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IJIEMR Transactions, online available on 16th Feb 2022. Link :http://www.ijiemr.org/downloads.php?vol=Volume-11&issue=ISSUE-02

DOI: 10.48047/IJIEMR/V11/I02/22

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Volume 11, Issue 02, Pages: 163-168

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Triple Octagonal Microstrip Patch Antenna for Satellite Applications

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Abstract:

In continuation of the endeavor for miniature antennas for satellite communications a compact Triple Octagonal Microstrip Patch Antenna has been designed and its results analyzed. The proposed antenna has a substrate and one side of the substrate consists of a rectangular radiating patch having triple octagonal shaped slots and other side having a ground plane. Keeping in view of the space constraints in satellite applications the proposed antenna is well with the industry set rules. This antenna is suitable for C, X, Ku, K and Ka band applications. This engineered antenna has almost achieved omni directional radiation pattern showing considerable gain across the desired microwave frequency bands.

Index Terms – Triple, Octagonal, VSWR, Return Loss, Radiation Pattern, HFSS.

Introduction

Modern technology today has become satellite and mobile communication centric. Micro has become the watch word in the world of antennas forcing researchers to develop microstrip patch antennas which are micro and yet capable of multi-tasking. They are in demand due to their versatility, mechanical robustness and for adaptability with MMIC designs. They are also economical to manufacture. The limitation of microstrip patch antennas (i) Drops in efficiency (ii) power spurious feed radiation (iii) a small frequency of bandwidth and (iv) hgh quality of cross polarization radiation [1]. To overcome these limitations research has led us to slotted antennas, microstrip patch antennas using with different feeding techniques, impedance matching techniques with multiple resonators [2-4].

Triple Octagonal Microstrip Patch Antenna (TOMPA) is designed on rectangular shaped patch by etching triple octagonal ring slots on patch and it is able to achieve microwave multiband (C, X, Ku, K, Ka and V**)** characteristics [5-9].

Slot antennas have become crucial for their easy engineering and they are also play a key role in tuning antenna resonant frequencies. Slot antennas help us to miniaturize the dimensions of the antenna by properly integrating slots using electric path mender [10-11]. Much research has been done with microstrip patch antenna using electromagnetic spectrum within the range of microwave frequencies 7.7, 8, 8.5, 11.4, 17.2, 20, 28.9, 36.2, 40.9, 45.5 and 48.5GHz [12-14].

ANTENNA DESIGN

The geometry of the octagonal microstrip patch antenna comprises of an octagonal patch through length (L), and width (W). The geometric center of the patch is called P. The patch is etched on a substrate of thickness (h) and dielectric permittivity (ε_r). Patch antenna resonant frequency calculated using the formula [15].

$$w = \frac{1}{2 f_r \sqrt{\mu_0 \varepsilon_0}} \times \sqrt{\frac{2}{\varepsilon_r + 1}} \quad \text{------ (1)}$$

$$L = \frac{1}{2 f_r \sqrt{\varepsilon_{eff}} \sqrt{\varepsilon_0 \mu_0}} - 2\Delta L \quad (2)$$

(3-----(3)

And

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + 12\frac{h}{w}}} \quad \text{----(4)}$$

Fig.1 shows the geometry of designed triple octagonal microstrip patch antenna. Fig.2 shows the screen shot of the HFSS design. The RT/Duroid 5880 is used for substrate material for the antenna and its dielectric constant is εr=2.2 and substrate thickness h=1mm. A single lumped port is used as an input of the antenna excitation with 50Ω micro strip line. The antenna substrate dimensions are 21, 24 and 1mm. The sides of the triple octagonal ring slot are taken as 4.59, 4.20, 3.82, 3.44, 3.06, 2.68 and 2.3 mm. The length and width of the microstrip feed line are taken as 7.20 and 1 mm.

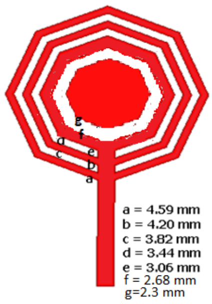
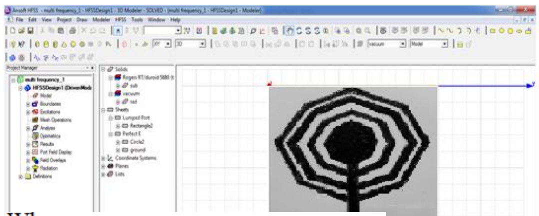


Fig1: Schematic drawing of the proposed antenna



Where

$$\Delta L = 0.41h \frac{\varepsilon_{eff} + 0.3}{\varepsilon_{eff} - 0.258} * \frac{\left(\frac{w}{h} + 0.264\right)}{\left(\frac{w}{h} + 0.8\right)}$$

Fig 2: HFSS screen shot of the designed antenna.

Simulation Results and Discussion

Software Ansys HFSS is used for the analysis and design of the antenna. It is a full-wave electromagnetic test system dependent on FEM. It breaks down 3D and multilayer structures of broad shapes. It has been generally utilized in the structure of MICs, RFICs, fixed reception apparatuses, wire antennas, and other RF/remote receiving antennas. It tends to be utilized to compute and plot the S_{11} parameters, VSWR in addition to the radiation patterns. HFSS version 15.0 is

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utilized to get the design and analysis of the antennas.

A. Return Loss

Efficiency of the antenna can be measured by observing the return loss of the antenna. Efficiency of the antenna will be high when the return loss is low; Fig.3 shows the simulated return loss of the proposed Triple Octagonal ring slot Antenna. Antenna resonates at 7.7, 8.0, 8.5, 11.4, 17.2, 20, 28.9, 36.2,40.9, 45.5 and 45.8 GHz corresponding return loss of -16.7 -24.1, -22.1, -17.1, -24.2, - 20.1, - 26.1, -23.2, -15.7, -16.3 and -11.7 dB respectively. It is observed that return loss is less than -10 dB for eleven frequencies in six (C, X, Ku, K, Ka and V) different bands.

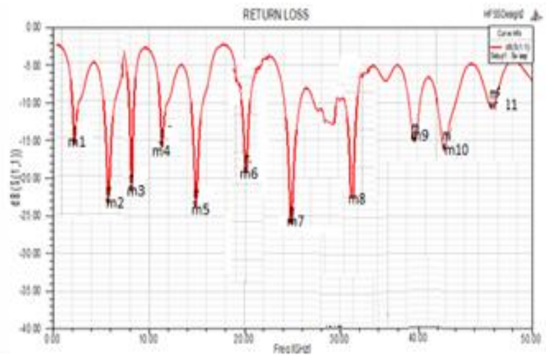

Fig 3: Return loss *versus* frequency of the antenna.

B. VSWR

A value of VSWR below 2 is considered suitable for many applications. The antenna is described as having a good match with the transmission line. A value above 2 is considered as a poor match. Fig.4 shows VSWR at different resonating frequencies of the designed antenna.

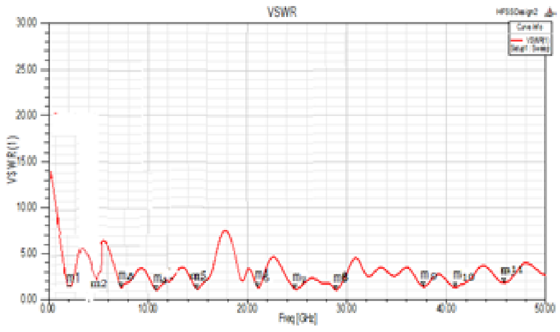

Fig 4: VSWR *versus* frequency of the antenna.

VSWR is less than 2 at eleven resonant frequencies for the proposed antenna shown in fig.4. The value of VSWR is about 1.27 at 7.5 GHz, it is about 1.47 at 8.0 GHz, it is about 1.34 at 8.5 GHz, it is about 1.82 at 11.4 GHz, it is about 1.76 at 17.2 GHz, it is about 1.34 at 20 GHz, it is about 1.10 at 28.9 GHz, it is about 1.17 at 36.2 GHz, it is about 1.32 at 40.9 GHz it is about 1.10 at 45.5 GHz and it is about 1.76 at 48.5 GHz. These eleven frequencies are in six bands, namely C,X, Ku, K, Ka, and V.

Simulated Radiation Pattern

Fig 5 represents the 3D radiation pattern for different resonance frequencies : (a) for 7.7GHz, (b) for 8.0 GHz, (c) for 8.5 GHz, (d) for 11.4 GHz, (e) 17.2 GHz, (f) 20 GHz, (g) 28.9 GHz, (h) 36.2 GHz, (i) 40.9 GHz, (j) 45.5 GHz and (k) 45.8 GHz. The proposed Triple octagonal microstrip patch antennas produced the desired radiation at a majority of the resonant frequencies.

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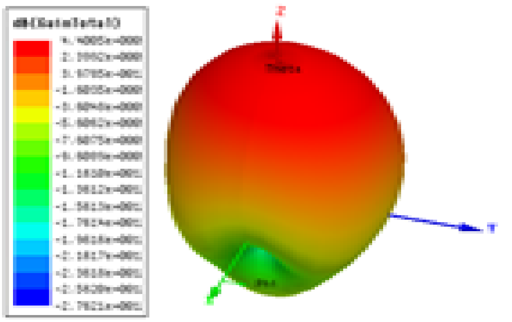
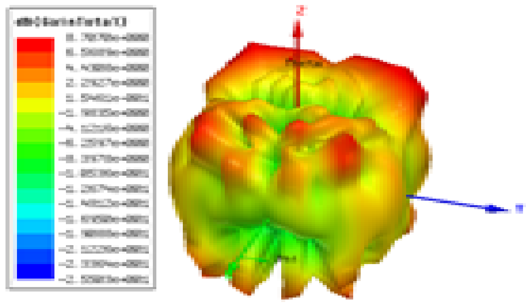

(a)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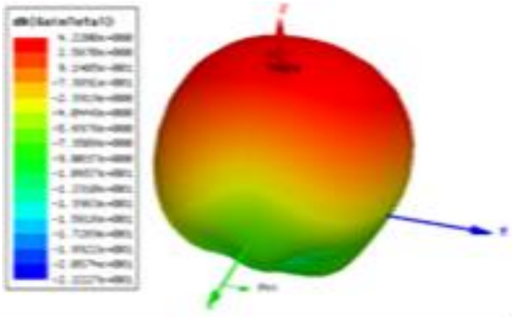
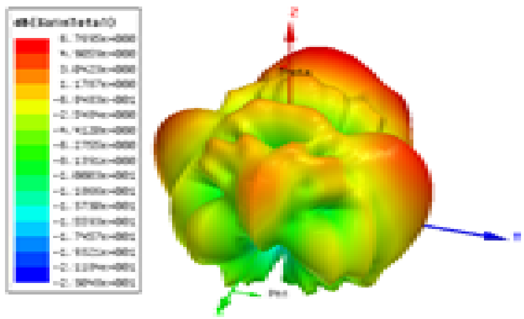
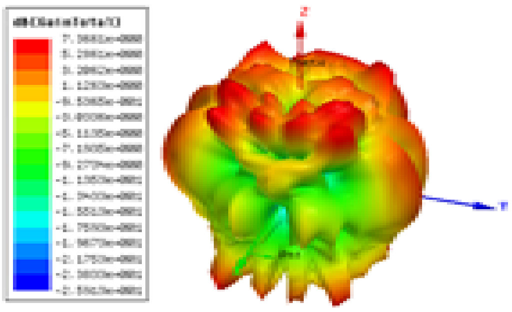
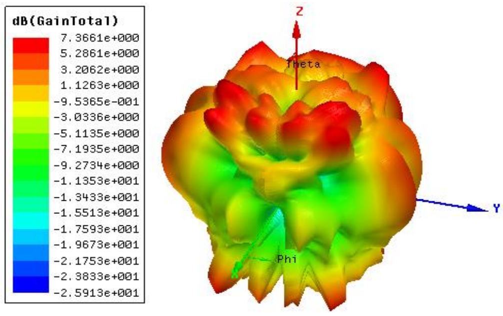
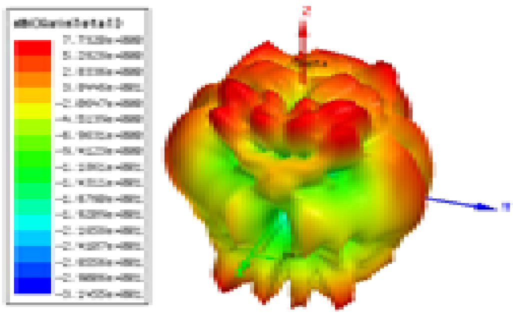

(b)


(f)


(c)



(g)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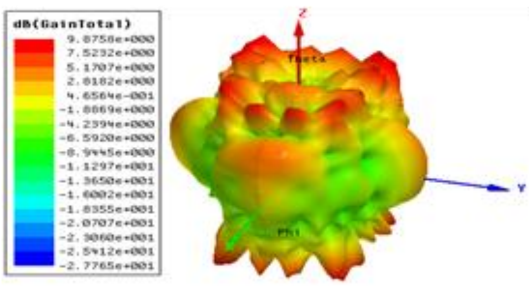

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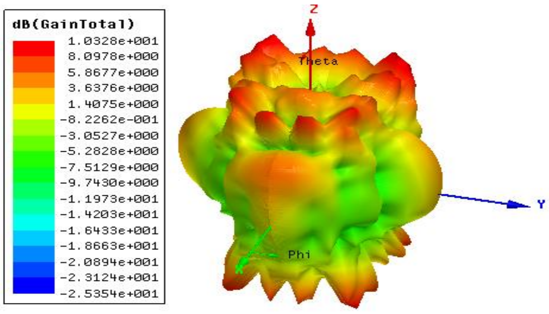
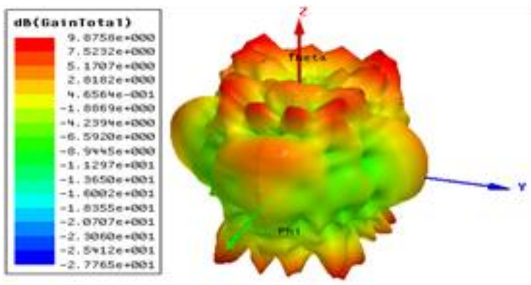
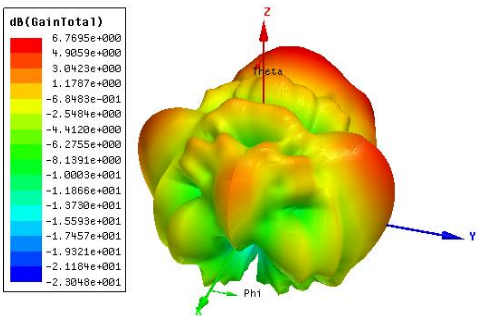


(i)



(j)



(k)

Fig 5 (a-k) : 3D representation of the simulated gain of the proposed triple octagonal ring slot antenna at eleven resonant frequencies i.e.,a) for 7.7GHz, (b) for 8.0 GHz, (c) for 8.5 GHz, (d) for 11.4 GHz, (e) 17.2 GHz, (f) 20 GHz, (g) 28.9 GHz, (h) 36.2 GHz, (i) 40.9 GHz, (j) 45.5 GHz and (k) 45.8 GHz.

Conclusion

The designed antenna Triple Octagonal Microstrip Patch Antenna (TOMPA) fulfills the multitasking requirements and versatility needed for satellite applications (Fixed, Mobile and for space research) and fulfills all the required parameters such as Return Loss, Radiation Patterns and VSWR.

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