Design, Simulation & Fabrication of Multiband Octagonal Patch Antenna

D. Sharmila*, M. Purnachandra Rao, P. S. V. Subbarao, S Nagakishore Bhavanam

Abstract - Due to rapid improvement in population multi band antenna are required because of a single antenna can work for multiple applications and antenna should behave as a versatile. In this paper a new model of multiband octagonal patch antenna is developed. The main advantages of multi band antennas are its reduced size and for multiband operation. The proposed multiband octagonal patch antenna can be operated in six different frequencies and 5 frequency bands. The developed antenna is applicable to C, Ku, K, Q and U-bands transmission. The proposed antenna has been designed, simulated by using HFSS (High Frequency Structural Simulator) software 15.0 and Fabricated, analyzed by combinational Analyzer. The simulated return losses obtained are -12.2dB, -14.0dB, -17.4dB, -17.8dB, -20.5dB and -10.9dB at 7.6GHz, 12.0GHz, 24.5GHz, 37.7GHz, 43.2GHz and 47.9GHz respectively and obtained VSWR (Voltage Standing Wave Ratio) values are 1.6, 1.4, 1.3, 1.2, 1.1 and 1.7. The measured (fabricated) return losses obtained are -11.9dB, -13.9dB, -17.1dB, -17.5dB, -20.1dB and -10.6dB at 7.6GHz, 12.0GHz, 24.5GHz, 37.7GHz, 43.2GHz and 47.9GHz respectively and obtained VSWR (Voltage Standing Wave Ratio) values are 1.5, 1.4, 1.2, 1.1, 1.1 and 1.6. The obtained VSWR values are <2 (ideal case is 1). It is observed that good agreement between measured (fabricated) and simulated results. The measured results are analyzed by combinational analyzer. The proposed antenna is capable of handling C, Ku, K, Q and U-band applications in an efficient manner.

***Index Terms*: Octagonal patch antenna, C-band, Ku-band, K-band, Q-band, U-band, HFSS, Return loss, VSWR.**

I. Introduction

A multiband antenna is that, the designed antenna can operate on several bands. Due to rapid population in world a single antenna can act as a versatile and it may have lower than average gain or physically larger in compensation. The development in use of electronic gadgets in everyday life rolled out improvements in remote correspondence frameworks. Expanded utilization of radars for correspondence reason causes request in little, multi band receiving wires. Because of this prerequisite Patch radio wire innovation utilized generally despite the fact that they have slender band radiation, poor polarization immaculateness, low productivity, low gain and restricted power limit. Aside from this impediments the fix reception apparatuses having following favorable circumstances. They are ease, low volume structures, less weight and simple to create. In Some extraordinary applications the correspondence frameworks, for example, radars, satellites and Global Positioning System will be worked in multi recurrence applications. Right now the utilization of number of various single band reception apparatuses can be dispensed with by utilizing single small scale strip fix radio wire. 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.

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II. Antenna Design

Micro strip patch antenna consists 3 layers ground, substrate and patch. The ground and patch are metallic plates where the radiation occurs.

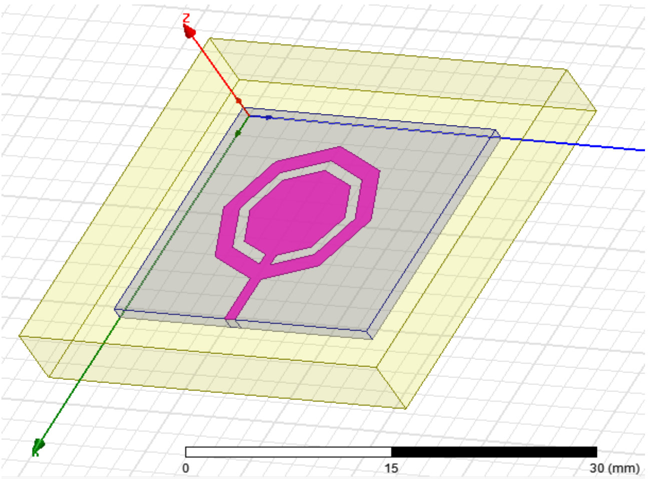

Fig.1: Proposed Antenna Model

The substrate used is Roger RT/Duriod 8330 with a dielectric constant $\varepsilon r=2.2$ 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 overall dimension of the designed antenna is 24 x 21 x 1 (in mm).

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The Designed multi frequency octagonal patch antenna has been shown in fig.2. The overall performance is good at some individual frequencies -12.2dB, -14.0dB, -17.4dB, -17.8dB, -20.5dB and -10.9dB at 7.6GHz, 12.0GHz, 24.5GHz, 37.7GHz, 43.2GHz and 47.9GHz respectively and obtained VSWR (Voltage Standing Wave Ratio) values are 1.6, 1.4, 1.3, 1.2, 1.1 and 1.7. These results are drawn by using HFSS.

The measured (fabricated) return losses obtained are -11.9dB, -13.9dB, -17.1dB, -17.5dB, -20.1dB and -10.6dB at 7.6GHz, 12.0GHz, 24.5GHz, 37.7GHz, 43.2GHz and 47.9GHz respectively and obtained VSWR (Voltage Standing Wave Ratio) values are 1.5, 1.4, 1.2, 1.1, 1.1 and 1.6. The obtained VSWR values are <2.

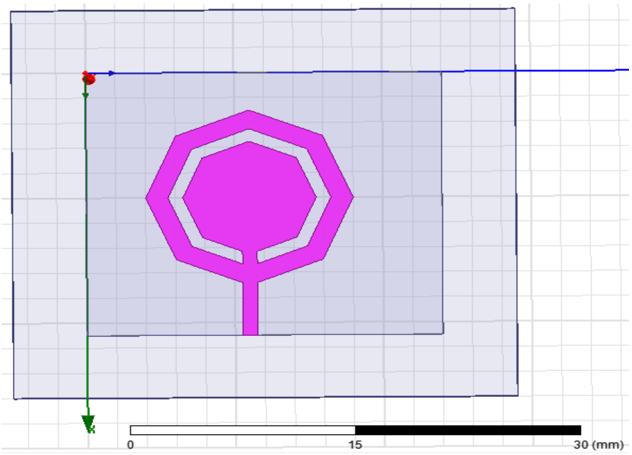

Fig.2 Proposed Multi Band Octagonal Patch Antenna Model

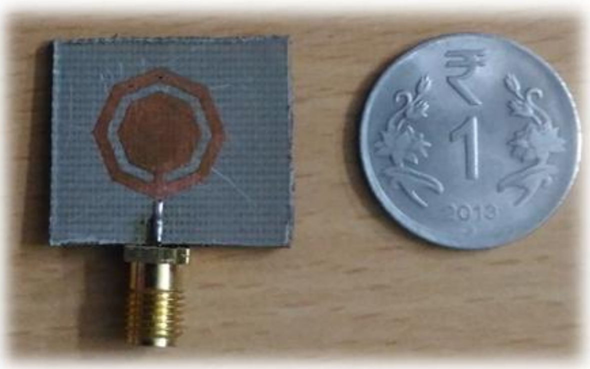

Fig.3 Fabricated Multi Band Octagonal Patch Antenna

The antenna is designed using HFSS (High Frequency Structural Simulator) Software 15.0. For an efficient gain, the width of octagonal patch antenna becomes

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

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

Where

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

And

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

Where, f_r =resonant frequency (in Hz), L=length of patch (in mm), W=width of patch (in mm), h=height of substrate (in mm) and ε_r=relative dielectric constant. Basically h/w << 1for better gain and bandwidth.

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 were arranged to improve the overall performance in the proposed Design.

III. HFSS SIMULATION RESULTS

This antenna is designed and optimized with the aid of Ansoft HFSS ver. 15.0.

A. Return Loss:

S11 discusses how much power is reflected from the radio wire, and in this way is known as the reflection coefficient or return misfortune. The return loss of the planned antenna is shown in the Fig. 4 and it can 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.

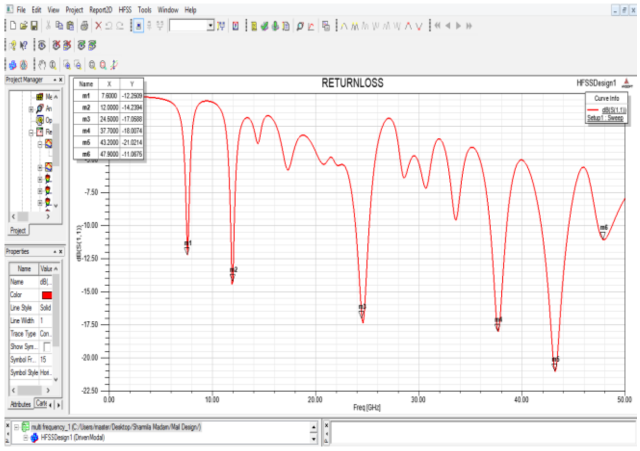

Fig.4 Return loss for Proposed Multi Band Octagonal Patch Antenna Model

B. VSWR:

VSWR is a measure of how effectively radio recurrence control is transmitted from a power source, through a transmission line, into a heap. The VSWR values are shown in below Figure.5.

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 which signifies that a decent impedance matching is attained and maximum power is transferred to the antenna.

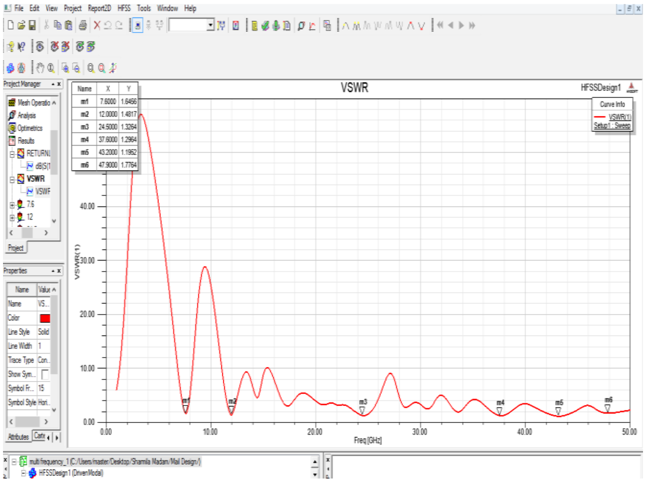

Fig.5 VSWR for proposed multi band octagonal patch Antenna model

C. GAIN:

It is defined as the ratio of the power delivered by the antenna from a source on the antenna's beam axis to the power delivered by a lossless antenna. The proposed antenna is having a stable gain of 8.98dB shown in Fig.6 and the individual gains are shown in figures from 7-12.

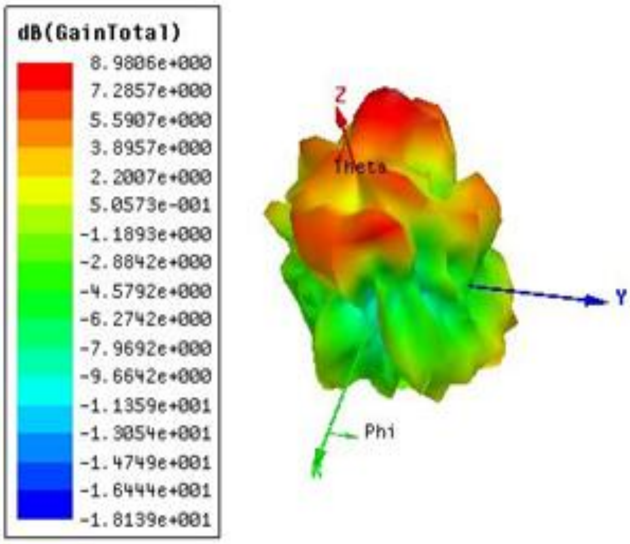

Fig.6 Overall gain for Proposed Multi Band Octagonal Patch Antenna Model

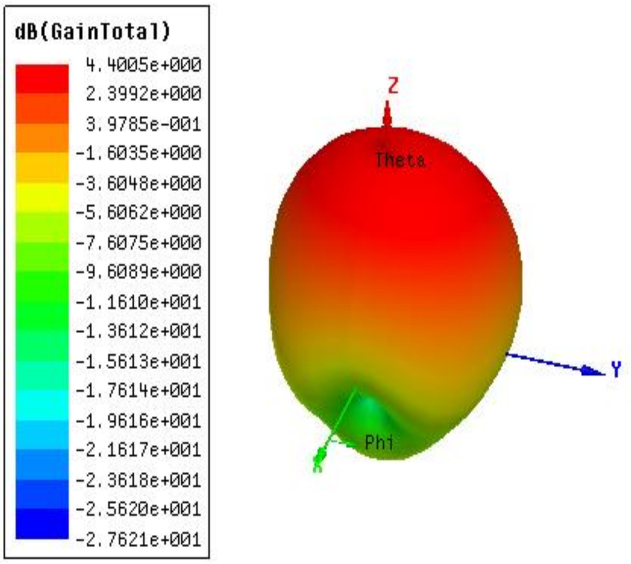

Fig.7 Gain at 7.6 GHz

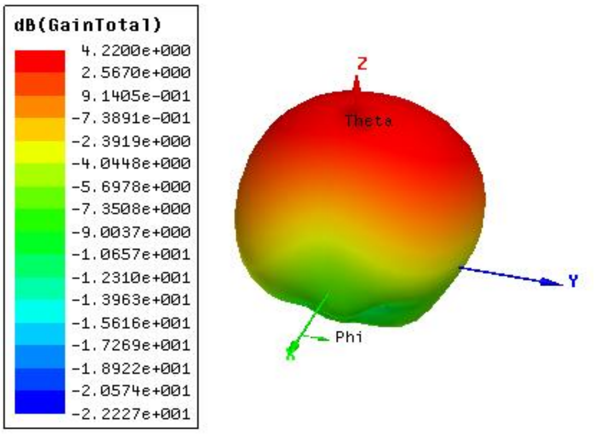

Fig.8 Gain at 12.0 GHz

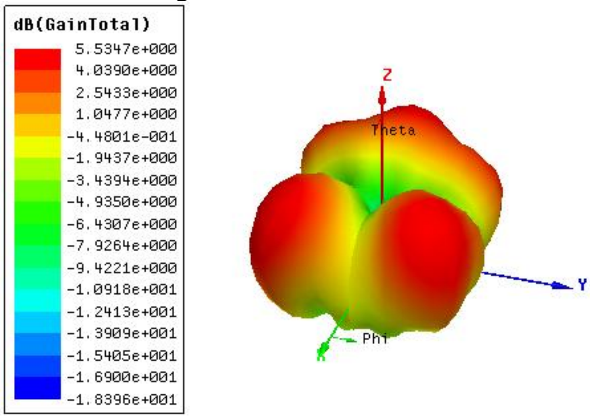

Fig.9 Gain at 24.5 GHz

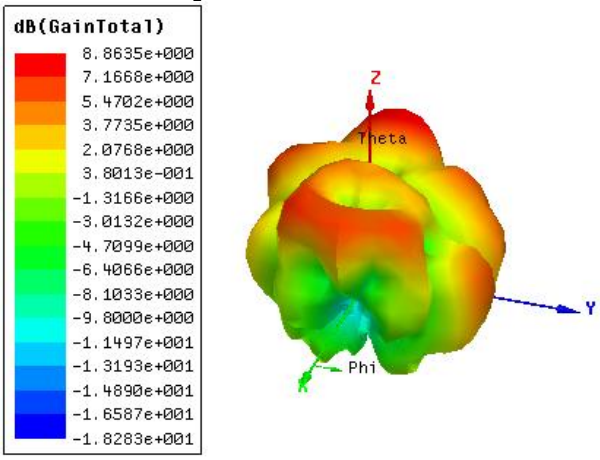

Fig.10 Gain at 37.7 GHz

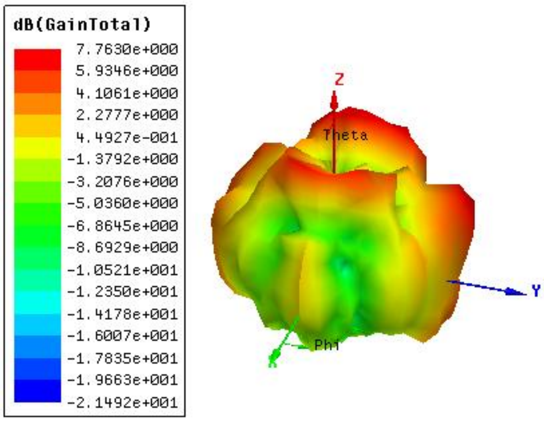

Fig.11 Gain at 43.2 GHz

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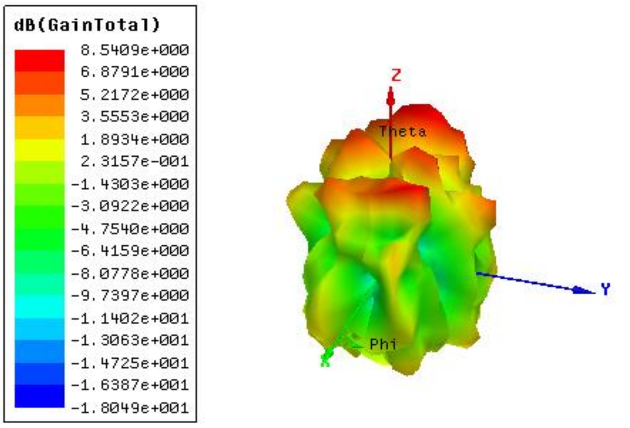

Fig.12 Gain at 47.9 GHz

IV. MEASURED RESULTS

The measured (fabrication) return loss, VSWR results have been shown below. Thisresults conclude that the multifrequency antenna is applicable to multiband operations and it is observed that good treaty between measured and simulated results. The measured results are analyzed by combinational analyzer.

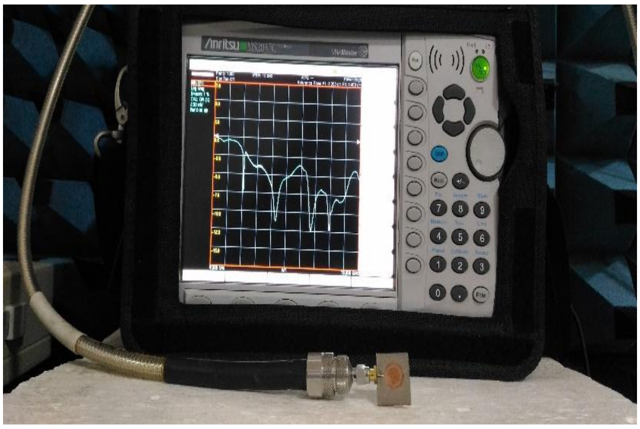

Fig.13 Measured Results Analyzed By Combinational Analyzer

The measured (fabricated) return losses obtained are -11.9dB, -13.9dB, -17.1dB, -17.5dB, -20.1dB and -10.6dB at 7.6GHz, 12.0GHz, 24.5GHz, 37.7GHz, 43.2GHz and 47.9GHz respectively and obtained VSWR (Voltage Standing Wave Ratio) values are 1.5, 1.4, 1.2, 1.1, 1.1 and 1.6. The obtained VSWR values are <2. Shown in Fig. 14 & Fig.15.

Fig 14 Returnloss for Proposed Multi Band Octagonal Patch Antenna Model

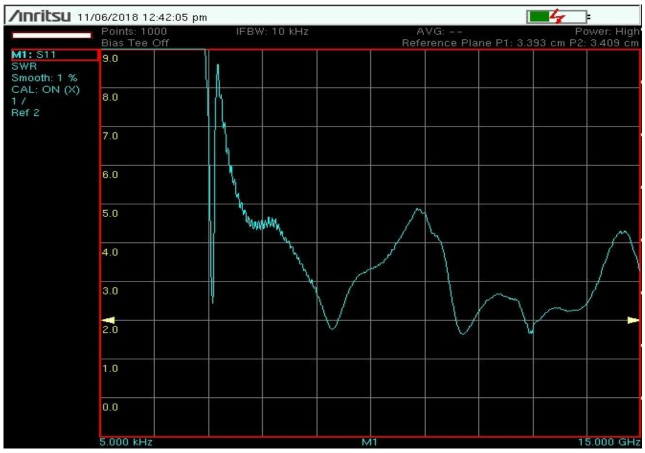

Fig 15 Measured VSWR for Proposed Multi Band Octagonal Patch Antenna Model

It is observed that good agreement between measured (fabricated) and simulated results. The measured results are analyzed by combinational analyzer. The proposed antenna is capable of handling C, Ku, K, Q and U-band applications in an efficient manner.

V. RESULT ANAYSIS

The measured results are compared with simulation results and observed that good agreement between measured (fabricated) and simulated results. The below tables represents the comparison.

Table: 1 Simulated Results

S. No	Frequency in GHz	Return loss in dB	VSWR	Gain in dB	Band
1	7.6	-12.20	1.6	4.4	C
2	12.0	-14.00	1.4	4.2	Ku
3	24.5	-17.40	1.3	5.5	K
4	37.7	-17.81	1.2	8.8	Q
5	43.2	-20.57	1.1	7.7	U
6	47.9	-10.90	1.7	8.5	U

Table: 2 Measured Results

S. No	Frequency in GHz	Return Loss in dB	VSWR	Band
1	7.6	-11.90	1.5	C
2	12.0	-13.90	1.4	Ku
3	24.5	-17.10	1.2	K
4	37.7	-17.50	1.1	Q
5	43.2	-20.10	1.1	U
6	47.9	-10.60	1.6	U

VI. CONCLUSION

The developed multi band octagonal patch antenna is of compact size which is capable in operating the antenna in five bands C-band, Ku-band, K-band, Q-band and U bands. The proposed octagonal patch antenna can be used for VSAT applications, Intelsat, INSAT, AsiaSat, Galaxy in C-band, Military requests like missile management, marine radar, air-borne tracking for X-band. Ku band is part into many sectors separated into topographical areas, as the ITU determines.

Fixed satellite service (FSS) like television transmission, Broadcast Satellite Service (BSS) like telecommunication, wireless communication and Satellite altimetry. The proposed antenna has been designed, simulated by using HFSS 15.0 and measured by using combinational analyzer.

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