



## Design and development of Tappered Spiral Helix Antenna for Broadband Applications

D.Arun Kumar

Assistant Professor, ECE Department, GMRIT, RAJAM  
[arundhupam@gmail.com](mailto:arundhupam@gmail.com)

**Abstract**— The Aim of the paper is to design and develop a tapered spiral helix antenna covering the frequency range 1-18GHz. Tappered spiral helix antenna is a compact state-of-the-art circularly polarized antenna, which works over multi-octave frequency bandwidth(1-18GHz). The antenna size has been reduced by 50 percent with respect to conventional spiral antenna used for same frequency band. This antenna adequately satisfies all of the generally standardized physical constraints and limitations placed upon airborne platforms.

The spiral helix consists of a spiral antenna with a spiral radiator, the balanced to unbalanced (balun) transformer, backing cavity and a helical antenna where the outer ends of spiral antenna are terminated with a helix. The helix is placed with its axis at  $90^\circ$  to the spiral lies behind it is designed to produce circularly polarized radiation over a range from 1-18GHz. In general spiral helix antenna provide frequency coverage unattainable in a single device.

The design of spiral circuit will be done using a computer generated program in MATLAB software. The design of helix is done in CST studio suite software and finally spiral and helical antennas are combined as single antenna and simulated in CST.

The simulated results are compared with aimed specifications.

**Keywords**— CST, BALUN, POLARIZATION, TAPPERED, ECM, ECCM.

### I. INTRODUCTION

Defense systems require antennas having wide bandwidth capable of receiving signals coming from any direction with any polarization in the absence of priori information about the threat signal. The requirements become more stringent for airborne applications where weight, size and volume are at premium. The bandwidth of conventional antennas is limited because the electrical aperture dimensions change with change of operating frequency. The size of the spiral antenna is determined by lowest frequency of operation. Cavity backed spiral antennas can be used extensively for airborne systems

because of their inherent characteristics of broadband, circular polarization, compact size, lightweight and flush mounting ability.

The spiral helix antennas maintain consistent gain and input impedance over wide bandwidths with circular polarization and hence a wide range of applications exists, ranging from military surveillance, ECM ECCM to numerous commercial and private uses including consolidation of multiple low gain communication antennas on moving vehicles. For airborne platform size and weight are at premium. Many applications such as direction-finding systems or reflector feeds require a broadband antenna element that provides orthogonal senses of polarization. Polarization capability such as vertical and horizontal or right and left circular from a common aperture with coincident phase centers is of particular interest. Therefore, we are going for the design of spiral antenna which is similar in size to the spiral element, has a beam width and gain approximately the same as the spiral, but provides two orthogonal senses of polarization

### II. DESIGN OF PRINTED CIRCUIT

Lowest frequency of operation	= 2GHz
Highest frequency of operation	= 18GHz
Largest round diameter	= $\lambda_{low\ freq} / \Pi = 47.7\text{mm}$
15% of the theoretical size	= 7.15mm
Actual diameter of the largest round diameter	= 63mm
Smallest round diameter	= $\lambda_{high\ freq} / \Pi = 5.30\text{mm}$
10% of actual size	= 0.530mm

Actual size of smallest round = 5.355mm  
 Number of turns = 24  
 For one arm number of turns = 4

### III. DESIGN OF HELIX

The optimized design parameters for helical antenna with cylindrical ground conductor are given below.

- Number of turns = 5.5
- Pitch angle = 7
- Radius change = -0.8
- Polygon radius = 0.5
- Start helix radius = 17
- Radius ratio = 0.65
- Angle =  $5.5 \times 360$
- Ground plane Diameter = 56.2
- Radius = 30

#### A. MEASURED RESULTS

TABLE 1 GAIN OF SPIRAL HELIX ANTENNA

S.No	Frequency(GHz)	Gain(dB)
1.	1	1.11
2.	2	4.598
3.	8	2.765
4.	18	3.899

TABLE 2 BEAM WIDTH OF SPIRAL HELIX ANTENNA

S.No	Frequency(GHz)	VP(Degrees)
1.	1	93.6
2.	1.2	87.3
3.	2	94
4.	4	105
5.	8	86.4
6.	18	98

TABLE 3 SQUINT OF SPIRAL HELIX ANTENNA

S.No	Frequency(GHz)	Squint (deg)
1.	1	1
2.	2	0
3.	4	5
4.	9.5	5
5.	14	3
6.	18	-6

TABLE 4 AXIAL RATIO OF SPIRAL HELIX ANTENNA

S.No	Frequency(GHz)	Axial Ratio
1.	1	2.7
2.	2	0.2
3.	4	0.8
4.	9.5	0.2
5.	14	0.1
6.	18	0.5

The measured VSWR and radiation pattern with respect to frequency are illustrated in the following figures.

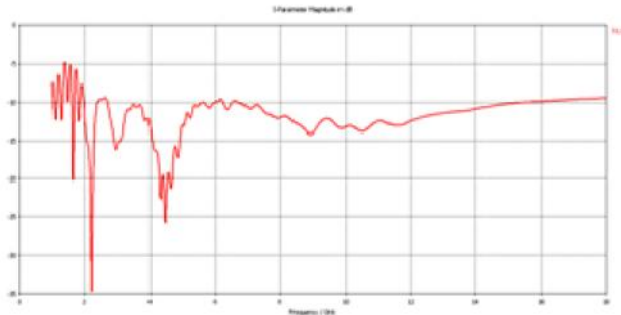


Fig. 1 VSWR measurement of Spiral Helix Antenna 1-18 GHz

The figure 1 represents the VSWR pattern of spiral helix antenna 1-18 GHz. From this diagram measured Maximum VSWR is 5.

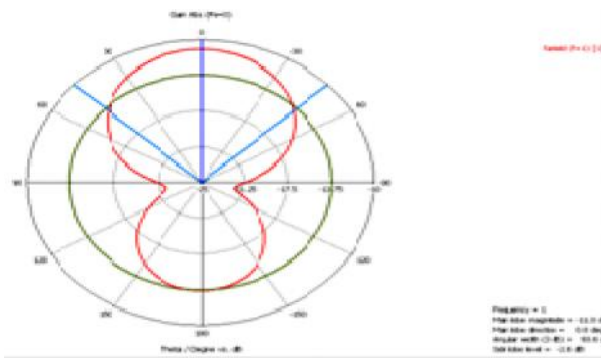


Fig. 2 Radiation Pattern of Spiral Helix Antenna at 1 GHz

whereas Fig. 3 shows an example of an image The figure 2 represents the radiation pattern at 1 GHz. From this diagram measured gain is 1.11dB, beam width is 94°, and squint is 1°.

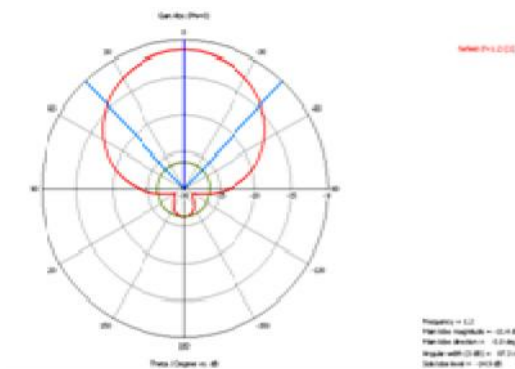


Fig.3 Radiation Pattern of Spiral Helix Antenna at 1.2 GHz

The figure 3 represents the radiation pattern at 1.2 GHz. From the diagram shown above the measured gain is -1.43 dB, beam width is 87.3°.

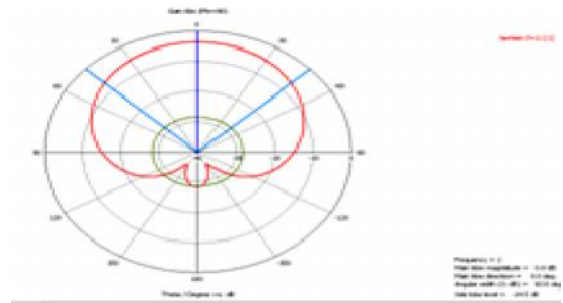


Fig 4 Radiation Pattern of Spiral Helix Antenna at 2 GHz

The figure 4 represents the radiation pattern at 2 GHz. From the diagram shown above the measured gain is 4.598 dB, beam width is 94°, squint is 0° and axial ratio is 0.2.

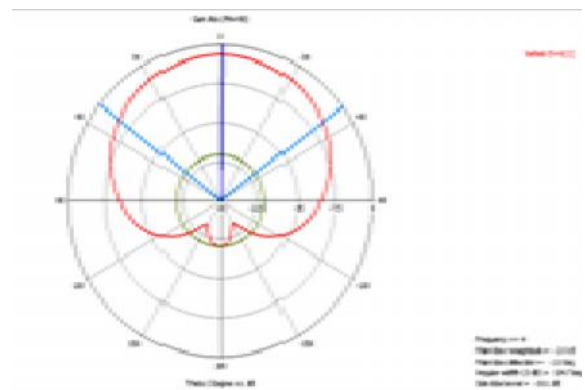


Fig 5. Radiation Pattern of Spiral Helix Antenna at 4 GHz

The figure 5 represents the radiation pattern at 4 GHz. From the diagram shown above the beam width is 105°, squint is 5° and axial ratio is 0.8.

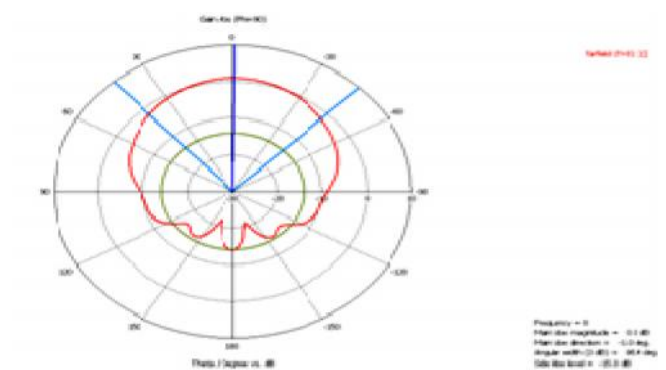


Fig 6. Radiation Pattern of Spiral Helix Antenna at 8 GHz

The figure 6 represents the radiation pattern at 8 GHz. From the diagram shown above the measured gain is 2.765dB, beam width is 86.4°.

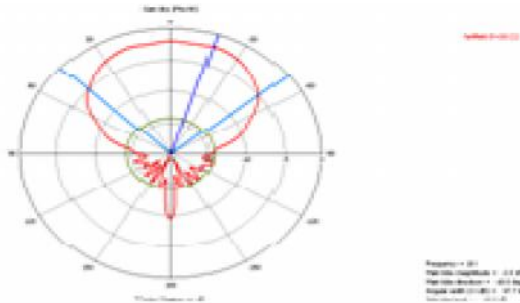


Fig 7. Radiation Pattern of Spiral Helix Antenna at 18 GHz

The figure 7 represents the radiation pattern at 18GHz. From the diagram shown above the measured gain is 3.89 dB, beam width is 98°, squint is -6° and axial ratio is 0.5.

**B. SIMULATED RESULTS**

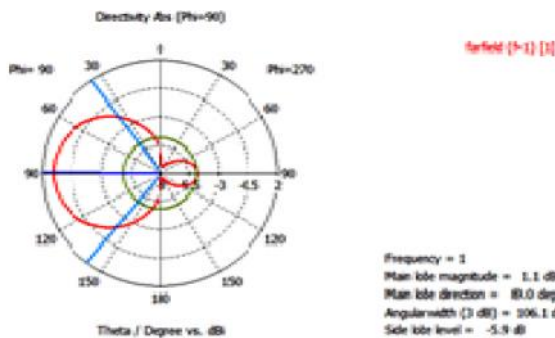


Fig. 8. Directivity

**C. MODEL OF SIMULATED ANTENNA**

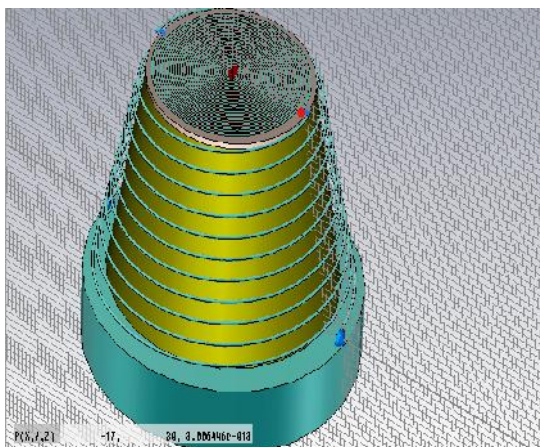


Fig. 9 Model of Simulated Antenna

**D. 3D RESULTS**

These 3Dimensionoanal results are represented in fig's 10 to 14. These results are obtained at different frequencies.

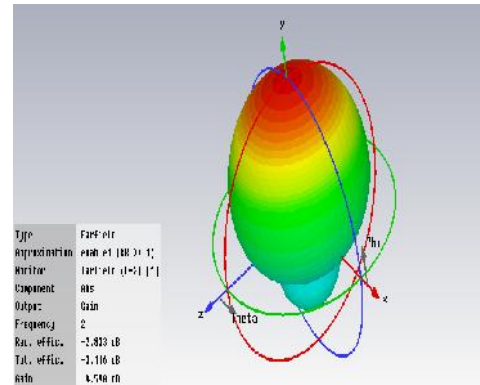


Fig. 10. 3d representation operating at frequency=2 GHz

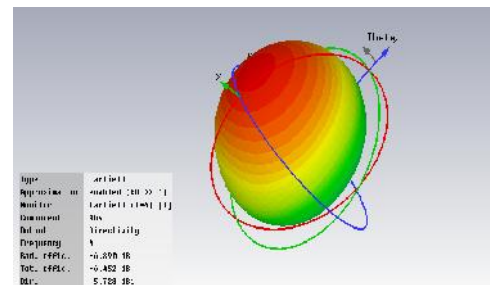


Fig. 11 .3d representation operating at frequency=4 GHz

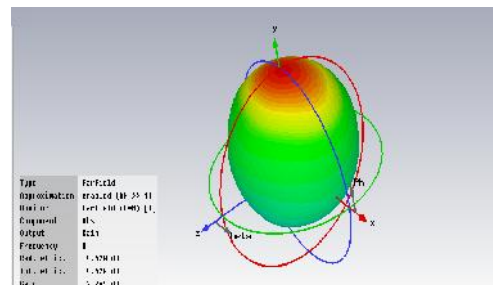


Fig. 12. 3d representation operating at frequency=8 GHz

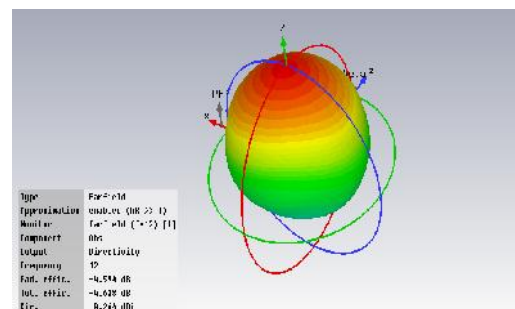


Fig. 13. 3d representation operating at frequency=12 GHz

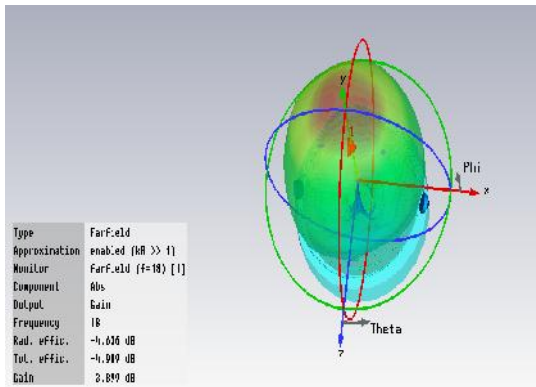


Fig. 14. 3d representation operating at frequency=18 GHz

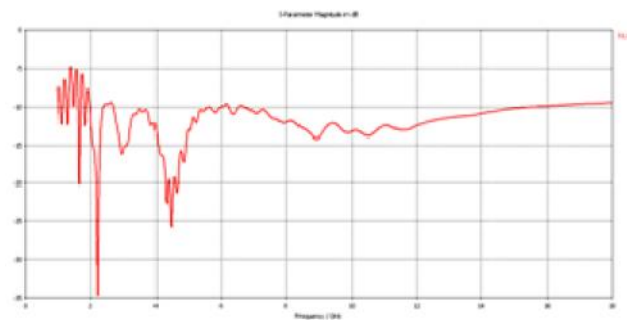


Fig. 11 Return Loss

#### IV. CONCLUSIONS

This report presents the complete theoretical analysis, and evaluation of an electrically small spiral helix antenna covering the frequency range of 1-18GHz.

The design of the cavity is very critical particularly when it is to operate over multi-octave bands. The complete design considerations of the cavity were also brought out in this report. The performance characteristics show that the antenna exhibited very good radiation characteristics over 1- 18 GHz. The measured VSWR of the Antenna is less than 3.65:1 over the entire band.

#### V. FUTURE SCOPE

Further scope of research is recommended in the following areas

1. In this paper a spiral helix antenna operating in 1 - 18GHz is designed.
2. Research work can be done on this type of antenna because of its advantages over conventional cavity backed spiral antennas

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#### Author Biography



I had done M.Tech in RADAR AND  
MICROWAVE at GITAM Institute of  
Technology (Affiliated to AU last batch).I had  
4yrs experience in teaching and published a few papers on  
microwaves, wireless communications, RADAR etc...