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Antenna & Propagation

Helical Antenna

by
Nor Hadzfizah Binti Mohd Radi
Faculty of Electric & Electronics Engineering
hadzfizah@ump.edu.my

Chapter Synopsis

In this course, the student will be exposed to the concept of helical antenna as one of broadband antenna

Teaching Outcome

At the end of this chapter student should be able to:

- ❑ Differentiate the types of helical antennas which are
  - ✓ Normal (Broadside) Mode
  - ✓ End Fire (Axial) Mode
  - ✓ Hansen Woodyard End Fire Mode

- ❑ Calculate the parameters related in designing the helical antenna

Outline

- Broadband Antenna
- The dimensions
- Normal (Broadside) Mode
- End Fire (Axial) Mode
- Hansen Woodyard End Fire Mode

Broadband Antenna

- The definition of a broadband antenna is somewhat arbitrary and depends on the particular antenna.
- If the impendence and pattern of an antenna do not change significantly over about an octave (*fu* / *fl* =2) or more, it will classified as a broadband antenna.
- Here are some of broadband antennas:
  - Loops antenna
  - **Helix antenna**
  - Yagi uda antenna
  - Log periodic antenna
- In this chapter, we will focusing in Helix antenna.

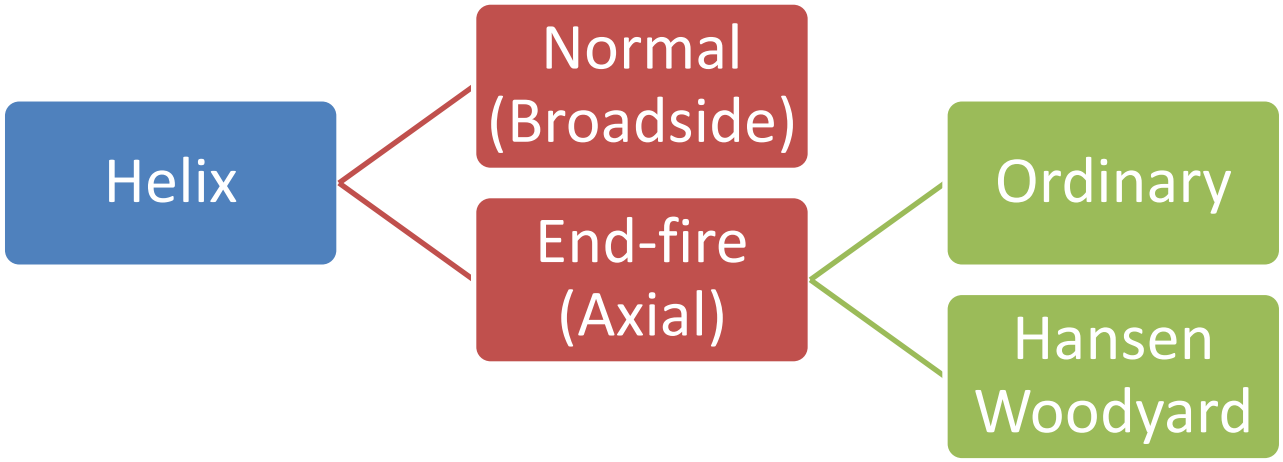
Helix Antenna (1)

- Helix antenna also commonly called helical antenna.
- It have a very distinctive shape, as can be seen in the figure here.
- 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.

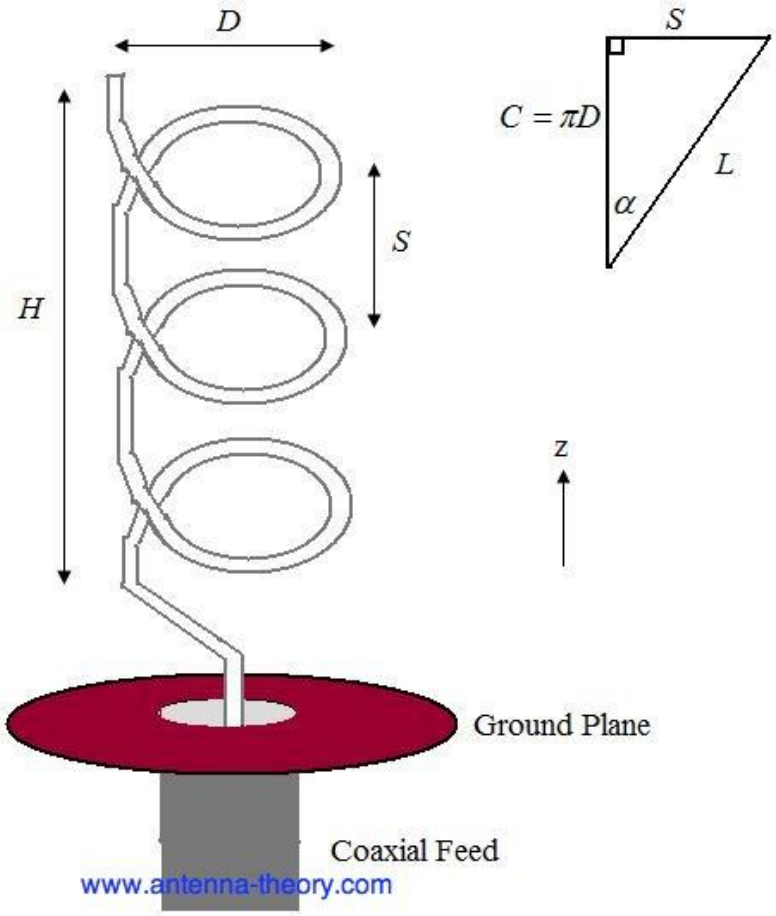
Source: https://commons.wikimedia.org

Helix Antenna (2)

- Below shows the type of Helix Antenna:



The General Dimensions



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

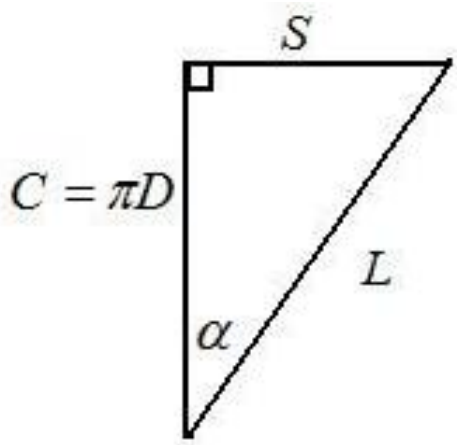
$$\alpha = \tan^{-1}\frac{S}{C}$$

- *N* - Number of turns on the helix antenna.
- H - Total height of helix antenna, H=NS.

Source: www.antenna-theory.com

The Length

- $L_o = \sqrt{S^2 + C^2} = single\ turn$
- $L_n = NL_o = N\sqrt{S^2 + C^2}$

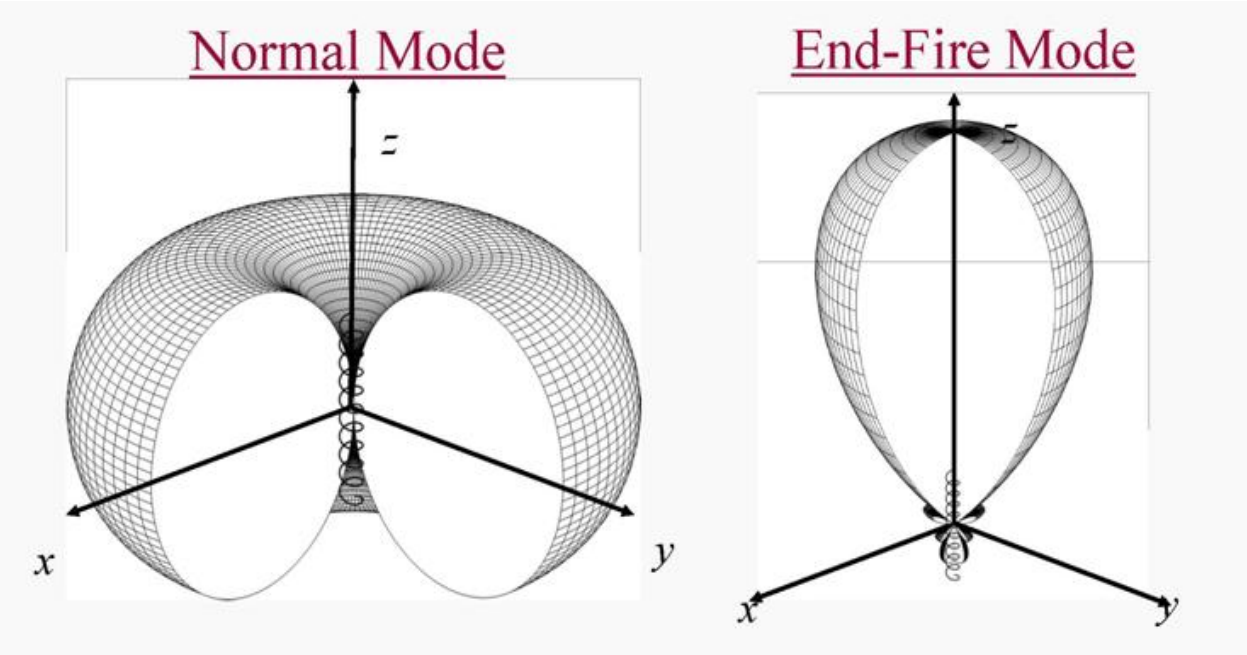


The Polarization

- To identify the polarization of helix antenna, you can used your hand rule.
- If you curl your fingers on your left hand around the helix your thumb would point up, 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.

Modes of Operation

- Figure below shows the 3-D normalized amplitude linear power patterns for normal and end fire modes helical design.



Normal @ Broadside Mode

Calculation of Helix Normal Mode:

- Axial Ratio, $AR = \frac{2\lambda_0}{(\pi D)^2} = 1$
- πD=C=$\sqrt{2\lambda_o S}$
- $\tan\alpha = \frac{S}{\pi D} = \frac{S}{\sqrt{2\lambda_o S}} = \sqrt{\frac{S}{2\lambda_o}} = \frac{\pi D}{2\lambda_o}$

Endfire @ Axial Mode

Calculation of Helix Endfire Mode

- Pitch angle: $12° < \alpha < 14°$
- Circumference of a turn: $\frac{3}{4}\lambda_o < C < \frac{4}{3}\lambda_o$
  - Near optimum, $C \cong \lambda_o$
- Number of turns, N>3
- Terminal Impedance, $R = \frac{140C}{\lambda_o}$
- HPBW (in degrees)=$\frac{52}{C}\sqrt{\frac{\lambda^3}{N.S}}$
- FNBW (in degrees) =$\frac{115}{C}\sqrt{\frac{\lambda^3}{N.S}}$
- Max directivity gain, $G_D = \frac{15NSC^2}{\lambda^3}$
- Axial Ratio, $AR = 1 + \frac{1}{2N}$

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Ordinary and Hansen Woodyard End Fire Mode

Helical Designs

Ordinary End-Fire

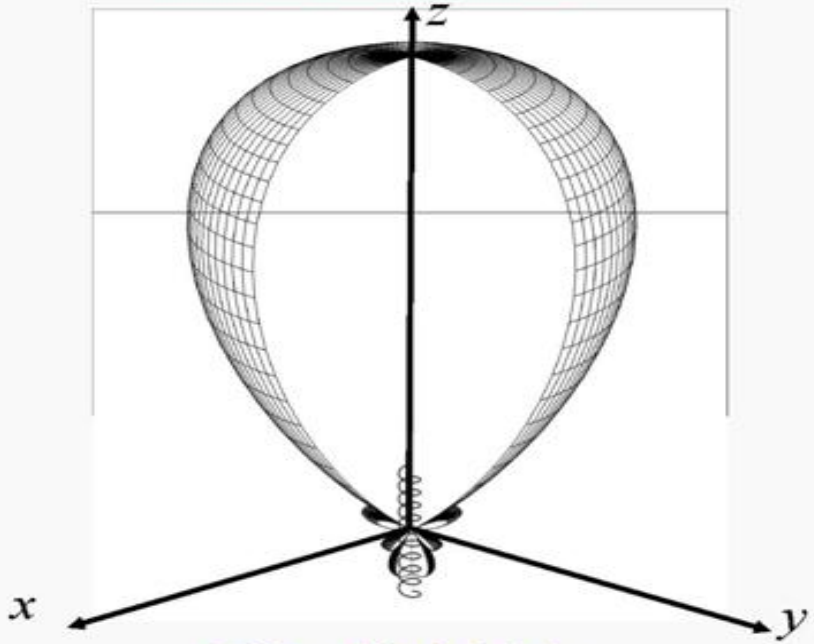

Fig. 10.16(a)

H-W End-Fire

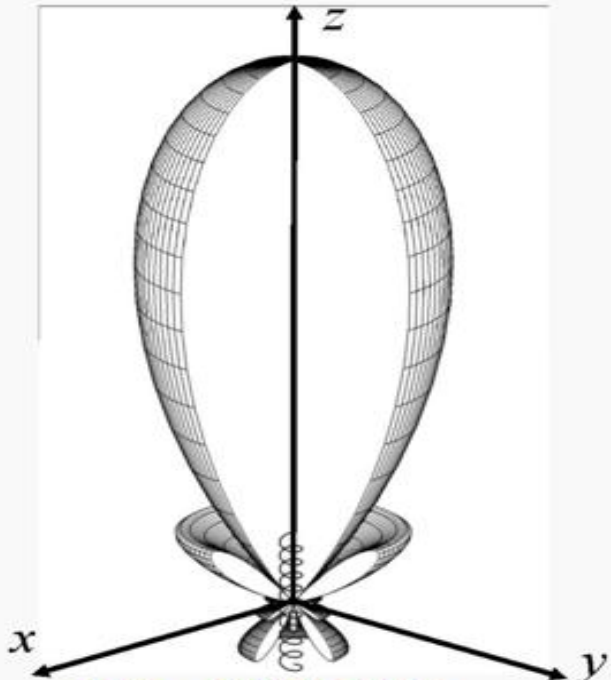

Fig. 10.16(b)

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Features of Helical Antenna

1. • Circular Polarization
2. • Widely used in VHF and UHF bands
3. • Axial mode helix antenna is widely used
4. • Axial mode: has larger bandwidth
   • Normal mode: bandwidth and efficiency both are same
5. • Construction is simple and high directivity
6. • AR=0 (linear polarization), AR=∞ (vertical polarization), AR=1 (circular polarization)

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References

[1] C.A. Balanis:"Antenna Theory: Analysis & Design", John Wiley & Sons, 2012.

[2] Stutzman and Thiele, *Antenna Theory and Design*, John Wiley, 2012.

[3] T. A. Milligan, "Modern Antenna Design" John Wiley, 2nd edition, 2005.

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Author Information

Nor Hadzfizah Binti Mohd Radi
Lecturer
FKEE, UMP
email
hadzfizah@ump.edu.my