

Antenas

Parte 2

Tipos

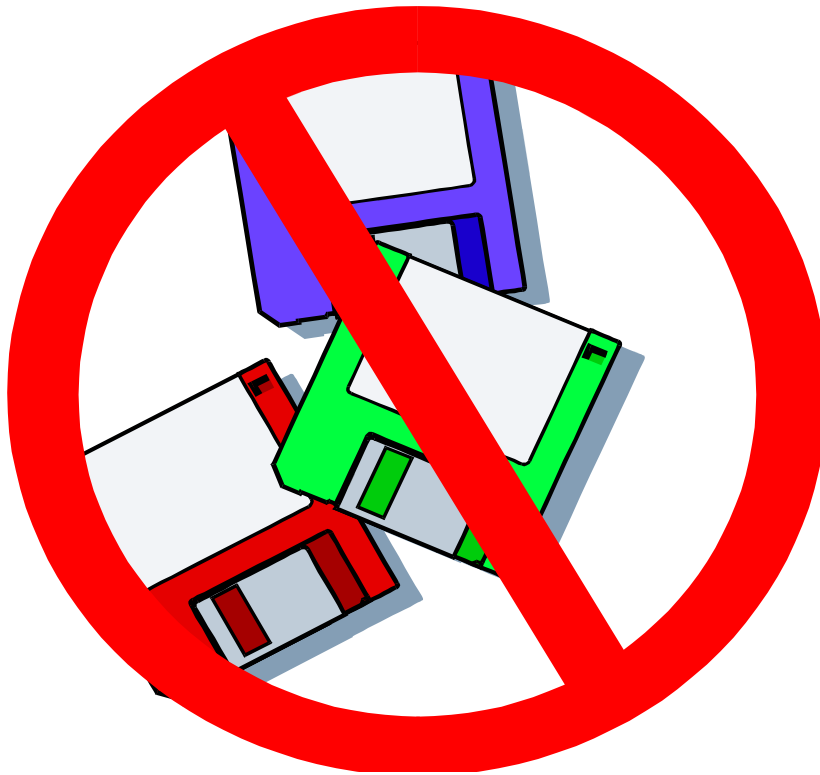
SEL 413 Telecomunicações

Amílcar Careli César

Departamento de Engenharia Elétrica da EESC-USP



Atenção!

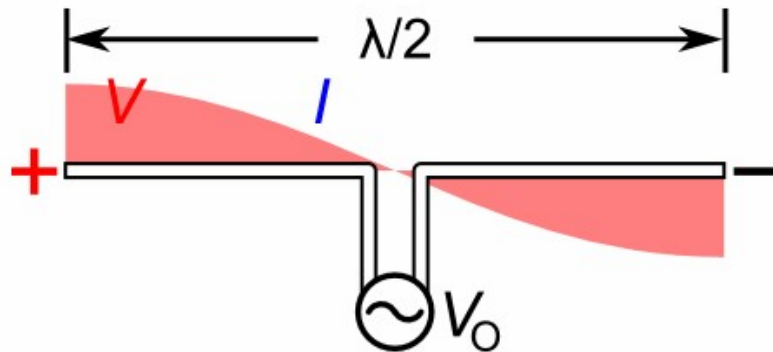


- ✓ Este material didático é planejado para servir de apoio às aulas de **SEL-413: Telecomunicações**, oferecida aos alunos regularmente matriculados no curso de engenharia aeronáutica.
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Dipolo
Monopolo
Parabólica
Helicoidal
Patch
Corneta
Arranjo (rede) de antenas

TIPOS DE ANTENAS

Antena dipolo de $\frac{1}{2}$ onda (1)



A half-wave dipole antenna receiving power from a radio wave.

Since the antenna is a half-wavelength long at the radio wave's frequency, it excites standing waves of voltage (V , red) and current in the antenna.

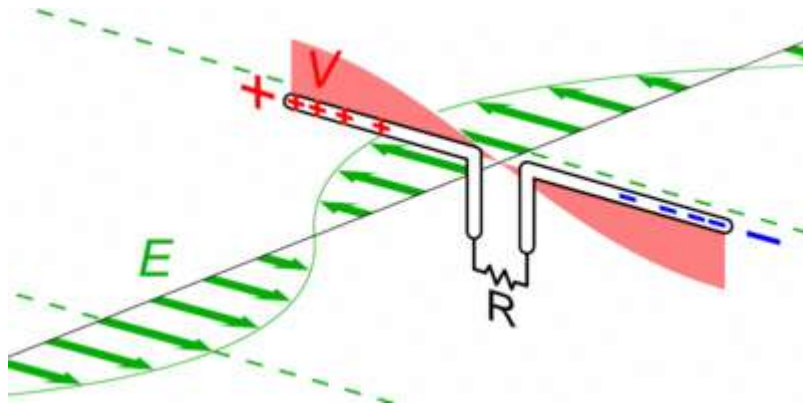
These oscillating currents flow down the transmission line into the radio receiver (represented by the resistor R).

The action is shown slowed down in this animation.

Animation showing the sinusoidal standing waves of voltage (V , red) and current (I , blue) on a half-wave dipole driven by an AC voltage at its resonant frequency.

https://en.wikipedia.org/wiki/Dipole_antenna

Antena dipolo de $\frac{1}{2}$ onda (2)



Animation showing the sinusoidal standing waves of voltage (**V, red**) and current (**I, blue**) on a half-wave dipole driven by an AC voltage at its resonant frequency.

A half-wave dipole antenna receiving power from a radio wave. The electric field of the wave (**E, green arrows**) pushes the electrons in the antenna elements back and forth (black arrows), charging the ends of the antenna alternately positive and negative.

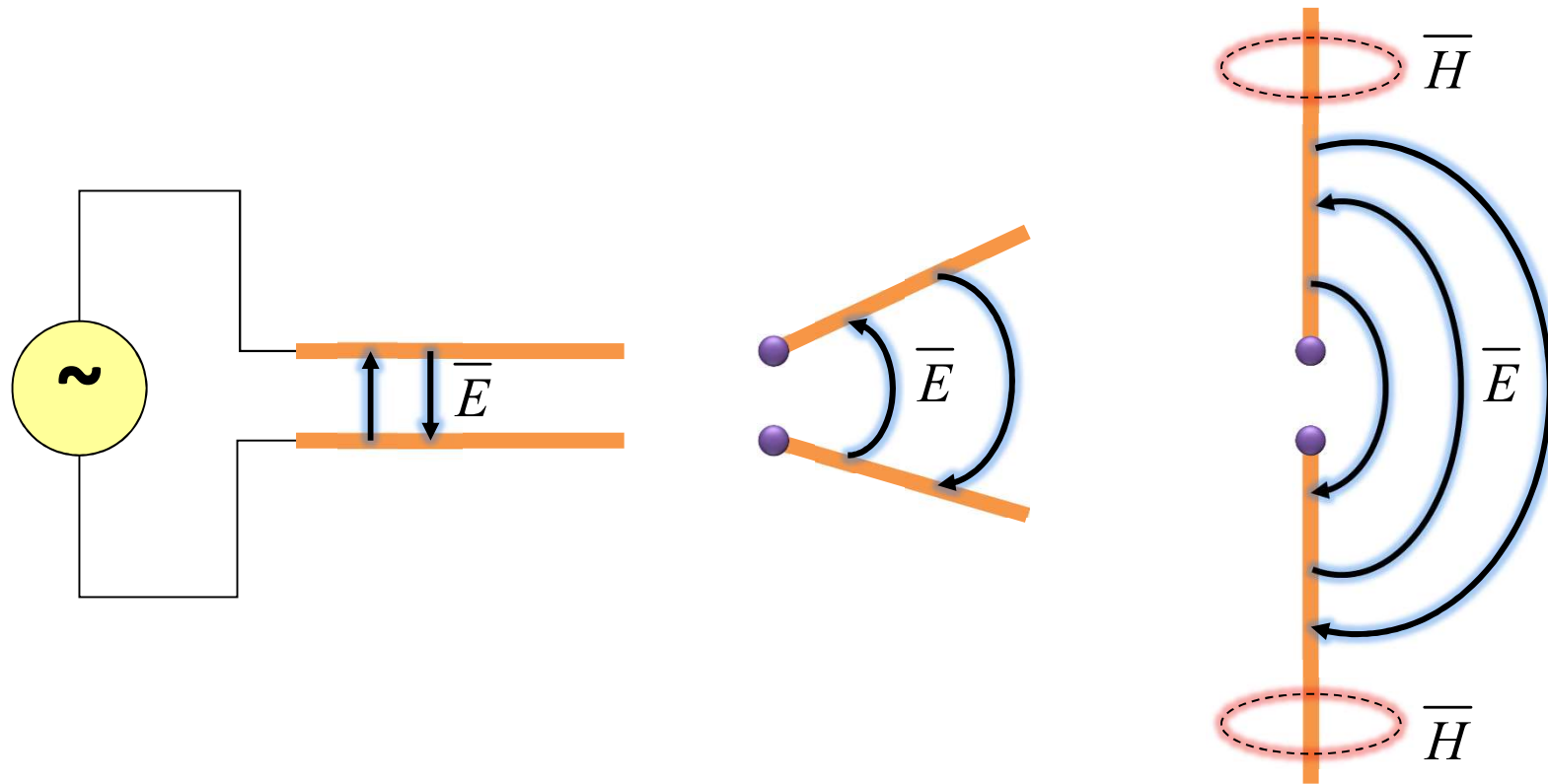
Since the antenna is a half-wavelength long at the radio wave's frequency, it excites standing waves of voltage (**V, red**) and current in the antenna.

These oscillating currents flow down the transmission line into the radio receiver (represented by the resistor **R**).

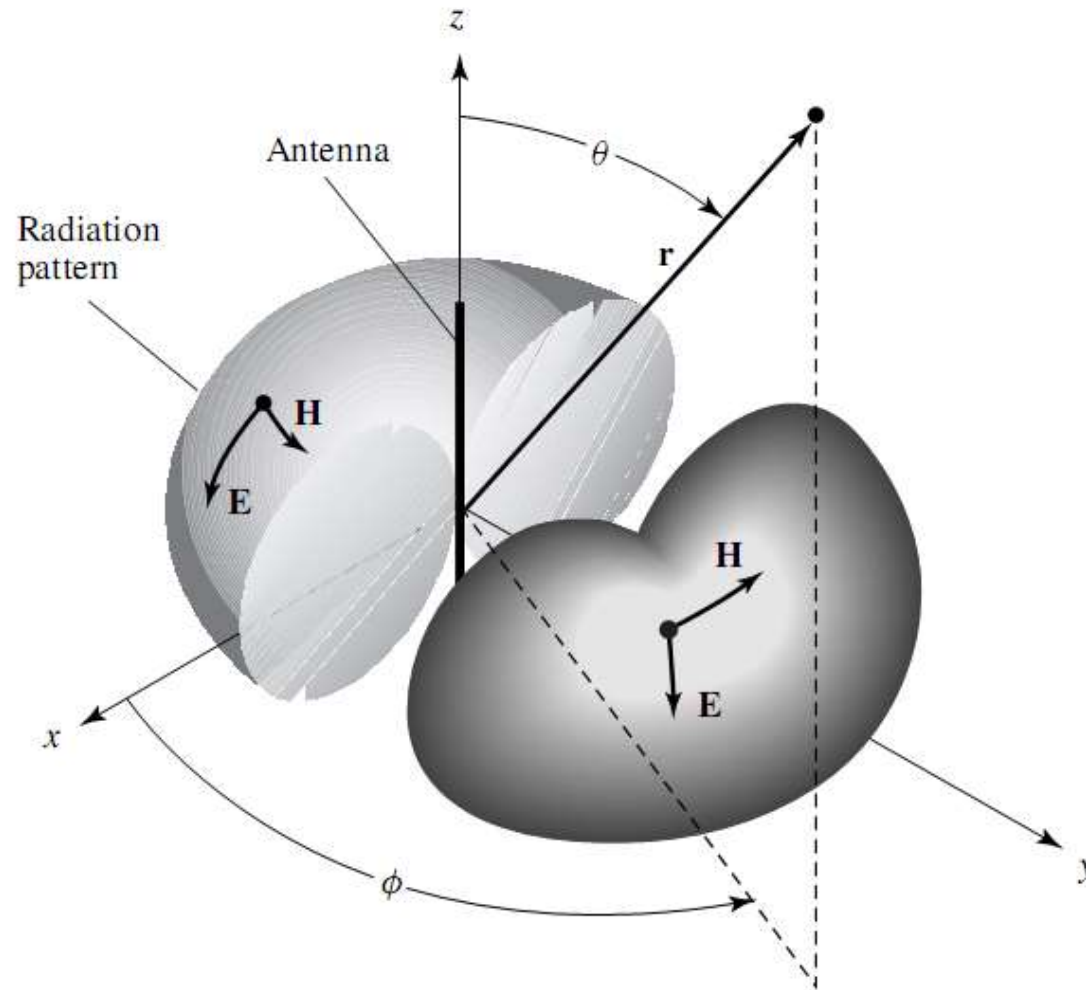
The action is shown slowed down in this animation.

https://en.wikipedia.org/wiki/Dipole_antenna

Antena dipolo-1



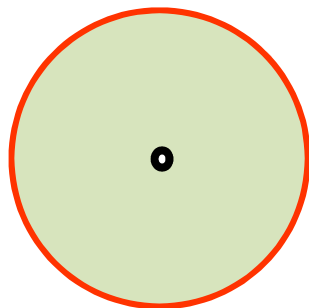
Padrão de diagrama onidirecional (dipolo)



Constantine A. Balanis, *Antenna Theory: Analysis Design*, 3ª edição, John Wiley & Sons, Inc., 2005, p. 33, Fig. 2.6

Diagramas de Radiação de Dipolo

Diagrama no plano vertical



Dipolo na posição horizontal (vista lateral)

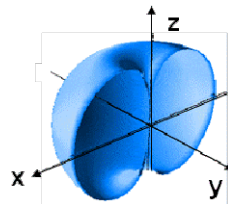
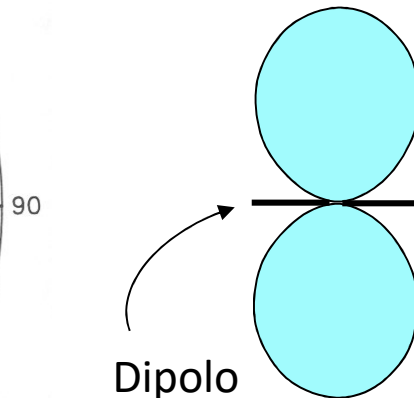
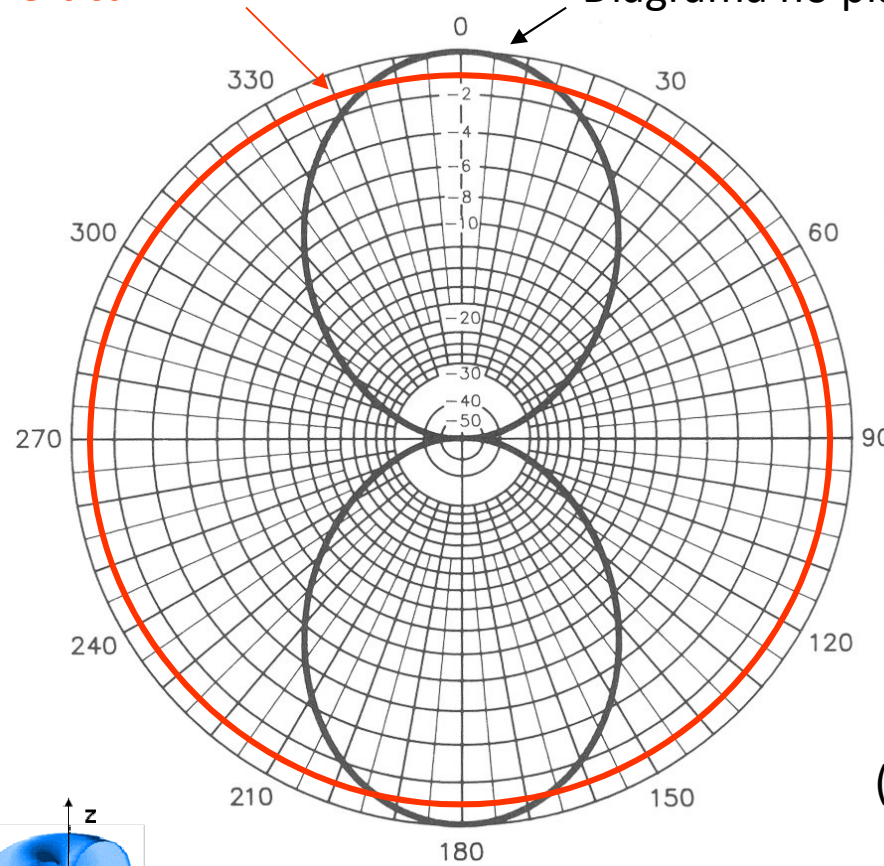
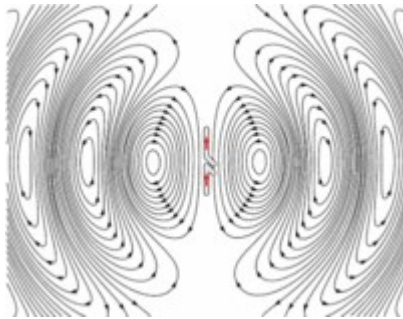


Diagrama no plano horizontal

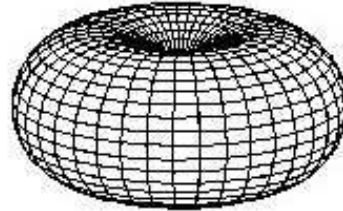


Dipolo na posição horizontal (visto por cima)

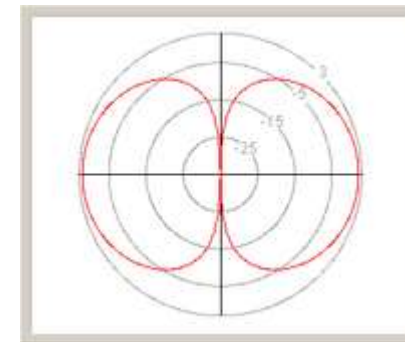
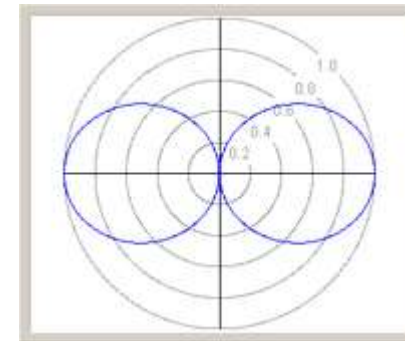
Antena dipolo de $\frac{1}{2}$ onda



Animation showing electric fields of a radiating vertical half-wave dipole antenna.



Three dimensional radiation pattern of a vertical half-wave dipole antenna.

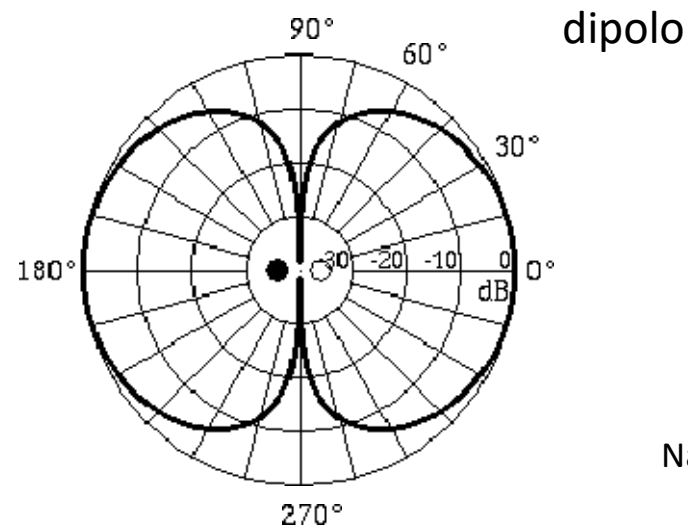
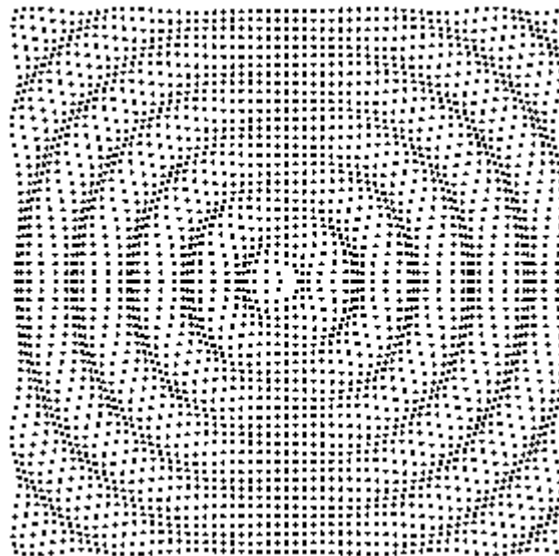
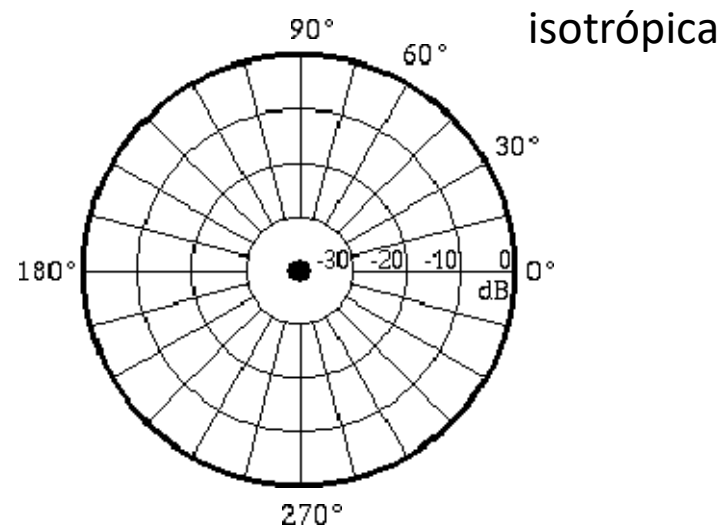
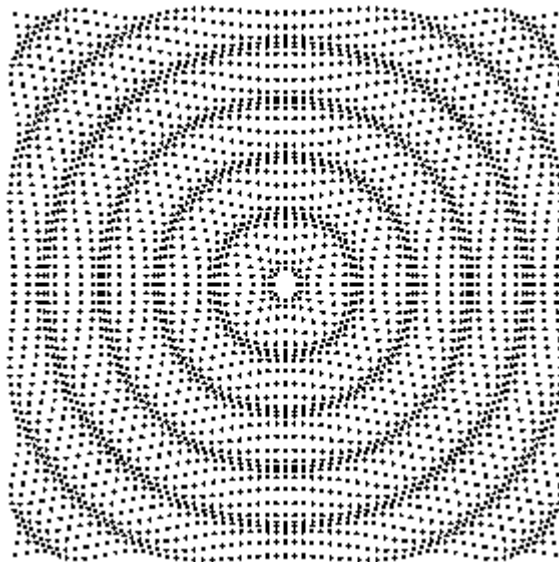


Radiation pattern of vertical half-wave dipole; vertical section.

(top) In linear scale
(bottom) In decibels isotropic (dBi)

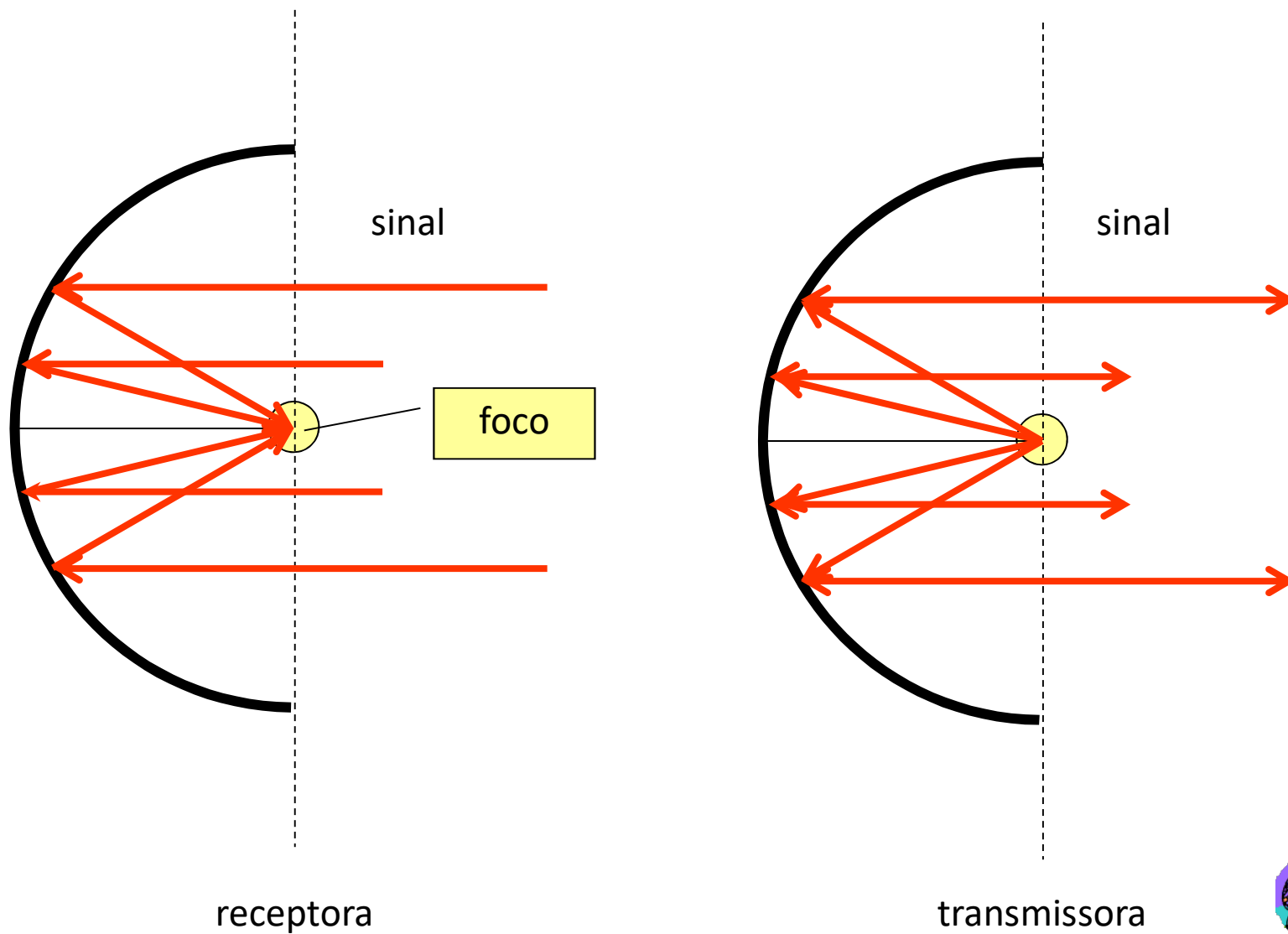
https://en.wikipedia.org/wiki/Dipole_antenna

Radiação das fontes isotrópica e dipolo

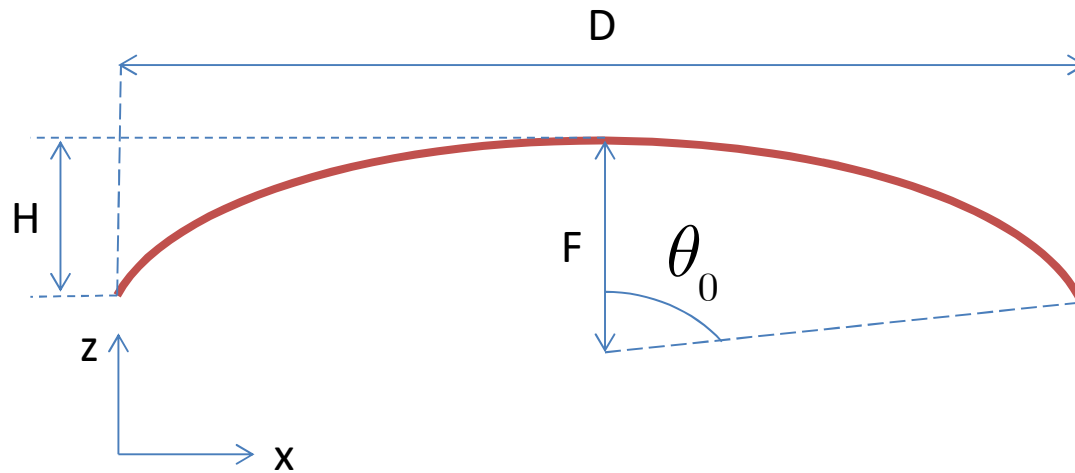


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www.ece.nus.edu.sg/stfpage/elehht/Teaching/EE4101/index.htm

Antena Parabólica-1



Antena parabólica-2



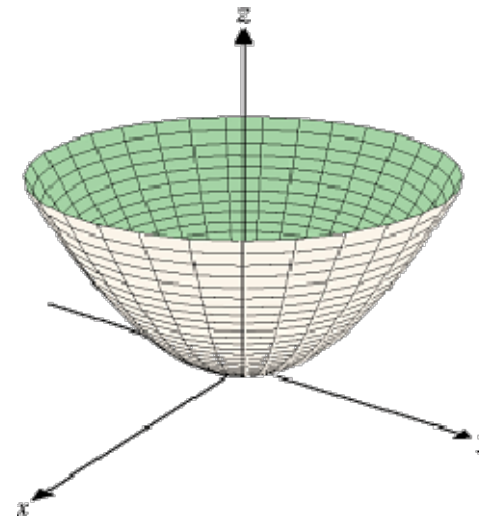
$$x^2 = 4F(F - z), \quad |x| \leq \frac{D}{2}$$

$$\frac{F}{D} = \frac{1}{4 \operatorname{tg}(\theta_0 / 2)}$$

$$F = \frac{D^2}{16H}$$

F : distância focal; D : diâmetro; H : altura

F / D : 0,3 a 1,0



Antena Parabólica-3

Características: ganho alto e feixe estreito

Ganho $G = 6 \left(\frac{D}{\lambda} \right)^2$ adimensional

Ângulo de ½ potência $HPBW = 58 \left(\frac{\lambda}{D} \right)$ grau

Ângulo 1o. nulo $FNBW = 70 \left(\frac{\lambda}{D} \right)$ grau

D : diâmetro. Quanto maior for λ/D , mais direcional será a antena

HPBW: half power beam width; **BWFN**: beam width first null

Antena Parabólica-4

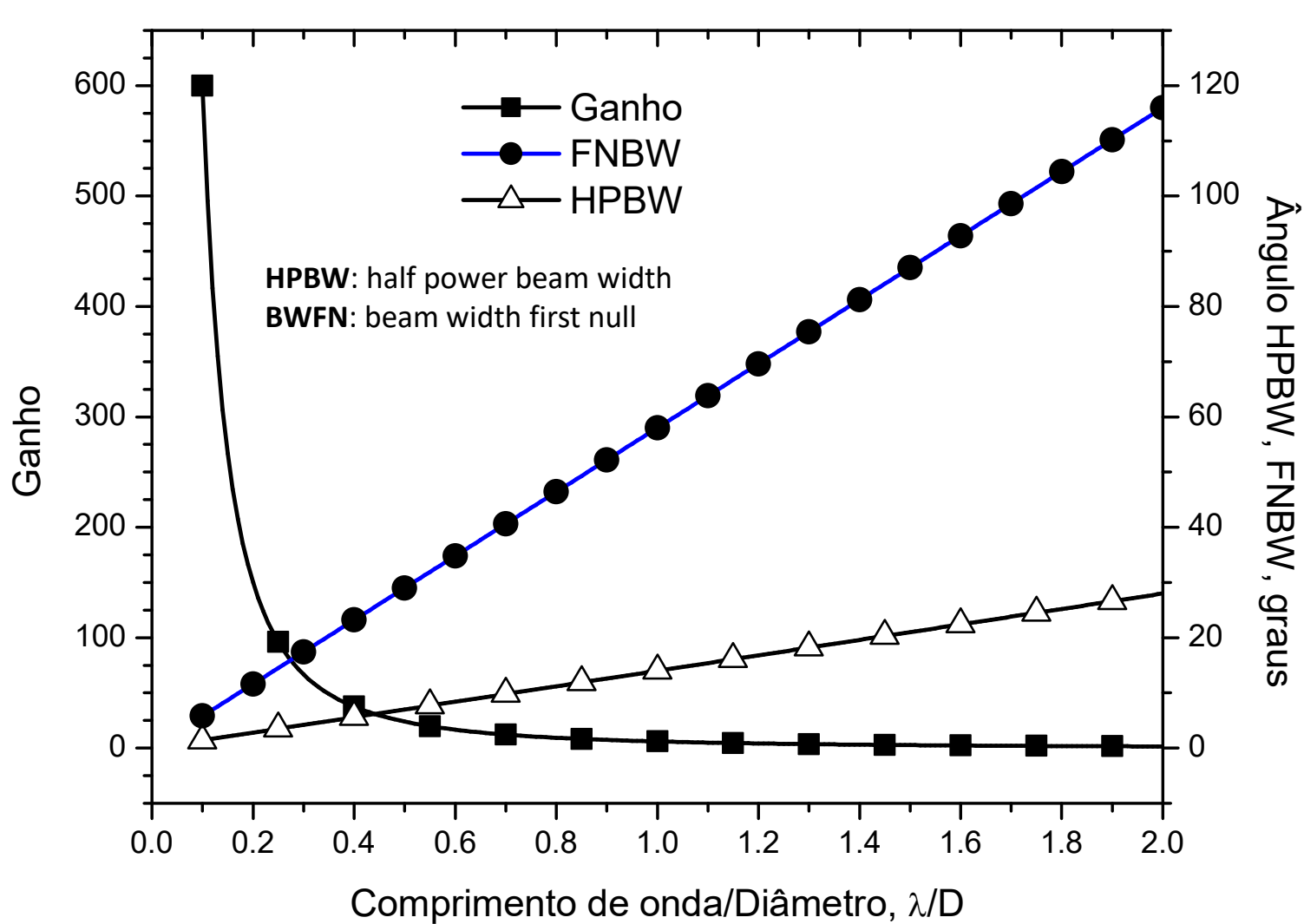
Exemplo: Calcular G , HPBW e FNBW para uma antena parabólica de $D=3$ m operando em $\lambda=2$ cm (15 GHz).

$$G = 6 \left(\frac{D}{\lambda} \right)^2 = 6 \left(\frac{3}{0,02} \right)^2 = 1,35 \times 10^5 \text{ ou } G = 10 \log(G) = 51,3 \text{ dB}$$

$$HPBW = 58 \left(\frac{\lambda}{D} \right) = 58 \left(\frac{0,02}{3} \right) = 0,38^\circ$$

$$FNBW = 70 \left(\frac{\lambda}{D} \right) = 70 \left(\frac{0,02}{3} \right) = 0,47^\circ$$

Antena Parabólica-5

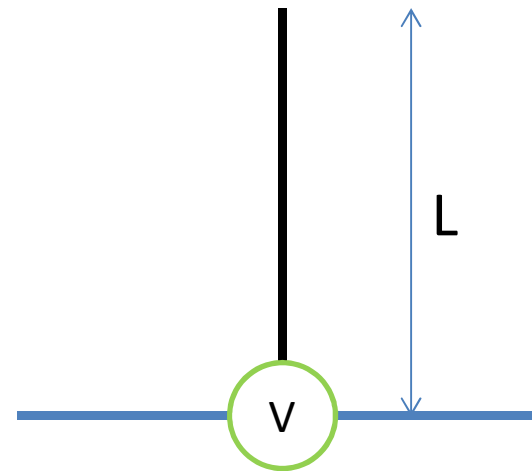
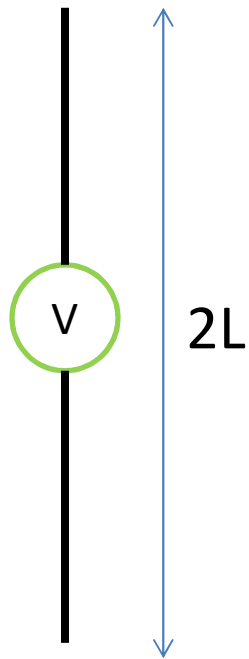


$$G = 6 \left(\frac{D}{\lambda} \right)^2$$

$$HPBW = 58 \left(\frac{\lambda}{D} \right)$$

$$FNBW = 70 \left(\frac{\lambda}{D} \right)$$

Antenas dipolo e monopolo



Condutor perfeito
Plano infinito

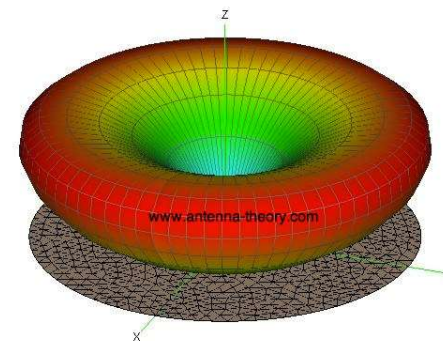
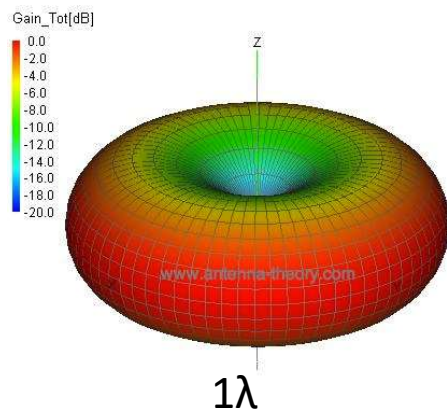
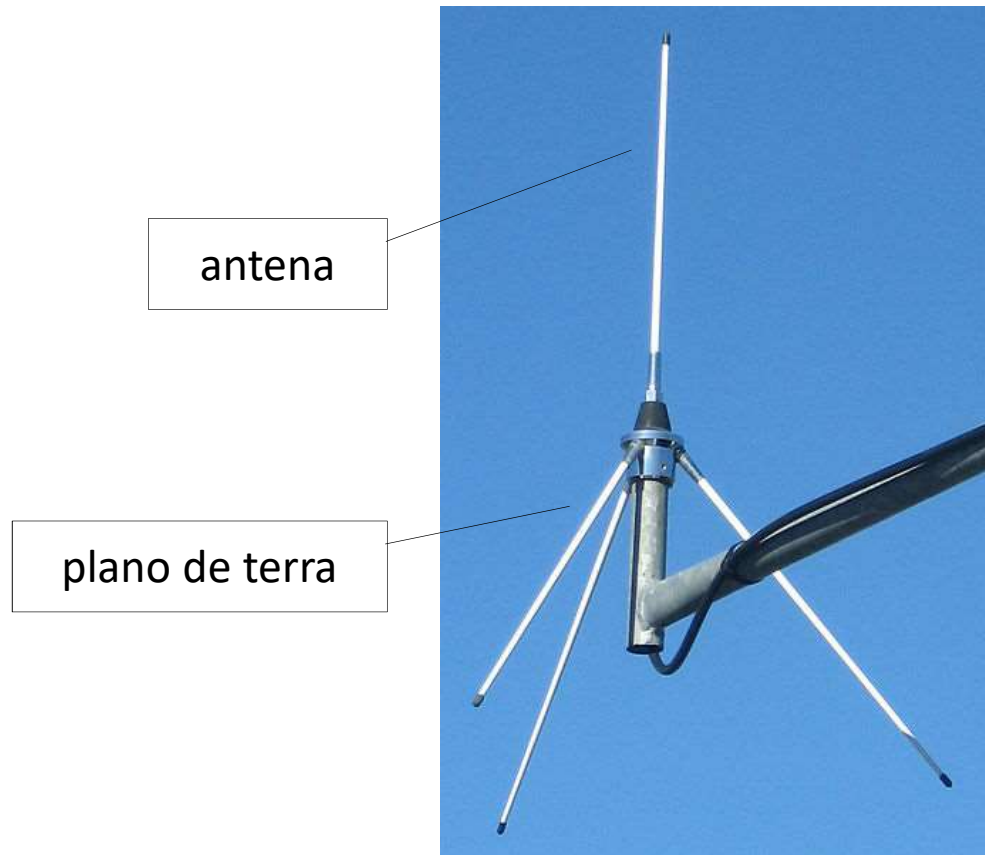


Diagrama para plano de terra 3λ

Antenas monopolo e dipolo

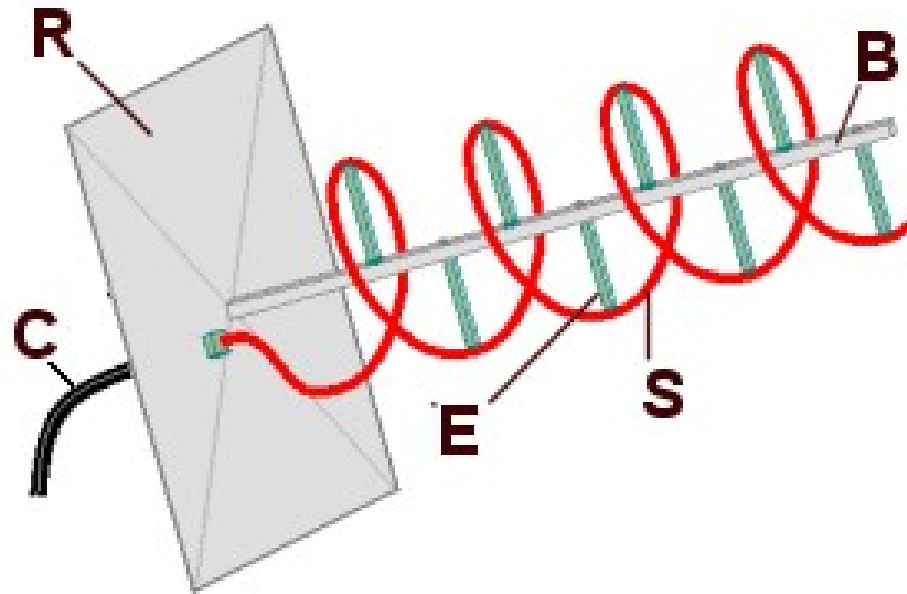


monopolo



dipolo

Antena helicoidal-1



- (B) Suporte central
- (C) Cabo coaxial de alimentação
- (E) Espaçadores/suportes
- (S) Elemento helicoidal

Antena helicoidal-2

✓ 2 modos de operação

— Normal

- Diâmetro e passo bem menores que λ de operação
- Atua como monopolo ou dipolo
- Diagrama de radiação onidirecional
- Polarização linear
- Tamanho reduzido; bom para equipamento portátil

— Axial

- Diâmetro e passo comparáveis ao λ de operação
- Atua como antena direcional
- Polarização circular
- Refletor em um lado da antena

Antena helicoidal-3: modo axial

Resistência de radiação

$$R \simeq 140 \left(\frac{C}{\lambda} \right), \Omega, \text{ entre } 100 \text{ e } 200 \Omega$$

Diretividade máxima

$$D_0 \simeq 15N \frac{C^2 S}{\lambda^3}, \text{ adimensional}$$

Largura de feixe de 1/2 potência

$$HPBW \simeq \frac{52\lambda^{3/2}}{C\sqrt{NS}}, \text{ grau}$$

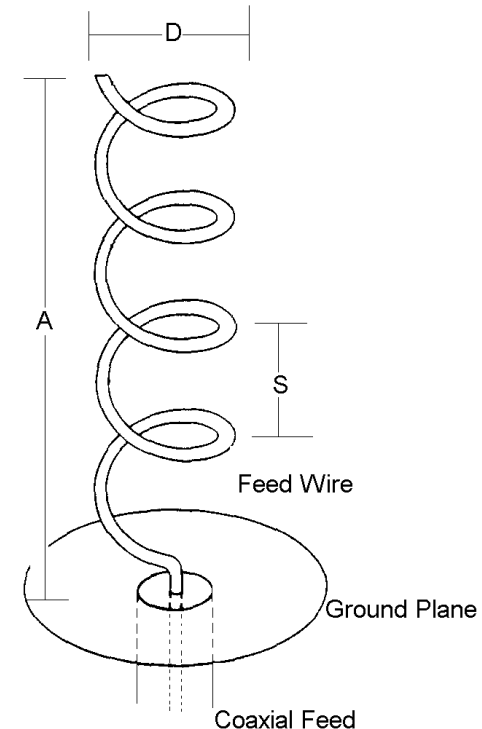
Largura de feixes entre nulos

$$FNBW \simeq \frac{115\lambda^{3/2}}{C\sqrt{NS}}, \text{ grau}$$

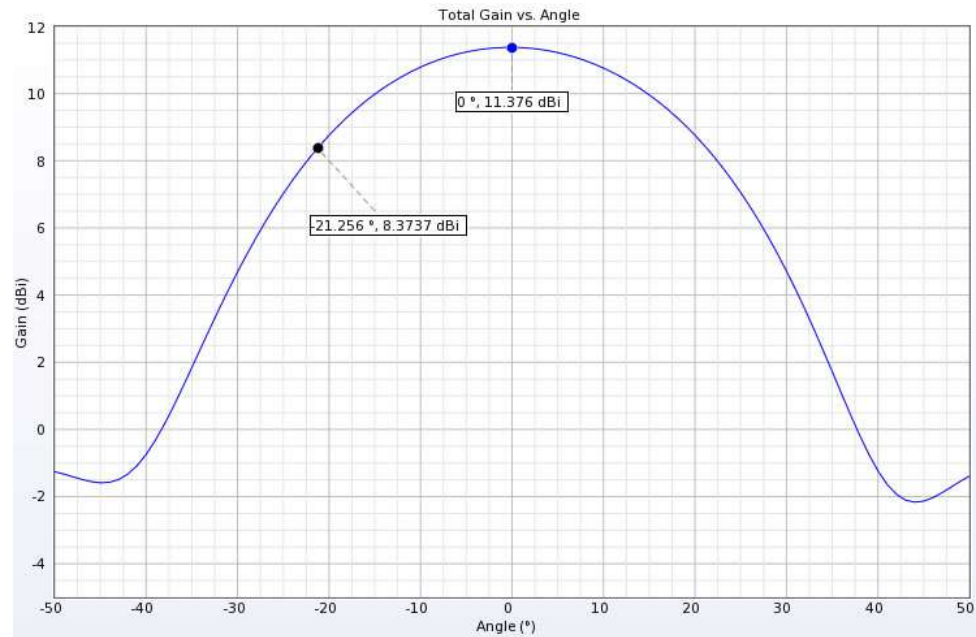
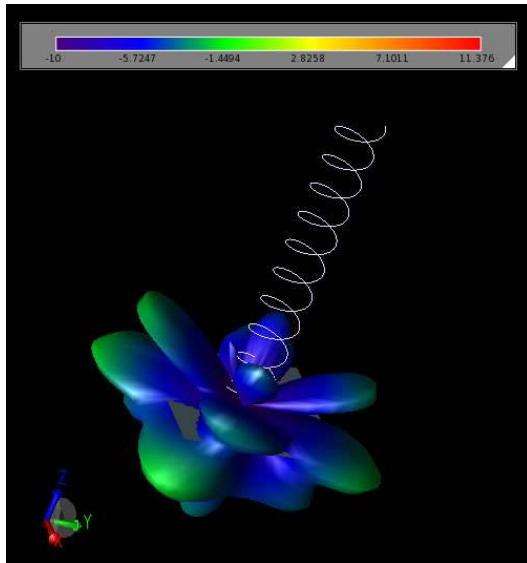
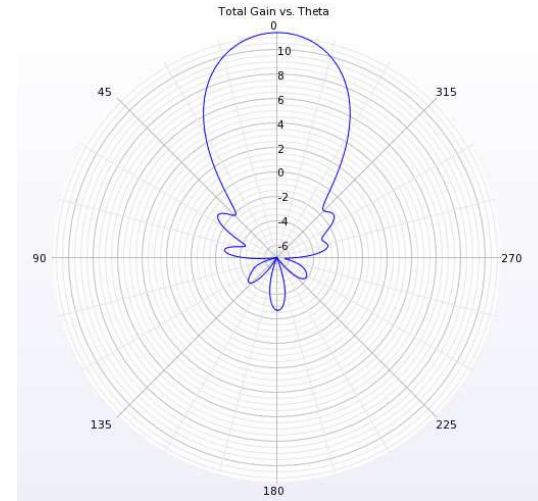
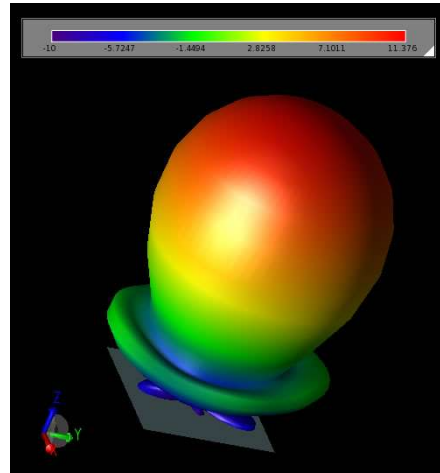
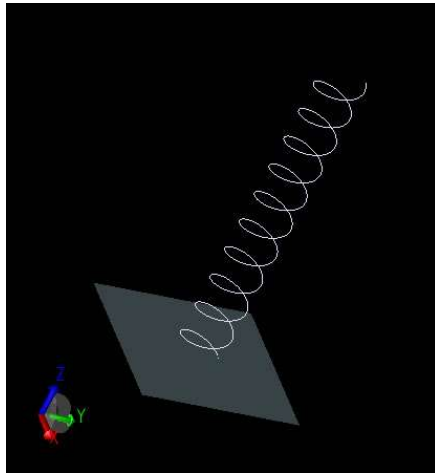
$C = \pi / D$: circunferência da hélice; λ : comprimento de onda

N : n° de voltas; S : espaçamento entre voltas (típico $\lambda/4$)

D : diâmetro da espira (típico λ/π)



Antena helicoidal-4: modo axial



www.remcom.com

Antena terrestre



D2000 Series: Multipole Military Antennas

The MULTIPOL™ Multiple Dipole Collinear Array concept has been specifically developed by TACO for ground-air-ground, air traffic control and base communications applications.

ELECTRICAL

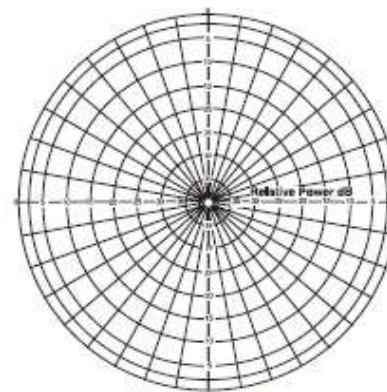
- Isolation (min.) 30.0 dB
- Polarization Vertical
- Omni Directional +0dB/-1dB
- Uniformity (azimuth)
- VSWR (max.) 2:1 (except D2211, 2.3:1)
- Terminals "N" Female
- Terminal Impedance 50 Ohms
- VHF Applied Power 350 W
- UHF Applied Power 250W
- Vertical Beam Deviation $\pm 10^\circ$ (horizon)
(-40° to 158° F)
- Operating Temp -40° to 70° C

VHF FREQUENCIES ONLY

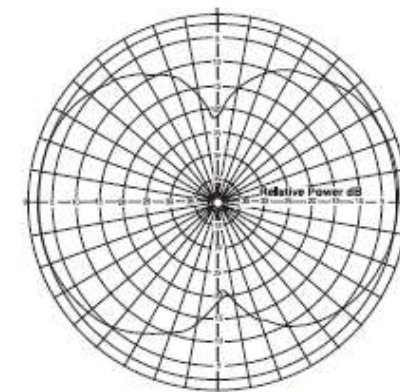
MODEL	VHF FREQUENCY (MHz)				GAIN (dBi)	# OF OUTPUTS	HPBW DEGREE
	108-174	116-150	118-136	150-174			
D2212		XX			2.0	2	75
D2212A				XX	2.0	2	75
D2216		X			2.0	1	75
D2260			XXX		2.0	3	75
D2260A				XXX	2.0	3	75
D2261A			XX		4.5	1	40
D2261A1*			XX		4.5	1	40
D2268	XXX				5.5	1	25
D2272*			XX		2.0	2	75
D2272A			XX		2.0	2	75
D2276*			X		2.0	1	75

X – Denotes number of active elements

TYPICAL RADIATION PATTERNS



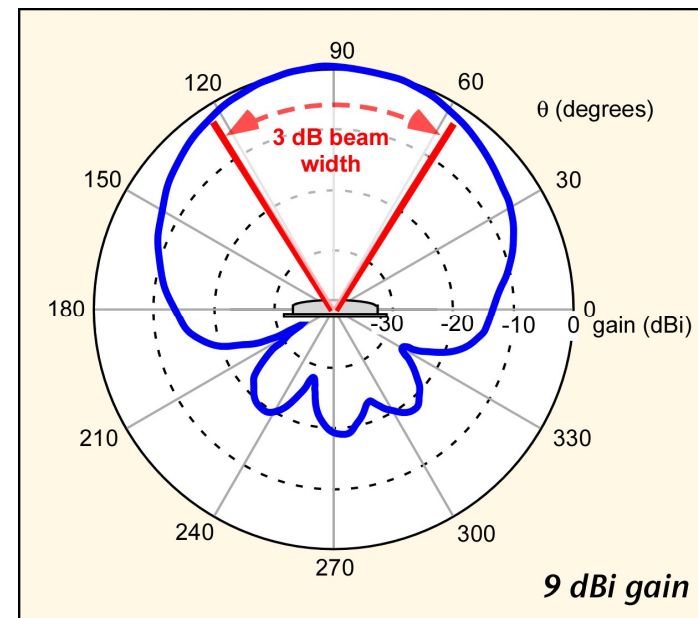
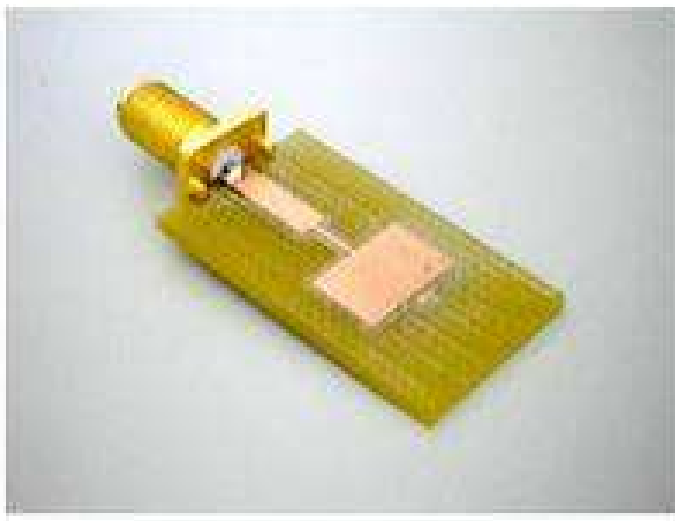
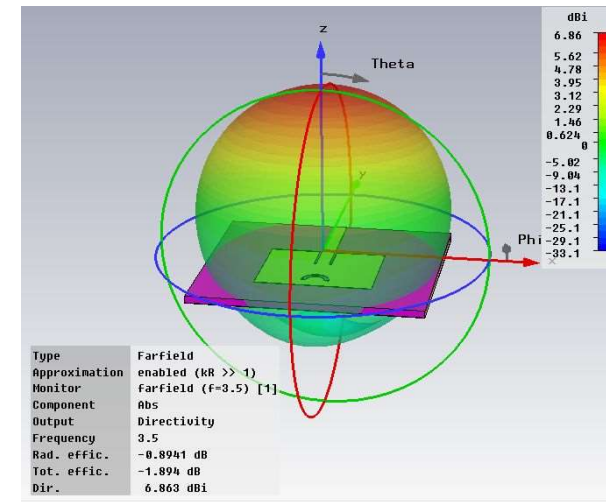
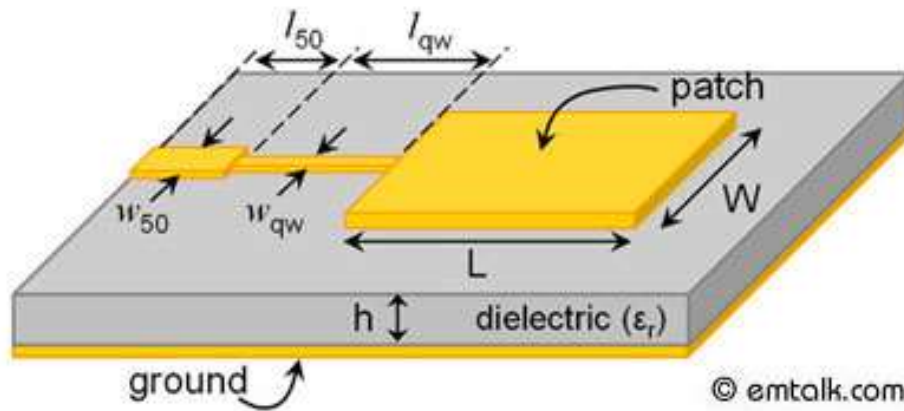
Horizontal Pattern



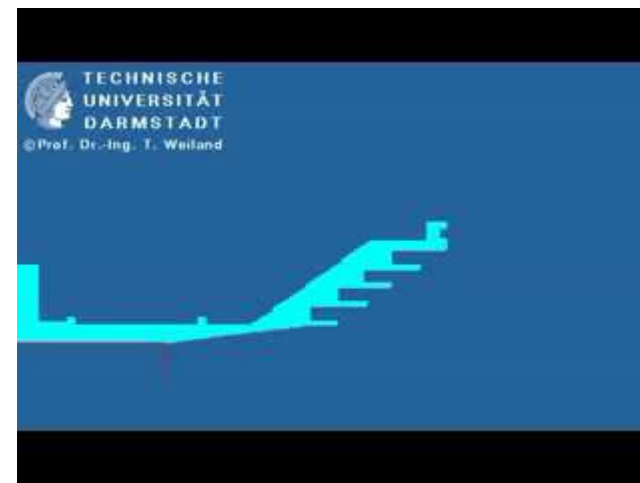
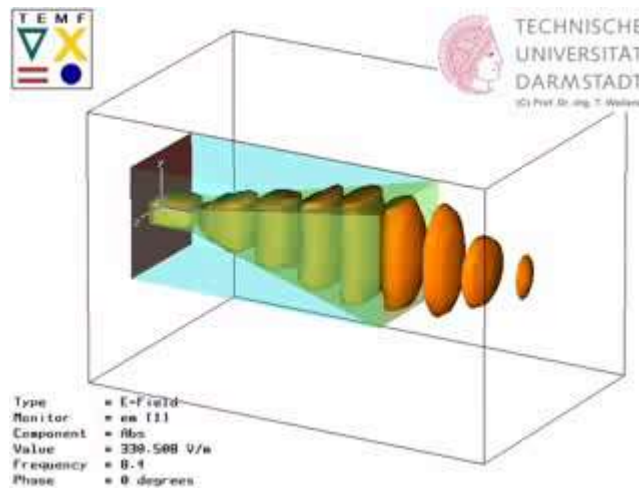
Vertical Pattern

www.wadeantenna.com/TACO/MilitaryAntennas.pdf

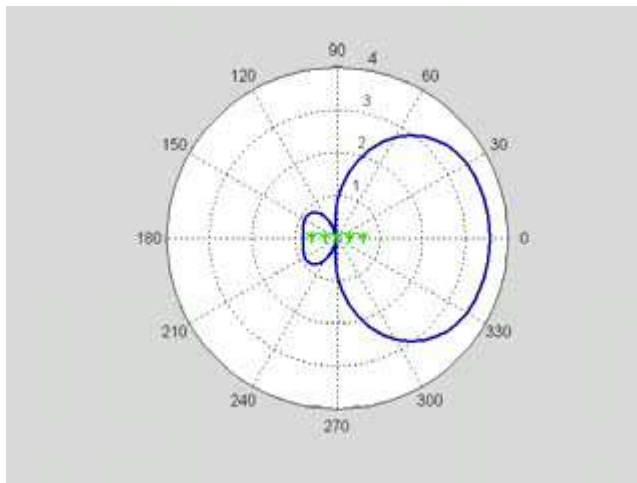
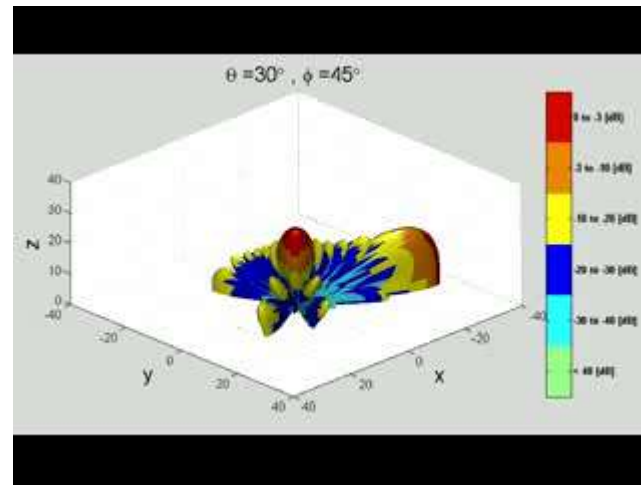
Antena patch



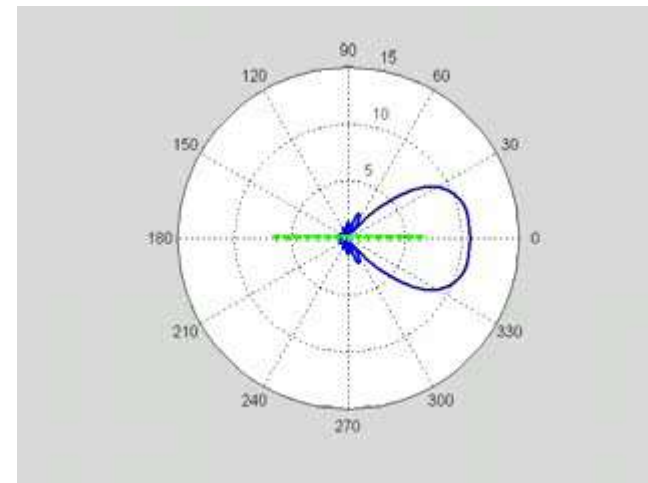
Animações: Antena corneta



Animações: Phased Array (redes)

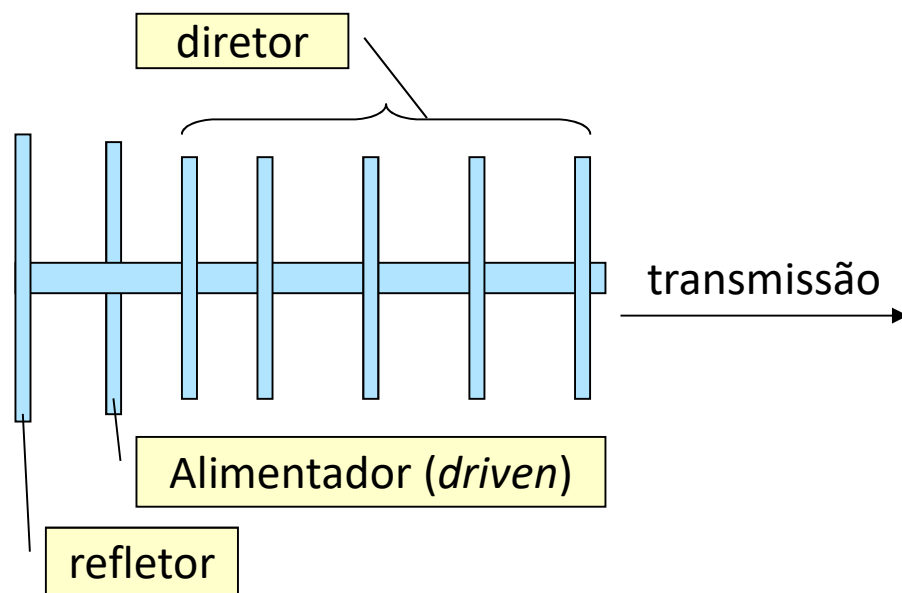


C5 antenas



C15 antenas

Antena Yagi-1



Hidetsugu Yagi

Antena Yagi: inventada por Hidetsugu Yagi (Tohoku Imperial University) e seu assistente Dr. Shintaro Uta

Característica: direcional; construída a partir de dipolos

Construção: no máximo 12 elementos (1 refletor, 1 alimentador, 10 diretores)

Ganho típico: entre 5 e 8 dBi

Patente: 1926

Aplicações: TV; radar na 2a. Guerra Mundial pelos aliados

Antena Yagi-2

Specifications

Electrical:

Frequency Range 2400 - 2484 MHz
VSWR..... Less than 2:1, 1.5:1 Nominal
Nominal Impedance..... 50 ohms
Gain 13.5 dBi (11.3 dBd) Nominal
Front-to-Back ratio greater than 20 dB
Half-power Beamwidth..... 30 degrees
Polarization..... Vertical

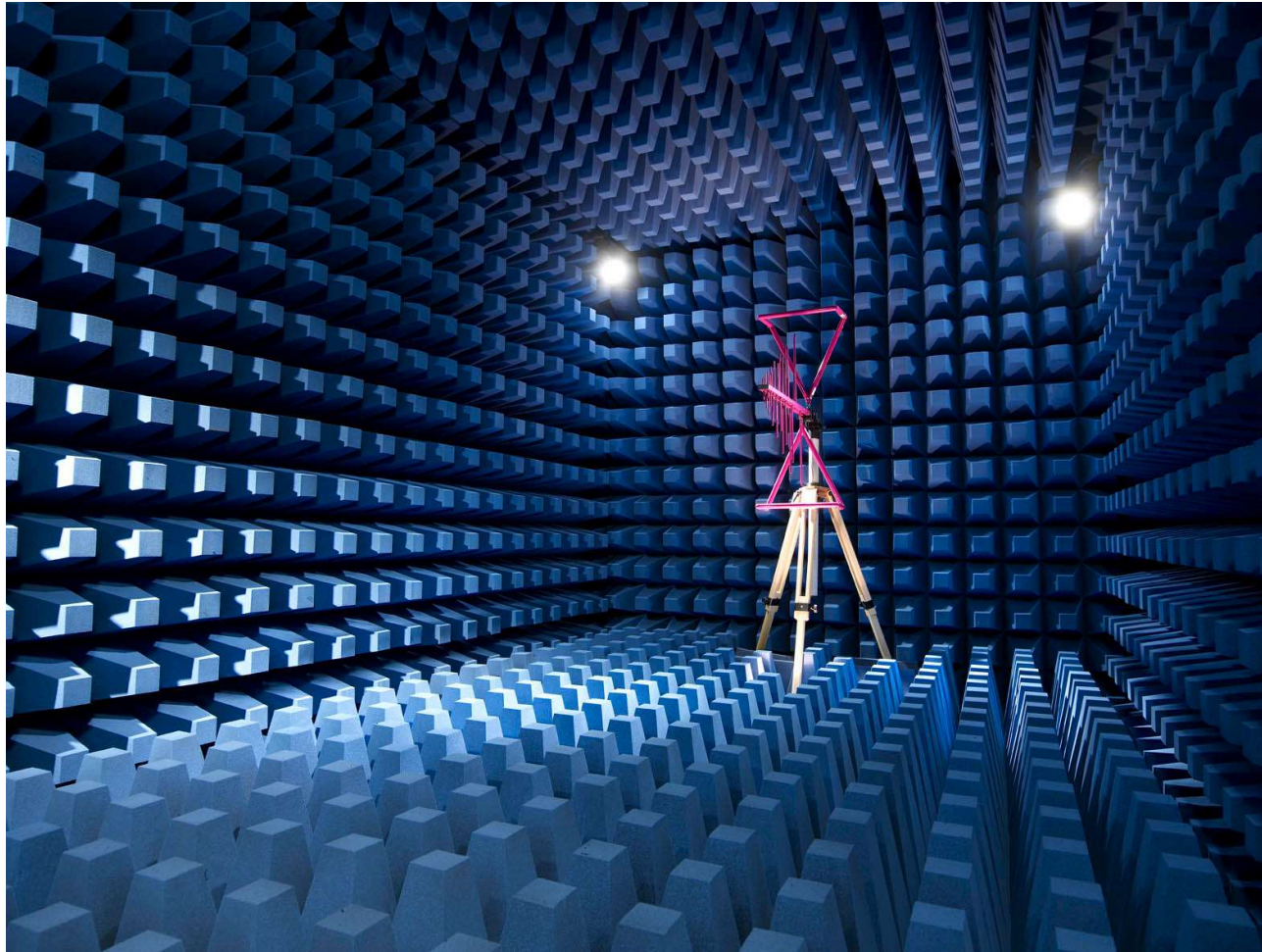
Mechanical:

Size 18" (46 cm) long
Mounting method clamps to vertical mast up to - 1 5/8" O.D.
Cable length 36" (91 cm)
Cable Type..... RG-58 A/U Type, 50 ohm, low-loss, white
Connector Reverse Polarity (RP) TNC



Ref.: www.wlanantennas.com

Câmara anecóica



www.vialite.com/antennas_overview.php

Instrument Landing System (ILS)

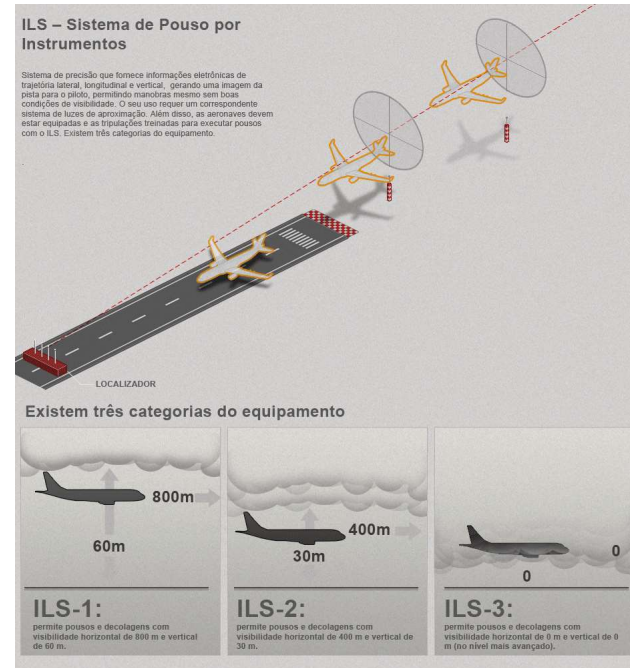
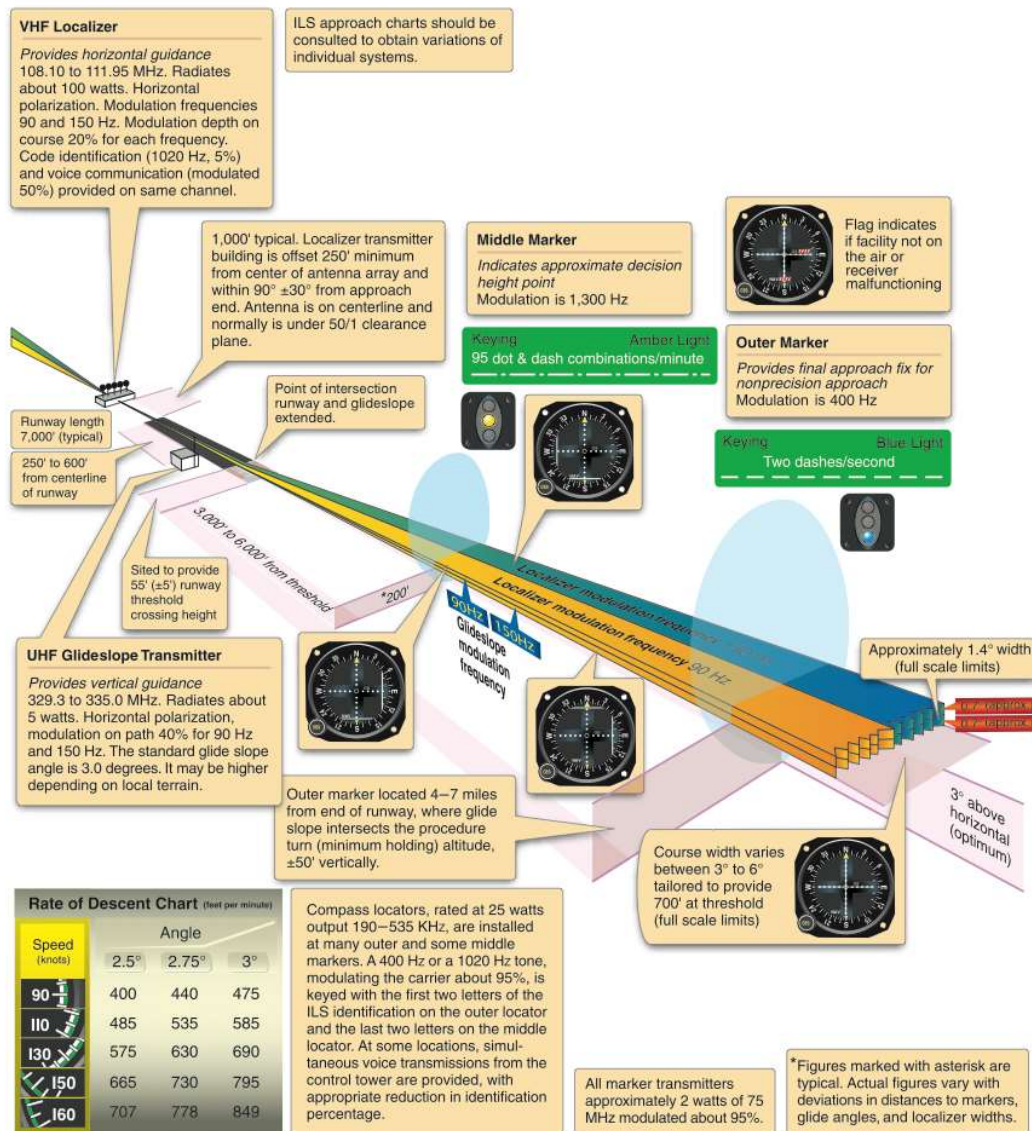
APLICAÇÃO DE ANTENAS

Instrument Landing System (ILS)



108,10 MHz a 111,95 MHz

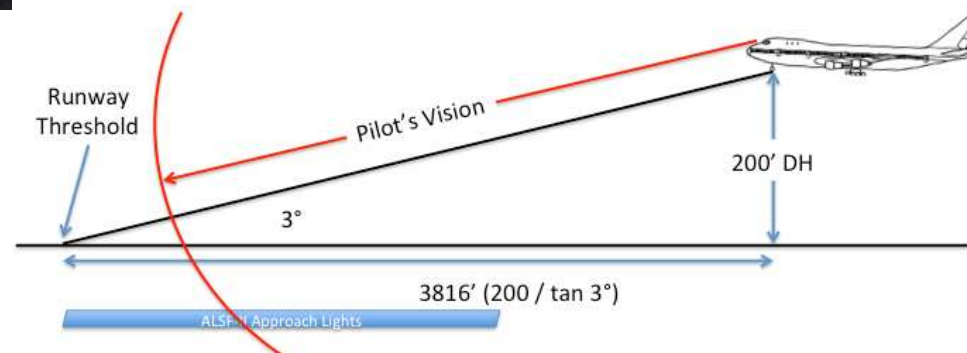
Instrument Landing System (ILS)



<http://12horasnotciassobreaviacao.blogspot.com.br/2013/05/sistema-antineblina-de-cumbica-sera.html>

<http://code7700.com/ils.html>

Instrument Landing System (ILS)



<http://code7700.com/ils.html>

Instrument Landing System (ILS)

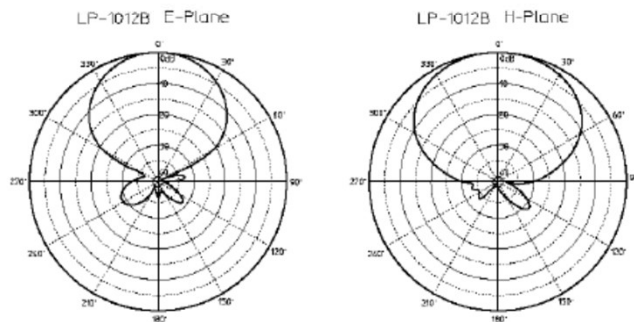
Specifications

Type name	LP-1012B
Frequency band	108~112 MHz
Polarization	Horizontal
Impedance	Nominal 50 Ω
Gain	More than 10 dBi
VSWR	Less than 1.2
E-plane beamwidth	$56 \pm 3^\circ$
H-plane beamwidth	$73 \pm 5^\circ$
F/B ($180^\circ \pm 60^\circ$)	More than 25 dB
Input power	50 W (Max)
Wind load (90 m/s)	3,960 N
Connector	N - J
Weight	34 ± 5 kg

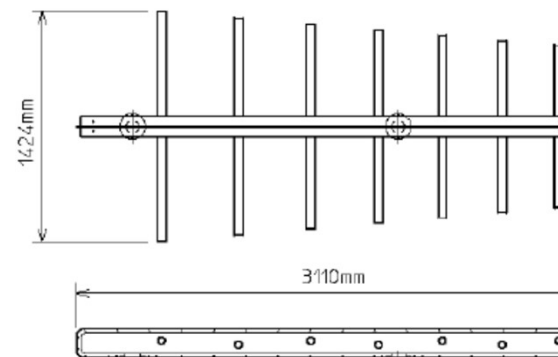


<http://www.antenna-giken.co.jp/global/business/satellite/index.html>

Patterns

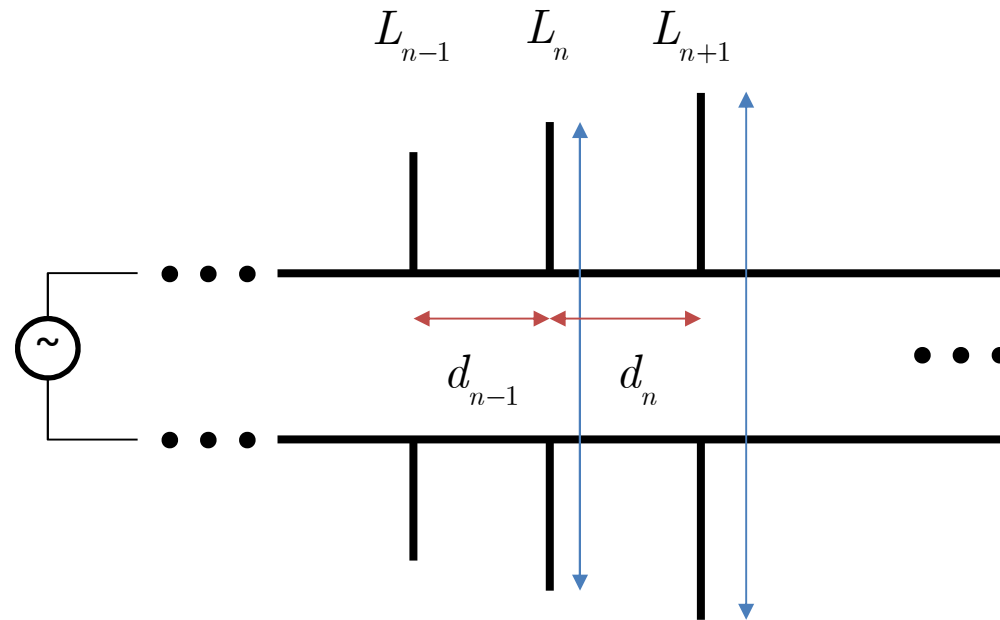


Dimensions



Antena log-periódica

Antena log-periódica (1)

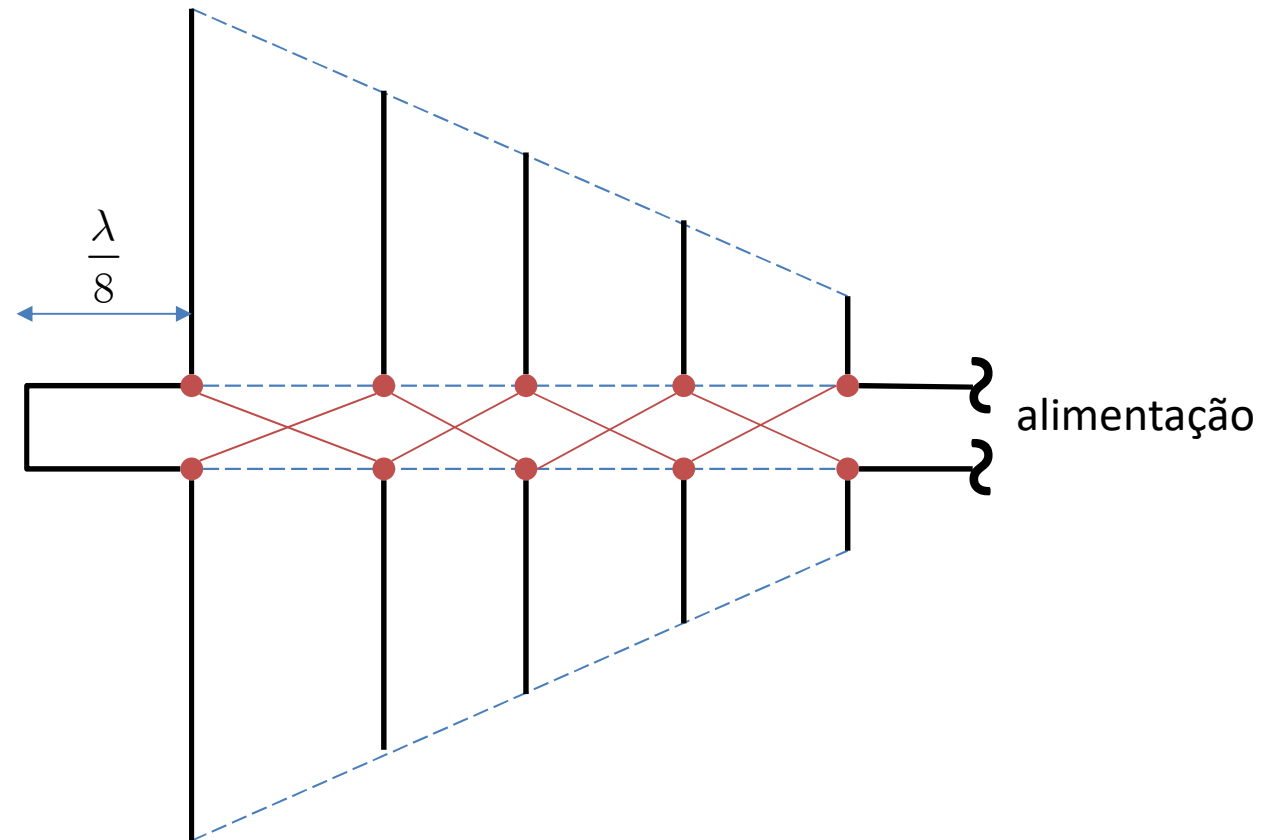


- ✓ Arranjo de antenas dipolo
- ✓ Antena faixa larga
- ✓ k : fator de escala
- ✓ Frequências de operação: menor e maior
- ✓ Número de elementos
- ✓ Ângulo do vértice da antena
- ✓ Ganho típico: 7 dBi

$$\frac{L_{n+1}}{L_n} = \frac{d_{n+1}}{d_n} = k$$

https://en.wikipedia.org/wiki/Log-periodic_antenna

Antena log-periódica (2)



Referências sobre antena log-periódica

✓ Projeto online

- Detalhado; fornece dimensões para elementos e distâncias entre elementos; projetos de outros tipos de antenas
- <http://www.changpuak.ch/electronics/lpda.php>

✓ Dimensões

- <http://www.antenna-theory.com/antennas/wideband/log-periodic-dipole.php>
- [http://www.members.westnet.com.au/impeh/log%20periodic A.htm](http://www.members.westnet.com.au/impeh/log%20periodic%20A.htm)

Animações

Carga elétrica em movimento

<http://www.cco.caltech.edu/~phys1/java.html>

[Phet](#)

Dish Antenna Animation (Parabolic antenna / reflector)

<http://www.youtube.com/watch?v=785kRIZ7ael>

Antena WiFi em aeronave

<http://www.youtube.com/watch?v=fd3dGtNhGis#t=92>

How To Identify Aircraft Antennas Through Understanding Aircraft...

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Antena, fabricação, Panasonic

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Animações

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Antena, fabricação, Panasonic

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Antenna Array

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