

An Analytic Review on Antenna Modelling

Akhil Gupta* and Krittika Goyal**

ABSTRACT

Antenna is the most significant component in the present wireless generation. The main objective of the antennas is to convert and transmit the electrical signals into radio waves at the transmitter end and vice versa. According to the demand at the transmitter and receiver end, the antennas are classified into various types with different characteristics. In this paper, an analytic review on antenna modelling has been presented. The core aim of this paper is to differentiate antennas on the basis of structure and applications. These different antennas are implemented and graphically represented with the help of MATLAB. This paper will also represent the steps involved in modelling and analysis of the antennas using MATLAB.

IndexTerms: Antenna, Communications, Helix antenna, Modelling.

1. INTRODUCTION

The most prior component in the present wireless generation is an antenna element. It helps in the communication while connecting the free space with the transmitter and correspondingly with the receiver. It helps in converting the radio frequency signal or an electrical signal into the electromagnetic wave signal at the transmitter end. While in the receiver end, it converts back the received electromagnetic signal into the electrical signal. The most important parameter for rating an antenna is the efficiency of that antenna. The antenna efficiency depends on the radiation resistance. If the radiation resistance of an antenna is high, then the corresponding antenna efficiency will also be high. An antenna is an important component in the several fields of the communication system for transmitting the signal in the form of audio, video and graphs. According to the demands of the users and researchers in the industry, the need to develop different communication antennas is of prime concern. Antennas are designed according to the application and according to the area in which it is going to be implemented. Different materials have also been used for building an antenna according to that material property. Antennas are designed for different communication systems like television, radio, cellular and satellite communication. Antennas are very useful in determining the properties of the system in which they are deployed. According to the demand of the system, different types of antennas are implemented. Directional antennas are used for transmitting in the particular direction, while omnidirectional antennas are used for the applications where the transmission is needed in all directions [1, 2, 3].

With the increased demand of the user and with the use of different applications, the demand for varying the antenna structure and material for specific applications is increasing day by day. This paper has classified the different types of antennas on the basis of structure and applications. The different classified antennas are implemented and graphically represented with the help of MATLAB in the section II. In the section III of this paper, the different steps involved in the modelling and analysis of an antenna has been described by taking an example of a helix antenna.

2. DIFFERENT TYPES OF ANTENNAS

The antennas are classified on the basis of structure and applications. The different classification of antennas are described below [1].

* School of Electrical and Electronics Engineering, Email: akhilgupta112001@gmail.com

** Lovely Professional University Phagwara, India, Email: krittika.20249@lpu.co.in

2.1. Dipole Antennas

The most extensive and simple class of the antenna used in mobile and radio communication is dipole antenna. The structural arrangement of the dipole antenna comprises of two similar elements that should be consensually identical and conductive, like metal rods or wires. Between the two halves of the antenna, input signal to the transmitter is applied and for the case of receiver, the output signal is taken. The conductors should be connected with each side of the feed line to the transmitter or receiver. This is contrary in the monopole antenna in which conductor is connected with only one side of the feed line, while other line is connected with the ground [1]. Dipole antennas are classified in to six different types and the graphical representation of these antennas using MATLAB are shown in Fig. 1 to Fig. 6.

2.1.1. Strip Dipole antenna

The graphical representation of the strip dipole antenna using MATLAB is shown in Fig. 1.

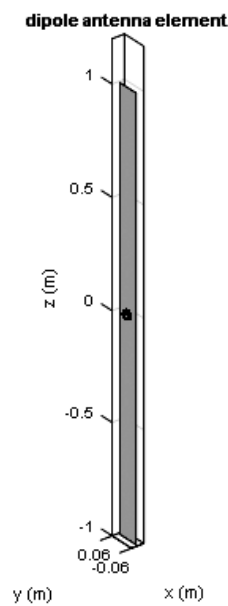


Figure 1: A strip dipole antenna element.

2.1.2. Rounded bowtie dipole antenna

The graphical representation of the rounded bowtie dipole antenna using MATLAB is shown in Fig. 2.

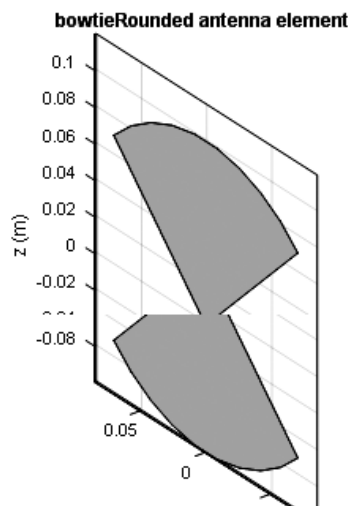


Figure 2: A bowtie rounded antenna element

2.1.3. Triangular bowtie dipole antenna

The graphical representation of the triangular bowtie dipole antenna using MATLAB is shown in Fig. 3.

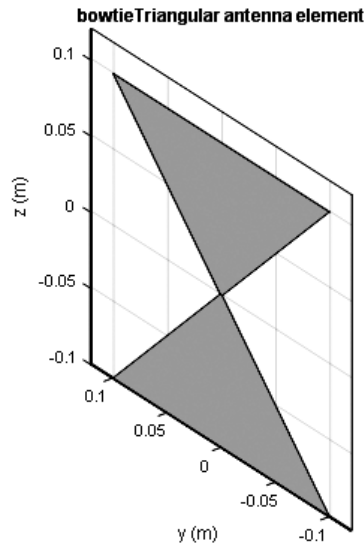


Figure 3: A bowtie triangular antenna element

2.1.4. Folded dipole antenna

The graphical representation of the folded dipole antenna using MATLAB is shown in Fig. 4.

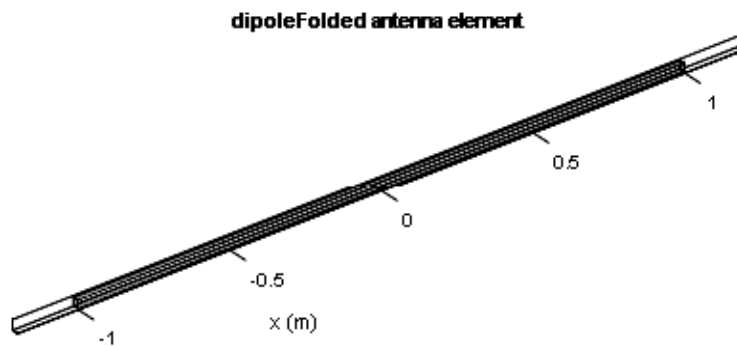


Figure 4: A folded dipole antenna element

2.1.5. Meander dipole antenna

The graphical representation of the meander dipole antenna using MATLAB is shown in Fig. 5

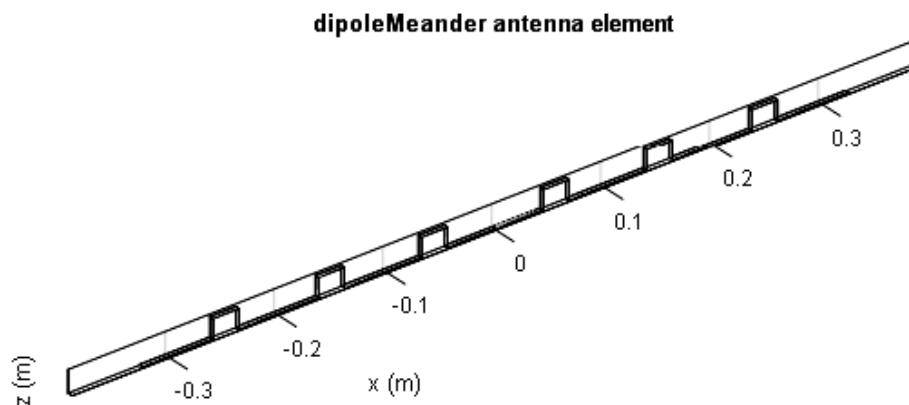


Figure 5: A meander dipole antenna element

2.1.6. V-dipole antenna

The graphical representation of the V dipole antenna using MATLAB is shown in Fig. 6.

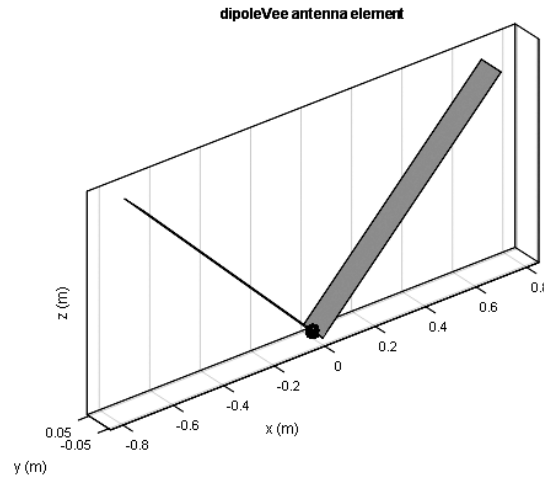


Figure 6: A V-dipole antenna element

2.2. Monopole Antennas

The monopole antenna as the name suggest is having a single pole as compared to the dipole antenna. It is half of the dipole antenna with radiation pattern also similar to the half wave dipole antenna. The power radiated field is also half as compared to the dipole antenna i.e. power is radiated only in the upper half hemisphere region. But the directivity of the monopole antenna is increased to double as compared to the dipole antenna and are used above the vehicles because they are providing the much needed ground plane for the antennas mounted above the earth [2]. Monopole antennas are classified in to four different types and the graphical representation of these antennas using MATLAB are shown in Fig. 7 to Fig. 10.

2.2.1. Inverted-F antenna over rectangular ground plane

The graphical representation of an inverted F antenna using MATLAB is shown in Fig. 7.

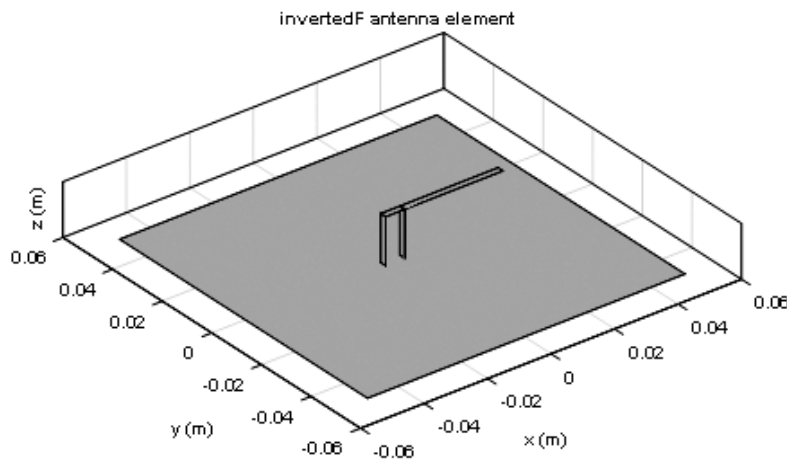


Figure 7: An inverted F antenna element

2.2.2. Inverted-L antenna over rectangular ground plane

The graphical representation of an inverted L antenna using MATLAB is shown in Fig. 8.

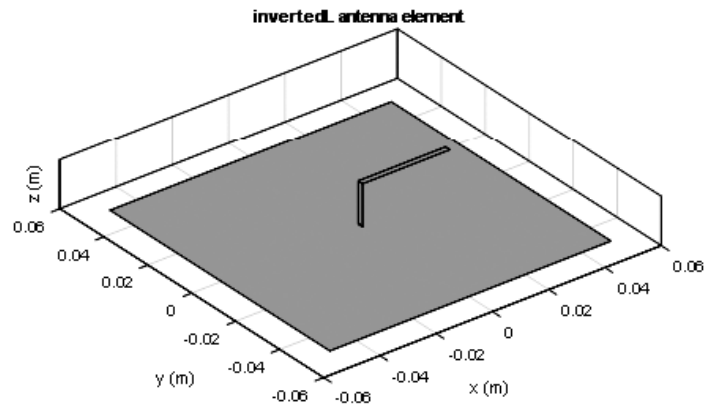


Figure 8: An inverted L antenna element

2.2.3. Monopole antenna over rectangular ground plane

The graphical representation of the monopole antenna using MATLAB is shown in Fig. 9.

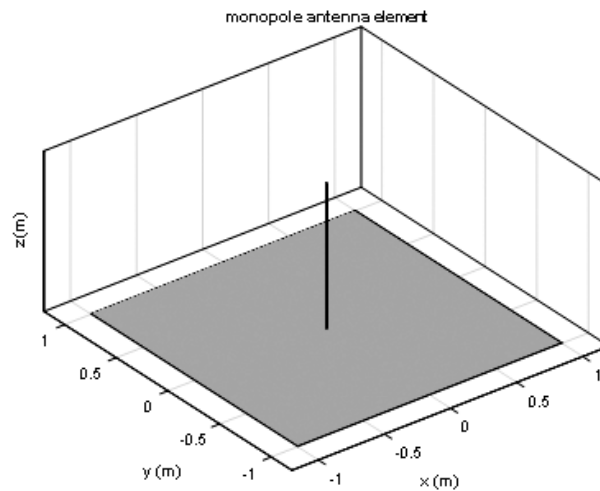


Figure 9: A monopole antenna element

2.2.4. Capacitive loaded monopole antenna over rectangular ground plane

The graphical representation of the capacitive loaded monopole antenna using MATLAB is shown in Fig. 10.

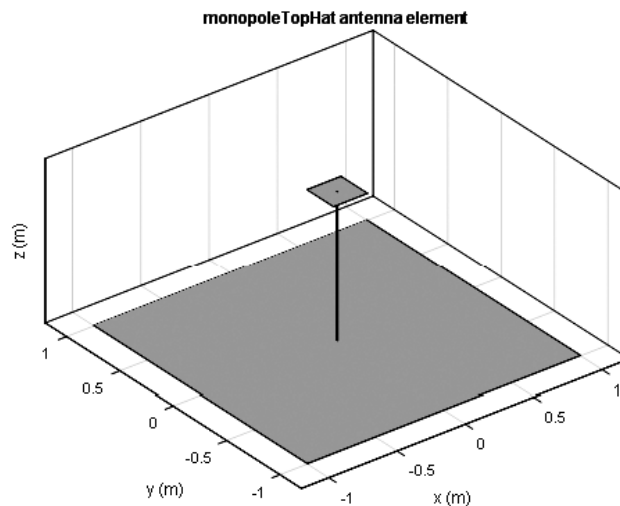


Figure 10: A capacitive loaded monopole antenna element

2.3. Loop Antennas

The most important characteristic of the loop antennas is that they are independent of their shape, while rest of the characteristics are similar with the dipole and monopole antennas. They are also very easy to construct. They are available in different shapes such as circular and rectangular. These types of antennas are very helpful in communication links having 3GHz frequency and can also be used as electromagnetic field probes in the microwave bands. The efficiency of this antenna depends on the circumference of its loop [3]. Loop antennas are classified in to two different types and the graphical representation of these loop antennas using MATLAB are shown in Fig. 11 to Fig. 12.

2.3.1. Circular loop antenna

The graphical representation of the circular loop antenna using MATLAB is shown in Fig. 11.

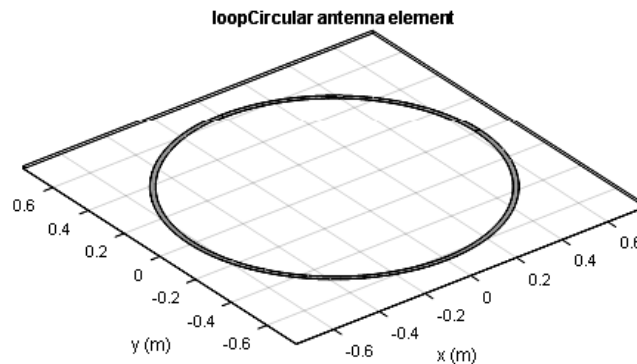


Figure 11: A circular loop antenna element

2.3.2. Rectangular loop antenna

The graphical representation of the rectangular loop antenna using MATLAB is shown in Fig. 12.

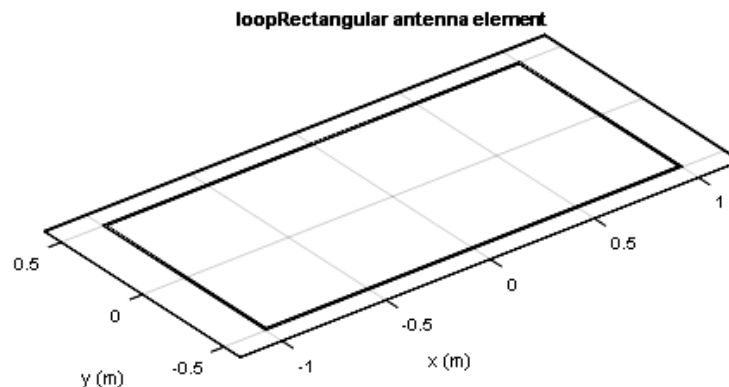


Figure 12: A rectangular loop antenna element

2.4. Spiral Antennas

A spiral antenna is an RF antenna which was first described in 1956. It has a two or more armed spiral shape and can operate over a wide range of frequencies. These antennas have low gain and are inherently circularly polarized, while the polarization, impedance and radiation pattern of these antennas will remain unchanged over a wide range of bandwidth. These antennas have very small structure due to its windings. For these kind of antennas, the unidirectional pattern is preferred and is achieved by eliminating the back lobes by placing the lossy cavities at the back [1]. Spiral antennas are classified in to two different types and the graphical representation of these spiral antennas using MATLAB are shown in Fig. 13 to Fig. 14.

2.4.1. Archimedean spiral antenna

The graphical representation of the Archimedean spiral antenna using MATLAB is shown in Fig. 13.

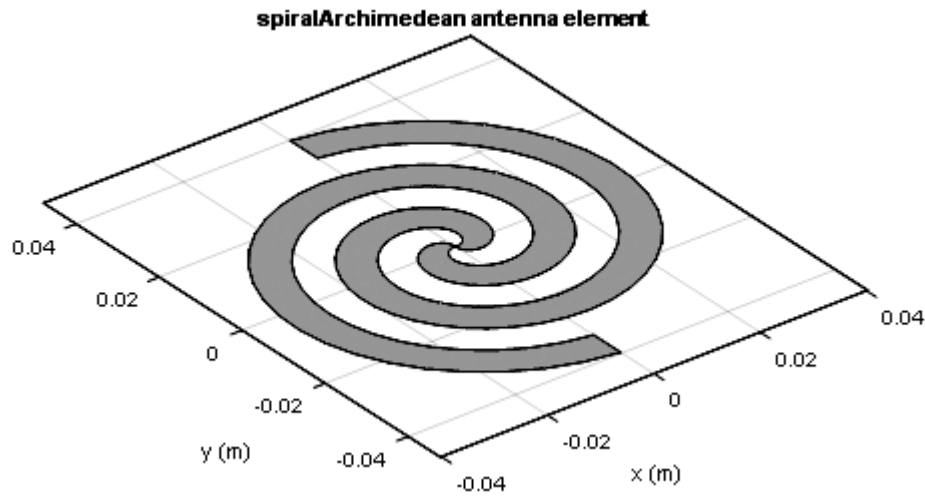


Figure 13: An Archimedean spiral antenna element

2.4.2. Equiangular spiral antenna

The graphical representation of an equiangular spiral antenna using MATLAB is shown in Fig. 14.

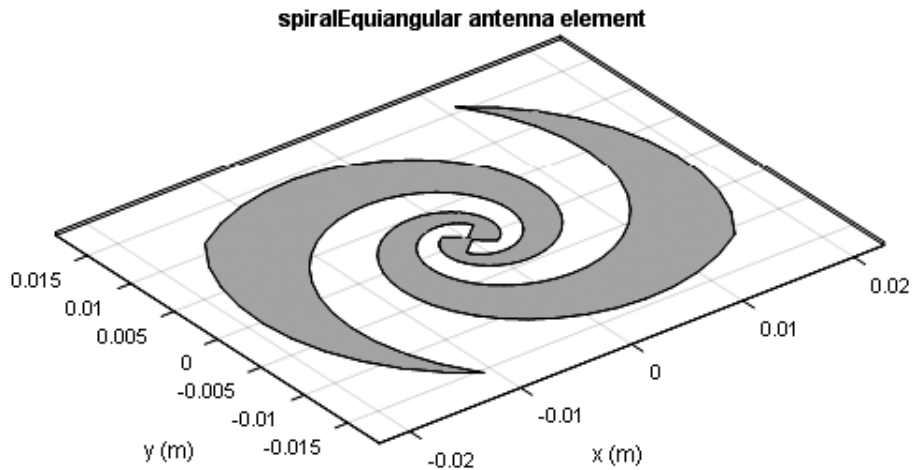


Figure 14: An equiangular spiral antenna element

2.5. Patch Antennas

The most popular type of patch antenna is microstrip patch antenna in which a small micro strip patch of metal is mounted on a flat rectangular sheet of metal. This combination of two metal sheets will form a resonant piece of microstrip transmission line. The length of the antenna should be less than one-half wavelength of the radio waves so that the antenna will become resonant because the radiation mechanism arises from discontinuities at every shortened edge of the microstrip transmission line. The modified version of the patch antenna is the planar inverted-F antenna (PIFA) which is usually used in the mobile phones [2]. Patch antennas are classified in to two different types and the graphical representation of these patch antennas using MATLAB are shown in Fig. 15 to Fig. 16.

2.5.1. Micro strip patch antenna

The graphical representation of the micro strip patch antenna using MATLAB is shown in Fig. 15.

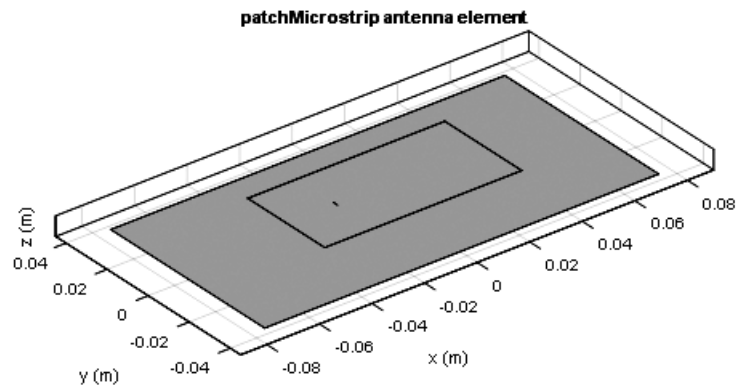


Figure 15: A micro strip patch antenna element

2.5.2. Planar inverted-F antenna

The graphical representation of the planar inverted F antenna using MATLAB is shown in Fig. 16.

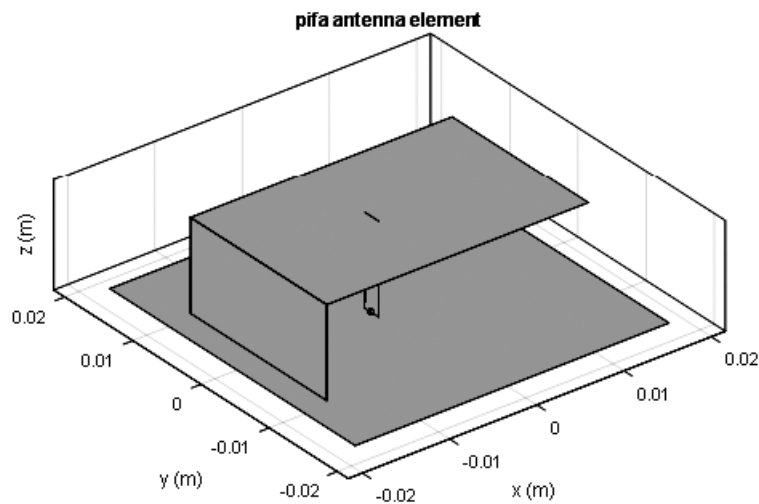


Figure 16: A planar inverted F antenna element

2.6. Cavity-backed antenna

The cavity backed antenna is basically a practical slot antenna which has conducting metallic walls and from inside it is hollow [3]. The graphical representation of the cavity backed antenna using MATLAB is shown in Fig. 17.

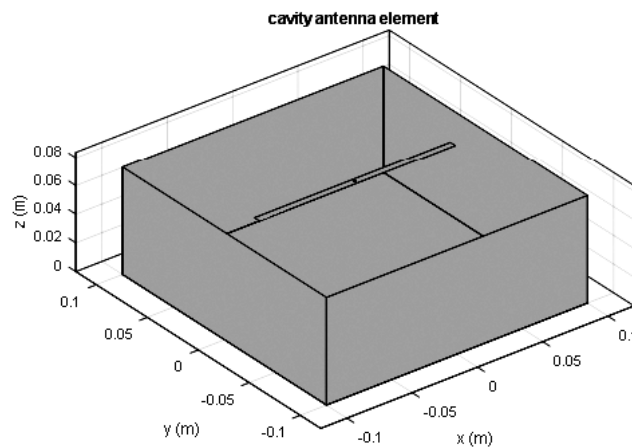


Figure 17: A cavity backed antenna element

2.7. Helix antenna on ground plane

Helix antennas are also known as helical antenna and have comparatively simple structure with more than one wires wound to form a helix. It is usually backed by a shaped reflector and driven by a suitable feed. The radiation properties of a helix antenna depends on the electrical size of the structure and usually works in two radiation modes: the normal mode and the axial mode. The size of the helix antenna in the normal mode is smaller as compared to the wavelength and thus act as a short dipole antenna. But the size of axial antenna is same as compared to the wavelength and thus act as a directional antenna[1]. The graphical representation of the helix antenna using MATLAB is shown in Fig. 18.

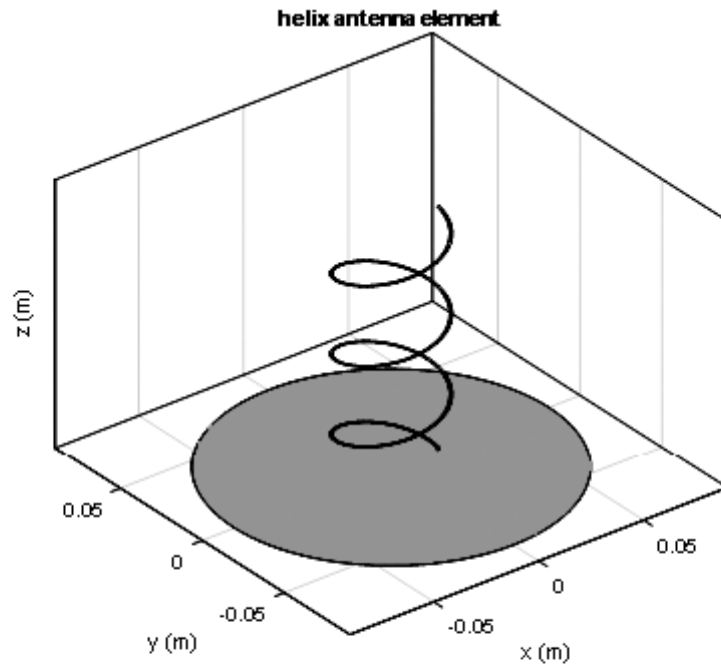


Figure 18: A helix antenna element

2.8. Reflector-backed antenna

The graphical representation of the reflector backed antenna using MATLAB is shown in Fig. 19.

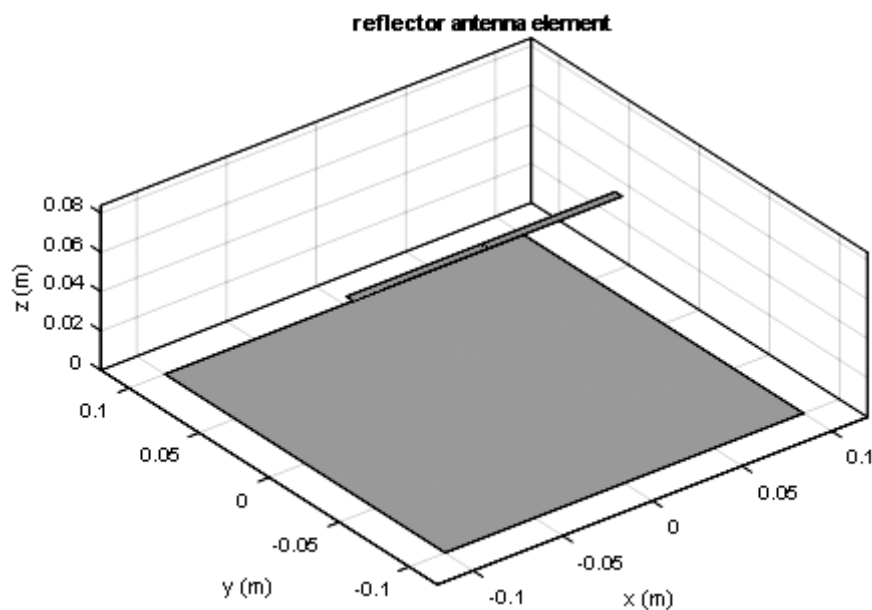


Figure 19: A reflector backed antenna element

2.9. Rectangular slot antenna on ground plane

The graphical representation of the rectangular slot antenna using MATLAB is shown in Fig. 20.

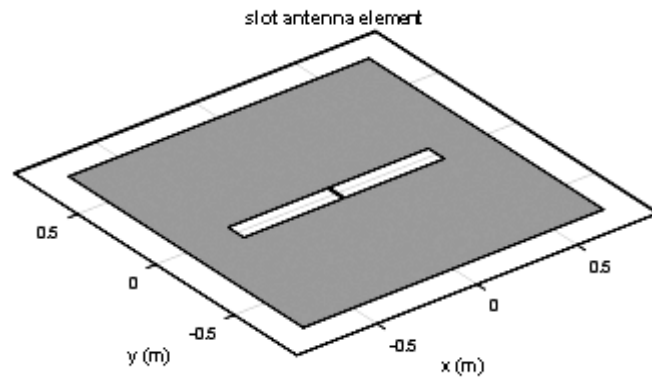


Figure 20: A rectangular slot antenna element

2.10. Vivaldi notch antenna on ground plane

The graphical representation of the Vivaldi notch antenna using MATLAB is shown in Fig. 21.

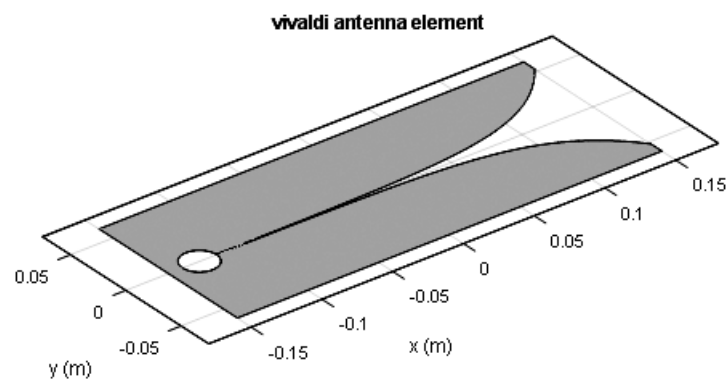


Figure 21: A Vivaldi notch antenna element

2.11. Yagi-Uda array antenna

The graphical representation of the Yagi-Uda array antenna using MATLAB is shown in Fig. 22.

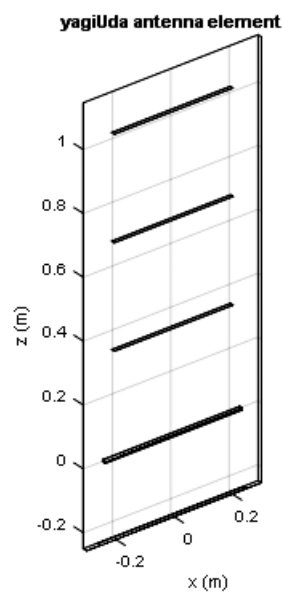


Figure 22: A Yagi uda array antenna element

3. ANTENNA MODELLING AND ANALYSIS

The antenna modelling and analysis can be done by following the below given steps for the helix antenna in MATLAB [1].

3.1. Define Antenna Element Using the Antenna Library

The first step is to define a helix antenna using the helix antenna element in the Antenna Modeling and Analysis library.

```
hx = helix
```

3.2. Show Structure of Antenna

The second step is to view the structure of the helix antenna. This can be done using the show function.

```
Show(hx)
```

The output of this function is visible in Fig. 23.

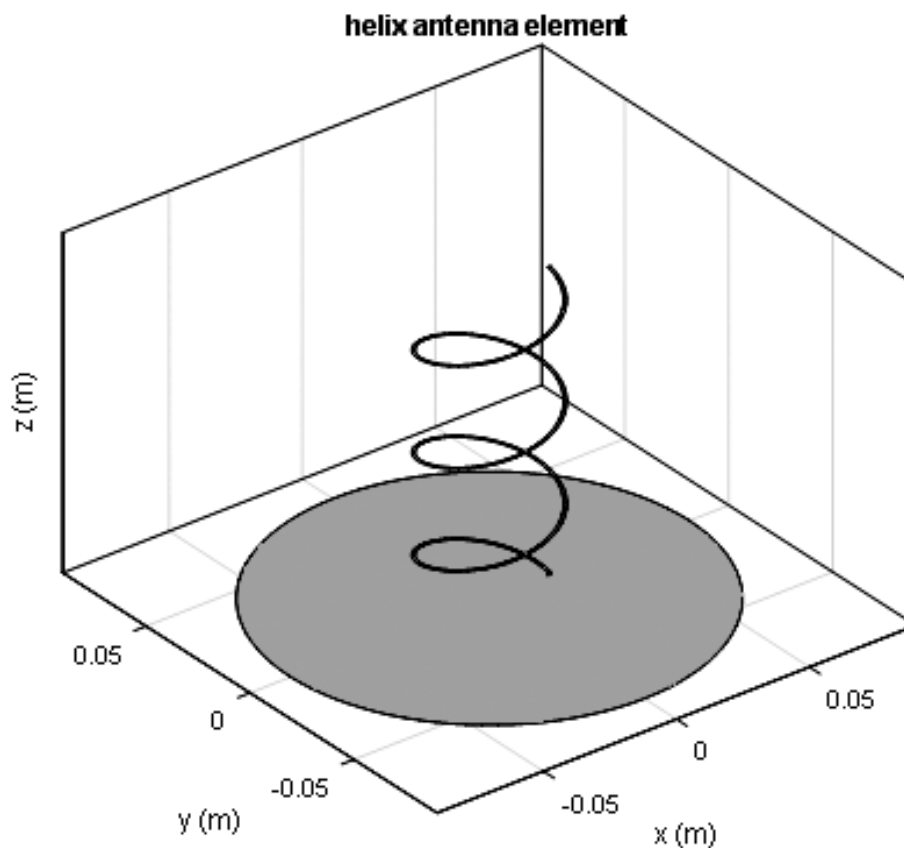


Figure 23: Structure of helix antenna element

3.3. Modify Properties of Antenna

The third step is to modify the properties of the helix antenna as:

```
hx = helix('Radius', 28e-3, 'Width', 1.2e-3, 'Turns', 4)
```

The modified helix antenna can be viewed by using the show function.

```
show(hx)
```

The output of this function with modified parameters is visible in Fig. 24.

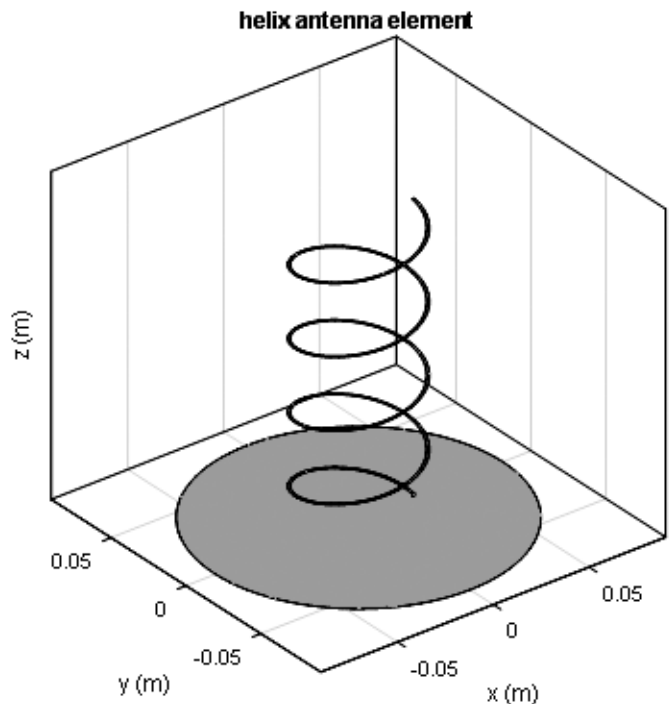


Figure 24: A helix antenna element

3.4. Plot Radiation Pattern of Antenna

The fourth step is to view the radiation pattern of the helix antenna. This can be achieved by using the pattern function. It will show the directivity of the antenna as

```
Pattern(hx, 1.8e9)
```

The output of this function is visible in Fig. 25.

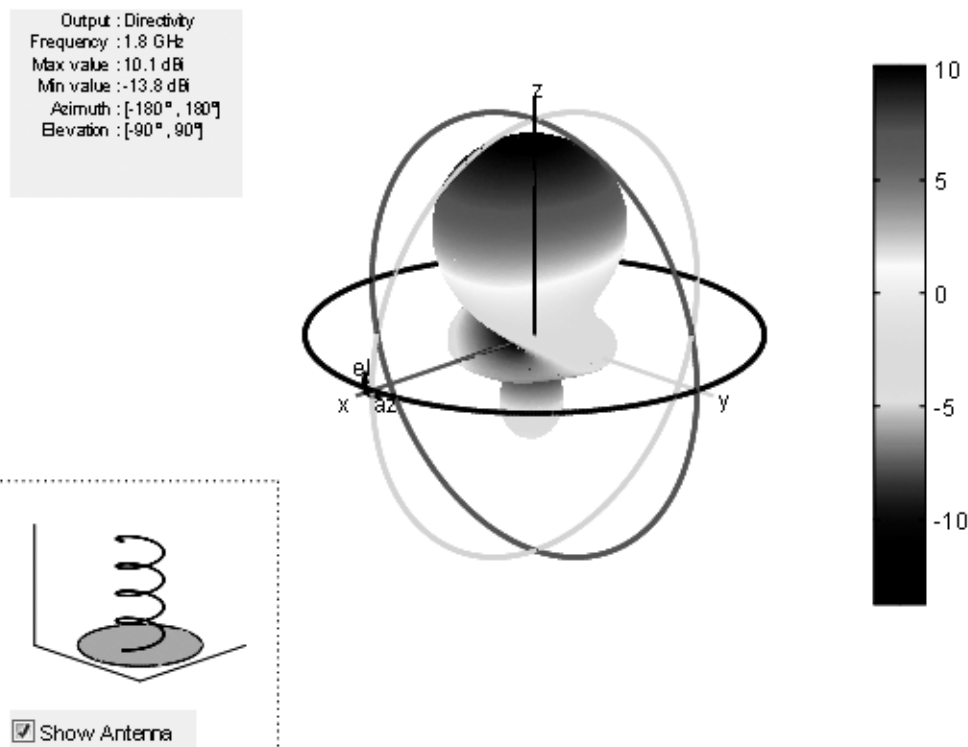


Figure 25: The radiation pattern of helix antenna element

3.5. Plot Azimuth and Elevation Pattern of Antenna

The fifth step is to view the azimuth and elevation pattern of a helix antenna. This can be done by using `patternAzimuth` and `patternElevation` functions as

```
patternAzimuth(hx,1.8e9)
```

The output of this function is visible in Fig. 26.

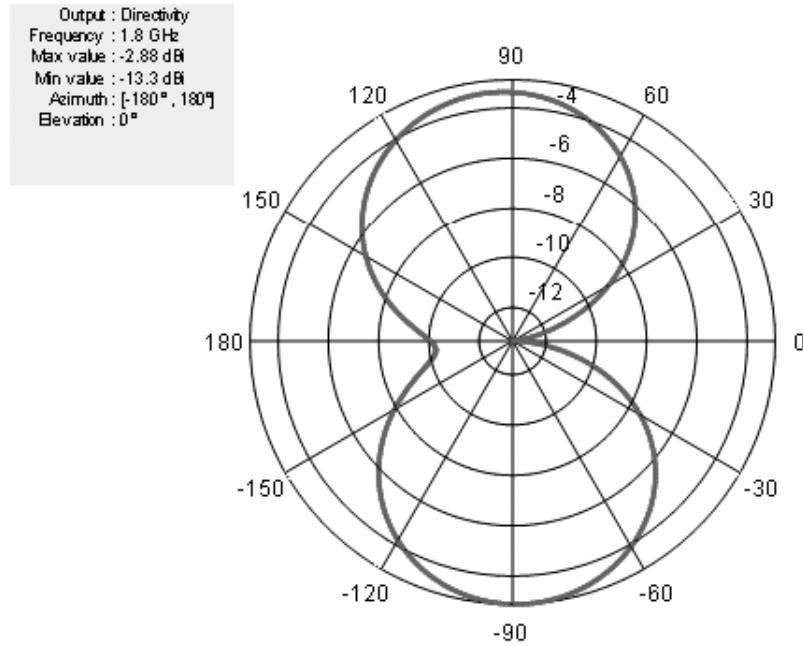


Figure 26: An azimuth pattern of helix antenna element

```
patternElevation (hx,1.8e9)
```

The output of this function is visible in Fig.27.

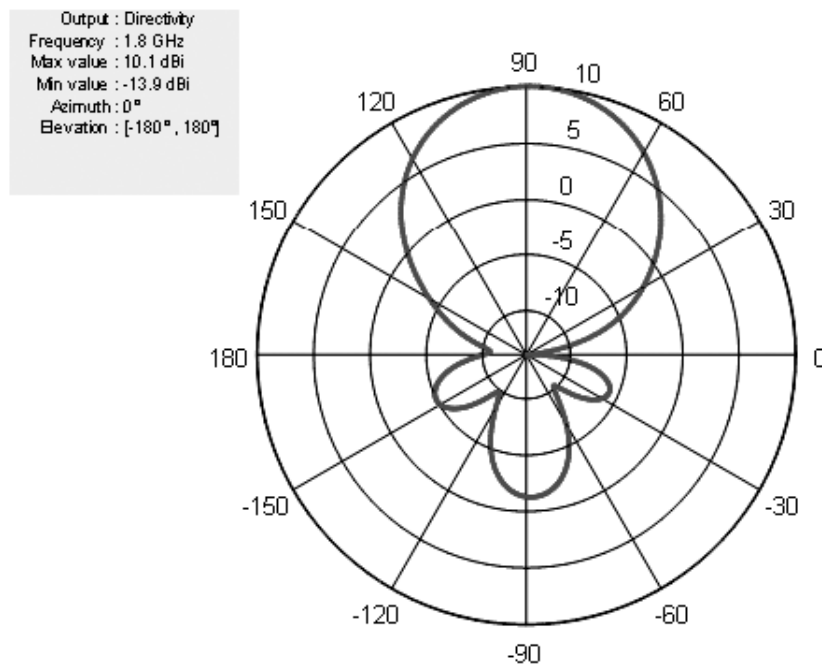


Figure 27: An elevation pattern of helix antenna element

3.6. Calculate Directivity of Antenna

The sixth step involves the calculation of the directivity of helix antenna. This can be done by using Directivity name-value pair in the output of the pattern function as

```
[Directivity] = pattern(hx, 1.8e9, 0, 90)
```

```
Directivity = 10.0744
```

3.7. Calculate EHfields of Antenna

The seventh step is to calculate the electric and magnetic fields of a helix antenna. This can be done by using EHfields function at a specific frequency and at specified points in space.

```
[E, H] = EHfields(hx, 1.8e9, [0; 0; 1])
```

$$E = \begin{bmatrix} -0.5327 - 0.5980i \\ -0.9102 + 0.5338i \\ -0.0041 + 0.0007i \end{bmatrix}$$

$$H = \begin{bmatrix} -0.0024 - 0.0014i \\ -0.0014 - 0.0016i \\ -0.0000 + 0.0000i \end{bmatrix}$$

3.8. Plot Different Polarizations of Antenna

The eighth step is to view the different polarization of the helix antenna. This can be done by using Polarization name-value pair in the pattern function. In this paper, the Right-Hand Circularly Polarized (RHCP) radiation pattern of the helix is shown as

```
pattern(hx, 1.8e9, 'Polarization', 'RHCP')
```

The output of this function is visible in Fig. 28.

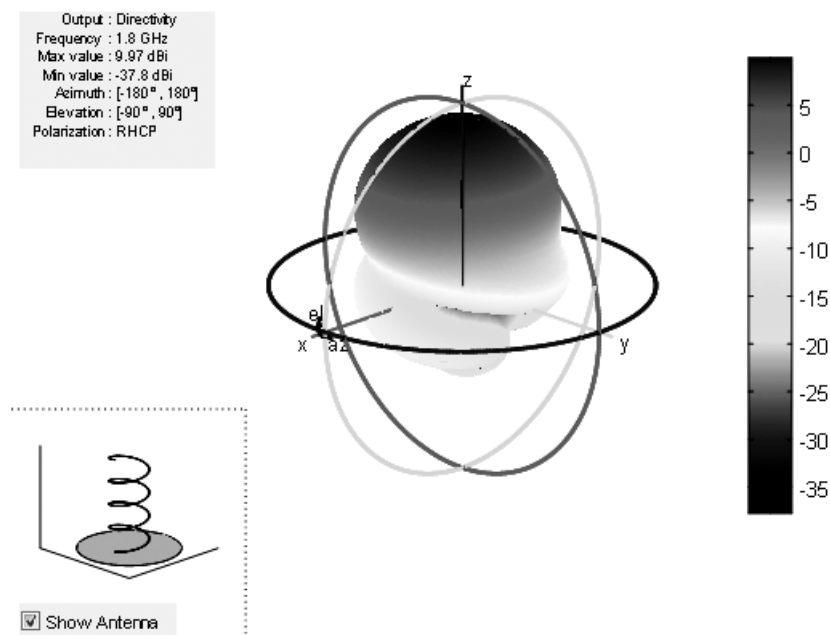


Figure 28: A Right-Hand Circularly Polarized (RHCP) radiation pattern of the helix antenna element

3.9. Calculate Axial Ratio of Antenna

The ninth step is to calculate the axial ratio of the helix antenna. This can be done by using axialRatio function as

```
ar = axialRatio(hx,1.8e9,20,30)
ar = 27.7584
```

3.10. Calculate Beamwidth of Antenna

The tenth step is to calculate the beamwidth of the helix antenna. This can be done by using the beamwidth function as

```
[bw, angles] = beamwidth(hx, 1.8e9, 0, 1:1:360)
bw = 58
angles = 60 118
```

3.11. Calculate Impedance of Antenna

The eleventh step is to calculate the impedance of the helix antenna. This can be done by using the impedance function as

```
Impedance(hx, 1.7e9:1e6:2.2e9)
```

The output of this function is visible in Fig.29.

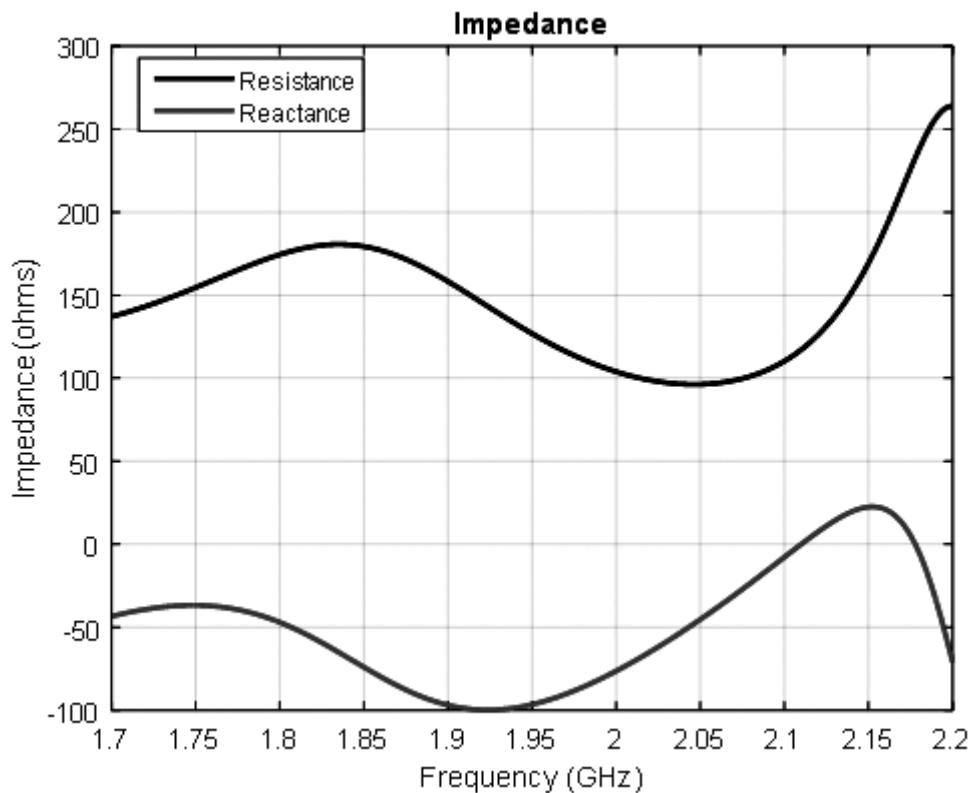


Figure 29: Input impedance of helix antenna element

3.12. Calculate Reflection Coefficient of Antenna

The twelfth step is to calculate the reflection coefficient of the helix antenna. This can be done using the sparameters function which will calculate the S11 value of the helix antenna as

```
S = sparameters(hx, 1.7e9:1e6:2.2e9, 72)
```

```
rfplot(S)
```

The output of this function is visible in Fig. 30.

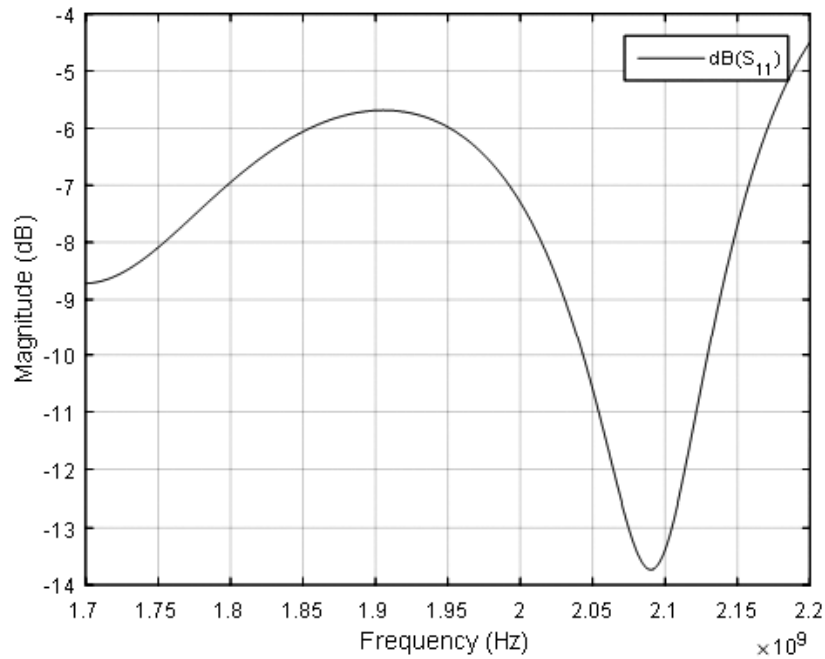


Figure 30: Reflection coefficient of helix antenna element

3.13. Calculate Return Loss of Antenna

The thirteenth step is to calculate the return loss of helix antenna element. This can be done by using the returnLoss function as

```
returnLoss(hx, 1.7e9:1e6:2.2e9, 72)
```

The output of this function is visible in Fig.31.

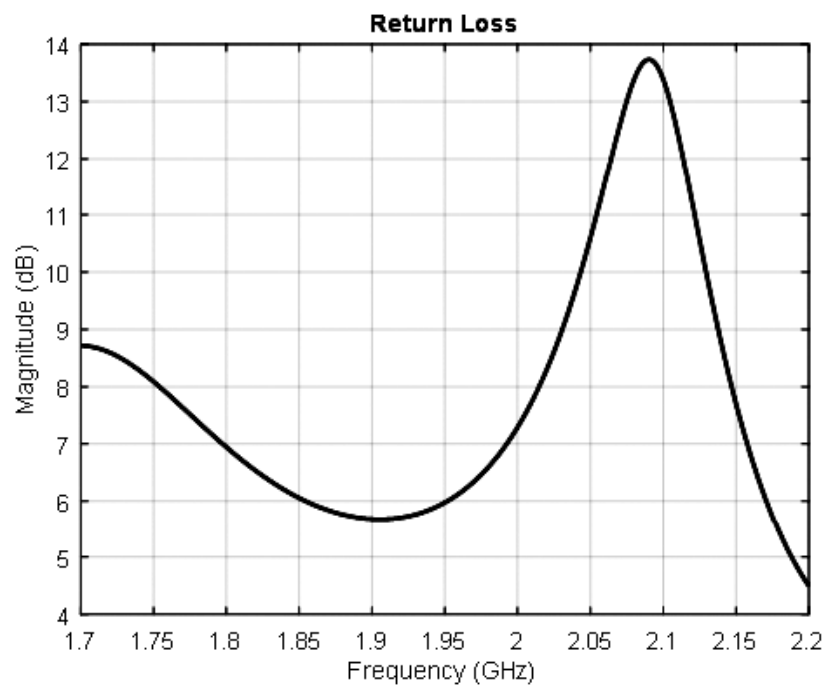


Figure 31: Return loss of helix antenna element

3.14. Calculate Voltage Standing Wave Ratio (VSWR) of Antenna

The fourteenth step is to calculate the voltage standing wave ratio of the helix antenna. This can be done by using the `vswr` function as

```
vswr(hx,1.7e9:1e6:2.2e9,72)
```

The output of this function is visible in Fig. 32.

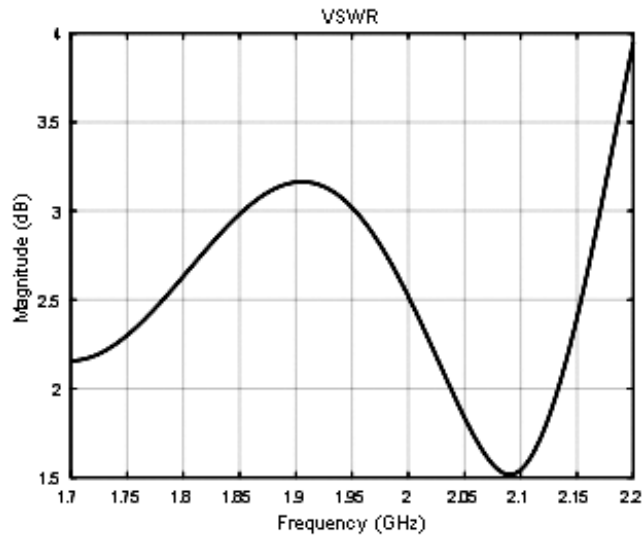


Figure 32: VSWR of helix antenna element

3.15. Calculate Current and Charge Distribution of Antenna

The fifteenth step is to calculate the current and charge distribution of helix antenna element. The charge distribution is calculated by using the `charge` function as.

```
charge(hx,2.01e9)
```

The output of this function is visible in Fig. 33.

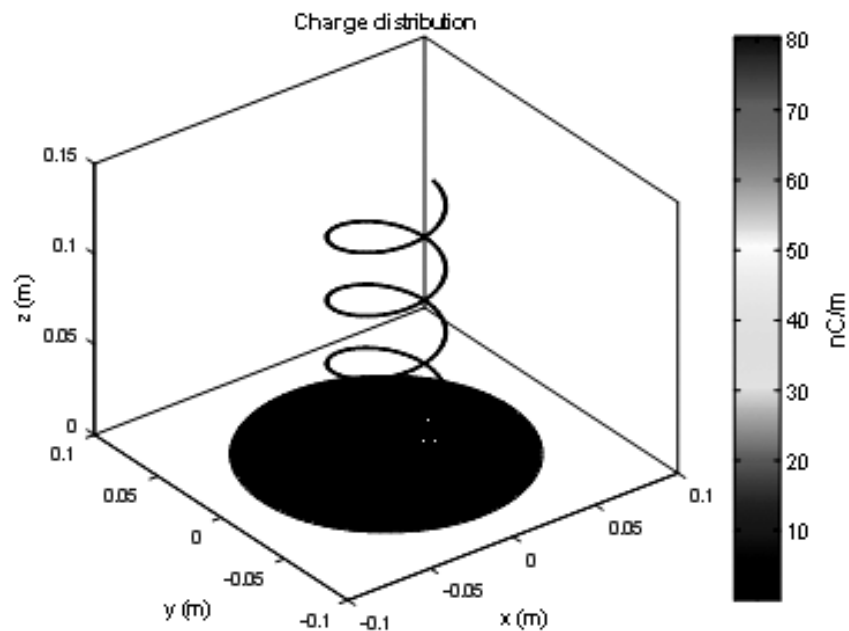


Figure 33: Charge distribution of helix antenna element

The current distribution is calculated by using the current function as $\text{current}(hx, 1.0e9)$

The output of this function is visible in Fig. 34.

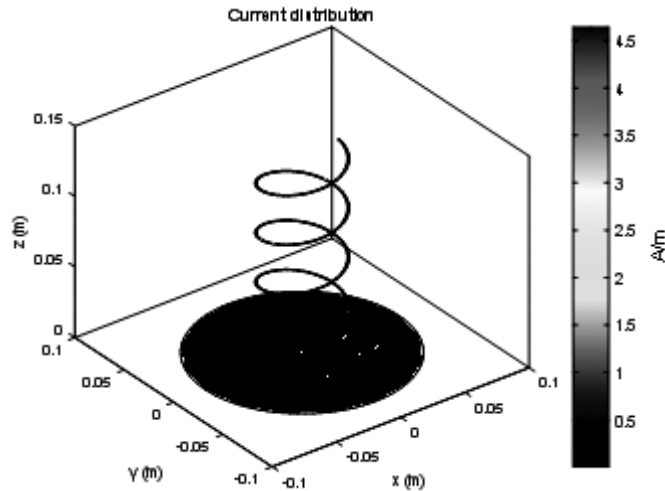


Figure 34: Current distribution of helix antenna element

4. CONCLUSION

It is concluded from the review that there exists a significant types of antennas that are proving to be useful for different applications in the communication industry. This paper has also shown the different steps that need to be followed for modelling a communication antenna. The analysis on the basis of different available antennas and the steps involved in modelling an antenna has shown that communication antennas are capable of providing a prodigious future along with the expansion of the quickly growing wireless communication industry.

REFERENCES

- [1] Balanis, C.A. "Antenna Theory. Analysis and Design", p. 514, Wiley, New York, 3rd Edition, 2005.
- [2] Prasad, K. D., and Deepak Handa. Antenna and wave propagation. Satya Prakashan, 2003.
- [3] Kraus, John D., Ronald J. Marhefka, and Ahmad S. Khan. Antennas and wave propagation. Tata McGraw-Hill Education, 2006.