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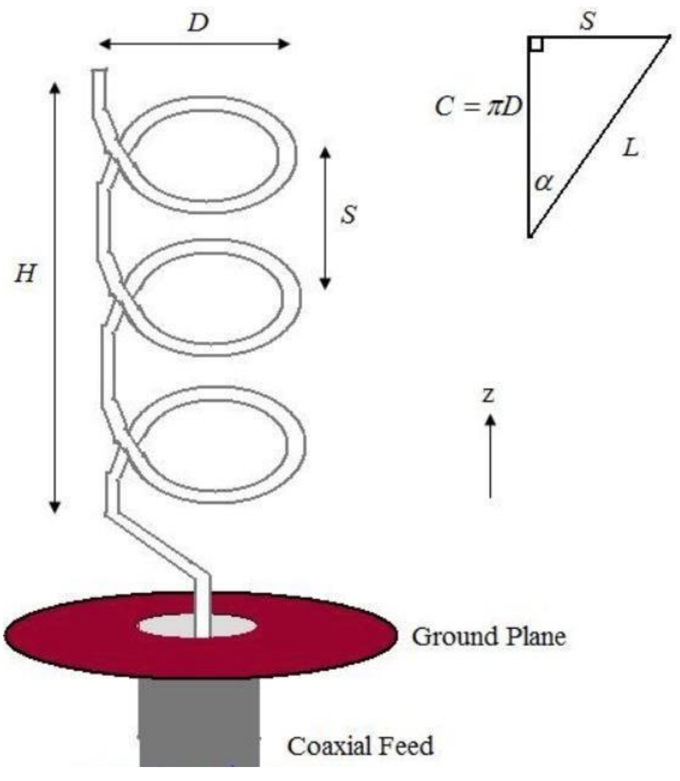
Helical antenna or helix antenna is the antenna in which the conducting wire is wound in helical shape and connected to the ground plate with a feeder line. It is the simplest antenna, which provides **circularly polarized waves**. It is used in extra-terrestrial communications in which satellite relays etc., are involved.

The above image shows a helical antenna system, which is used for satellite communications. These antennas require wider outdoor space.

It consists of a helix of thick copper wire or tubing wound in the shape of a screw thread used as an antenna in conjunction with a flat metal plate called a ground plate. One end of the helix is connected to the center conductor of the cable and the outer conductor is connected to the ground plate.

The most popular helical antenna (helix) is a travelling wave antenna in the shape of a corkscrew that produces radiation along the axis of the helix antenna. These helix antennas are referred to as axial-mode helical antennas. The benefits of this helix antenna is it has a wide bandwidth, is easily constructed, has a real input impedance, and can produce circularly polarized fields. The basic geometry of the helix antenna shown in the following figure



The parameters of the helix antenna are defined below.

D - Diameter of a turn on the helix antenna.

C - Circumference of a turn on the helix antenna (*C*=pi**D*).

S - Vertical separation between turns for helical antenna.

α - pitch angle, which controls how far the helix antenna grows in the z-direction per turn, and is given by $\alpha = tan^{-1} \frac{S}{C}$

N - Number of turns on the helix antenna.

H - Total height of helix antenna, *H=NS*.

The antenna in the above figure is a left-handed helix antenna, because if you curl your fingers on your left hand around the helix your thumb would point up (also, the waves emitted from this helix antenna are Left Hand Circularly Polarized). If the helix antenna was wound the other way, it would be a right-handed helical antenna.

The radiation pattern will be maximum in the +z direction (along the helical axis).

Operating Bandwidth:

Helix antennas of at least 3 turns will have close to circular polarization in the +z direction when the circumference C is close to a wavelength:

$$\frac{3\lambda}{4} \leq C \leq \frac{4\lambda}{3}$$

Once the circumference C is chosen, the inequalities above roughly determine the operating bandwidth of the helix antenna. For instance, if C=19.68 inches (0.5 meters), then the highest frequency of operation will be given by the smallest wavelength that fits into the above equation, or λ=0.75C=0.375 meters, which corresponds to a frequency of 800 MHz. The lowest frequency of operation will be given by the largest wavelength that fits into the above equation, or λ =1.333C=0.667 meters, which corresponds to a frequency of 450 MHz. Hence, the fractional BW is 56%, which is true of axial helical antennas in general.

Input Impedance:

The helix antenna is a travelling wave antenna, which means the current travels along the antenna and the phase varies continuously. In addition, the input impedance is primarily real and can be approximated in Ohms by:

$$C$$

Pitch Angle:

The helix antenna functions well for pitch angles (α) between 12 and 14 degrees. Typically, the pitch angle is taken as 13 degrees.

Radiation Pattern:

The normalized radiation pattern for the E-field components are given by:

$$E_\theta \propto E_\phi \propto \sin\frac{\pi}{2N}\cos\theta\frac{\sin\frac{N\Omega}{2}}{\sin(\Omega/2)}$$

$$\Omega = kS(\cos\theta - 1) - \pi(2 + 1/N)$$

Half Power Beamwidth:

$$\boxed{\text{HPBW (degrees)} \simeq \frac{52\lambda_0^{3/2}}{C\sqrt{NS}}}$$

First Null Beamwidth:

$$\boxed{\text{FNBW (degrees)} \simeq \frac{115\lambda_0^{3/2}}{C\sqrt{NS}}}$$

Directivity:

$$\boxed{D_0 \text{ (dimensionless)} \simeq 15N\frac{C^2 S}{\lambda_0^3}}$$

Advantages

The various advantages of the helical antenna are:

1. These offer simple construction.
2. The helical antenna exhibits **highly directional behaviour**.
3. It offers wide operating bandwidth.
4. The operational frequency range is very high i.e., operates in VHF and UHF.
5. It is very robust in construction.

Disadvantages

The drawbacks associated with helical antennas are as follows:

1. The end-fire helical antenna exhibit **large size** thus is bulky.
2. For higher number of turns its efficiency decreases. The maximum efficiency of about 80% can be achieved with the use of 3 to 4 turns.
3. It is higher in cost.

Applications of Helical Antenna

Helical antennas majorly find applications in **space communication**. Their simplicity, high directivity, wide bandwidth and circular polarization serve as the parameters for operating in space communication.
Generally, the telemetry data in space communication is propagated through helical antennas.

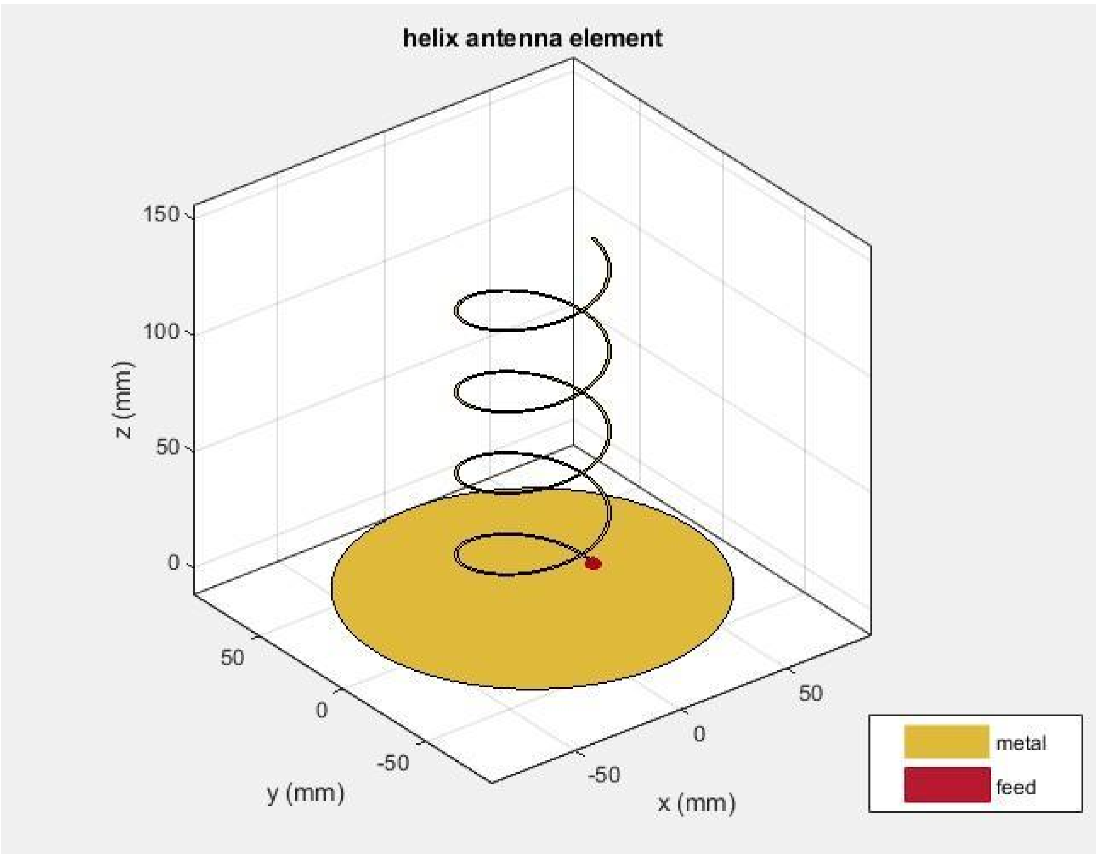
Also, by placing either single or array of the helical antenna in the surface, **ionospheric wave propagation** can be achieved. This allows the transmission and reception of VHF signals. Thus, satellite and space probe propagation use helical antennas.
Helical antennas configured in axial mode can receive signals of arbitrary polarization easily. As end-fire helical antennas offer circularly polarized waves over a wider bandwidth. Hence is widely used than broadside helical antennas.

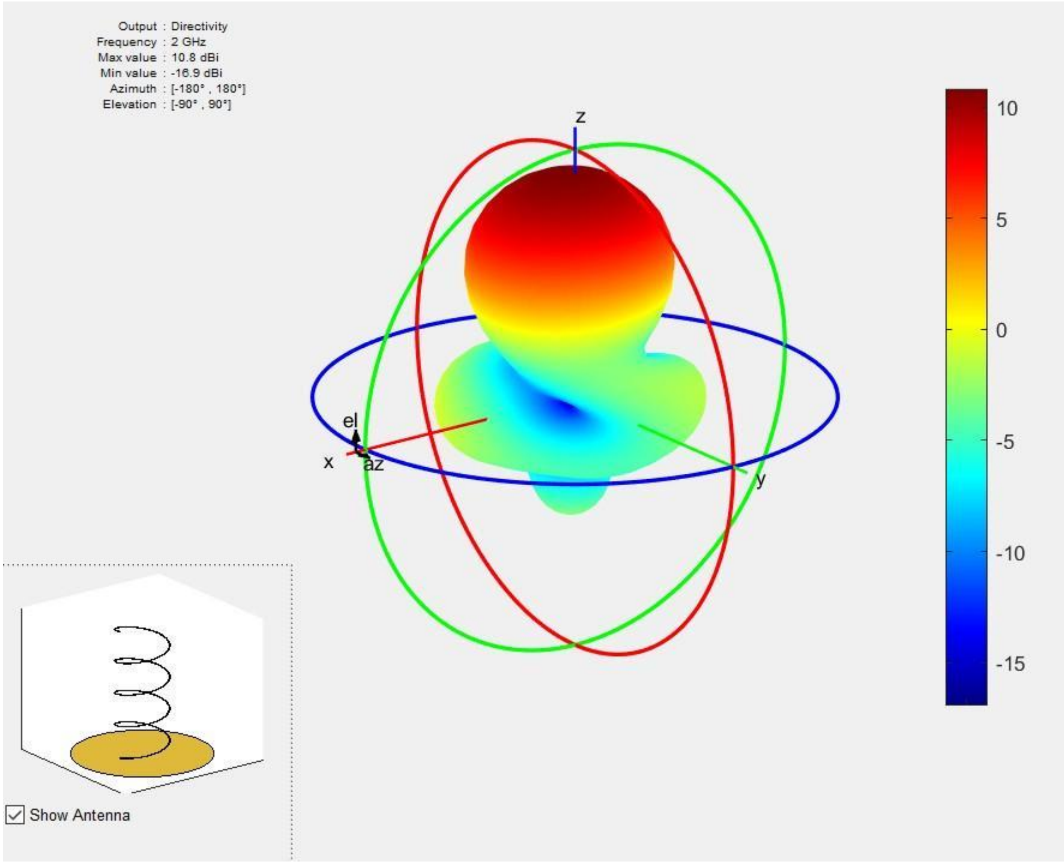
<u>MATLAB Simulation Example:</u> helix antenna that has a 28 mm turn radius, 1.2 mm strip width, and 4 turns.

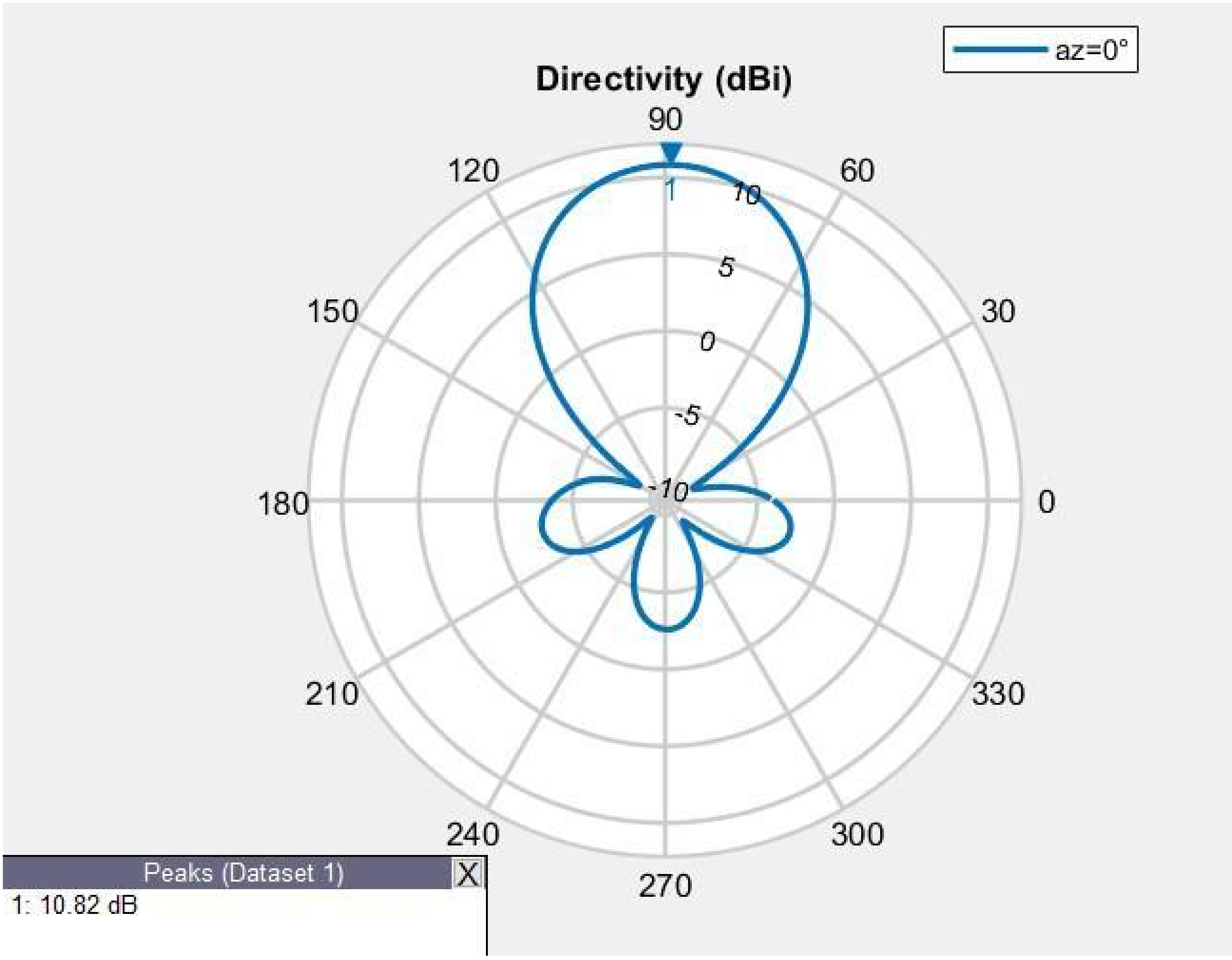
```
hx = helix('Radius',28e-3,'Width',1.2e-3,'Turns',4)
figure
show(hx);
figure
pattern(hx,2e9);
figure
pattern (hx, 2e9, 0, 1:1:360);
```

```
helix with properties:

               Radius: 0.0280
                Width: 0.0012
                Turns: 4
              Spacing: 0.0350
     WindingDirection: 'CCW'
       FeedStubHeight: 1.0000e-03
     GroundPlaneRadius: 0.0750
                 Tilt: 0
             TiltAxis: [1 0 0]
                 Load: [1×1 lumpedElement]
```




Output : Directivity
Frequency : 2 GHz
Max value : 10.8 dBi
Min value : -16.9 dBi
Azimuth : [-180° , 180°]
Elevation : [-90° , 90°]
z
x
y
el
az
10
5
0
-5
-10
-15
Show Antenna


Directivity (dBi)
az=0°
90
60
30
0
330
300
270
240
210
180
150
120
10
5
0
-5
-10
1
Peaks (Dataset 1)
1: 10.82 dB