Design of Spiral Antenna for Multiband Applications

J Lavanya, S Nagakishore Bhavanam, Vasujadevi Midasala, M Sekhar

Abstract*: Present communication requires antennas with multiple band characteristics for supporting different wireless applications. The proposed antenna model is designed and simulated with the help of HFSS (High Frequency Structure Simulator) of 14.0 version. Microstrip antenna is designed by the Rogers/duroid 5880 (tm) substrate with a dielectric constant ($\in_r$) of 2.2 having 0.6mm thickness. The proposed design composed of octagonal spiral antenna with a feed width of 1 mm using the Microstrip feeding technique. The exhibited Return loss are -32.4dB, -13.3dB, -20.6dB,-15dB, -18.8dB, -12dB, -12.3dB, -13.3dB at the frequencies are 31.9GHz, 34.8GHz, 35.7GHz, 36.8GHz, 43GHz, 46.8GHz, 59.3GHz, 64.3GHz with VSWR (voltage standing wave ratio) between the acceptable range of 1 and 2. The observed results are applicable in Ka-band, Q-band, and U-band respectively.

***Index Terms*: Octagonal Spiral antenna, HFSS, VSWR, Return loss.**

I. INTRODUCTION

Microstrip antennas are popular in the 1970's. Today they are mostly used for government and commercial applications. Microstrip antennas are very popular it is replacing many other antennas whether it is Mobile, satellite, aeroplane, Missile majority of places microstrip antenna are used. Defense communication requires high performance and rugged antenna structures. These are extremely compatible in hand held devices such as cellular phones and pagers due to their advantages such as light weight, small size, less cost and fabrication is easy.

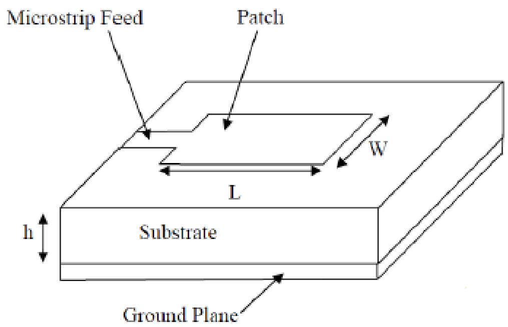

Fig.1 Geometry of the Microstrip patch antenna

But Even though they have some disadvantages like narrow Bandwidth, low gain, and low efficiency. Generally microstrip antenna (or) patch antenna is composed of a Ground, Substrate and a radiating patch. The geometry of the Microstrip patch antenna is shown in fig.1. The radiating patch can be of different shapes and sizes with the demand of applications and the size compatibility. Mostly preferred structures are given in the fig.2.

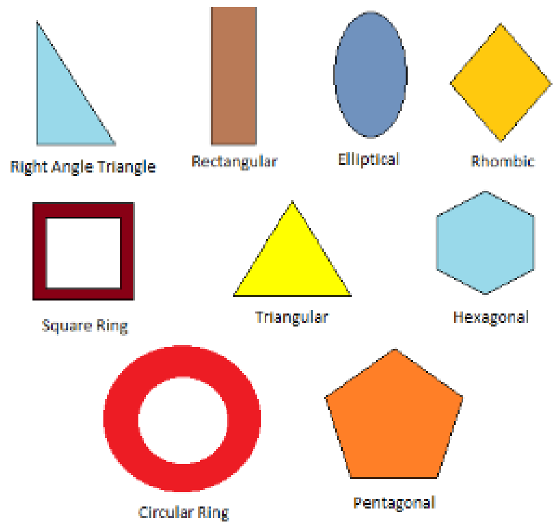

Fig.2 Different antenna shapes

With the development growth in the present technology requires the antennas with supporting different bands in an efficient manner. Increasing the generation's makes the single antenna can only handle all the operations. This comes to the topic of multiband antenna. Global system for mobile (GPS), Global positioning system (GSM), Radars to detect air crafts, Track/guide supersonic missiles are the applications accomplish the path to make the spiral designs. One of the important parameter of spiral antenna design is the Number of turns. It is found to that use three turns work well. For keeping the current reflections at the end of the spiral arms use resistive loads. Spiral antennas are widely used in the defense industry, where very wideband antennas that do not take up much space are needed.

II. ANTENNA DESIGN

In this paper the Microstrip patch antenna is developed by using the Rogers/duroid 5880 (tm) with the thickness of h= 0.6 mm and the dielectric constant $\in_r$ = 2.2.

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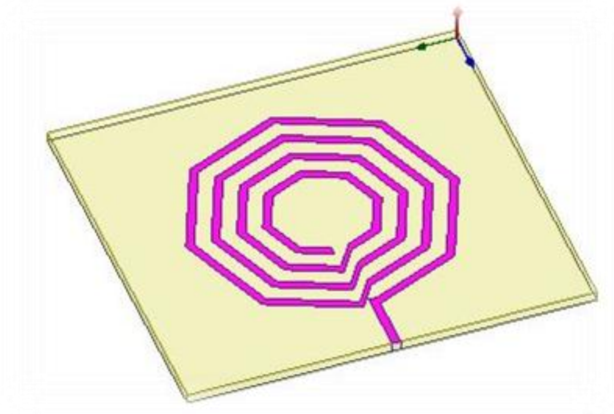

Fig.3- 3D view of the octagonal spiral antenna

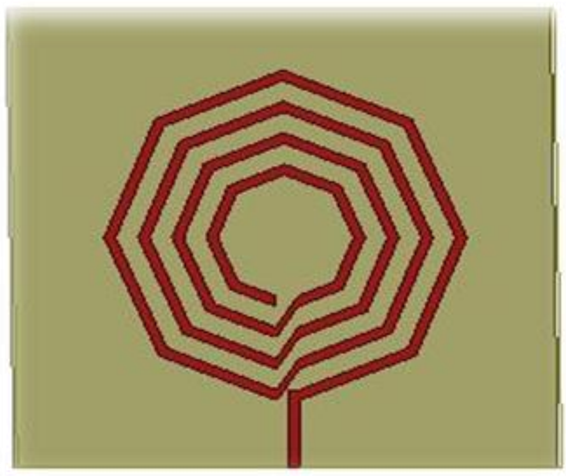

Fig.4- Top view of the Proposed design

Substrate can be of the dimensions are length= 24 mm, width= 22 mm, and h=0.6 mm by considering the design equations. Ground and the radiating patch choosen to be Perfect metallic conductors and Microstrip feeding is employed by taking the Lumped port of 50 impedance for the design. The Proposed design model is shown in below fig.3 and fig.4.

A. Design Procedure

Step 1: Initially choosing the resonant frequency f_r

thickness (h) and $\in_r$

Step 2: Width of the patch is calculated by the equation

$$w = \frac{c}{2 f_r}\sqrt{\frac{2}{\in_r + 1}} \quad (1)$$

Step 3: And then the length is given by

$$L = L_{eff} - 2\Delta L \quad (2)$$

$$L_{eff} = \frac{c}{2 f_r \sqrt{\in_{reff}}} \quad (3)$$

$$\in_{reff} = \frac{\in_r + 1}{2} + \frac{\in_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}} \quad (4)$$

Step 4: Calculating the substrate dimensions like this Ls= L+6h and Ws= W+6h

Step 5: Octagonal patch element radius can be obtained from the circular patch with eight segments. Equation for the circular patch is given by

$$a = \frac{F}{\left\{1 + \left(\frac{2h}{\pi \in_r F}\right)\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{1/2}} \quad (5)$$

$$a_e = a\left\{1 + \left(\frac{2h}{\pi a \in_r}\right)\left[\ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{1/2} \quad (6)$$

Where

Where W= width of the patch
c= velocity of free space
$\in_r$= Dielectic constant of the substrate
a= Actual radius of the patch
h= height of the substrate
a_e=effective radius of the circular patch
L= length of the patch

B. Design parameters

Substrate length (Ls)	24mm
Substrate width (Ws)	22mm
Dielectric medium	2.2
Thickness of the medium (h)	0.6mm
Octagonal patch width	0.5mm
Microstrip feed width (Wf)	0.5mm
Radius of the Spiral element	8mm

III. SIMULATION RESULTS

The proposed octagonal spiral antenna is designed using the HFSS (High Frequency Structure Simulator) software 14.0 version. HFSS is an commercial tool for antenna design, wave guides, Transmission lines including filters. In fact observed parameters are Returnloss, VSWR, and total gain schematics are shown below. These design is operated in Eight resonant frequencies with Ka-band, Q-band, and U-band applications.

A. Returnloss

Returnloss is used in microwave circuits where impedance matching is important. The propagation of a signal that is reflected back as a result of impedance mismatch. For perfect matched transmission line returnloss is zero. Normally calculated as follows

$$RL = -20\log_{10}|\Gamma|(dB)$$

The simulated results S11 of the designed antenna are -32.46 (dB), -13.3(dB), -20.64(dB), -15.18(dB), -18.8(dB), -12.05(dB), -12.3(dB), and -13.3(dB) at the 31.9GHz, 34.8GHz, 35.7GHz, 36.8GHz, 43GHz, 46.8GHz, 59.3GHz, and 64.3GHz respectively.

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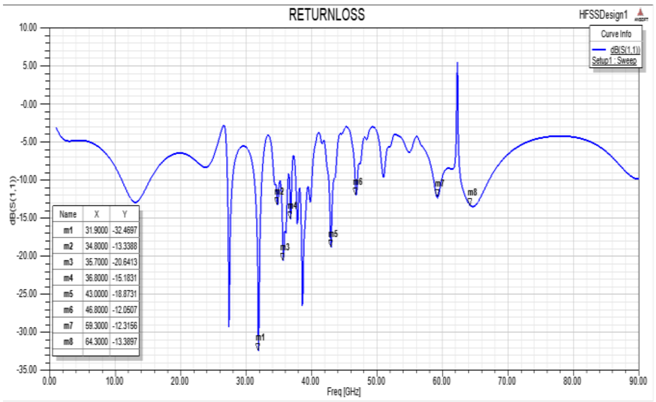

Fig.5 Simulated returnloss of the Proposed design

B. VSWR

The ratio of the Maximum amplitude of the transmission lines voltage to the minimum amplitude of transmission line voltage gives the VSWR, this means the degree of mismatch at the load.

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$$

Simulated voltage standing wave ratio results are 1.04, 1.54, 1.20, 1.42, 1.25, 1.66, 1.63, and 1.54 at 31.9GHz, 34.8GHz, 35.7GHz, 36.8GHz, 43GHz, 46.8GHz, 59.3GHz, and 64.3GHz respectively.

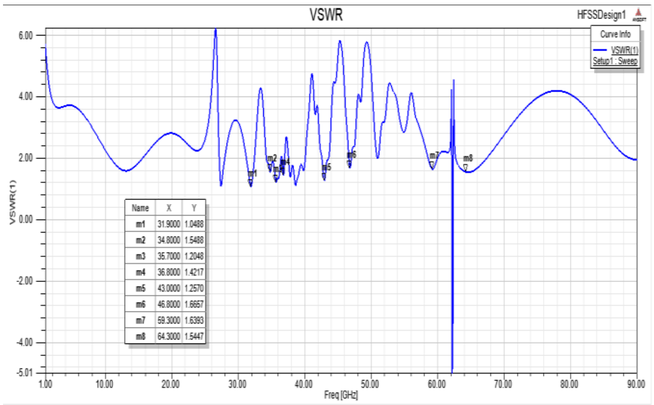

Fig.6 Simulated VSWR of the Proposed design

C. Gain

It says that amount of power is transmitted in the direction of peak radiation to that of Isotropic source.

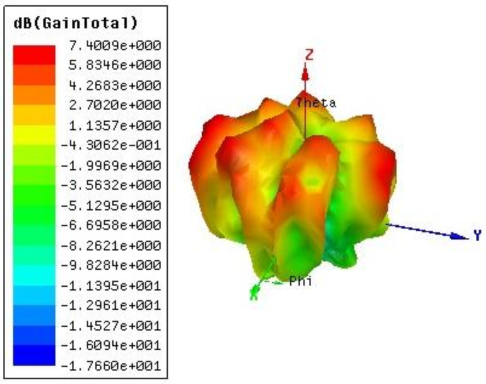

Fig.7 Simulated Total gain of the proposed design

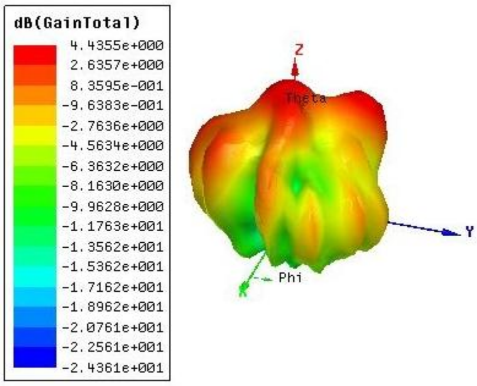

Fig.8 Gain of the antenna at 31.9GHz

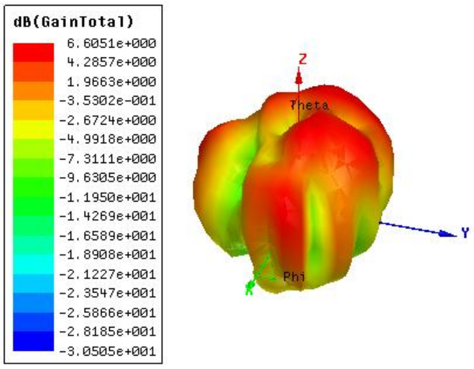

Fig.9 Gain of the antenna at 34.8GHz

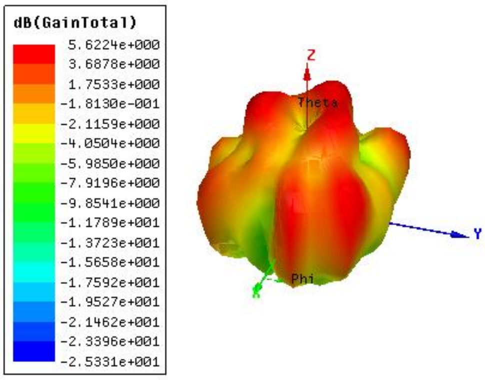

Fig.10 Gain of the antenna at 35.7GHz

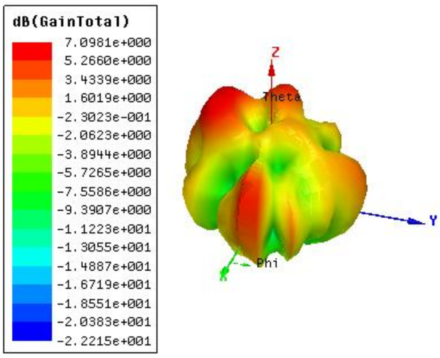

Fig.11 Gain of the antenna at 36.8GHz

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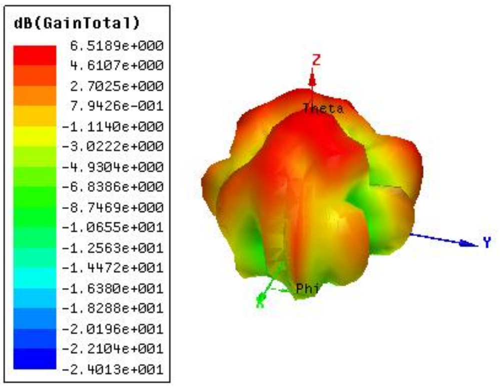

Fig.12 Gain of the antenna at 43GHz

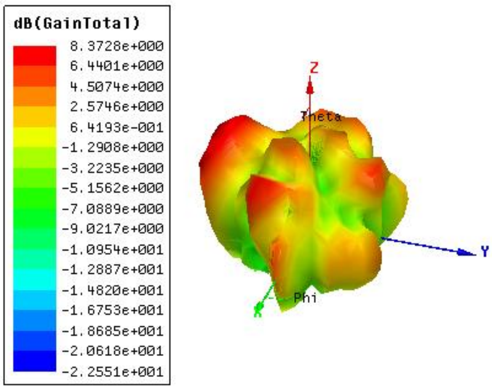

Fig.13 Gain of the antenna at 46.8GHz

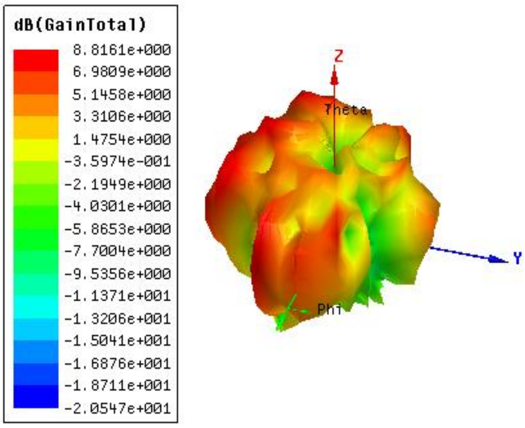

Fig.14 Gain of the antenna at 59.3GHz

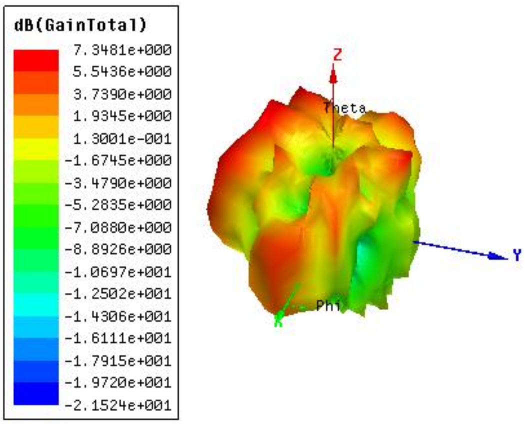

Fig.15 Gain of the antenna at 64.3GHz

Table 1: Comparison table of simulation results of proposed antenna design

S.No	Frequency (GHz)	S11(dB)	VSWR	Gain (dB)
1.	31.9	-32.46	1.048	4.43
2.	34.8	-13.3	1.548	6.6
3.	35.7	-20.64	1.204	5.6
4.	36.8	-15.18	1.421	7.0
5.	43	-18.8	1.257	6.51
6.	46.8	-12.05	1.666	8.3
7.	59.3	-12.31	1.639	8.8
8.	64.3	-13.38	1.544	7.3

The above table represents the S11, VSWR and gain values in detail manner.

IV. CONCULSION

The Proposed octagonal spiral antenna is small volume compact antenna to be capable of operating Multiple bands such as Ka-band, Q-band, and U-band. The designed antenna is mostly preferred to applicable in Fixed satellite services, Deep space research, terrestrial microwave communications radio astronomy studies, radar and other kind of researches. The designed octagonal spiral Microstrip patch antenna can be analyzed by using the HFSS software 14.0 version.

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