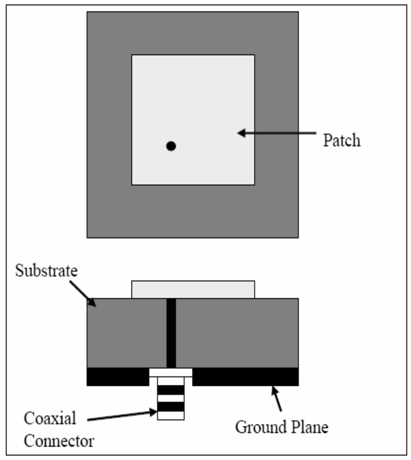
Table 1. Geometric specifications of proposed antenna (mm)

Parameters	Dimensions (mm)
L	55
W	45
L1	45
W2	35

2.1. Design considerations

The design uses a 1.6 mm FR4 epoxy substrate and a coaxial feed technique. The use of coaxial technique as in figure 4 is due to several advantages offered by it including easy fabrication, low spurious radiation and simple matching techniques.

Figure 4. Coaxial feeding technique



The basic design equations [5] for rectangular microstrip patch antenna are listed in table 2.

Table 2. Design Equations for theproposed antenna

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

3. Results and discussion

3.1. Reflection coefficient and bandwidth

Figure 5 shows that the design offers 6 band of frequencies including 110 MHz band resonant at 5.04 GHz with a reflection coefficient [6] of -17.5 dB, 160 MHz band with a minimum reflection coefficient of -22.2 dB achieved at 5.74 GHz and 300 MHz bandwidth with resonance frequency of 7.65 GHz offering a -11.7 dB reflection coefficient. The 900 MHz band offers resonance at 9.16 GHz and 9.76 GHz with reflection coefficients of -15.6 D band -25.7 dB. Finally, the 260 MHz band is resonant at 11.36 GHz with a reflection coefficient of -26.2 dB.

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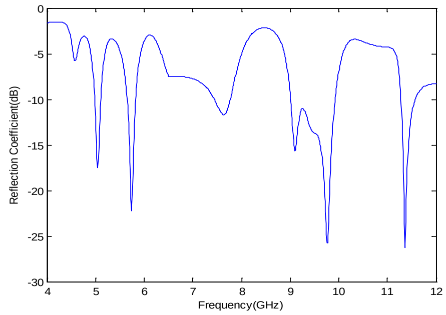
Figure 5. Reflection coefficient curve for the proposed geometry



3.2. Radiation pattern and gain

Figures 6-8 shows the plots of the overall radiation pattern [7], radiation pattern in azimuthal plane and that in the elevation plane for the proposed geometry.

Figure 6. Overall radiation pattern

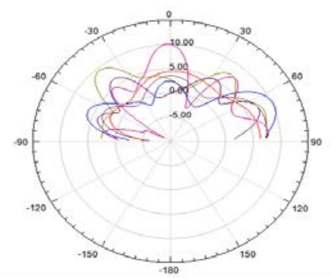


Figure 7. Radiation pattern in azimuthal plane

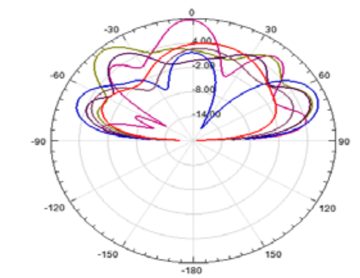
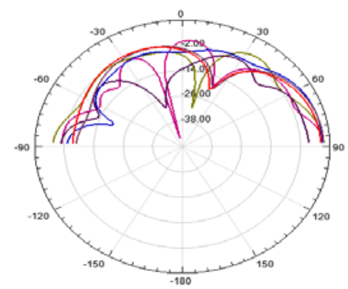


Figure 8. Radiation pattern in elevation plane

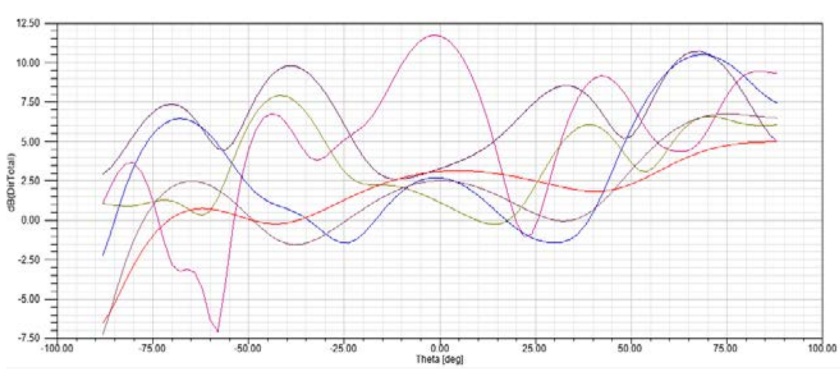


In the figures 6-8, the red curve denotes gain variations at 5.04 GHz which has a peak gain of 6.3 dBi, light purple curve denotes variations at 5.74 GHz with a peak gain of 7.6 dBi, blue curve denotes those at 7.65 GHz with a maximum gain of 10.3 dBi and dark purple denotes the gain variations at 9.16 GHz with peak gain of 7.3 dBi. The gain variations at 9.76 GHz are represented by golden colour with a maximum gain of 9.5 dBi and those at 11.36 GHz with a peak gain of 10.1 dBi are represented by pink colour. The maximum gain at different frequencies is as per the overall radiation pattern.

3.3. Directivity

Figure 9 shows the angular variations of directivity [8] at different resonant frequencies that achieves a maximum value of 5 dB at 5.04 GHz, 6.8 dB at 5.74 GHz, 10.5 dB at 7.65 GHz, 10.7 dBat9.16 GHz, 8 dB at 9.76 GHz and 10.1 dB at 11.36 GHz.

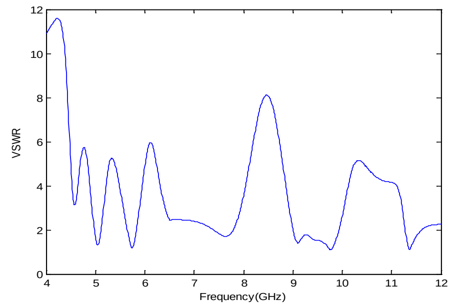
Figure 9. Directivity variations for the proposed antenna at different resonant frequencies



3.4. VSWR

The VSWR [9] expresses the matching extent between the impedance and the transmission line that has a value of 1.3 at 5.04 GHz, 1.2 at 5.74 GHz, 1.71 at 7.65 GHz, 1.4 at 9.16 GHz, 1.1 at 9.76 GHz and 1.1 at 11.36 GHz for the proposed geometry as shown in figure 10. The attained values are less than 2 and satisfies the required condition.

Figure 10. Variations of VSWR with frequency



The tabulated result is given table 3.

Table 3. Tabulated results

Resonating Freq(GHz)	Reflection Coefficient(dB)	Gain(dBi)	BW(MHz)
5.04	-17.5	6.3	110
5.74	-22.2	7.6	160
7.65	-11.7	10.3	300
9.16	-15.6	7.3	900
9.76	-25.7	9.5	900
11.36	-26.2	10.1	260

4. Conclusion

Hex band microstrip envelope patch antenna well suited for multiple space applications was designed. The structure was found to be resonant at different frequencies with reflection coefficient, gain and bandwidth.

5. References

1. Prateek Kumar Singh, Ishita Sharma, Gurinder Singh, H.S. Dhanny. Multiband microstripantennawith circular polarization for wireless local area network. 2016 International Conference on Innovation and Challenges in Cyber Security (ICICCS) 2016, 319-322.
2. Abhishek Kumar, T Shanmuganantham. A CPW fed octagonal patched antenna for UWB applications. *International Journal of Engineering Sciences & Research Technology.* 2013, 2(11), 1-5.
3. F. Malek, M. Md. Shukor, M. Z. A. Abd Aziz, H. Nornikman, M. S. Zulkefli, H. M. Mat,B. H. Ahmad, M.F. AbdMalek,M. A. Othman. Equilateral triangular microstrip patch antenna with spur lines embedded. *IEEE Loughborough Antennas & Propagation Conference.*2013.
4. Alamdeep Kaur, Amandeep Kaur. Amarveer Singh Dhillon, Ekambir Sidhu. Inverted L shape slotted microstrip patch antenna for IMT, WiMAX and WLAN applications. *IEEE 2016 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET).* 2016, 1003-1007.
5. HoudaWerfelli, KhaoulaTayari, MondherChaoui, MongiLahiani, HamadiGhariani. Design of rectangular microstrip patch antenna. *2nd International Conference on Advanced Technologies for Signal and Image Processing-* (ATSIP),Monastir, Tunisia. 2016, 798-803.
6. S. Ashok Kumar, T. Shanmuganantham. Coplanar waveguide-fed ISM band implantable crossed- type triangular slot antenna for biomedical applications. *International Journal of Microwave and Wireless Technologies.*2014; 6(2), 167-172.
7. S.AshokKumar, T. Shanmuganantham. Design of implantable CPW fed monopole H-slot antenna for 2.45 GHz ISM band applications. *International Journal of Electronics and Communications (AEU).* 2014; 68(7), 661-666.
8. Yaqeen S. Mezaal. New compact microstrip patch antennas: design and simulation results. *Indian Journal of Science and Technology.*2016; 9(12), 1-6.
9. GalabaSai Rajesh,Vijay Kumar. CSRR Loaded multi substrate antenna for 4G LTE and Wi-MAX applications. *Indian Journal of Science and Technology.* 2016; 9(40), 1-5.

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