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Design of a Multiband Octagonal Patch Antenna

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Abstract

Objectives: Compact and multiband microstrip patch antenna design is essential to meet the huge demand of advanced wireless applications. The objective of the study is to design a serrated structure of patch antenna which is reformed into octagonal shape is proposed to meet the objective. **Method**: Rogers RT/Duriod 8330(ε_r=2.2) is used to develop the patch of the proposed antenna. The design is simulated an analyzed by Finite Element Method (FEM) of HFSS software to obtain the output parameters called Returnloss (<-10db), Voltage Standing Wave Ratio (1<VSWR<2). **Findings:** The developed antenna is capable of handling C, Ku, K, Q and U-band applications in an efficient manner. **Applications:** This type of antenna will be useful in radar, satellite and mobile applications.

Keywords: Octogonal Patch, Returnloss, Serrated Structure, FEM, HFSS, VSWR

1. Introduction

The growth in usage of electronic devices in day to day life made changes in wireless communication systems. Increased usage of radars for communication purpose causes demand in small, multi band antennas. Due to this requirement patch antenna technology used widely even though they have narrow band radiation, poor polarization purity, low efficiency, low gain and limited power capacity. Apart from this disadvantages the patch antennas having following advantages. They are low cost, low volume structures, less weight and easy to fabricate. In Some special applications the communication systems such as radars, satellites and GPS (Global Positioning System) are going to be operated in multi frequency applications[1]. At this time the usage of number of different single band antennas can be eliminated by using single micro strip patch antenna.

The design of multiband patch antenna is simple as compared to multi frequency and broad band patch antennas. Due to this a Multiband Octagonal Patch Antenna has been designed for working in six different frequencies presented in multi band (C, Ku, K, Q and U bands). Main applications of these bands are used in terrestrial microwave communications such as radar, satellite, aircraft, mobile and space craft communications and for radio astronomy[2,3].

2. Methodology

In General, micro strip patch antenna consists of three layers: 1. Ground, 2. Substrate and 3. Patch. The ground and patch are metallic plates where the radiation occurs. Serrated structure is a method used to change the shape and size of the patch in terms of length, width and height of the substrate[4]. Serrated structures are useful to make the

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antenna compact and to be operated in multiple bands[5,6]. The dimensions of the proposed serrated structure are calculated by using following mathematical model[3].

$$w = \left(\frac{1}{2\, fr \sqrt{\mu o \varepsilon o}} \right) * \sqrt{2/(\varepsilon r + 1)} \quad (1)$$

$$L = \left(\frac{1}{2\, fr \sqrt{\mu o \varepsilon o \varepsilon eff}} \right) - 2\Delta L \quad (2)$$

$$\Delta L = 0.41h\left((\varepsilon eff + 0.3) / (\varepsilon eff - 0.258) \right) * \frac{\left(\frac{w}{h} + 0.264 \right)}{\frac{w}{h} + 0.8} \quad (3)$$

And

$$\varepsilon eff = \left(\frac{\varepsilon r + 1}{2} \right) + \frac{\varepsilon r - 1}{2\sqrt{1 + 12(h/w)}} \quad (4)$$

where, fr =resonant frequency (in Hz), L=length of patch (in mm), W=width of patch (in mm), h=height of substrate (in mm) and εr=relative dielectric constant. Basically h/w << 1for better gain and bandwidth[7,8]. With the calculated dimensions, the octagonal shape is proposed as the serrated structure as shown in Figure 1.

3. Roposed Antenna Design Parameters

The substrate used in the proposed antenna is Roger RT/Duriod 8330 with a dielectric constant εr=2.2 and height (thickness) of substrate, h=1mm. Antenna consists of a single lumped port as input excitation with 50Ω micro strip line. The measurements of designed antenna are in mm range. The whole dimension of the designed antenna is 24 x 21 x 1 (in mm). The dimensions are optimized to obtain high gain and performance. The proposed antenna model is designed using HFSS software and shown in Figure 2.

4. Simulation Results and Discussion

The Designed Octagonal micro strip patch antenna is simulated and analyzed by FEM method HFSS software.

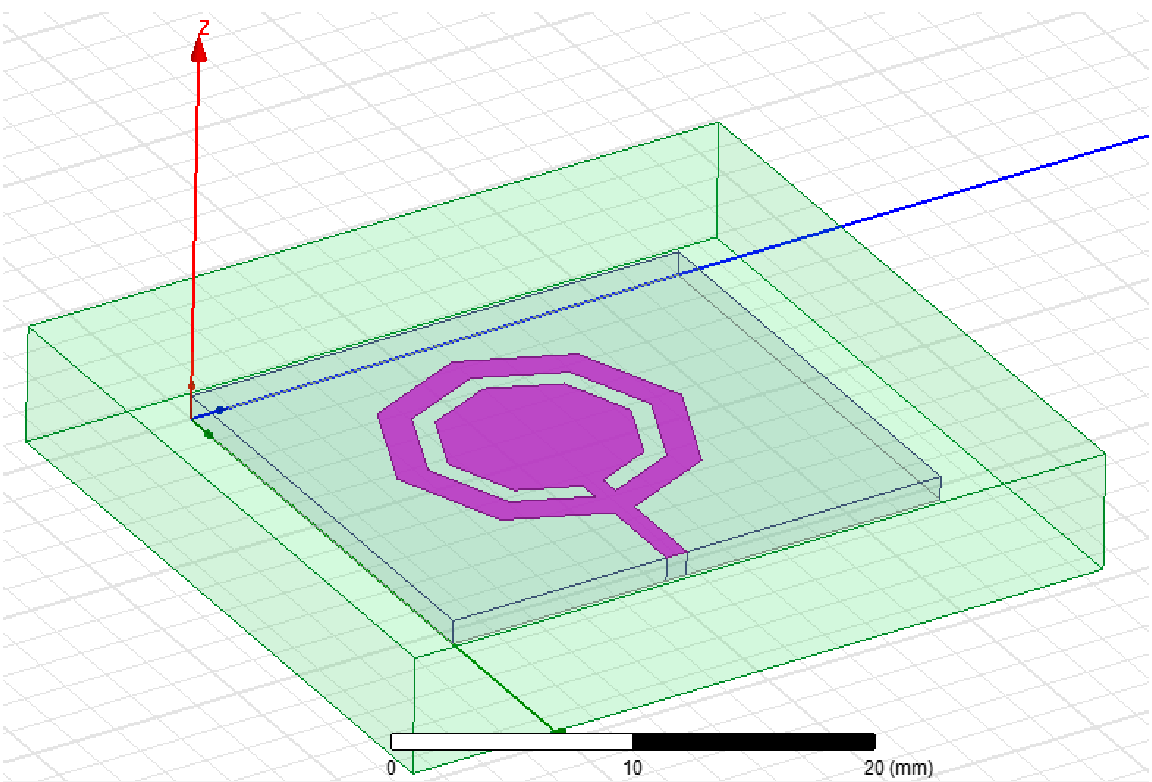

Figure 1. Octagonal patch antenna model.

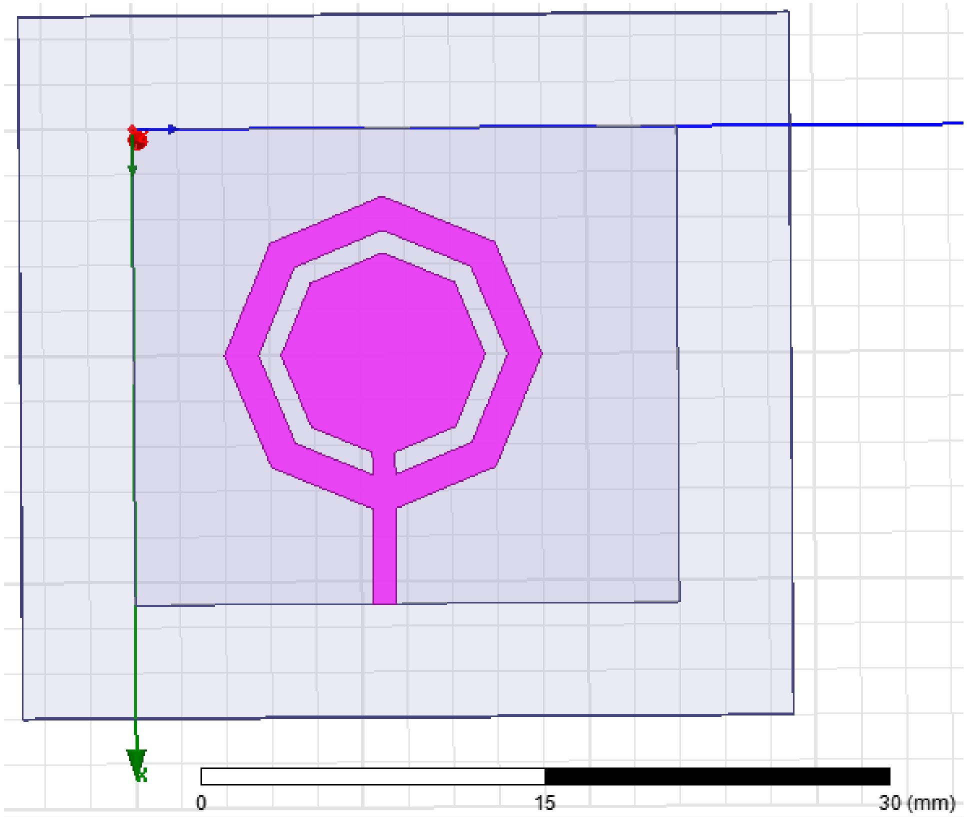

Figure 2. Proposed multi band octagonal patch antenna model top view.

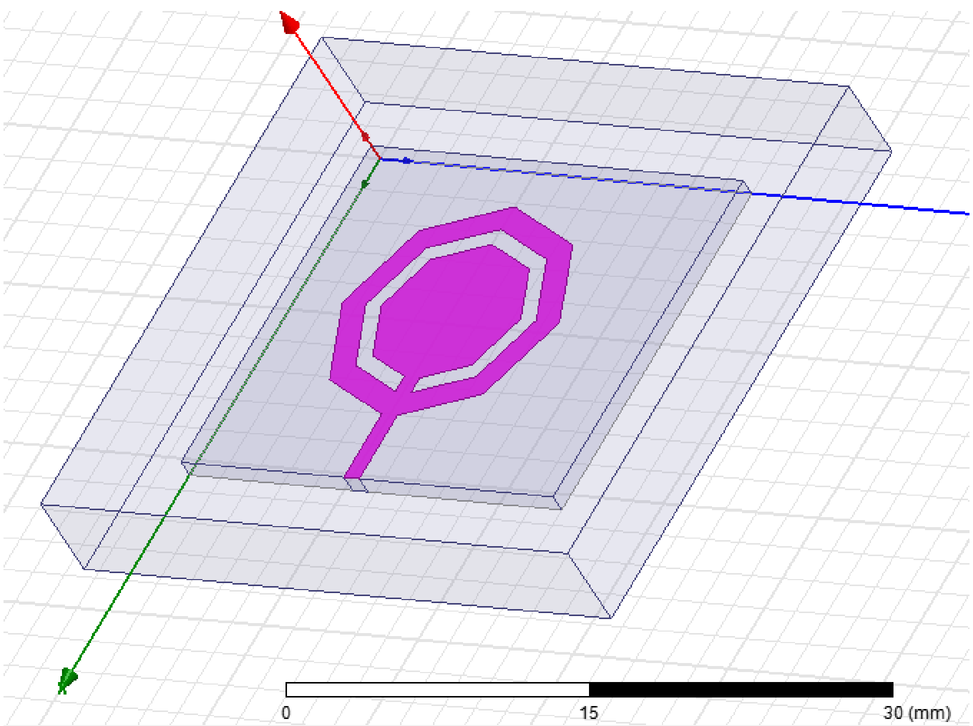

Figure 3. Proposed multi band octagonal patch antenna model side view.

To achieve better performance, slot should be introduced into patch. The slot is of 0.5 mm wide which is inserted into the patch as shown in the figure. Single slot was arranged to improve the overall performance in the proposed design as shown in Figure 3.

The overall performance is good at some individual frequencies 7.6GHz, 12.0GHz, 24.5GHz, 37.7GHz, 43.2GHz and 47.9GHz with return loss (<-10db) and VSWR(<2), Gain 8.6db. The recorded Schematics of return loss, VSWR and overall gain pattern have been recorded. The Designed octagonal patch antenna is applicable to multi band operations without any modification based on the HFSS simulated results.

This antenna is planned and optimized by HFSS. The return loss of the planned antenna is exposed in the Figure 4 and it covers C, Ku, K, Q and U-bands with frequencies of 7.6GHz, 12.0GHz, 24.5GHz, 37.7GHz, 43.2GHz and 47.9GHz and a return loss of -12.2dB, -14.0dB, -17.4dB, -17.8dB, -20.5dB and -10.9dB respectively.

The VSWR of the antenna at the frequencies 7.6GHz, 12.0GHz, 24.5GHz, 37.7GHz, 43.2GHz and 47.9GHz is 1.6, 1.4, 1.3, 1.2, 1.1 and 1.7 respectively and shown in the Figure 5. The planned antenna haves a stable gain of 8.98dB shown in Figure 6.

5. Conclusion

A multi band octagonal patch antenna is presented in this study. This antenna has a close size of 24 x 21 x 1 (in mm), which is informal to be integrated in tiny devices. Results show that the planned antenna covers C, Ku, K, Q and U-bands transmission at 7.6GHz, 12.0GHz, 24.5GHz, 37.7GHz, 43.2GHz and 47.9GHz respectively and return loss calculated at corresponding frequencies obtained are -12.2dB, -14.0dB, -17.4dB, -17.8dB, -20.5dB and -10.9dB and obtained VSWR (Voltage Standing Wave Ratio) values are 1.6, 1.4, 1.3, 1.2, 1.1 and 1.7. The simulated results have a good agreement and the planned antenna can be applicable for wireless communication applications radar, satellite, aircraft, mobile and space craft communications and for radio astronomy.

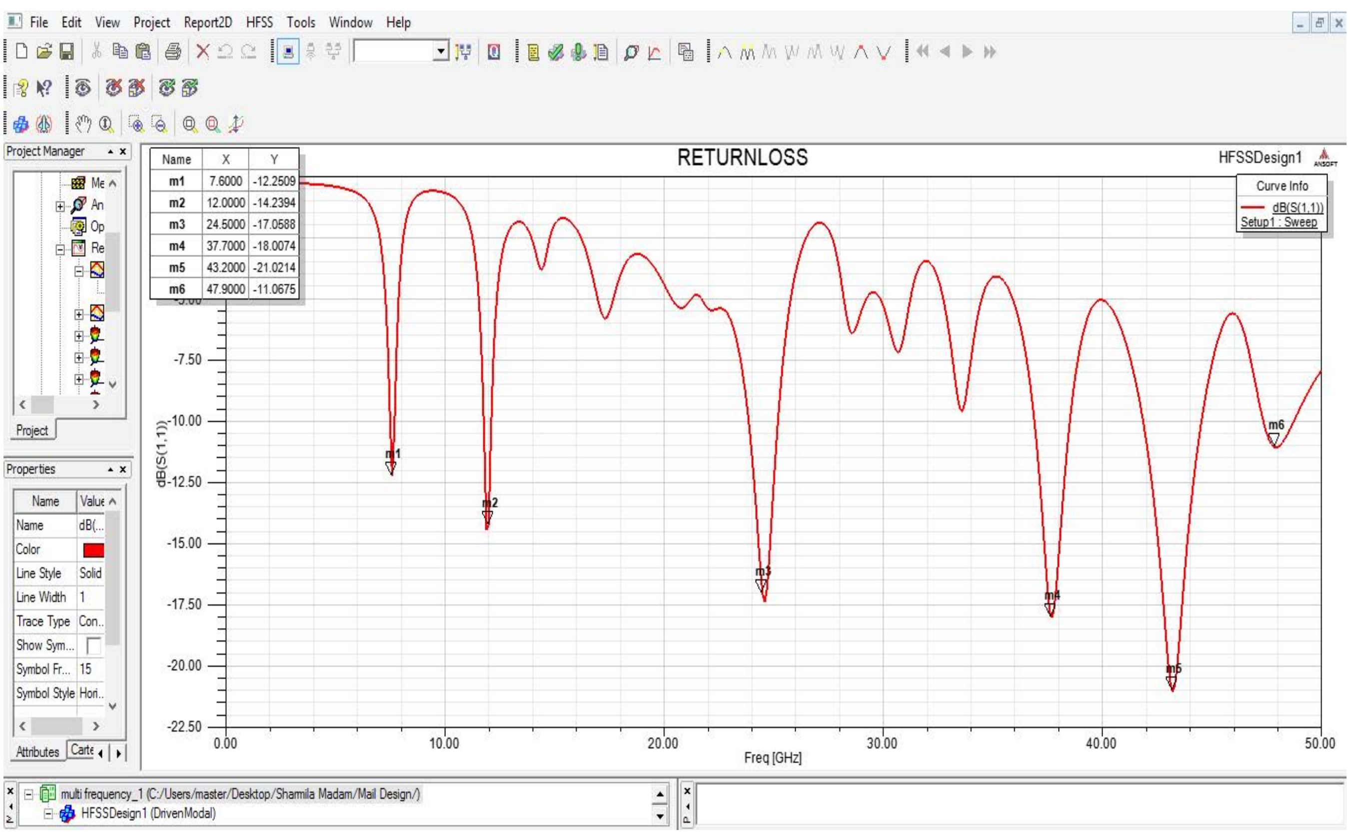

Figure 4. Return loss for proposed multi band octagonal patch antenna model.

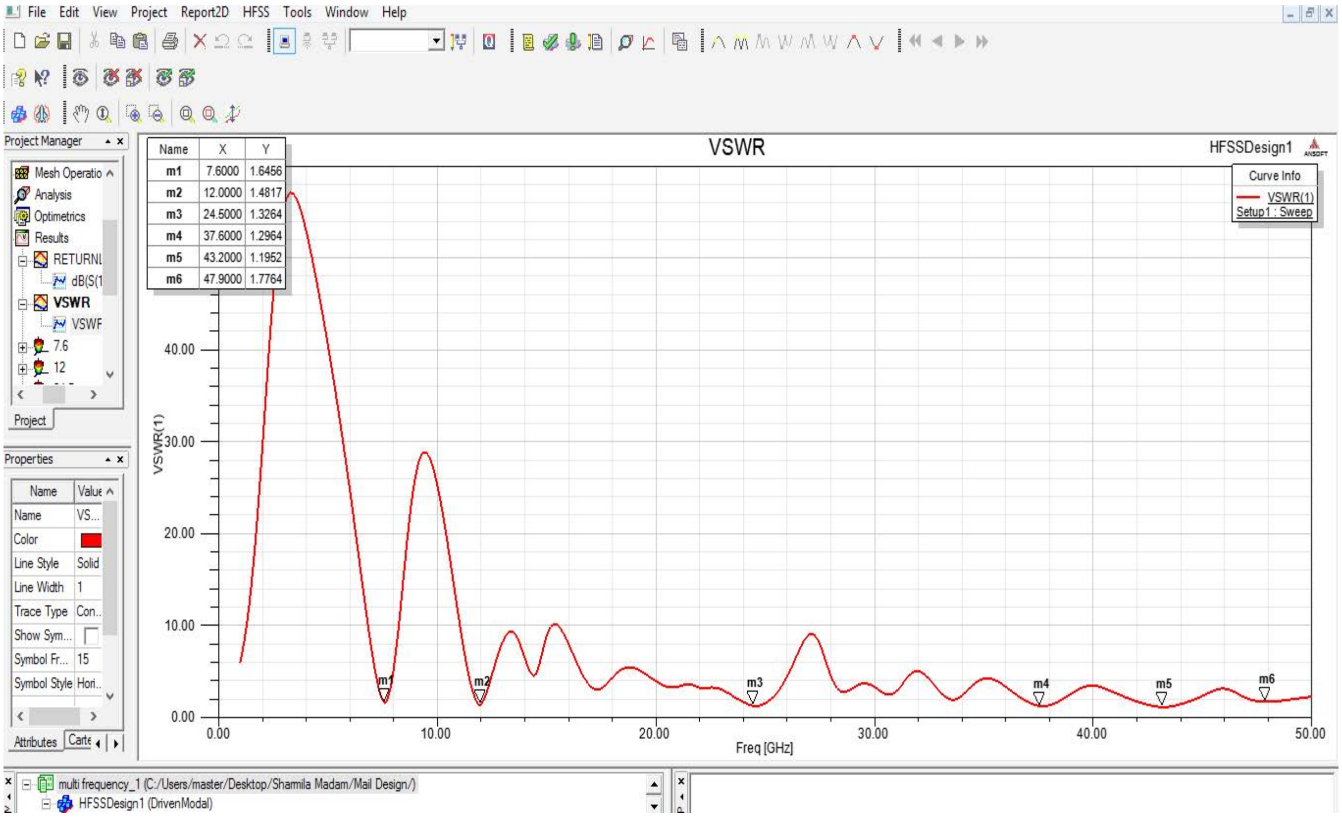

Figure 5. VSWR for proposed multi band octagonal patch antenna model.

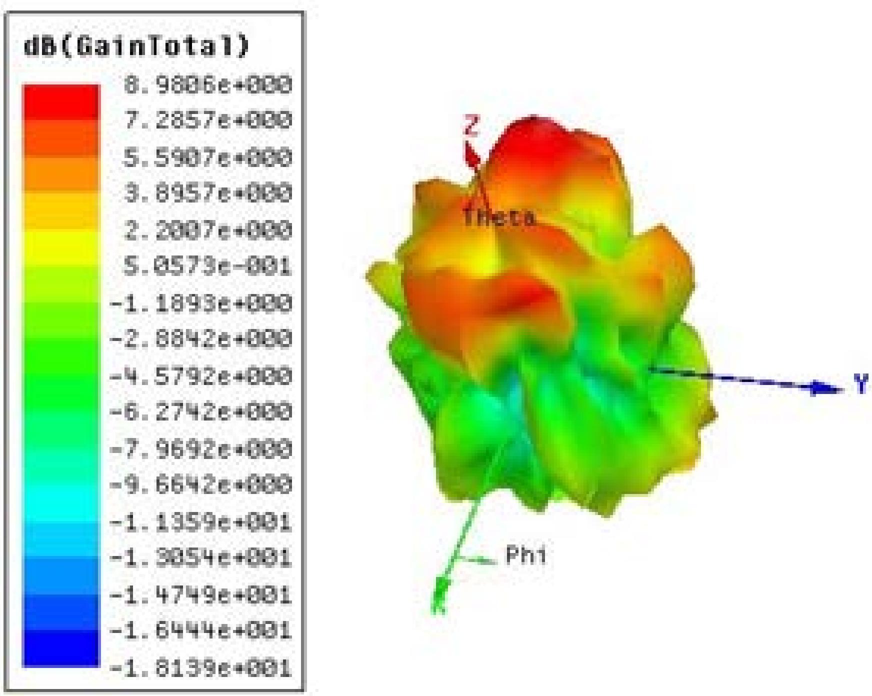

Figure 6. Overall gains for proposed multi band octagonal patch antenna model.

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