Helix Antennas

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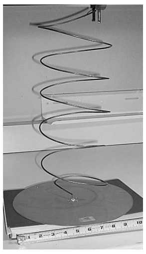
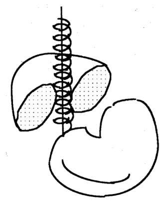
Antenna Theory and Design



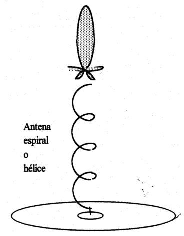
Helix antenna was invented by J. D. Kraus.

- There are two modes of operation, normal and axial.



Normal Mode

$NL << \lambda$



Axial Mode

$3/4\ \lambda < C < 4/3\ \lambda$

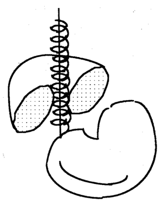
not so Normal mode $NL << \lambda$

- Pattern is

$$E_\theta = \frac{j\eta k I_o S e^{-jkr}}{4\pi r}\sin\theta \quad \text{(dipolo)}$$

$$E_\phi = \frac{\eta k^2 (D/2)^2 I_o e^{-jkr}}{4r}\sin\theta \quad \text{(lazo)}$$

(i) *Si* $|E_\theta| = |E_\phi|$ tenemos polarización circular.
(ii) En general la polarización será elíptica.
(iii) Tiene un ancho de banda angosto debido a la dependencia en sus dimensiones geométricas.



Normal Mode

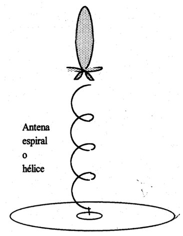
Axial Mode $3/4\ \lambda < C < 4/3\ \lambda$

- Most widely used mode
- Pattern has form:

$$E = \sin\frac{\pi}{2N}\left[\cos\theta\right]\left[\frac{\sin\left(\frac{N}{2}\psi\right)}{\sin\left(\frac{\psi}{2}\right)}\right]$$

where

$$\psi = 2\pi\left[\frac{S}{\lambda}(1-\cos\theta)+\frac{1}{2N}\right]$$



Axial Mode

Helix parameters

S = espaciamiento entre las vueltas
N = número de vueltas
α = ángulo de salida ("pitch angle")
C = circunferencia de cada vuelta = πD
D = diámetro

- Dimensions that render an optimum pattern are :

$12^o \le \alpha \le 18^o$

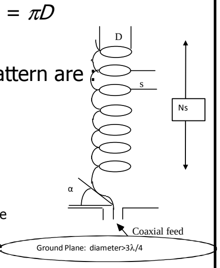
$\frac{3}{4}\lambda < C_\lambda < \frac{4}{3}\lambda$

$N > 3$

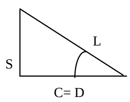
$C = \lambda \quad \alpha = 14^o$

$S \approx \frac{\lambda}{4}$

Para aparear la *R*, se puede aplastar el alambre a medida que se acerca al plano de la tierra ("ground plane") y se separa de este mediante un material dieléctrico



One loop in the helix…



$$L = \sqrt{s^2 + C^2}$$

Axial mode

$$R \cong 140\frac{C}{\lambda}$$

$$HPBW^o \cong \frac{52\lambda^{3/2}}{C\sqrt{NS}}$$

$$D_o \cong \frac{15NC^2S}{\lambda^3}$$

- Tiene mayor ancho de banda.
- El patrón es más dirigido.
- Se encuentra que a mayor número de vueltas, se obtiene mayor ganancia.
- La impedancia de entrada de la espiral en este modo es casi toda real.

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1. Design an end-fire right-hand circularly polarized helix having a half-power beamwidth of 45°, pitch angle of 13°, and a circumference of 60 cm at a frequency of 500 MHz.

Determine

- turns needed
- directivity
- axial ration
- lower and upper frequencies of the bandwidth over which the required parameters remain relatively constant
- input impedance at the center frequency and the edges of the band from part d)

Answer: N=6, D=20.8 (13 dB), AR = 1.083, 375-667MHz, 140, 105, 187 Ω

10.27 Design a helical antenna with a directivity of 15 dB that is operating in the axial mode and whose polarization is nearly circular. The spacing between the runs is λ/10.

Determine the

1. number of turns
2. axial ratio, both as a dimensionless quantity and in dB
3. Directivity according to Krauss equation (in DB)

Answer: N=21, AR =1.02, HPBW= 36.8° D= 14.5dB or 15dB

10.28 Design a 10 turn helical antenna so that at the center frequency of 10 GHz, the circumference of each turn is 0.95λ. Assuming a pitch angle of 14°, determine the

a. mode in which the antenna operates
b. half-power beamwidth (degrees)
c. directivity in dB.

Answer: Axial mode, HPBW=36° , D=15dB

10.29 A lossless 10-turn helical antenna with a circumference of one-wavelength is connected to a 78-ohm coaxial line, and it is used as a transmitting antenna in a 500 MHz spacecraft communication system. The spacing between turns is λ/10. The power in the coaxial line from the transmitter is 5 watts.

Assuming the antenna is lossless:

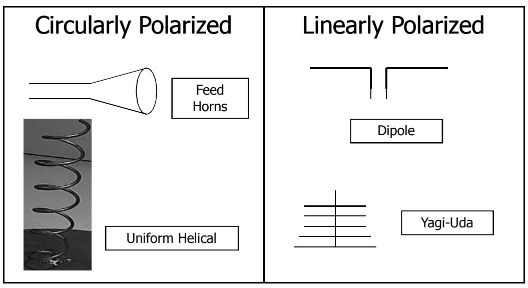
a. what is radiated power?
b. If the antenna were isotropic, what would the power density (W/m²) be at a distance of 10 km?
c. What is the power density at the same distance when the transmitting antenna is a the 10-turn helix and the observation are made along the maximum of the major lobe?
d. it at 10 – km along the maximum of the major lobe an identical 10-turn helix was placed as a receiving antenna, which was polarization-matched to the incoming wave, what is the maximum power (in watts) that can be received?

Answer: *Answer*: R= 140 Ω, P_{rad}=4.595W, S_{iso}=3.656nW/m², D=15, S_{helix} =54.8nW/m², Ae=0.6m², P_{rec}=26.6nW

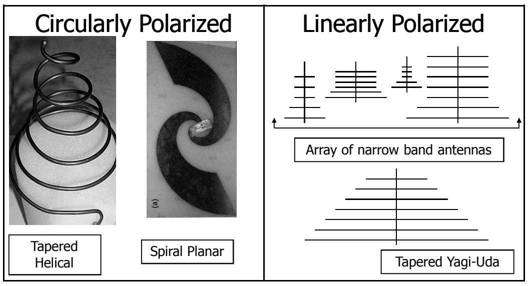
Application

- At Arecibo Observatory :some receivers work at
  - frequency range :300 MHz up to 6 GHz
  - plan to extend the range up to 10 GHz.
- A good way to do a preliminary check to see if these receivers are working is by sending a test signal, circular or linear (vertical), depending on which receiver is being used.

Narrow Band Antennas

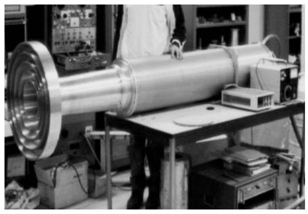


Broad Band Antennas



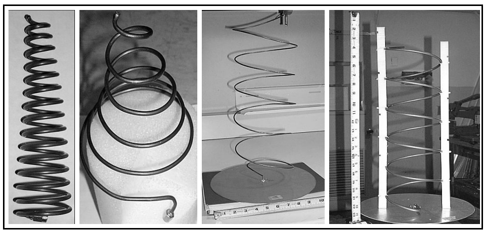
At the Arecibo Observatory

Some of their antennas look like these:



Polarization

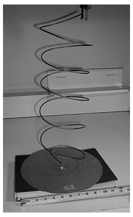
helical antennas have circular polarization



Parameters Varied

Conductor material

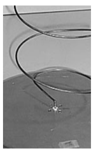
Size of conductor



Cont. Parameters Varied

SMA connector

Feeding point



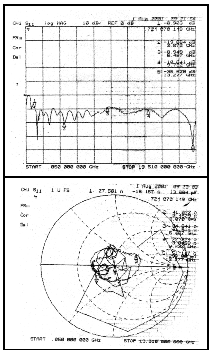
Tuning

From Ing.Natalia Figueroa UPRM,Lisa S. Wray &Edgar Castro (Arecibo Obs),2001

Preliminary Tests

Large_B

S_{11} parameters tests where done on the Large_B antenna. These measures the return loss on the antenna, ideally we want –10 dB. Also a the Smith Chart results where plotted.



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