BROADCAST ANTENNAS

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BROADCAST ANTENNAS

- IEEE BROADCAST TECHNOLOGY SOCIETY SUPPORT IS GREATLY APPRECIATED MAKING THIS SEMINAR POSSIBLE

BROADCAST ANTENNAS

- OUTLINE
- 1. FUNDAMENTAL CONCEPTS
- 2. HF, VHF AND UHF ANTENNAS

Some Magnitudes

- E Electric Field Intensity [V/m]
- H Magnetic Field Intensity [A/m]
- P Radiated Power Density [W/m^2]
- U Radiation Intensity [W/Rad^2]
- W_T Total Radiated Power [W]
- D Directivity [times o dBi]
- G Gain [times o dBi]
- Z_a Antenna Impedance [Ω]
- R_R Radiation Resistance [Ω]
- T_a Antenna Noise Temperature [ºK]
- Z_0 Transmission Line Characteristic Impedance [Ω]

Some Magnitudes

- Z_{00} Free Space Impedance [Ω]
- ε_0 Free Space Permittivity [F/m]
- μ_0 Free Space Permeability [H/m]
- c Free Space Velocity [m/s]]
- σ Conductivity [S/m]
- ρ Resistivity [Ω m]
- f Frequency [Hz]
- λ Wavelength [m]
- γ Propagation Constant [1/m]
- α Attenuation Constant [Nep/m]
- β Space Phase Constant [Rad/m]
- ω Time Phase Constant [Rad/S]

Antenna Parameters

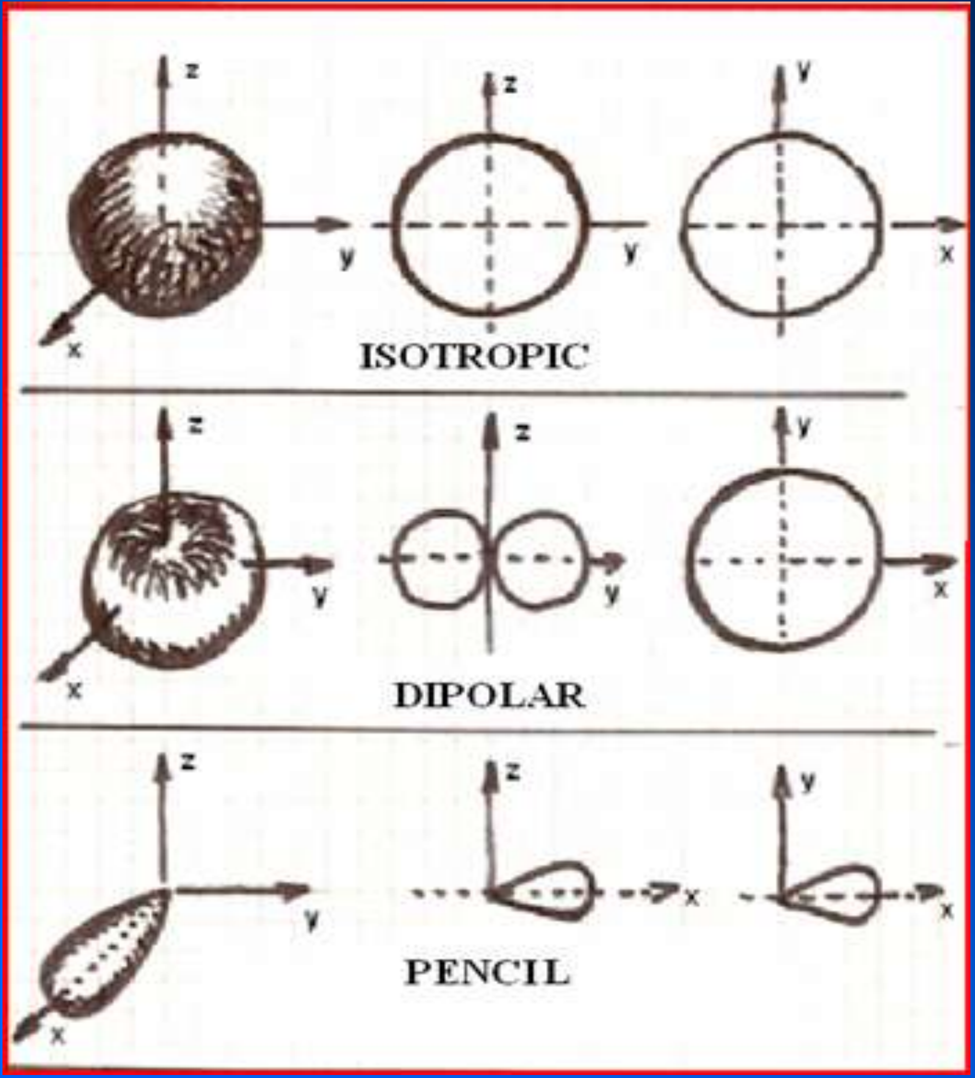
- A) Radiation Pattern
- B) Directivity
- C) Gain
- D) Efficiency
- E) Effective Height
- F) Área, Aperture or Surface
- G) Impedance
- H) Temperature
- I) Power Handling
- J) Bandwith
- K) Polarization

Antenna Radiation Patterns

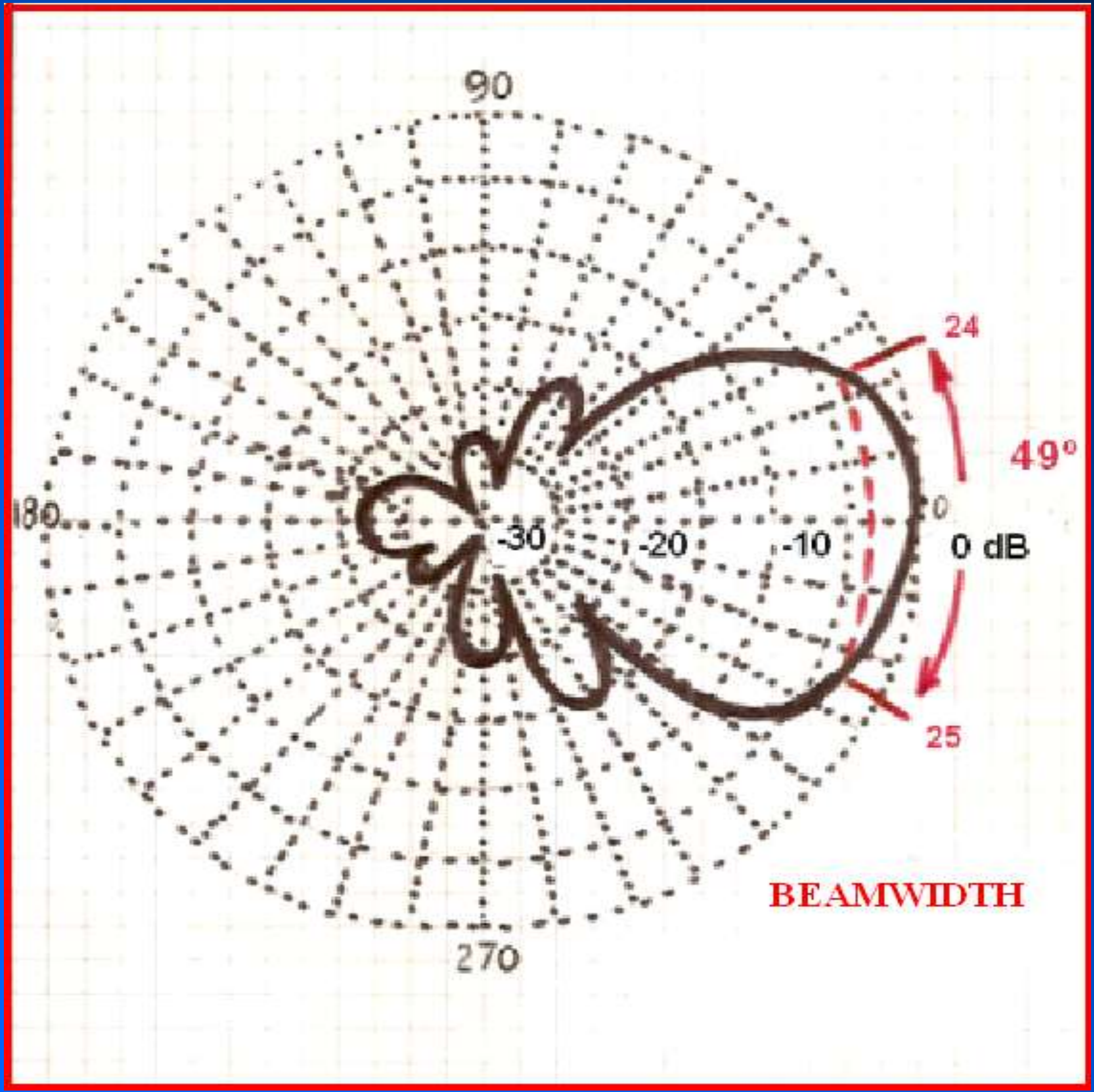
- Antenna Radiation Pattern is a representation of the Radiated Energy in Space.

- It can be:
  - Absolute
  - Relative:
    - » Polar
    - » Rectangular

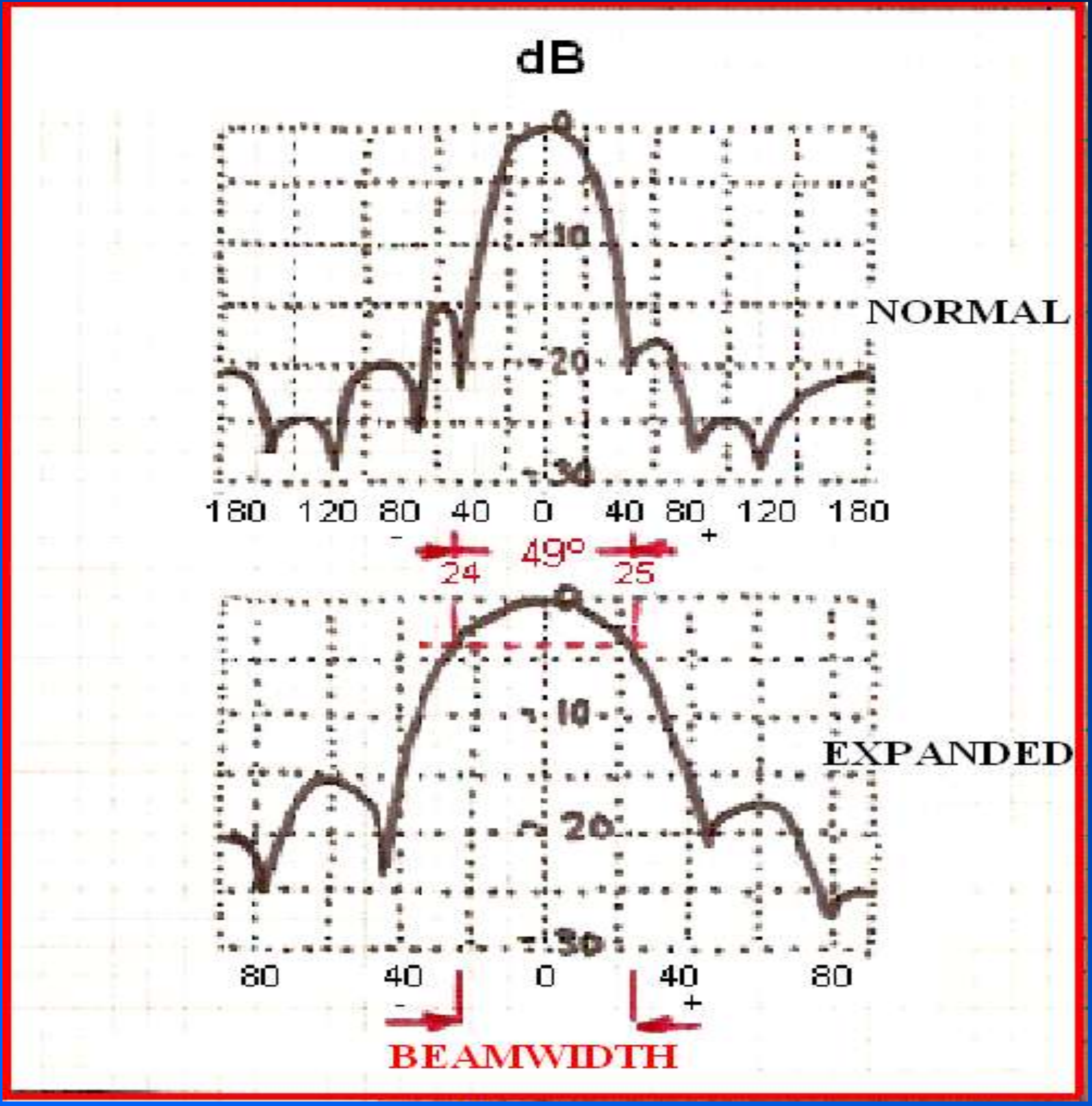
Antenna Radiation Patterns



Polar Radiation Pattern



Antenna Rectangular Radiation Pattern



Antenna Directivity

$$D = \frac{U_M}{U_0} = \frac{\text{Maximum radiation intensity}}{\text{Average radiation intensity}}$$

Average radiation intensity is equal to the radiation intensity of the isotropic radiator.

It is equivalent to:

$$D = \frac{4\pi U_M}{W_T} = \frac{4\pi \text{ Maximum radiation intensity}}{\text{Total radiated power}(W_T)}$$

IEEE STD 149-1979

Antenna Gain

$$G = \frac{4\pi \text{ Maximum radiation intensity}}{\text{Total input power}}$$

$$W_{in} = \text{Total input power (W)}$$

$$W_T = \eta W_{in} \text{ Total radiated power}$$

$$\eta = \text{Efficiency}$$

$$G = \frac{4\pi\, \eta\, U(\theta;\phi)_{MAX}}{W_T}$$

$$G = \eta D$$

Antenna Efficiency

- a) Transmitting Case:
- Antenna Efficiency is the ratio between the antenna radiated power W_T to the antenna input power W_{in}

  – $\eta = W_T / W_{in}$

Antenna Efficiency

$$\eta = \frac{|I_g|^2 R_r}{|I_g|^2 (R_r + R_p)}$$

Transmitting case

R_{rad}=R_r = Radiation Resistance [Ω]

R_p= Loss Resistance [Ω]

It depends on the conductors and dielectrics in the antenna circuit. Mismatching or Transmission Line Losses are not included.

Antenna Efficiency

- b) Receiving Case:
- Antenna Efficiency is the ratio between the received power W_R to the maximum received power W_{RM} of the same ideal antenna perfectly matched and resonant.

  – $\eta = W_R / W_{RM}$

Antenna Area or Aperture

- Several Areas can be defined:
- Effective Areas
- Reradiating or Scattering Area
- Loss Area
- Collective Area
- Physical Area

Antenna Area or Aperture

- a) Antenna Effective Area:
- Is the ratio between the received or available load power W_R to the incident wave power density P_i on the receiving antenna

- $A_{eR} = W_R / P_i$

Antenna Area

- b) Antenna Reradiated or Scattering Area:
  - Is the ratio between the reradiated power W_S to the incident wave power density P_i on the receiving antenna

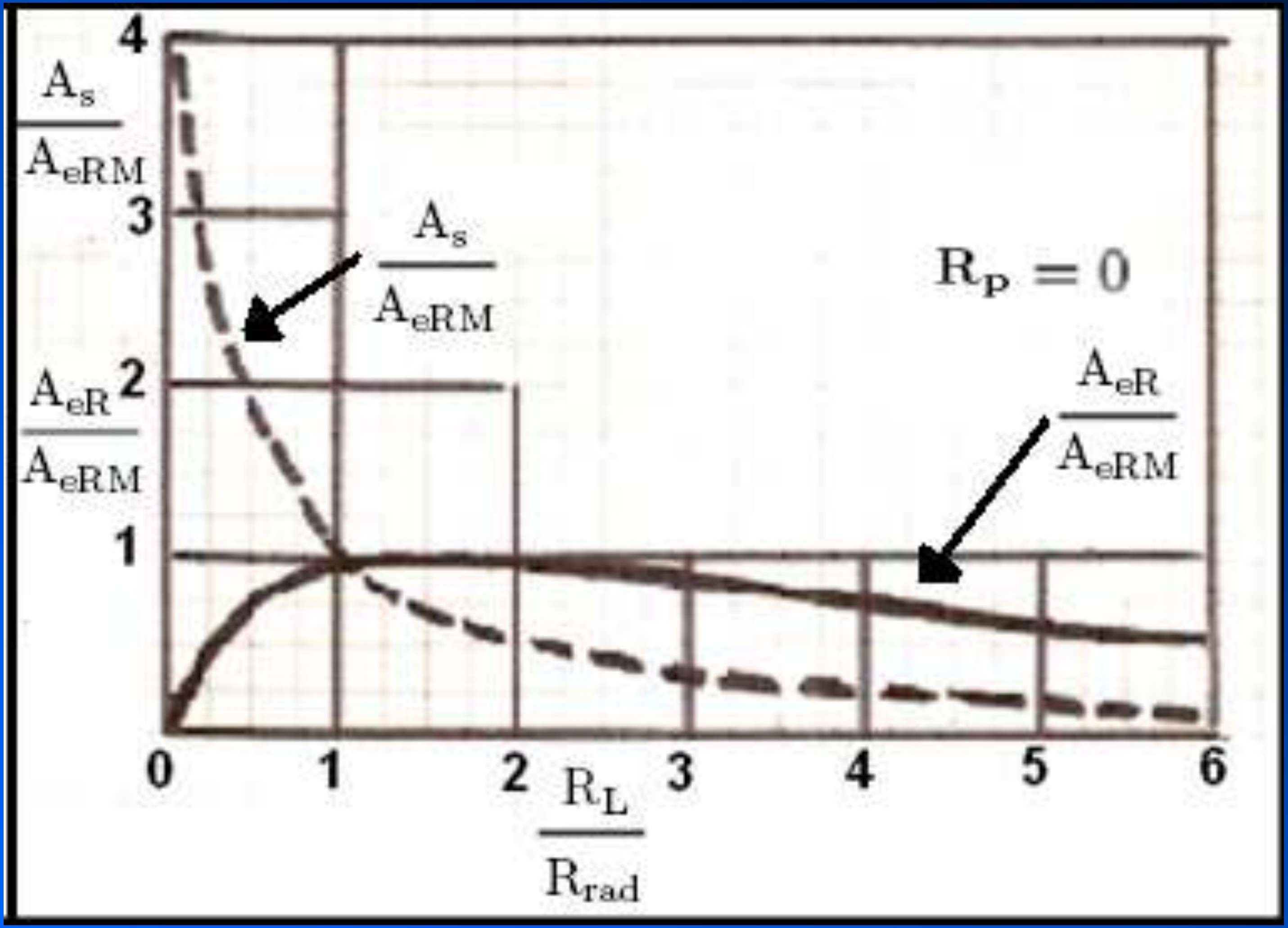
- $A_s = W_s / P_i$

Antenna Area

- c) Antenna Loss Area:
- Is the ratio between the loss power W_P to the incident wave power density P_i on the receiving antenna

- $A_P = W_P / P_i$

Antenna Area or Aperture



Antenna Area or Aperture

- All areas have been obtained in a theoretical case or with no losses.

- In real cases, these areas will be of a lower value according to the antenna losses

Effective length or height

$$W_R = \frac{1}{4}\frac{V^2}{R_{rad}} = \frac{h_e^2 E^2}{4R_{rad}}$$

$$R_{rad} = R_L$$

matching

Z_{00} space intrinsic impedace: 377 Ω

$$h_e = 2\sqrt{\frac{R_{rad} A_{eR}}{Z_{00}}}$$

$$A_{eR} = \frac{h_e^2 Z_{00}}{4R_{rad}}$$

h_e and A_{eR} are related through R_{rad} and Z_{00}

Friis Equation

- **ANTENNA POWER DENSITY IN SPACE**
- $P_i = W_T\, D_T / 4\pi\, r^2$

- **ANTENNA RECEIVED POWER**
- $W_R = P_i\, A_{eR}$

- $W_R = W_T\, D_T\, A_{eR} / 4\pi\, r^2$

Friis Equation

- TRANSMITTING ANTENNA EFFECTIVE AREA
- $A_{eT} = \lambda^2 D_T / 4\pi$
- Area Friis Equation (Power Relationship)

$$W_T / W_R = (\lambda r)^2 / A_{eT} A_{eR}$$

Friis Equation

- **Directivity Friis Equation (Power Relationship)**

$$W_T / W_R = (4\pi / \lambda)^2 (1/ D_T D_R)$$

Free Space Nondissipative Loss

$$A_{FS} = (4\pi r / \lambda)^2$$

Harald Friis (1883-1976)

Site Attenuation

- IS THE POWER RELATIONSHIP BETWEEN THE TRANSMITTED POWER W_T AND THE AVAILABLE RECEIVED POWER W_R
- $A = W_T / W_R$
- $A = A_{FS} / D_T D_R$
- $A\ (dB) = A_{FS}(dB) - [\, D_T(dBi) + D_R(dBi)\,]$
- $A_{FS}\ (dB) - A\ (dB) = [\, D_T(dBi) + D_R(dBi)\,]$

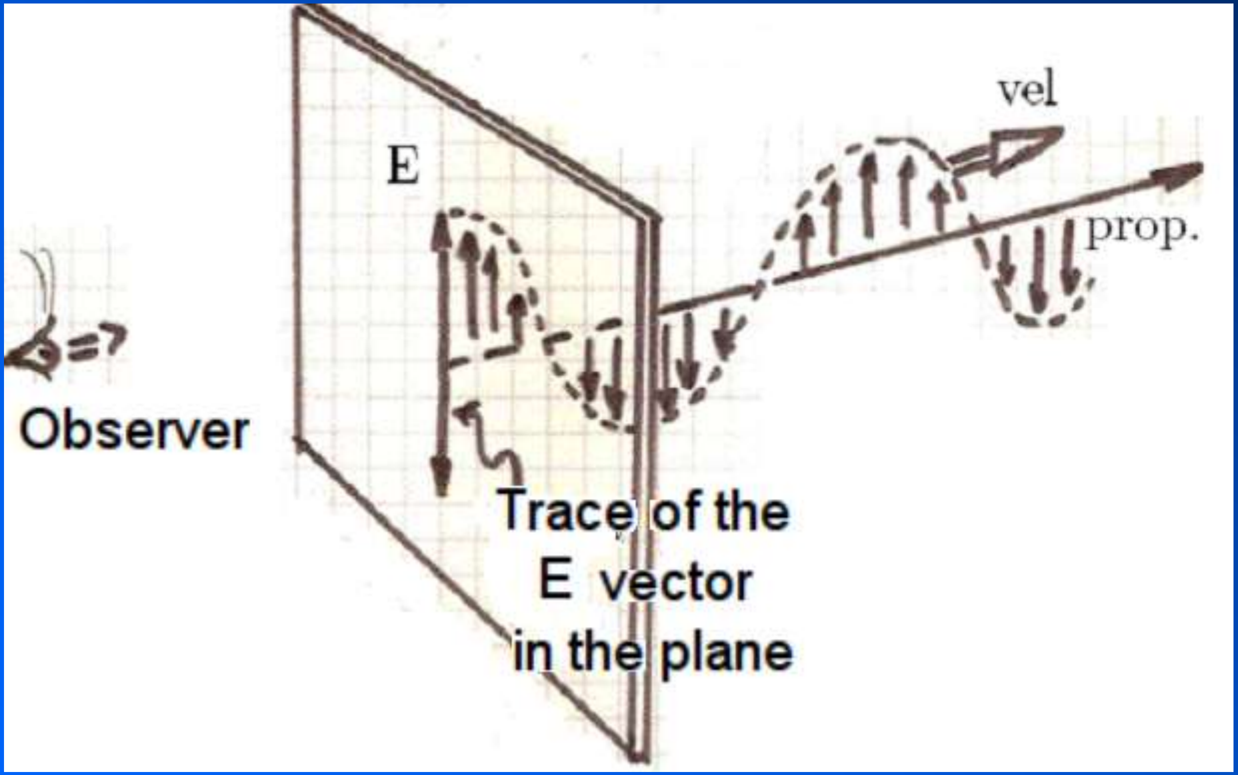
Antenna Impedance

- Is the Impedance on the Antenna
- Feeding Points.
- Is a Function of the Antenna Geometry, Close Objects or Other Antennas and of course on the Operation Frequency

Antenna Polarization

Wave Polarization depends on the Antenna Electric Field Vector Orientation

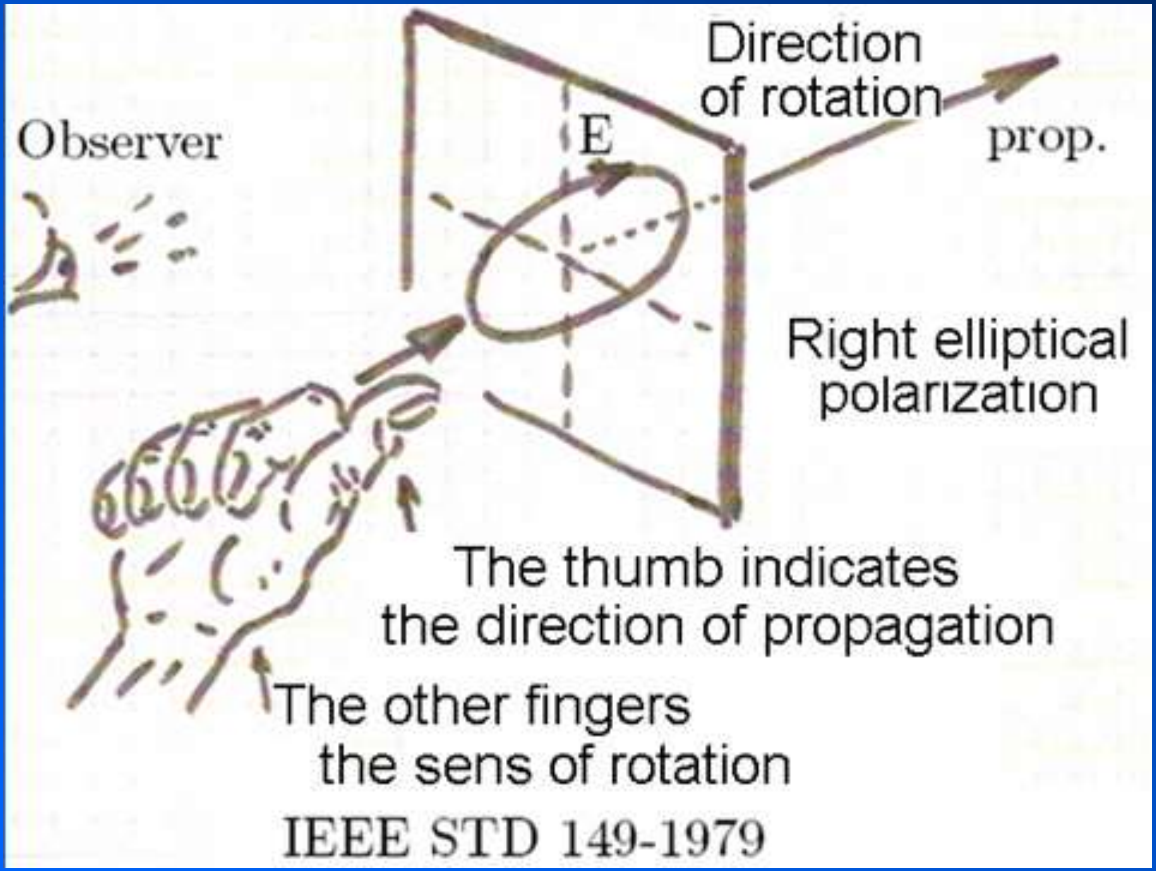
Transverse Plane



Antenna Polarization

Generally Polarization is ellíptic. Linear Polarization and Circular Polarization are Particular Cases.

Transverse Plane



Antenna Polarization

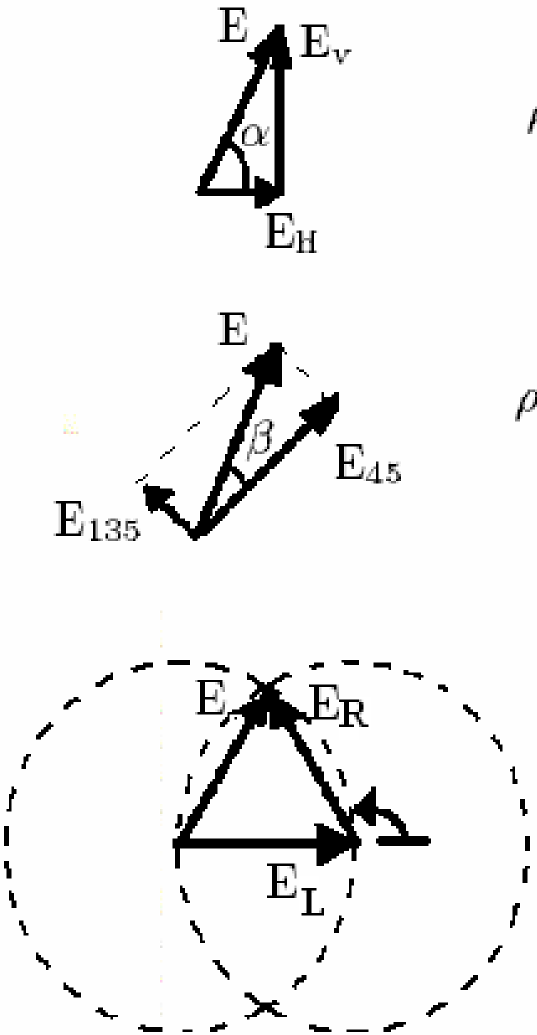
Transmitting Antenna Polarization in a given Direction is the Transmitting Wave Polarization (IEEE STD 145-1983).

Many Antennas are Identical and have the same Polarization Properties in Transmission and Reception.

For Receiving Antennas the Polarization definition is the Polarization of an Incident Plane Wave from a given direction producing maximum available power on the Antenna Terminals (IEEE 145-1983).

Antenna Polarization

Polarization Ratio



$$\rho_L = \frac{E_V}{E_H} = \tan\alpha$$

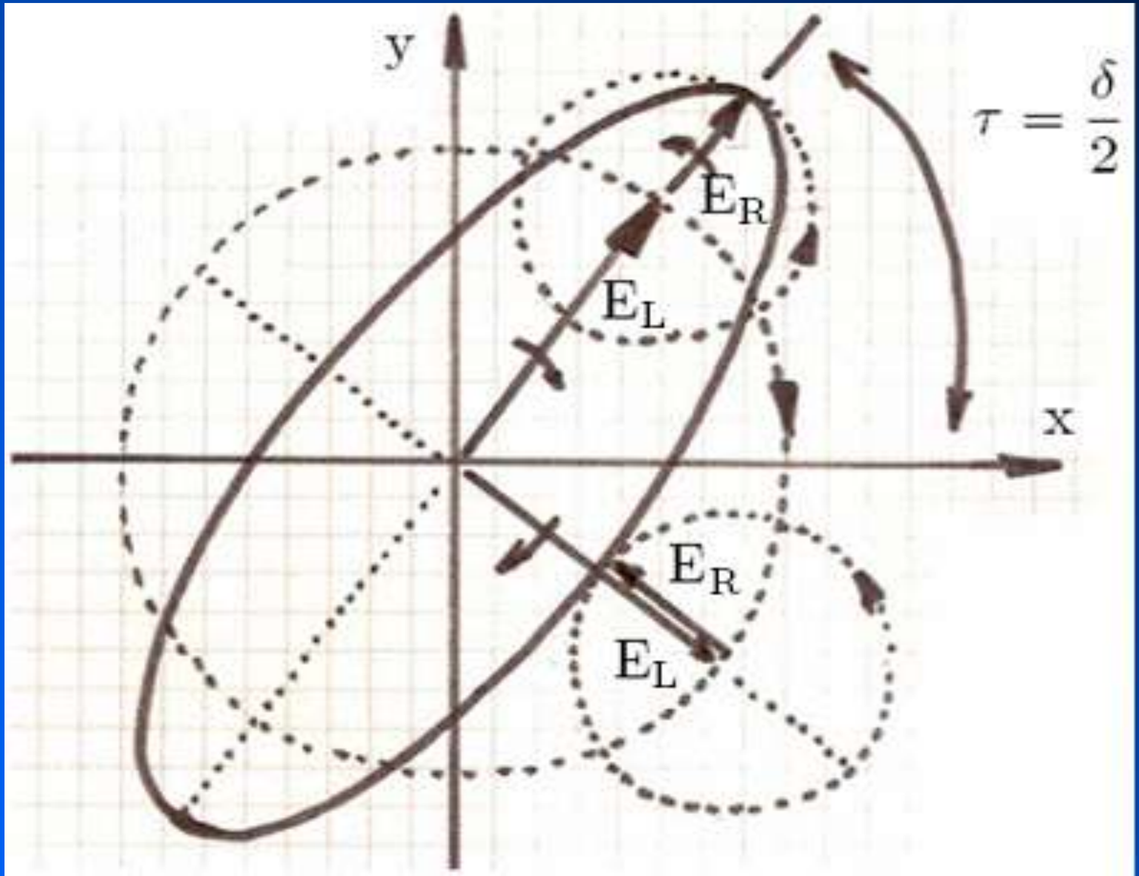
$$\rho_D = \frac{E_{135}}{E_{45}} = \tan\beta$$

Diagonal

$$\rho_c = \frac{E_R}{E_L} = \tan\delta$$

Circular

Antenna Polarization



Axial Ratio $\quad R = \dfrac{E_R + E_L}{E_R - E_L}$

$$R(\mathrm{dB}) = 20 \log \left| \frac{E_R + E_L}{E_R - E_L} \right|$$

Antenna Polarización

Polarization	Polarization Ratio	Axial Ratio
Linear Vertical	$\rho_L = \infty$ $\rho_D = 1$ $\rho_C = 1$	$R = \infty$ $R = \infty$ dB
Linear Horizontal	$\rho_L = 0$ $\rho_D = 1$ $\rho_C = 1$	$R = \infty$ $R = \infty$ dB
Right Circular	$\rho_L = 1$ $\rho_D = 1$ $\rho_C = \infty$	$R = 1$ $R = 0$ dB
Left Circular	$\rho_L = 1$ $\rho_D = 1$ $\rho_C = 0$	$R = -1$ $R = 0$ dB

AntennaPolarization

Polarization		Loss
Antenna	**Wave**	**dB**
Horizontal	Horizontal	0
Horizontal	Vertical	➢20
Horizontal	Circular	3
Vertical	Vertical	0
Vertical	Horizontal	➢20
Vertical	Circular	3
Circular	Horizontal	3
Circular	Vertical	3
Left Circular	Left Circular	0
Left Circular	Right Circular	➢25
Right Circular	Right Circular	0
Right Circular	Left Circular	➢25
Slant 45	Horizontal	3
Slant 45	Vertical	3
Slant 45	Circular	3

Antenna Bandwidth

- **Maximum Permissible VSWR:**
- **Standard Communications…………………1.5**
- **Wide Band Communications……………....2.0**
- **Wide Band Military Communications…...3.0**
- **LF and MF Transmitting Broadcastings...1.2**
- **FM and TV Transmitting Broadcastings...1.1**

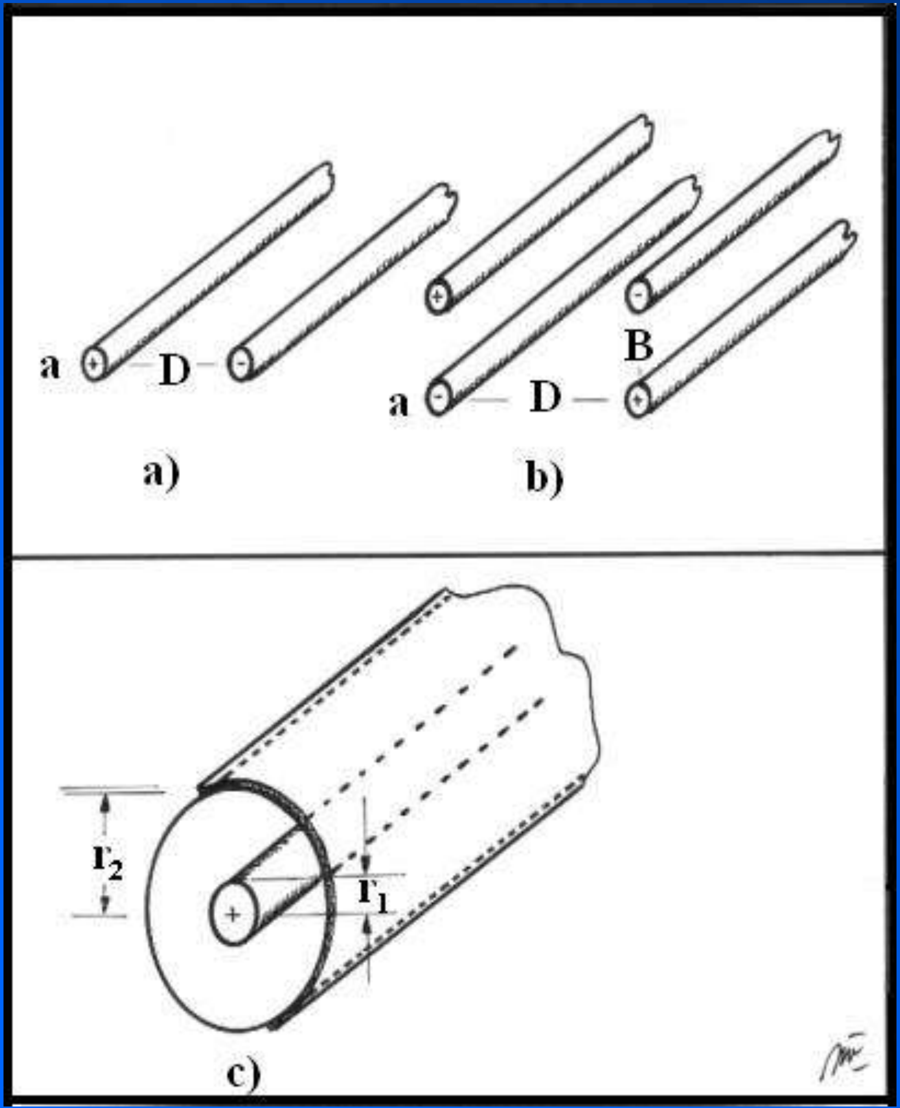
Antenna Bandwidth

- TRANSMISSION LINE TYPES:

- a) Open Wire ………600 < Z_0 < 150 Ω
- b) Quasi-Coaxial……....50 < Z_0 < 300 Ω

  c) Coaxial…..................50 < Z_0 < 100 Ω

Transmission lines



Open wires

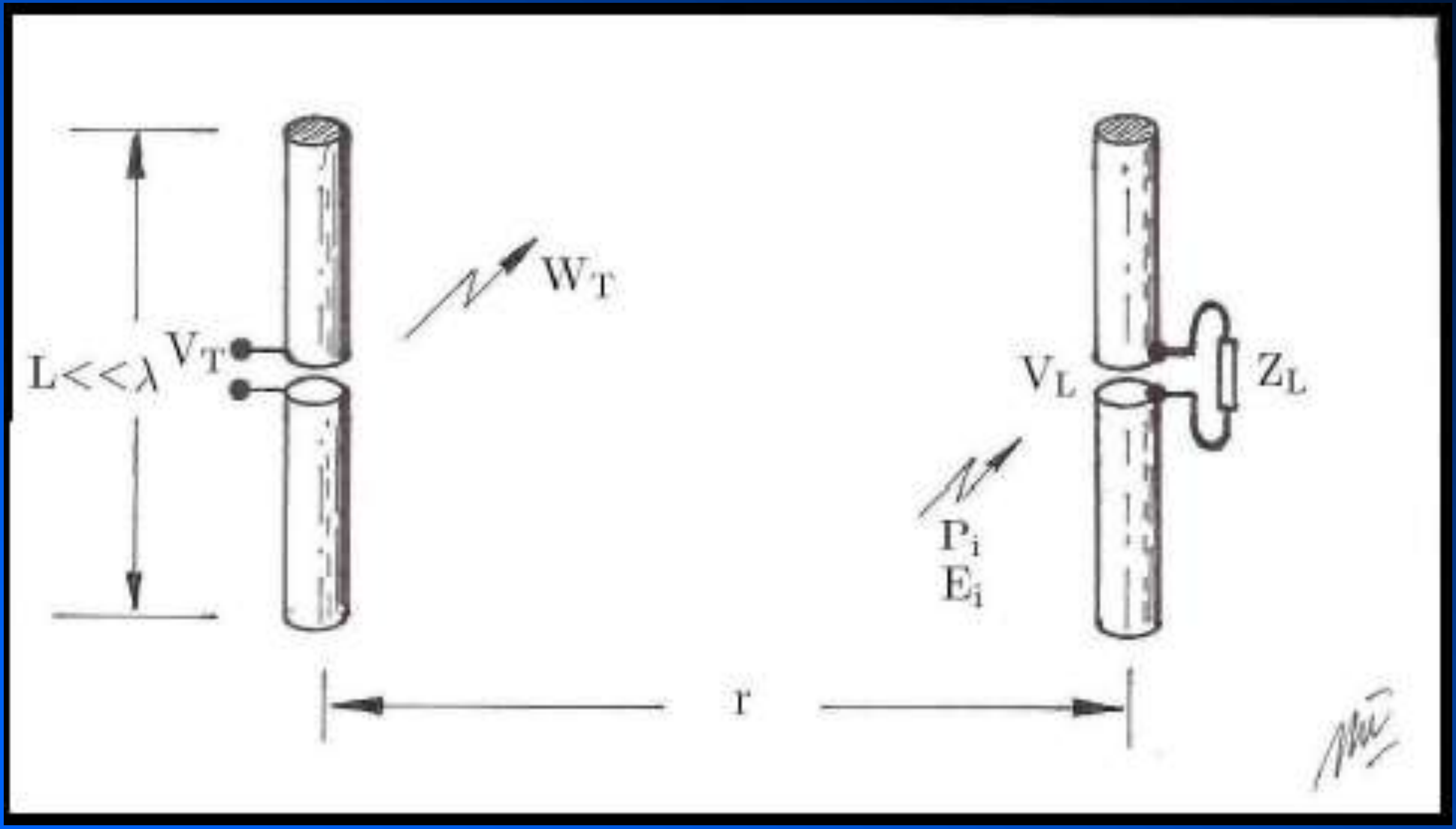
$$Z_0 = 120 \ln(D/a)$$

$$Z_0 = 60 \ln\left[\frac{2B}{a[1+(B/D)^2]^{0.5}}\right]$$

Coaxial

$$Z_0 = 60 \ln(r_2/r_1)$$

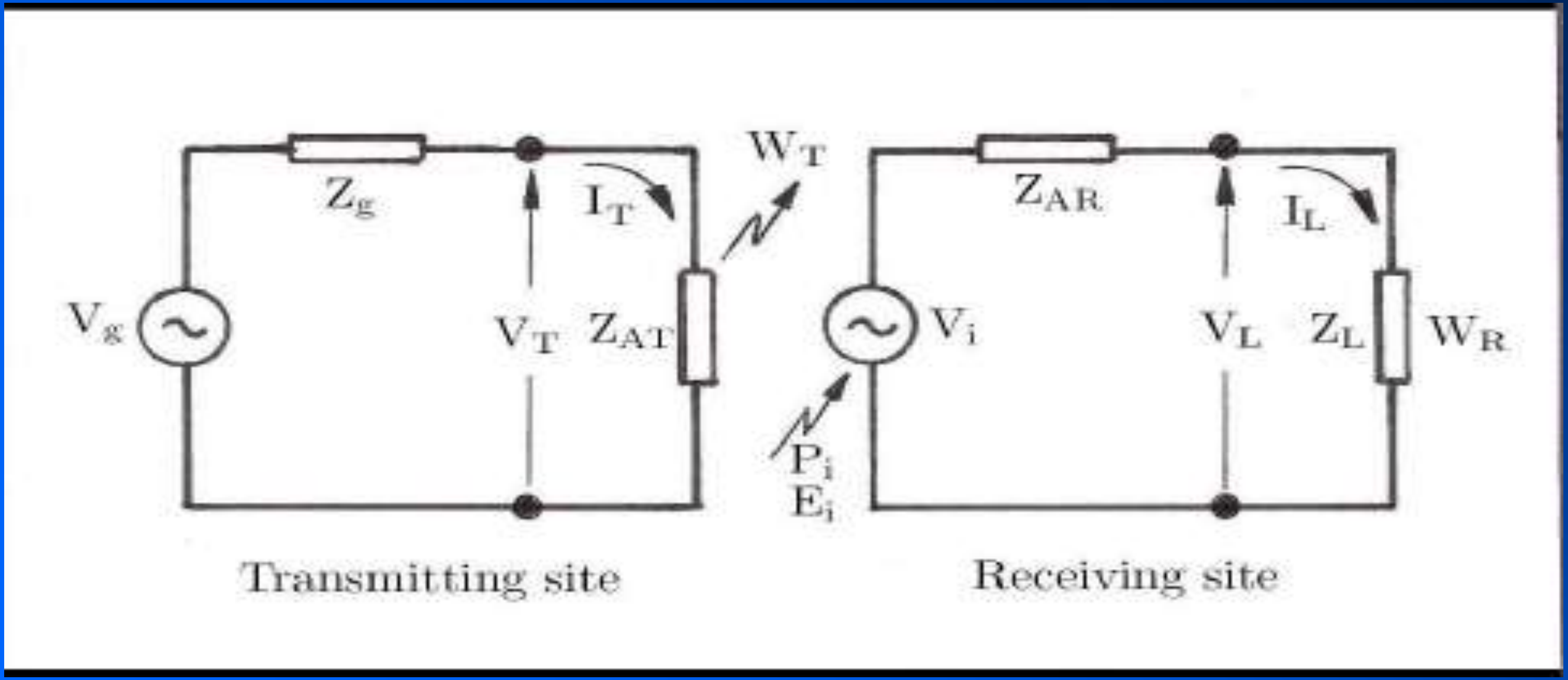
Antenna Link



Radio Link between two Short Dipoles (Free Space)

Antenna Link

- Radio Link between two Short Dipoles
    - in Free Space



FUNDAMENTAL PARAMETERS

ELECTRIC FIELD STRENGTH

E [V/m] o [dBμV/m]

MAGNETIC FIELD STRENGTH

H [A/m] o [dBμA/m]

POWER DENSITY

P [w/m^2] o [dBpw/m^2]

[1 w/m^2]= 0.1 [mw/cm^2]

Example: 100 w/m^2 = 10 mw/cm^2

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FUNDAMENTAL PARAMETERS

ELECTRIC FLUX DENSITY

D [C/m^2]

MAGNETIC FLUX DENSITY

B [Web/m^2] = [T]

CORRENT DENSITY

J [A/m^2]

ELECTRIC VOLUMETRIC CHARGE DENSITY

ρ [C/m^3]

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FUNDAMENTAL PARAMETERS

WAVE IN FREE SPACE (DRY AIR)

PROPAGATION VELOCITY $c = 3*10^{8}$ [m/s]

INTRINSEC IMPEDANCE $Z_{00} = E/H = 377$ [Ω]

ELECTRIC PERMITTIVITY $\varepsilon_0 = 8.854*10^{-12}$ [F/m]

MAGNETIC PERMEABILITY $\mu_0 = 4\pi*10^{-7}$ [H/m]

ELECTRIC CONDUCTIVITY $\sigma = 0$ [S/m]

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ELEMENTARY RADIATORS

ISOTROPIC SOURCE

IDEAL REFERENCE ANTENNA WITH UNIFORM RADIATION IN EVERY SPACE DIRECTION, (FREE SPACE)

GAIN = DIRECTIVITY

EFFICIENCY = 1

D= 1

D= 0 dBi

ELEMENTARY RADIATORS

HEMISPHERIC SOURCE

IDEAL REFERENCE ANTENNA WITH UNIFORM RADIATION IN EVERY SPACE DIRECTION, (OVER PERFECT GROUND PLANE)

GAIN = DIRECTIVITY

EFFICIENCY = 1

$\boxed{D = 2}$

$\boxed{D = 3 \text{ dBi}}$

ELEMENTARY RADIATORS

THEORETICAL HALF WAVE DIPOLE

IDEAL REFERENCE ANTENNA IN FREE SPACE $H/a=\infty$

GAIN = DIRECTIVITY

EFFICIENCY = 1

D= 1.64

D= 2.15dBi

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ELEMENTARY RADIATORS

THEORETICAL ELEMENTARY VERTICAL MONOPOLE (ITU)

IDEAL REFERENCE ANTENNA (OVER PERFECT GROUND PLANE)

GAIN = DIRECTIVITY

EFFICIENCY = 1

D= 3

D= 4.77 dBi

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RADIOELECTRIC SPECTRUM

Band name	Abbr	Frequency and wavelength in air
Extremely low frequency	ELF	3–30 Hz 100,000 km – 10,000 km
Super low frequency	SLF	30–300 Hz 10,000 km – 1000 km
Ultra low frequency	ULF	300–3000 Hz 1000 km – 100 km
Very low frequency	VLF	3–30 kHz 100 km – 10 km
Low frequency	LF	30–300 kHz 10 km – 1 km
Medium frequency	MF	300–3000 kHz 1 km – 100 m
High frequency	HF	3–30 MHz 100 m – 10 m
Very high frequency	VHF	30–300 MHz 10 m – 1 m
Ultra high frequency	UHF	300–3000 MHz 1 m – 100 mm
Super high frequency	SHF	3–30 GHz 100 mm – 10 mm
Extremely high frequency	EHF	30–300 GHz 10 mm – 1 mm

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BROADCAST RADIOELECTRIC SPECTRUM

- LF (AM)……………………150-290 kHz
- MF (AM)…………………..535-1705 kHz
- HF (AM)…………………..2.30-26.1 MHz
- VHF (LOW TV)………...54-72 MHz
- VHF (LOW TV)………...76-88 MHz
- VHF (FM)………………..87.5-108 MHz
- VHF (HIGH TV)………..174-216 MHz
- UHF (TV)………………..470-806 MHz

BROADCASTING WORLD REGIONS

REGION 1...EUROPE AFRICA

REGION 2.…AMERICAS

REGION 3…ASIA OCEANIA

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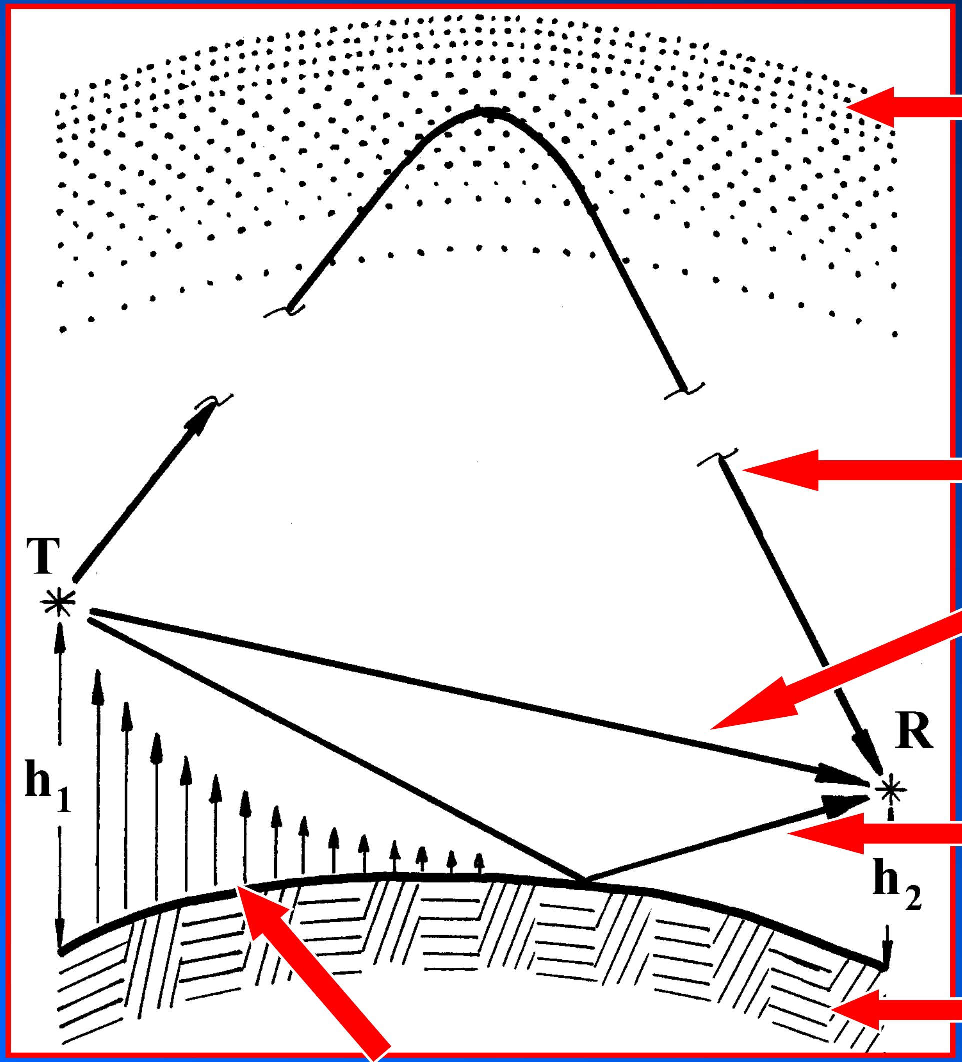
WAVE PROPAGATION



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WAVE PROPAGATION

ELECTRIC FIELD EQUATION

$$E = E_0 e^{-j\beta r}\left[\frac{1}{r_{dir}} + \Gamma\frac{1}{r_{ref}}e^{-j\Delta} + (1-\Gamma)\frac{1}{r}A\,e^{-j\Delta} + \sum_{i}^{n} A_i\frac{1}{r_i}e^{-j\Delta_i}\right]$$

IONOSPHERIC

DIRECTED

SURFACE

REFLECTED

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WAVE PROPAGATION

SPACE WAVE = DIRECT + REFLECTED

$$E = \frac{E_0 e^{-j\beta r_{dir}}}{r_{dir}}$$

DIRECT WAVE

$$E = \frac{E_0 e^{-j\beta r_{ref}}}{r_{ref}} \Gamma e^{-\Delta}$$

REFLECTED WAVE

$$E = E_0 \left[\frac{e^{-j\beta r_{ref}}}{r_{ref}} \Gamma e^{-\Delta} + \frac{e^{-j\beta r_{dir}}}{r_{dir}} \right]$$

SPACE WAVE

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WAVE PROPAGATION

SURFACE WAVE

$$E_{su} = \frac{E_0 e^{-j\beta r}}{r}\left[\left(1 - \Gamma A e^{-\Delta}\right)\right]$$

$$\Gamma(\psi = 0) = -1$$

$$\Delta = 0$$

$$h_T = h_r = 0$$

SPACE WAVE (NULL)

$$\left|E_{su}\right| = \frac{2E_0}{r} A$$

SUPERFACE WAVE FOR PLANE EARTH

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WAVE PROPAGATION

SURFACE WAVE FOR SPHERICAL EARTH

$$|E| = \frac{2E_0}{r} A A_1$$

$$A_1 = e^{-A_2 \frac{r}{r_H}}$$

$$r_H = \frac{80}{f^{1/3}(MHz)}$$

r_H: RADIO HORIZON DISTANCE

A_1= DIFFRACTION O SHADOW FACTOR

$A_2 \approx 0.1$ TO 0.2

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WAVE PROPAGATION

IONOSPHERIC WAVE

$$E = E_0 \sum_{i=1}^{n} \frac{A_i e^{-j\beta j_i} e^{-\Delta_i}}{r_i}$$

IONOSPHERIC WAVE $\Rightarrow$ **NOCTURNAL EFFECT**

SELECTIVE FADING

WAVE PROPAGATION

FROM THE EQUATION THREE WAVES ARE SEEN:

SURFACE WAVE

SPACE WAVE

IONOSPHERIC OR SKY WAVE

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WAVE PROPAGATION

SURFACE WAVE

NO ATTENUATED FIELD AT THE UNIT DISTANCE

$$\left|E_{su}\right| = \frac{2E_0}{r}A$$

$$A = 1$$

$$\left|E_{su}\right| = \frac{\sqrt{30 \cdot Wt \cdot D}}{r}$$

r = 1km

ISOTROPIC SOURCE

D = 1

W_T = 1 kW

Esu = 173.2 mV/m

(104.77 dBμV/m)

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BROADCAST ANTENNAS

- HF ANTENNAS
- FM ANTENNAS
- TV ANTENNAS

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HF BROADCAST BANDS

• 120 m	(2300-2498 kHz)
• 90 m	(3200-3400 kHz)
• 75 m	(3900-4000 kHz)
• 60 m	(4750-4995 kHz)
• 49 m	(5950-6200 kHz)
• 39 m	(7100-7300 kHz)
• 31 m	(9500-9900 kHz)

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HF BROADCAST BANDS

- 25 m (11650-11975 kHz)
- 22 m (13600-13800 kHz)
- 19 m (15510-15600 kHz)
- 16 m (17550-17900 kHz)
- 13 m (21450-21850 kHz)
- 11 m (25670-26100 kHz)

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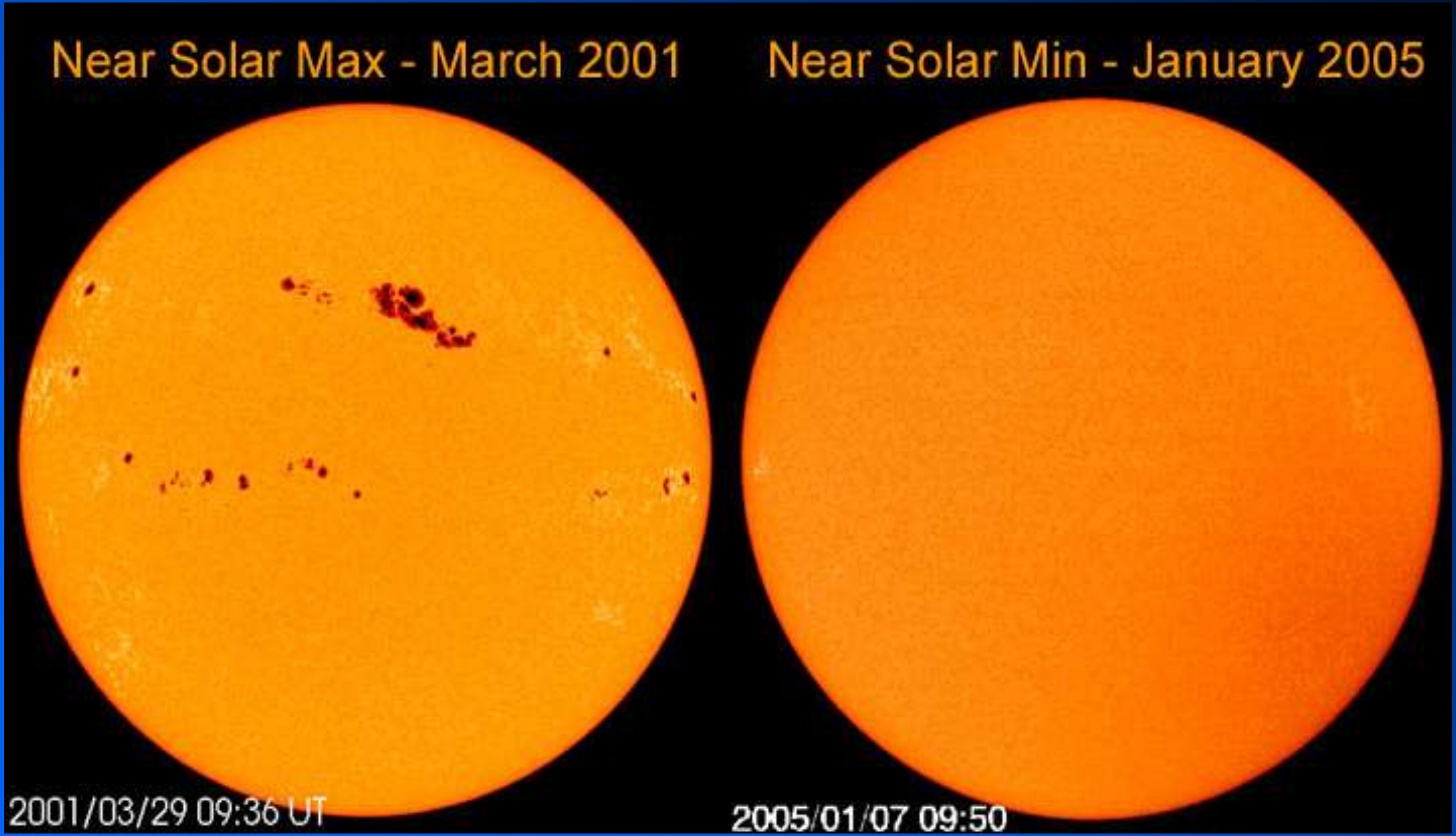
HF BROADCAST BANDS



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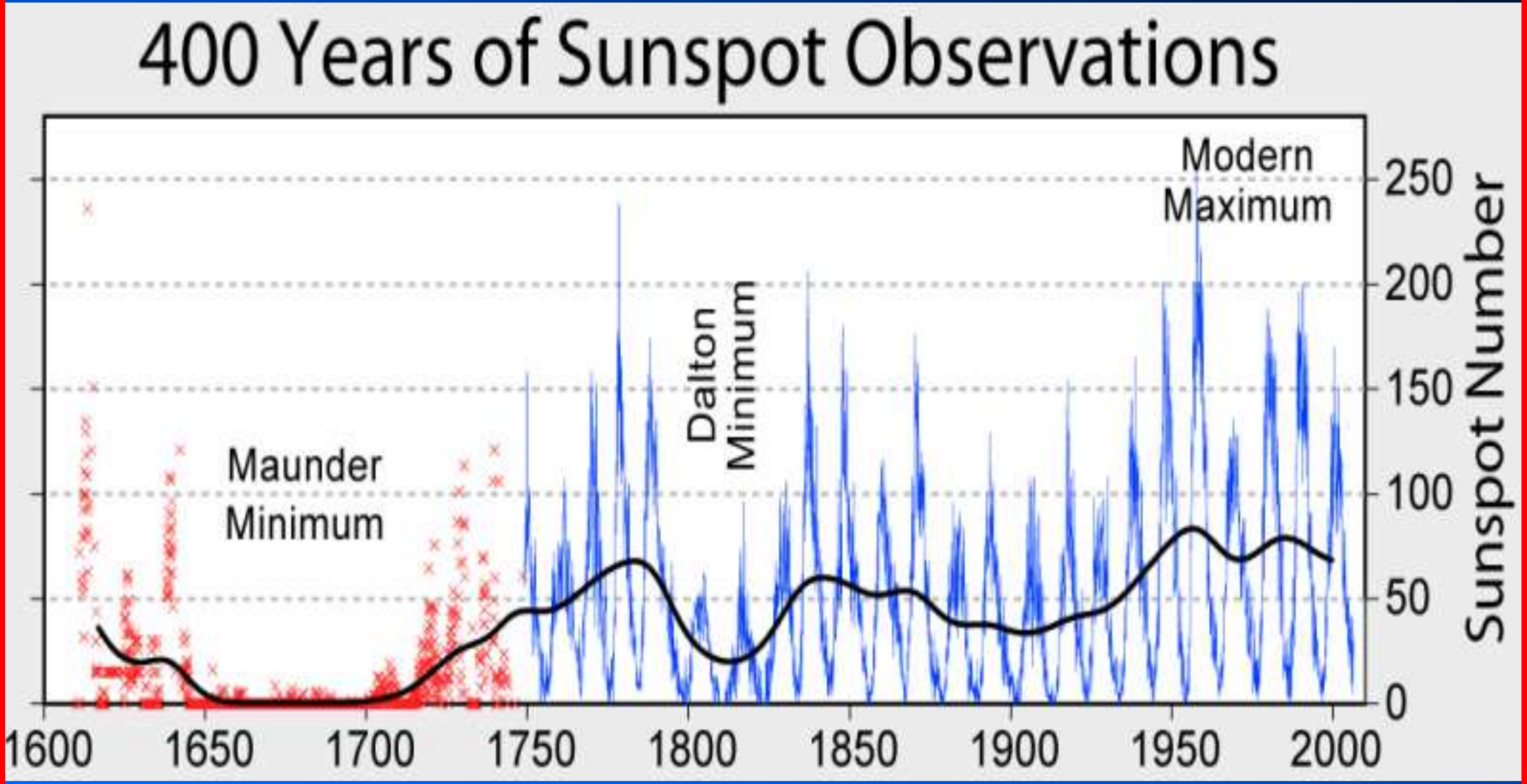
HF BROADCAST BANDS



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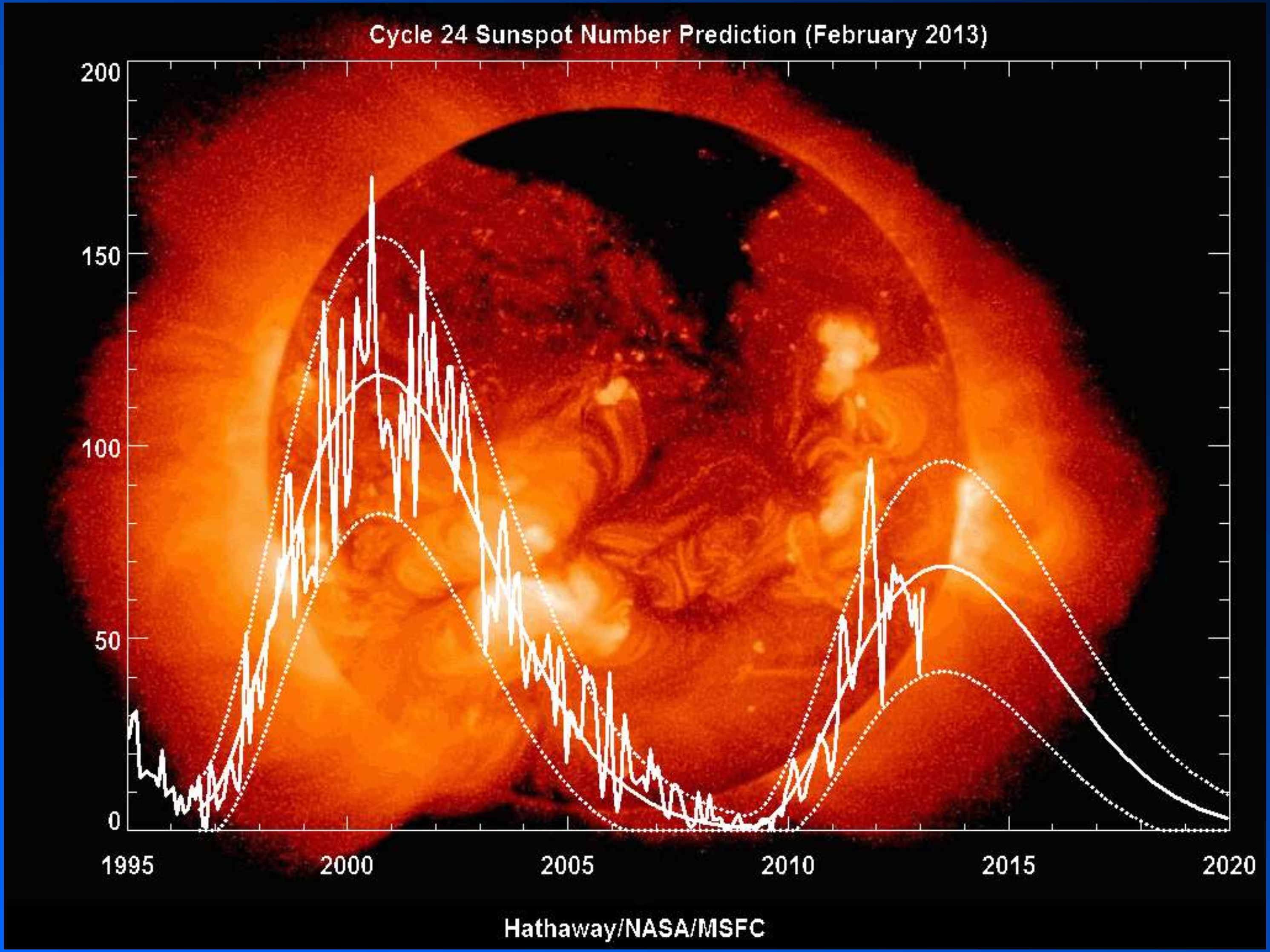
HF BROADCAST BANDS



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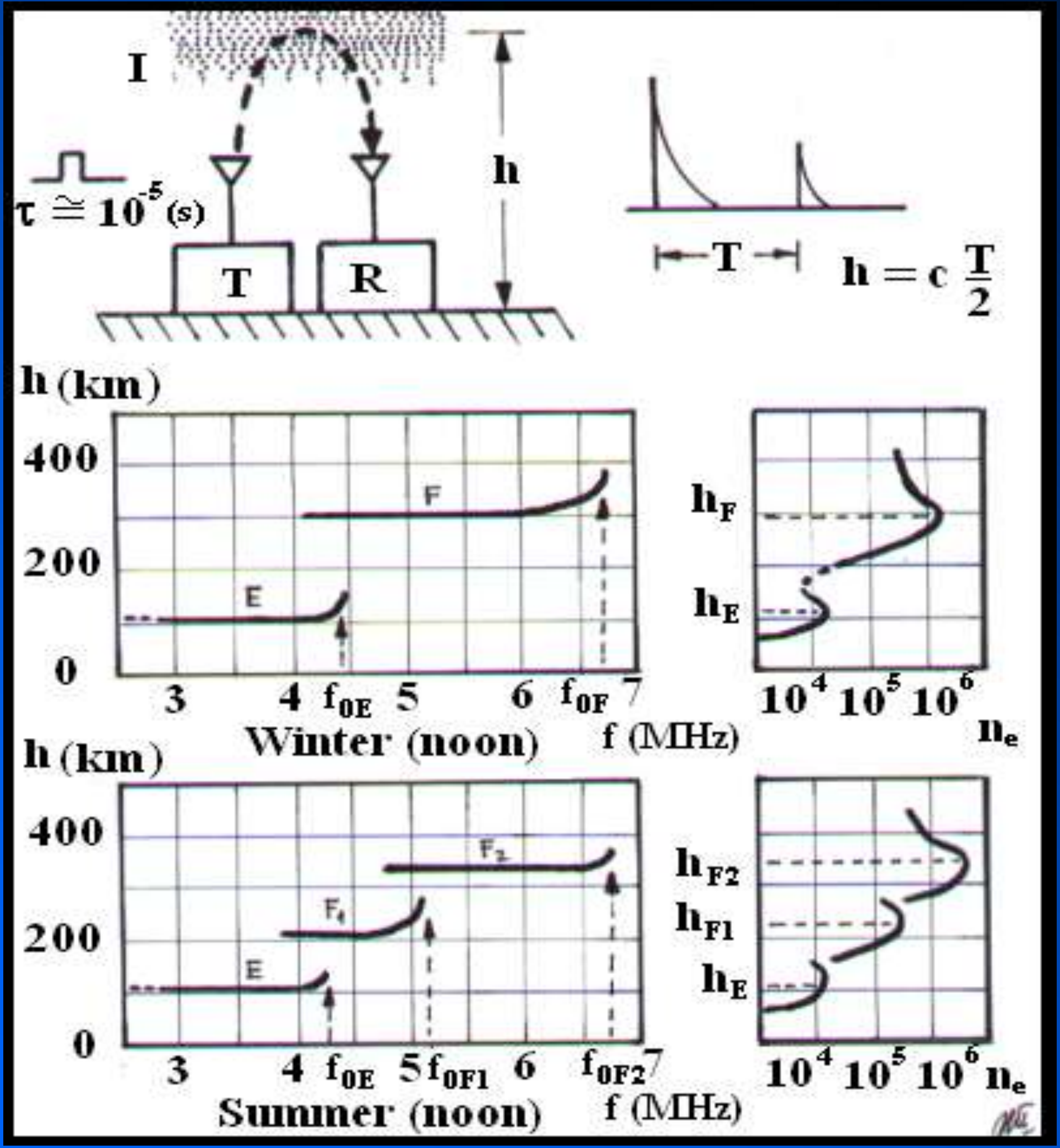
IONOSPHERIC PROPAGATION

Critical

Frequencies



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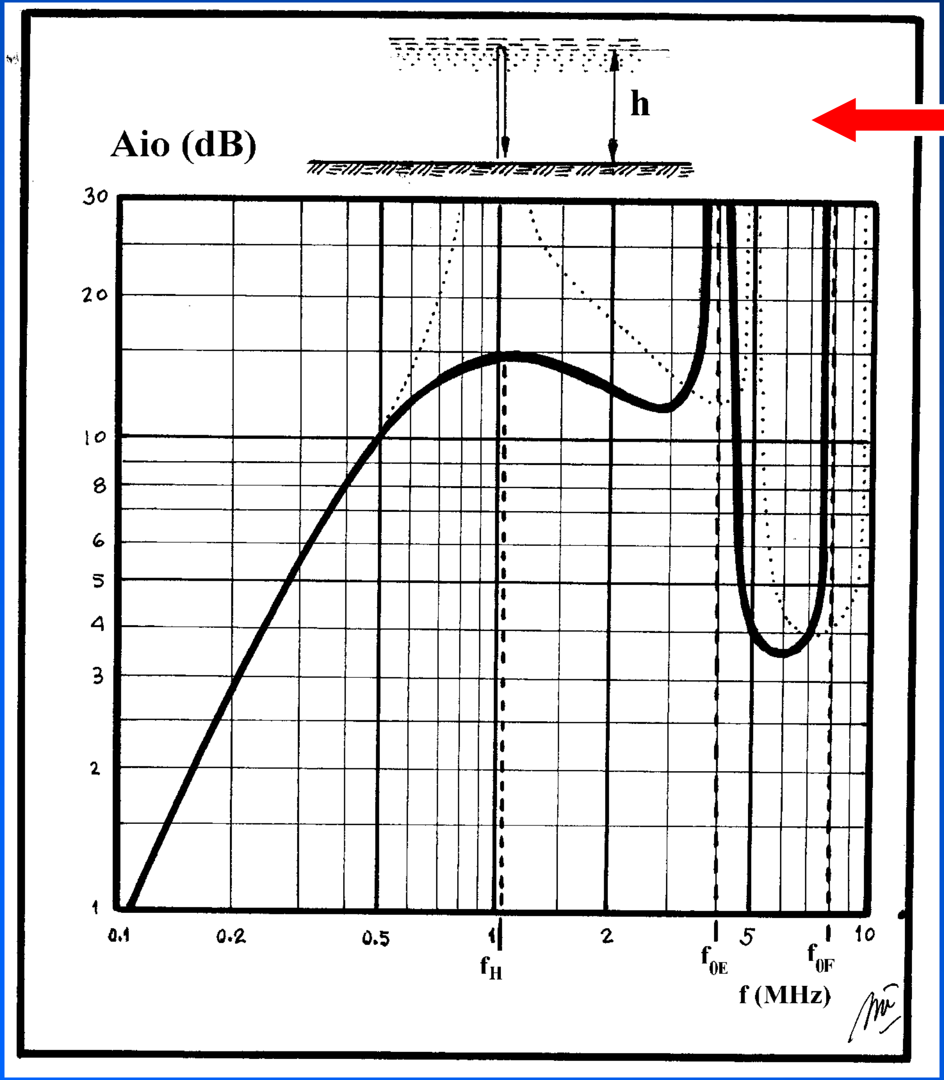
IONOSPHERIC PROPAGATION



Virtual height

Ionospheric absorption index A_{i0} (vertical incidence)

f_H = Gyrofrequency

f_{0E} = E critical freq.

f_{0F} = F critical freq.

$A_{i0} = 20 \log(E_0/E_1)$

E_0 = Theoretical field

E_1 = Measured field

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IONOSPHERIC PROPAGATION

- **CRITICAL FREQUENCY:**

Maximum Frequency to be reflected by a Ionospheric Layer for Vertical Incidence.

- **CRITICAL ANGLE:**

Maximum Elevation Angle permitting Ionospheric Reflexion.

- **TAKE OFF ANGLE:**

Depends on the layer height and the distance on the earth surface.

IONOSPHERIC PROPAGATION

- **MAXIMUM USEFUL FREQUENCY:**

Depends on the critical frequency and on the take off angle (Cosecant Law).

<u>It does not depends on the radiated power.</u>

- **MINIMUM USEFUL FREQUENCY:**

It depends on the ionospheric absortion.

<u>It depends on the radiated power</u>.

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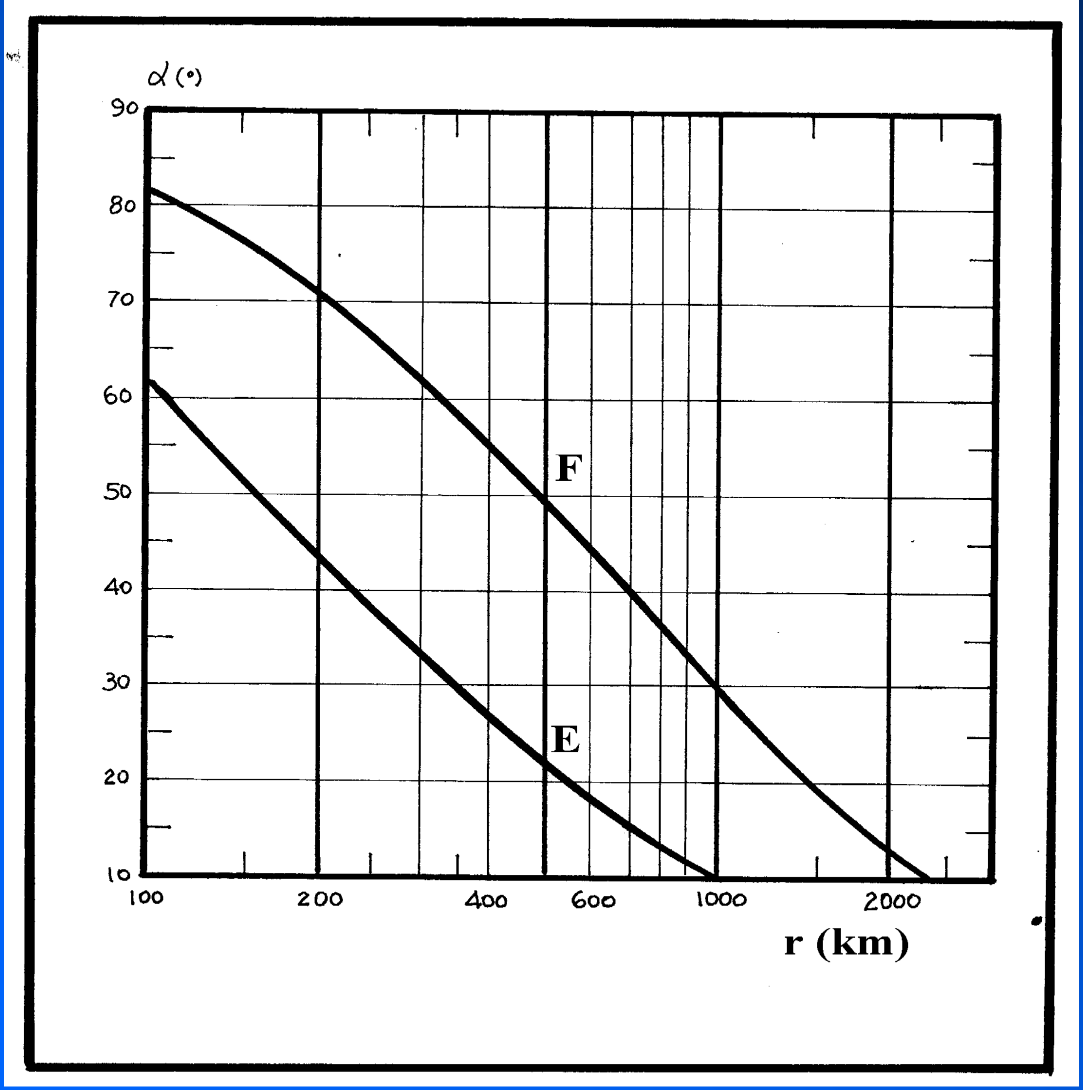
IONOSPHERIC PROPAGATION



Distance r as a function of take off angle for E and F layer

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IONOSPHERIC PROPAGATION

- EXAMPLE:
- Link distance $r = 1000$ km
- Take off angle $\alpha = 30º$
- Critical Frequency $f_{0} = 4$ MHz
- MUF = f_0*cosec α = 8 MHz
- OWF = 0.85 MUF = 6.8 MHz

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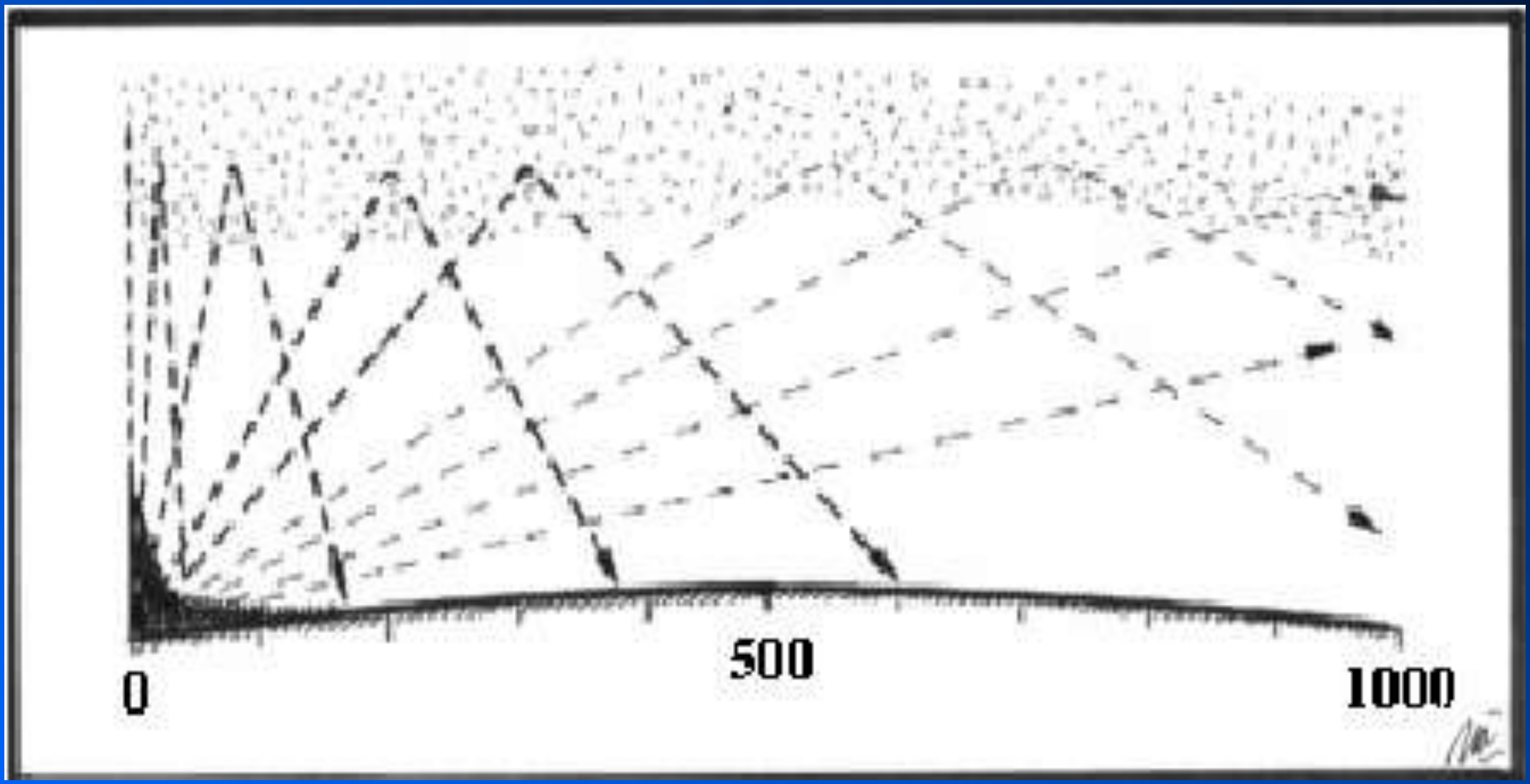
IONOSPHERIC PROPAGATION

- EXAMPLE:
- Link distance r = 2000 km
- Take off angle α = 20º
- Critical Frequency $f_{0} =$ 4 MHz
- MUF = f_0*cosec α = 12 MHz
- OWF = 0.85 MUF = 10 MHz

IONOSPHERIC PROPAGATION



- f_0 = 4 MHz
- $f = f_0$
- No Silence Zone

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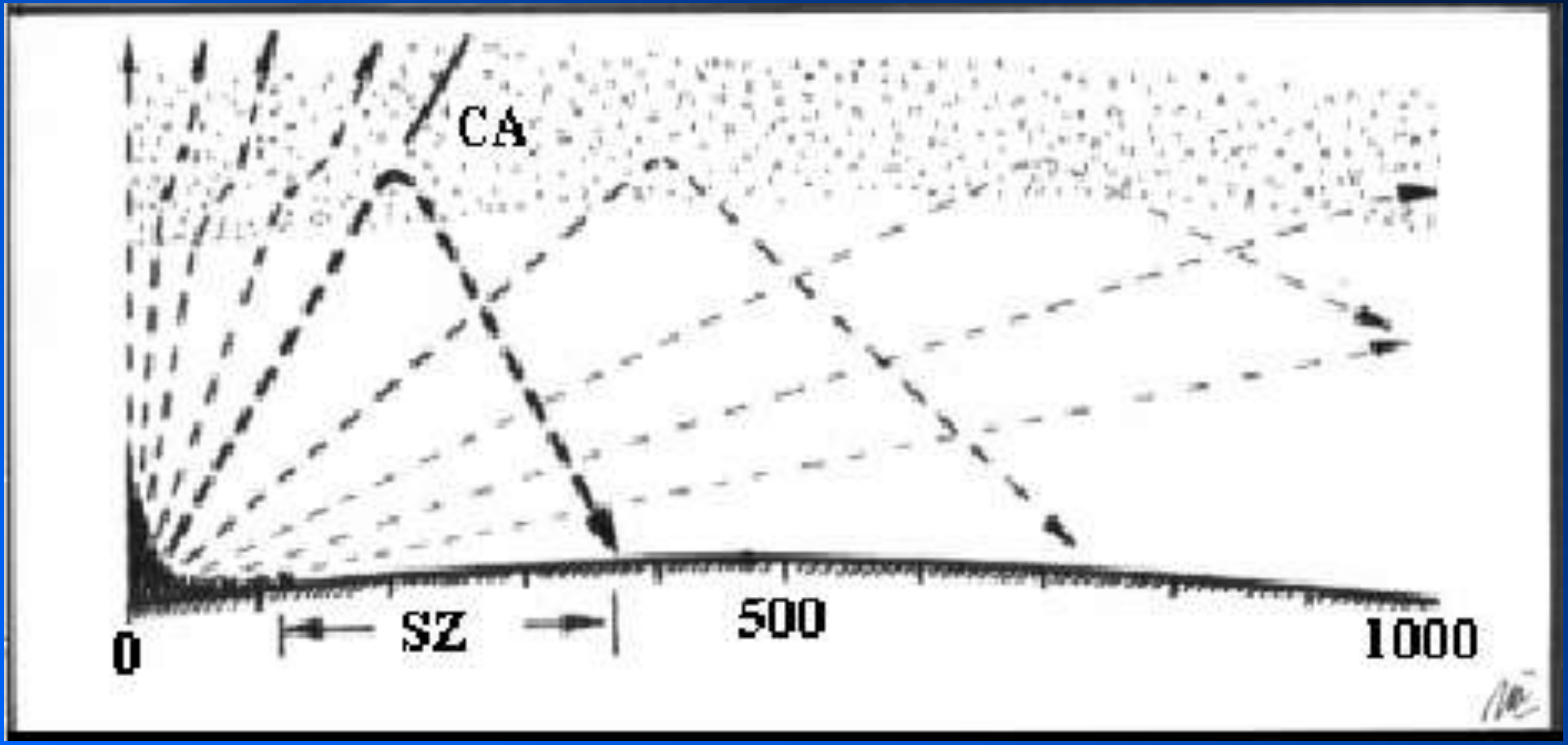
IONOSPHERIC PROPAGATION



- f_0 = 5 MHz
- $f > f_0$
- Silence Zone

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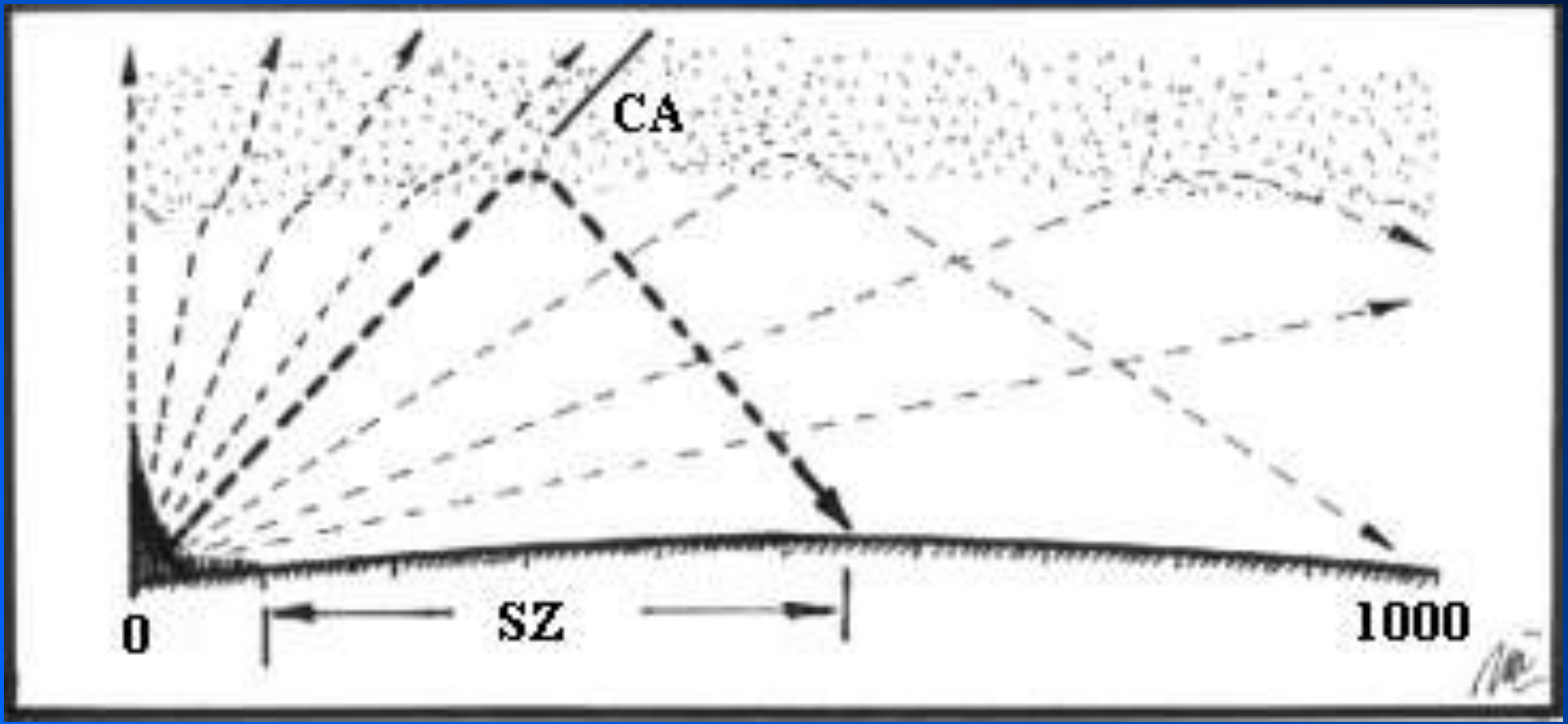
IONOSPHERIC PROPAGATION



- f_0 = 6 MHz
- $f > f_0$
- Silence Zone

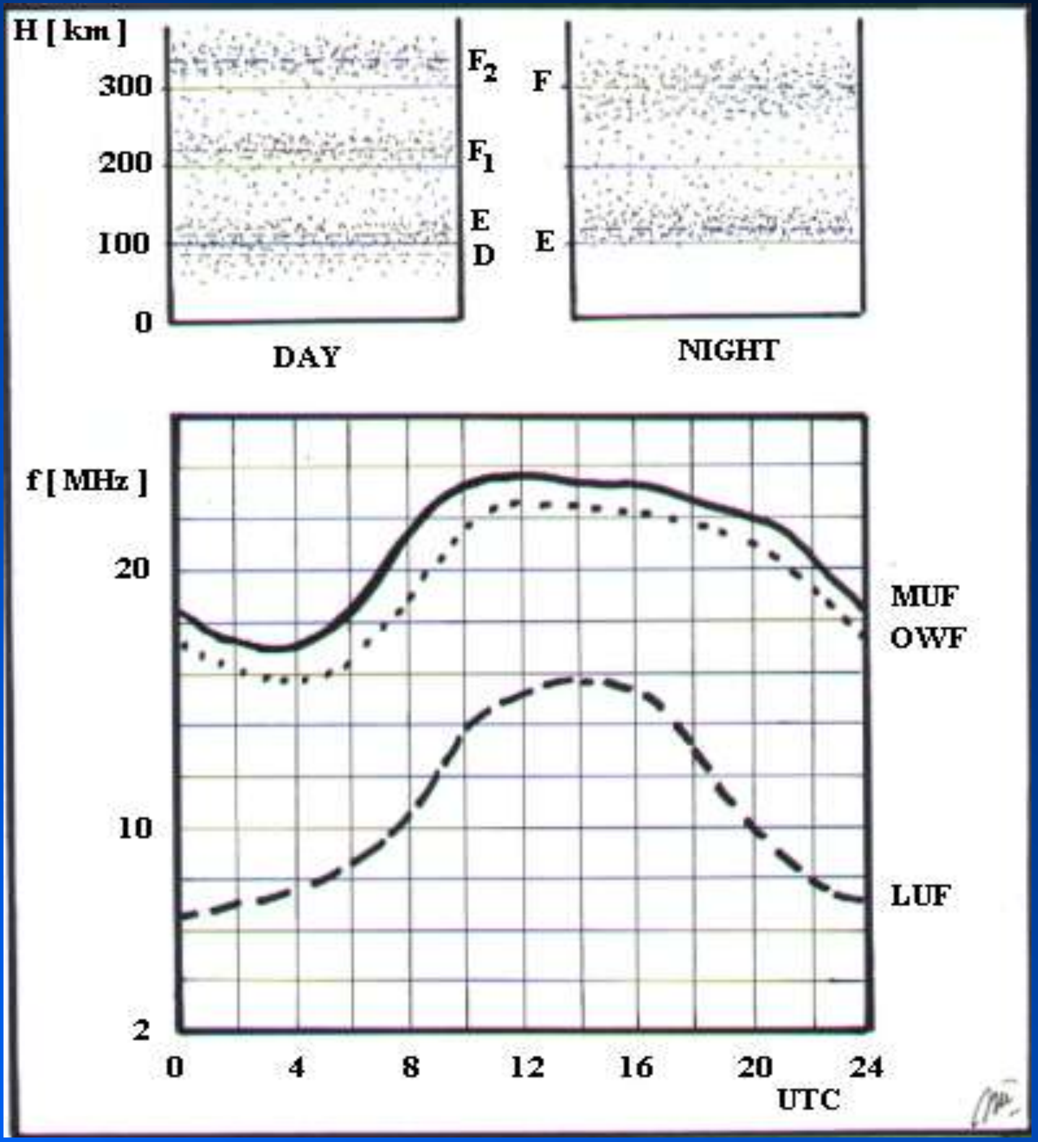
IONOSPHERIC PROPAGATION

FORECAST

MUF = Maximum Useful Frequency

OWF = Optimum Working Frequency

LUF = Lowest Useful Frequency



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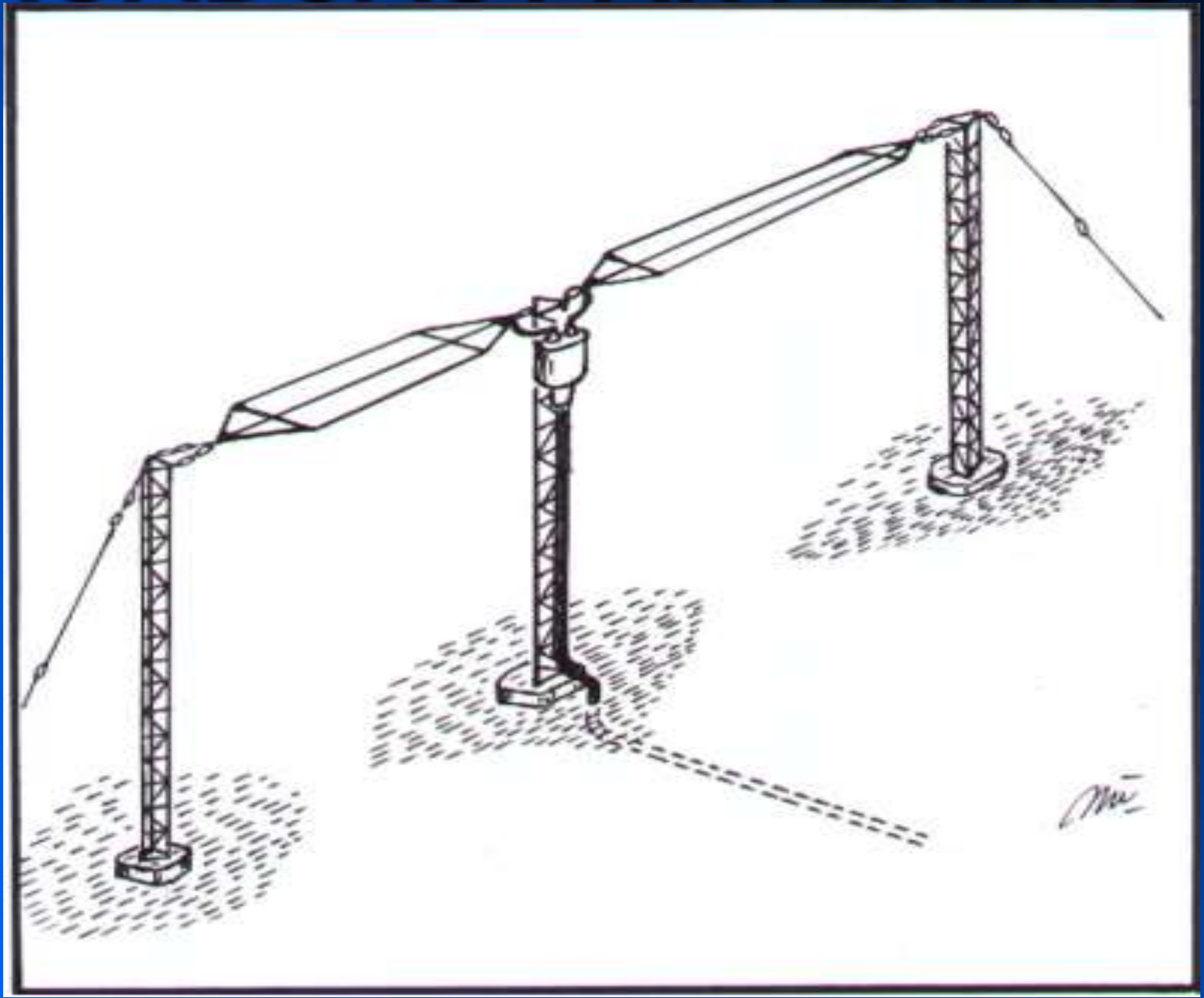
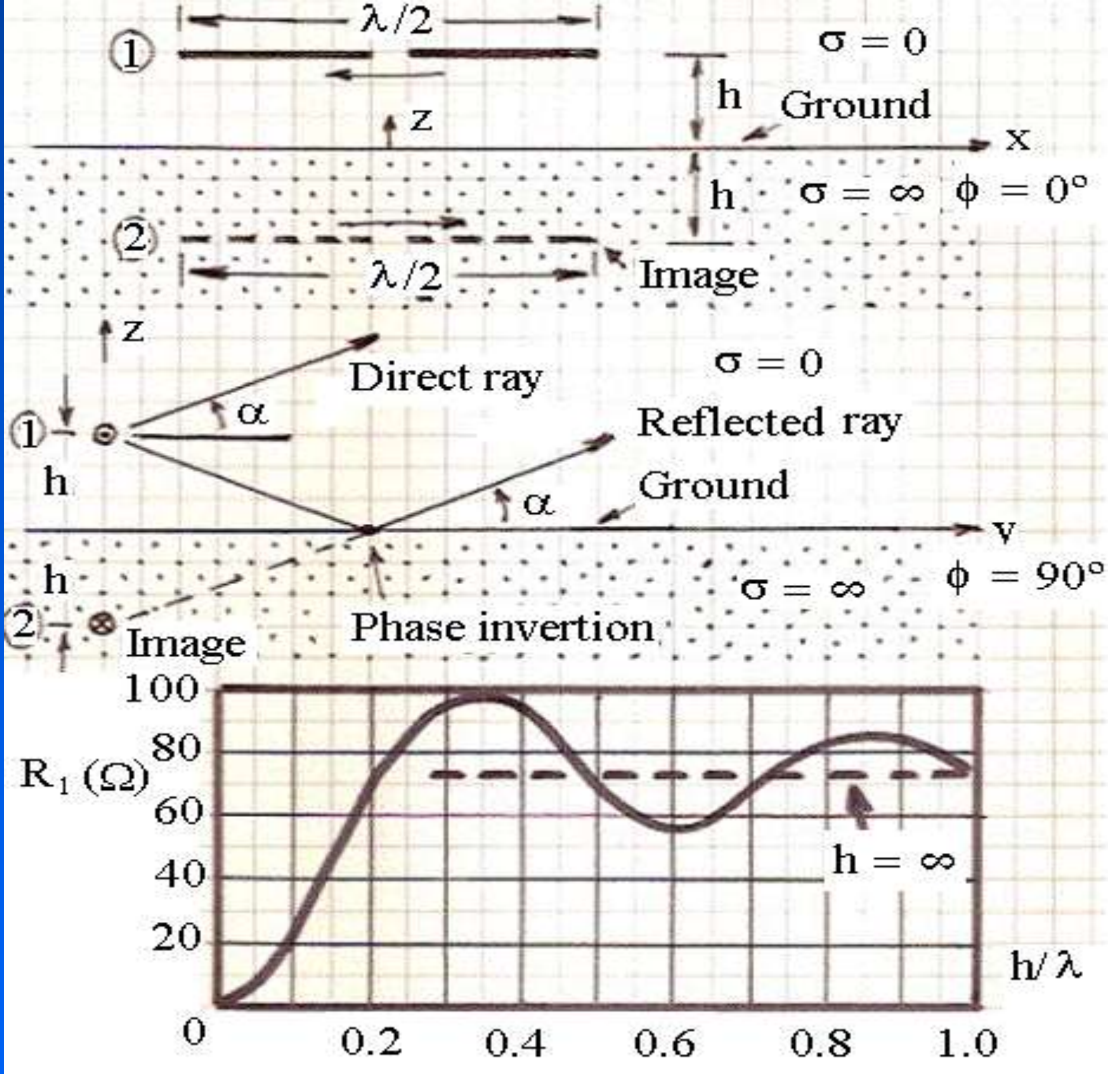
HF BROADCAST ANTENNAS



HF High Power Dipole

HF BROADCAST ANTENNAS

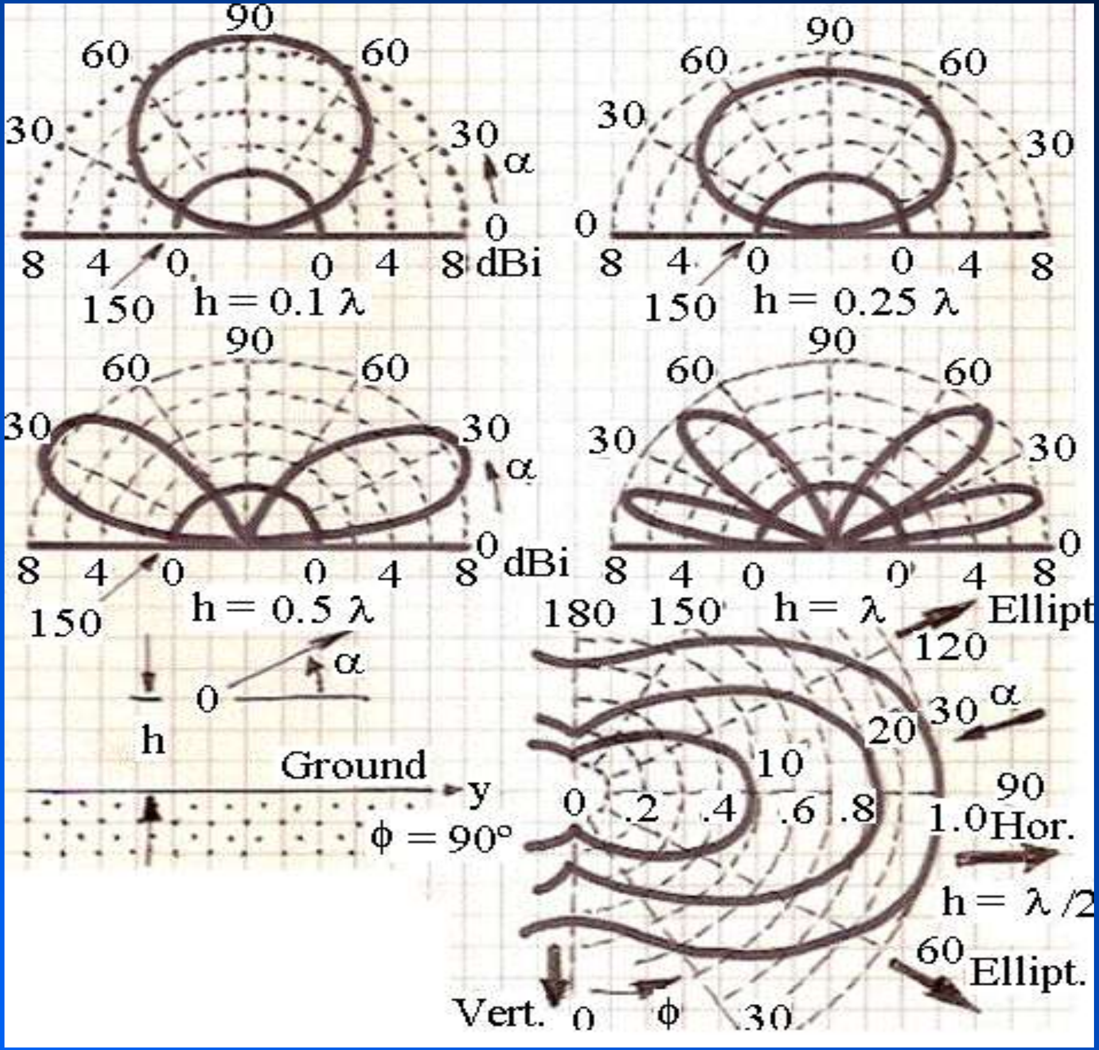
λ/2 **Dipole** over real ground



HF BROADCAST ANTENNAS

Dipole λ/2 over ground

Radiation Patterns



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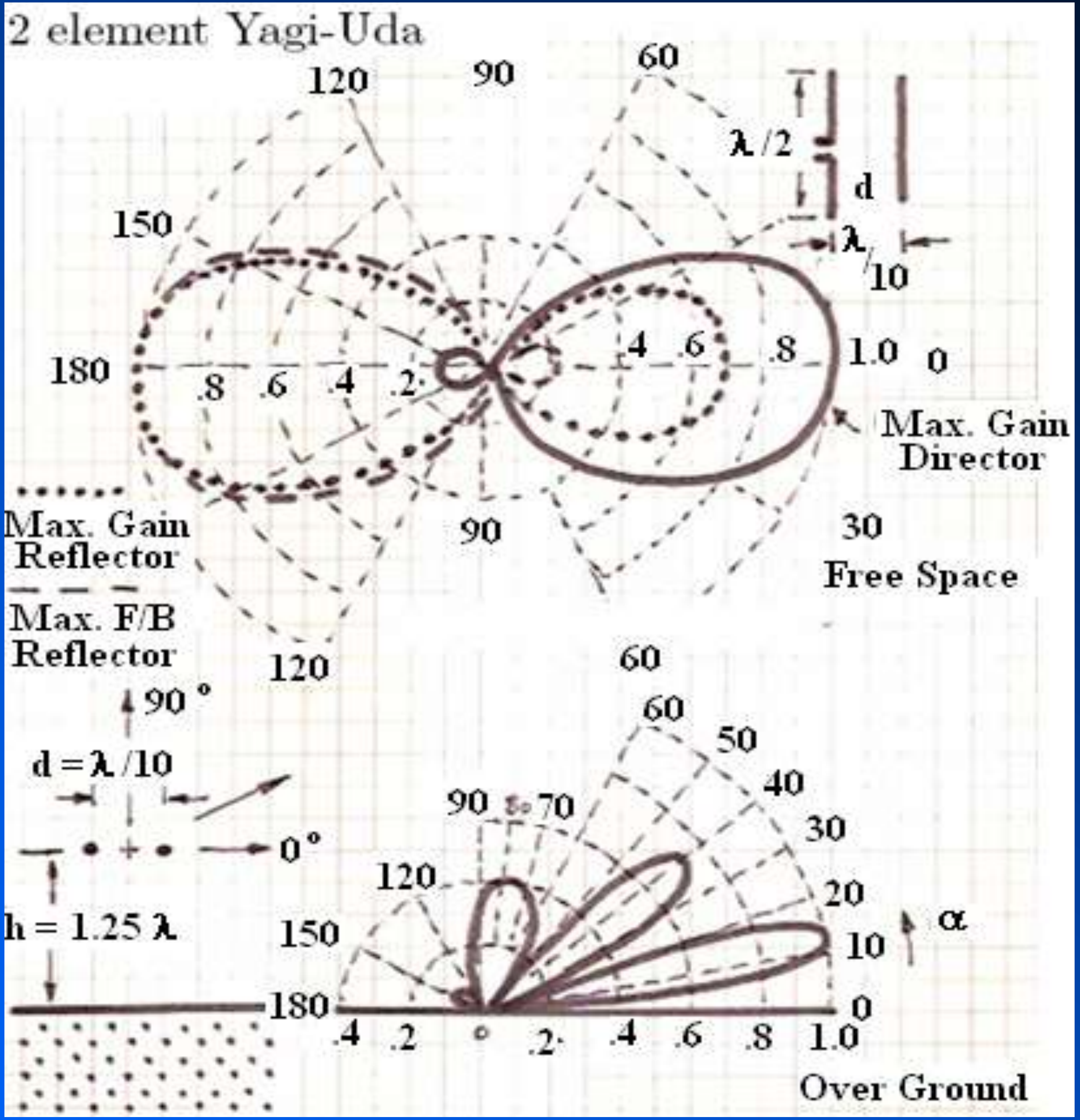
HF BROADCAST ANTENNAS

Yagi-Uda Antenna



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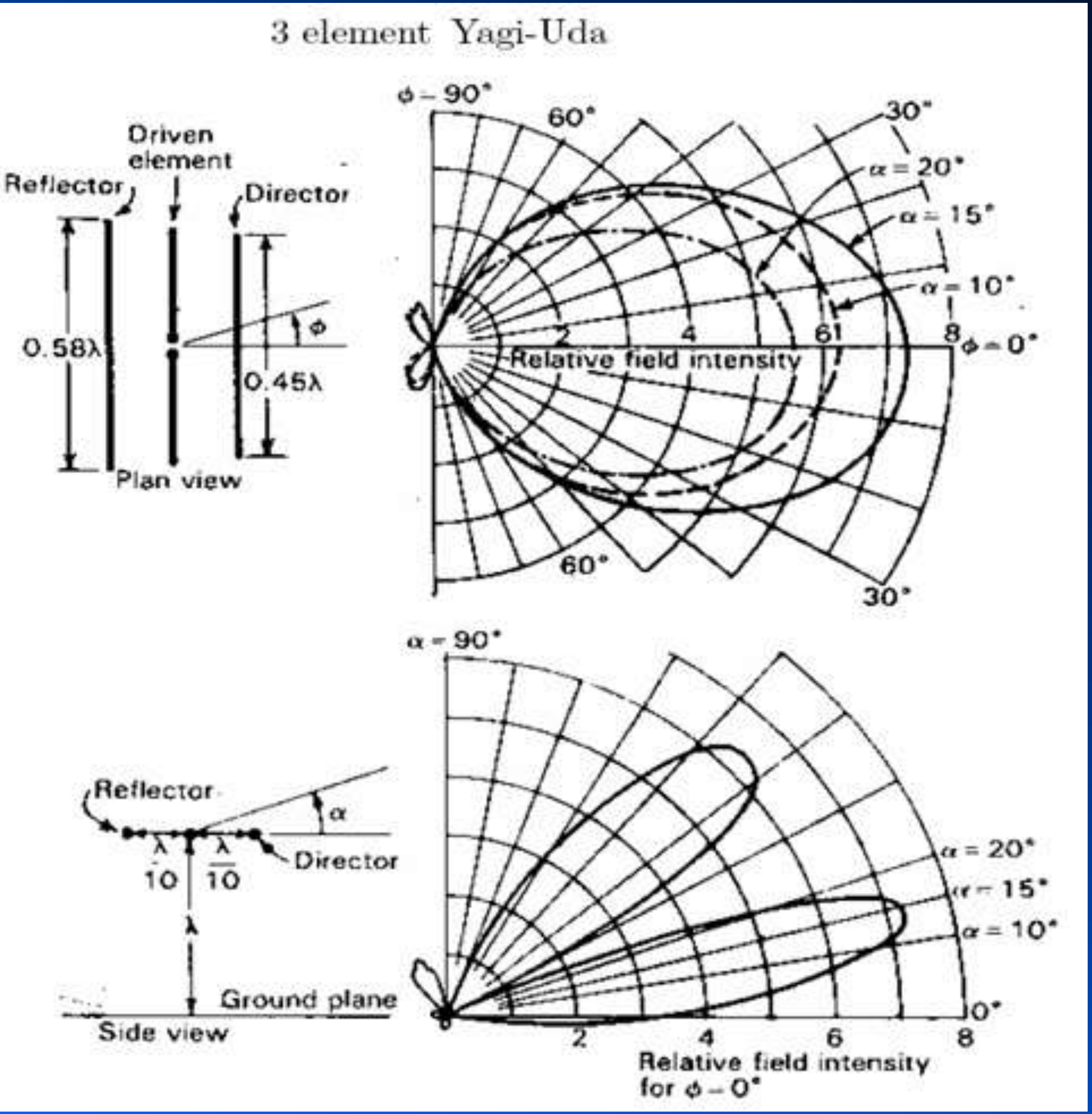
HF BROADCAST ANTENNAS

Yagi-Uda Antenna



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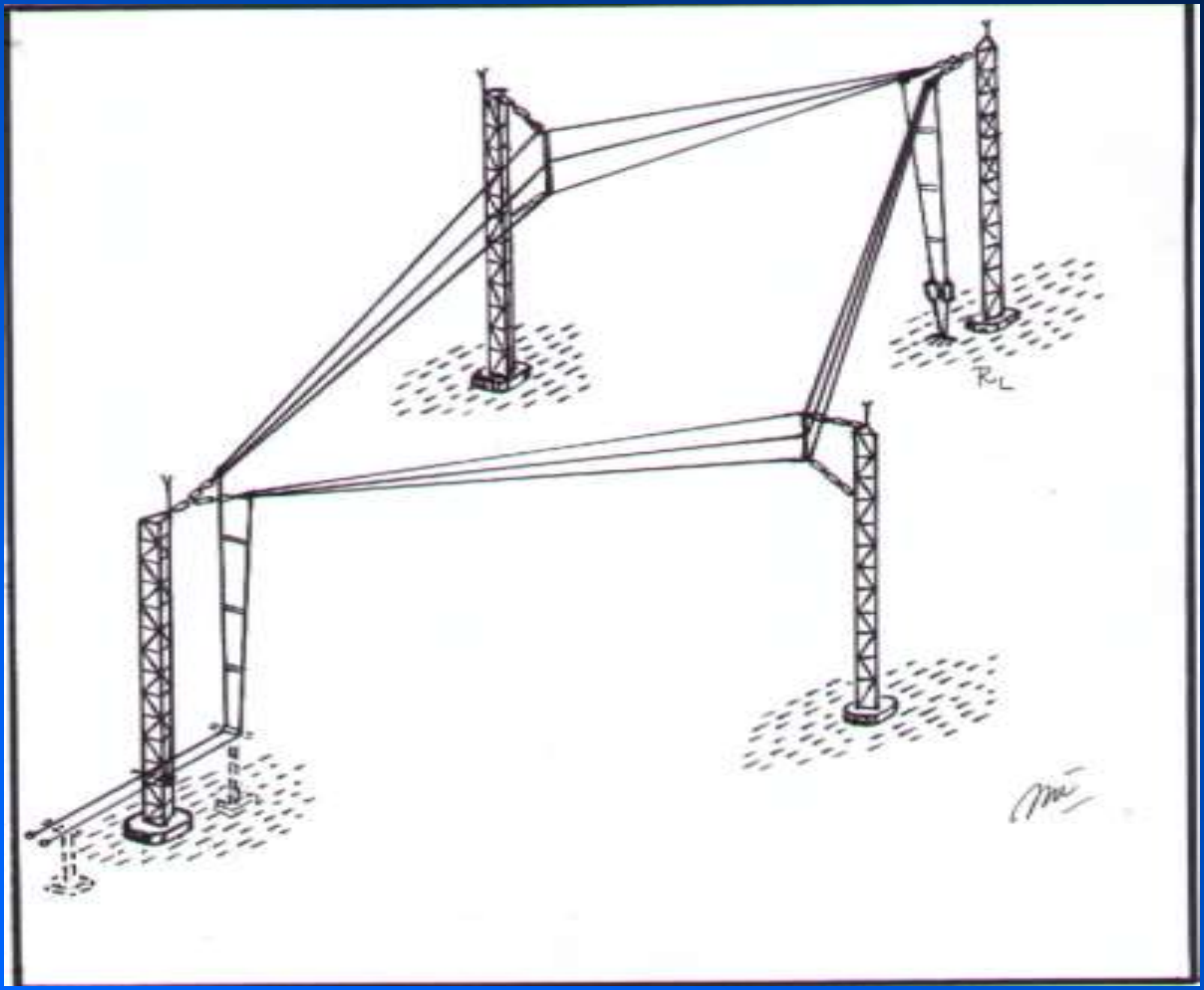
HF BROADCAST ANTENNAS



L = Length

D = Width

H = Height

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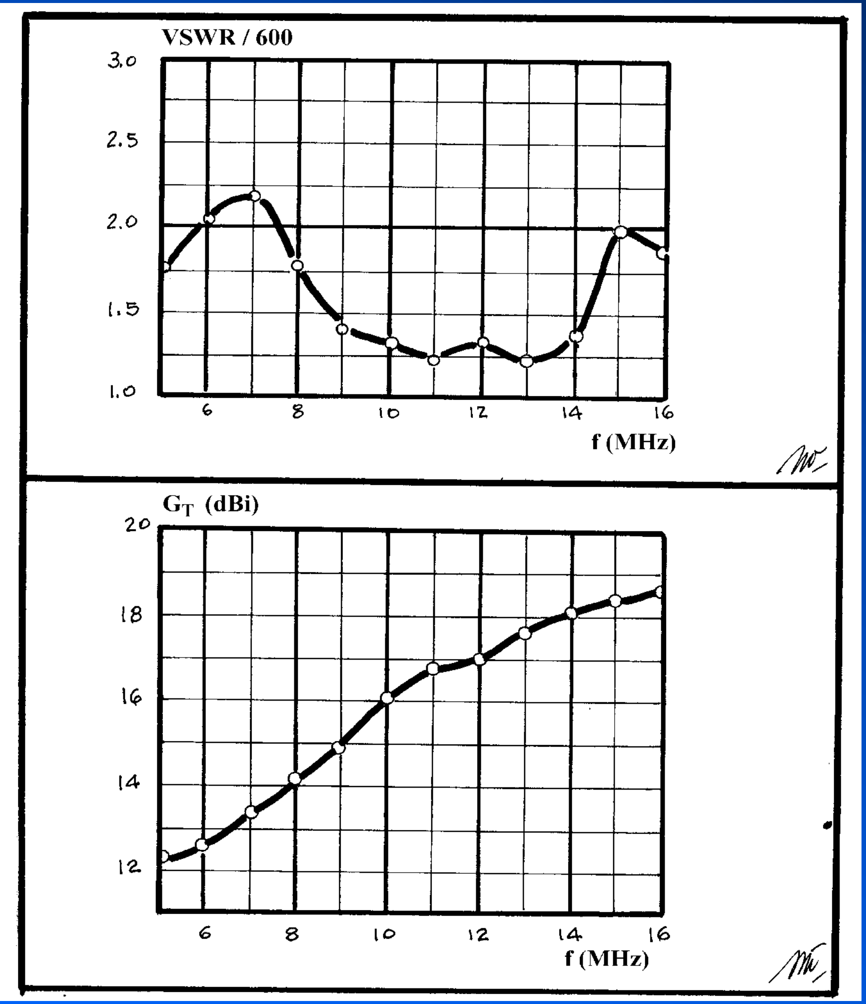
HF High Power Rombic Antenna

HF BROADCAST ANTENNAS



VSWR and Gain of HF Rhombic Antenna

L = 100 m
D = 60 m
H = 18 m

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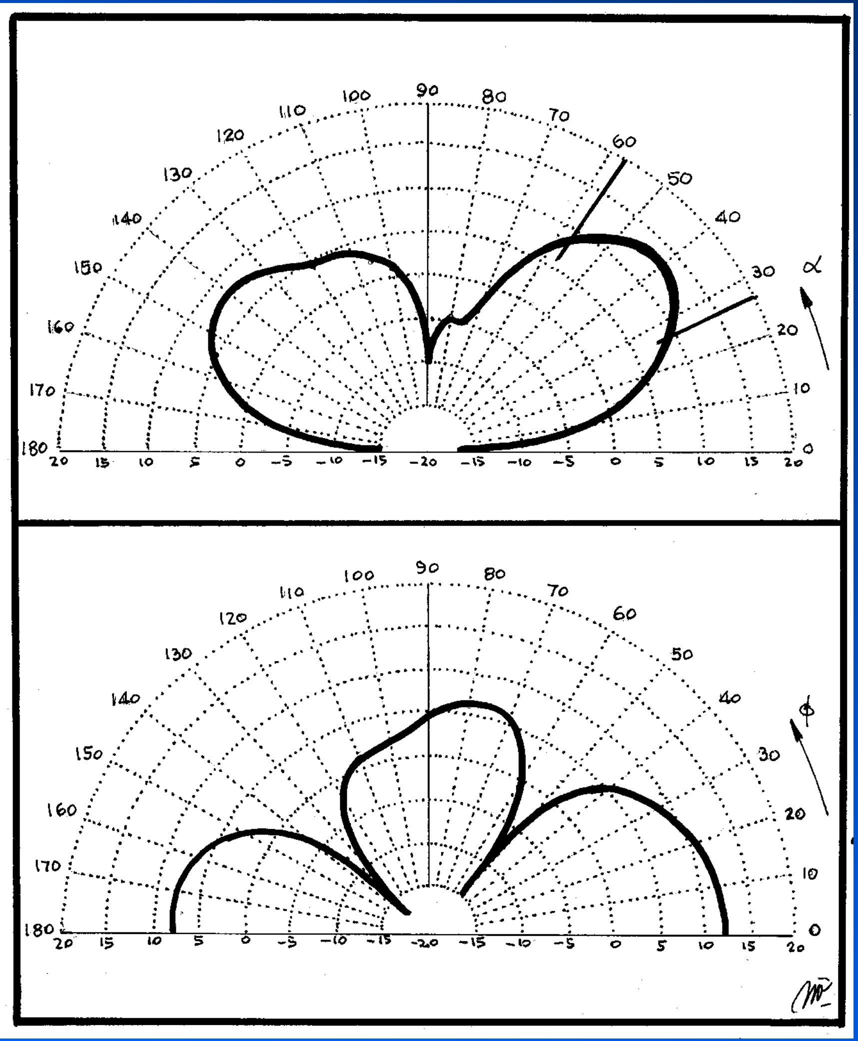
HF BROADCAST ANTENNAS



Typical Radiation Pattern at 49 m Band

α = 40º

G_T = 12.4 dBi

L = 2λ

D = 1.2λ

H = 0.36λ

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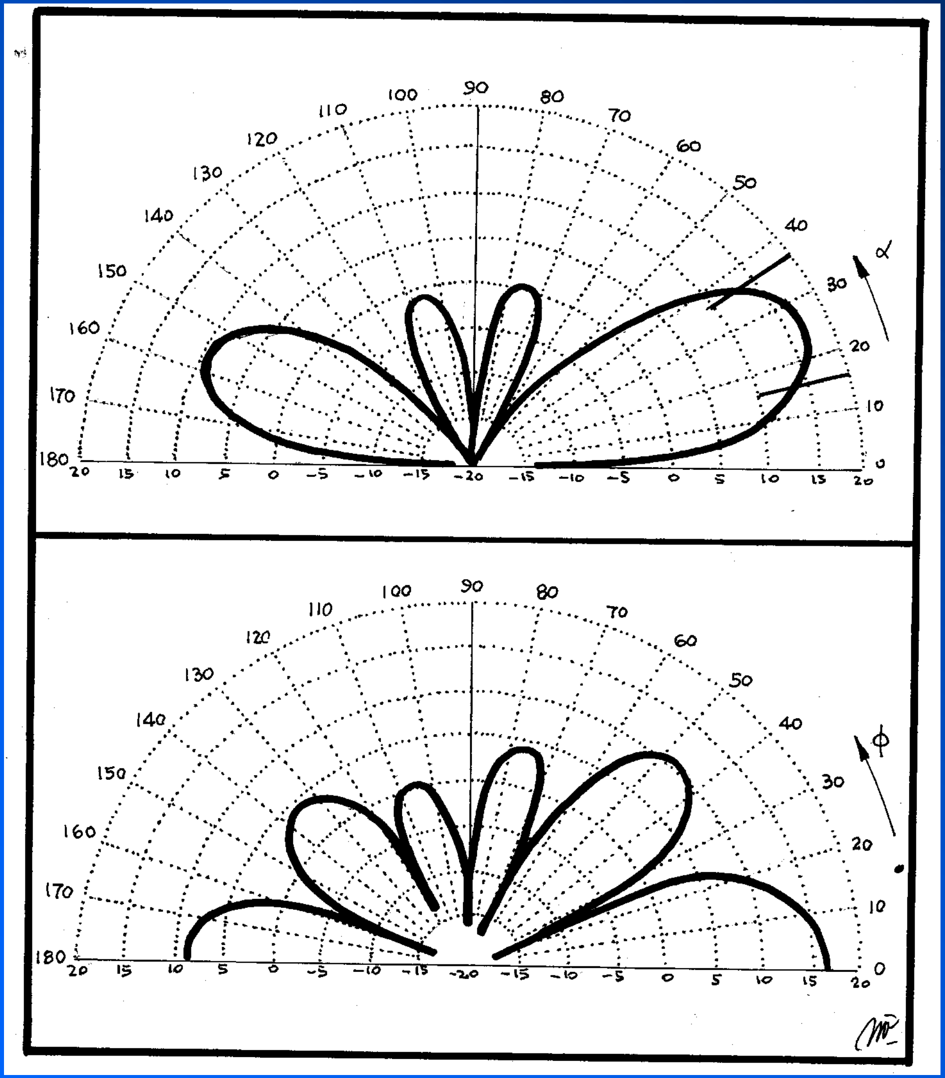
HF High Power Rhombic Antenna

HF BROADCAST ANTENNAS



Typical Radiation Pattern at 31 m Band

$\alpha = 25^{\circ}$

$G_T = 16.2$ dBi

$L = 3.3\lambda$

$D = 2\lambda$

$H = 0.6\lambda$

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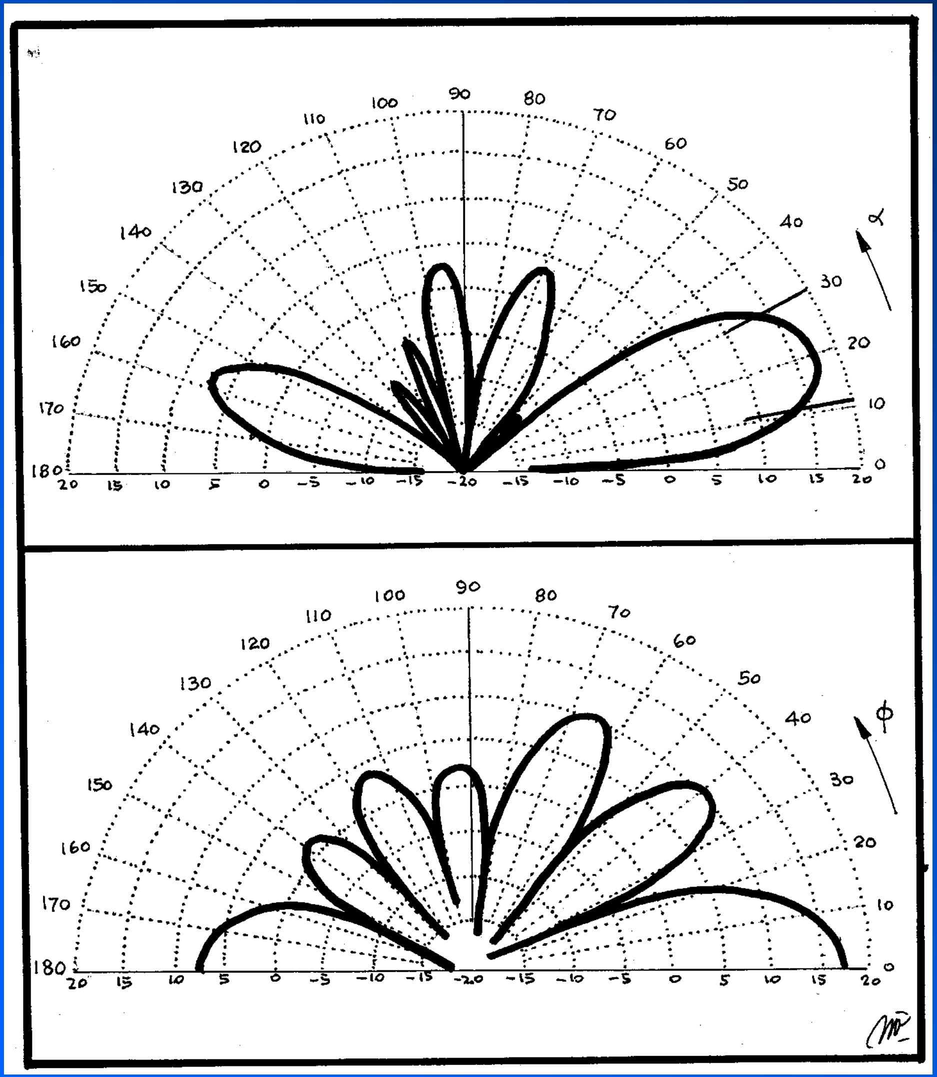
HF High Power Rhombic Antenna

HF BROADCAST ANTENNAS



Typical Radiation Pattern at 25 m Band

α = 20º

G_T = 16.9 dBi

L = 4λ

D = 2.4λ

H = 0.72λ

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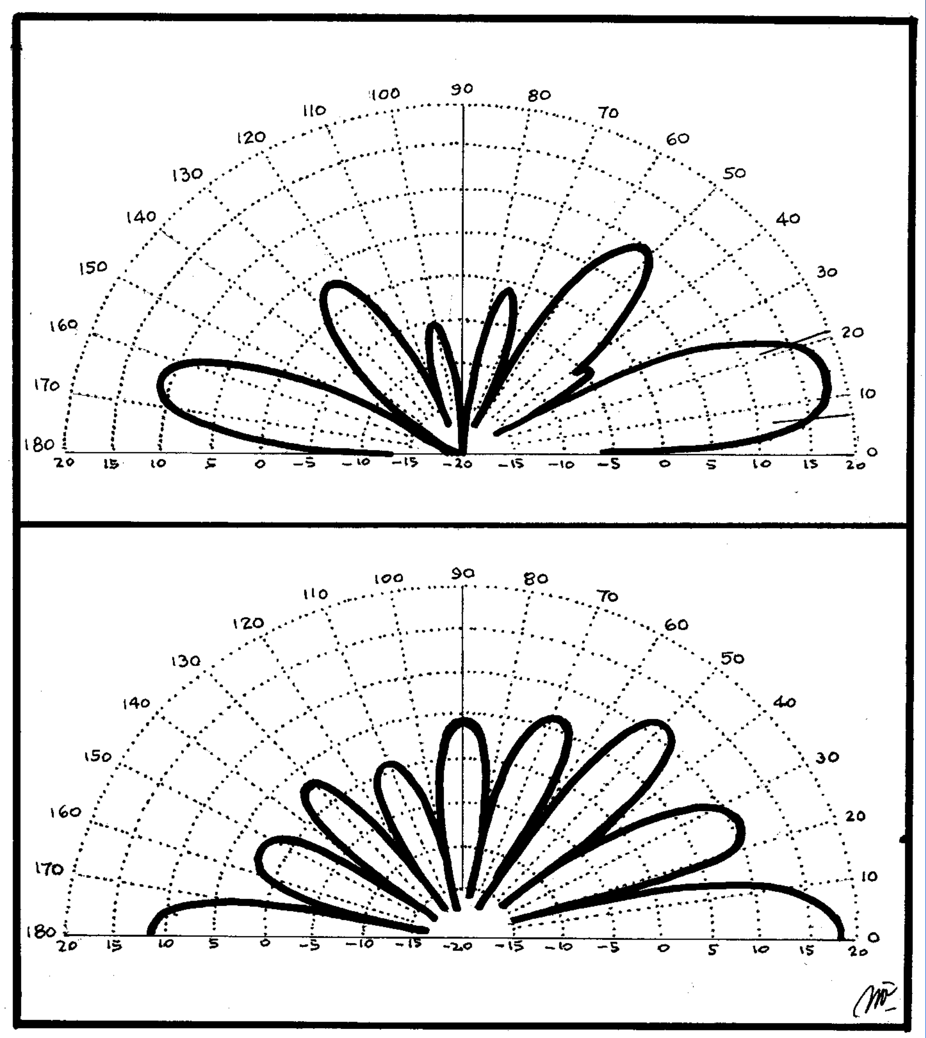
HF High Power Rhombic Antenna

HF BROADCAST ANTENNAS



Typical Radiation Pattern at 17 m Band

$\alpha = 14^{o}$

$G_T = 18.6$ dBi

$L = 5.33\lambda$

$D = 3.2\lambda$

$H = 0.96\lambda$

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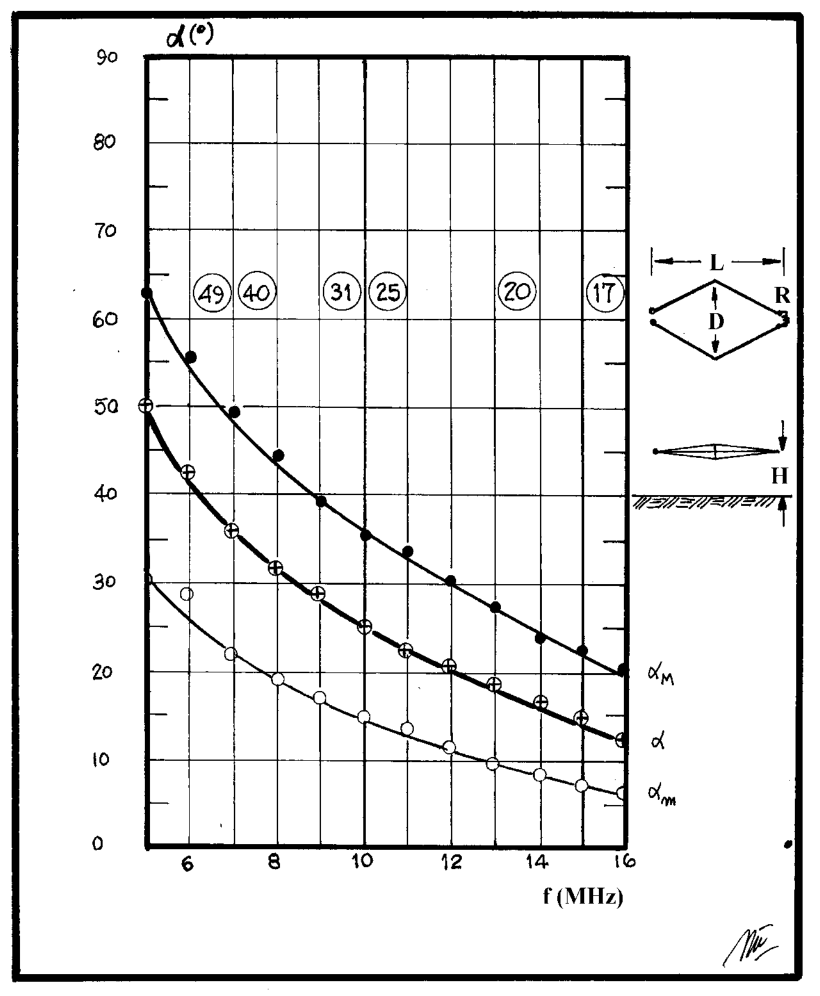
HF High Power Rhombic Antenna

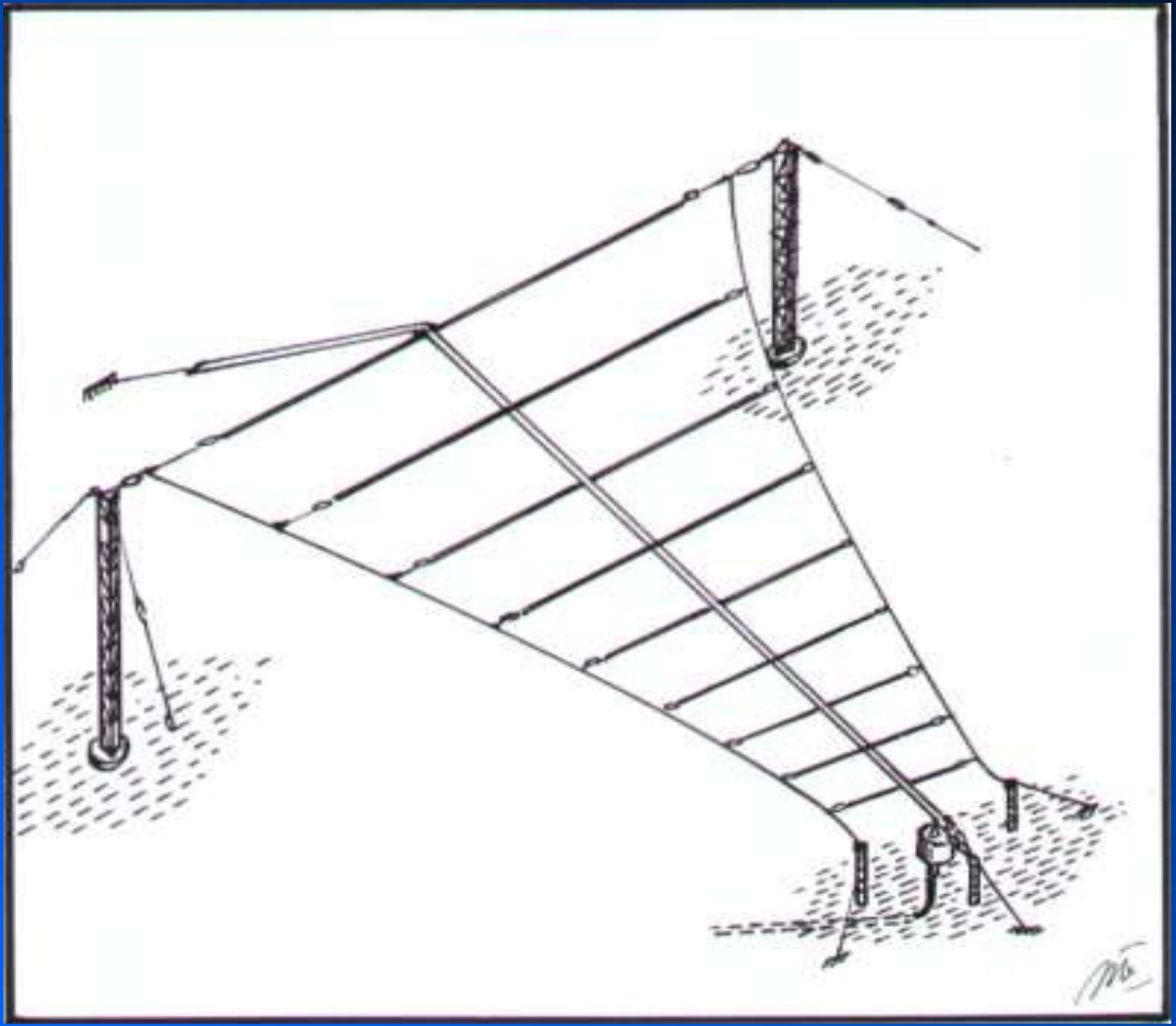
HF BROADCAST ANTENNAS



Take off angle as a function of frequency

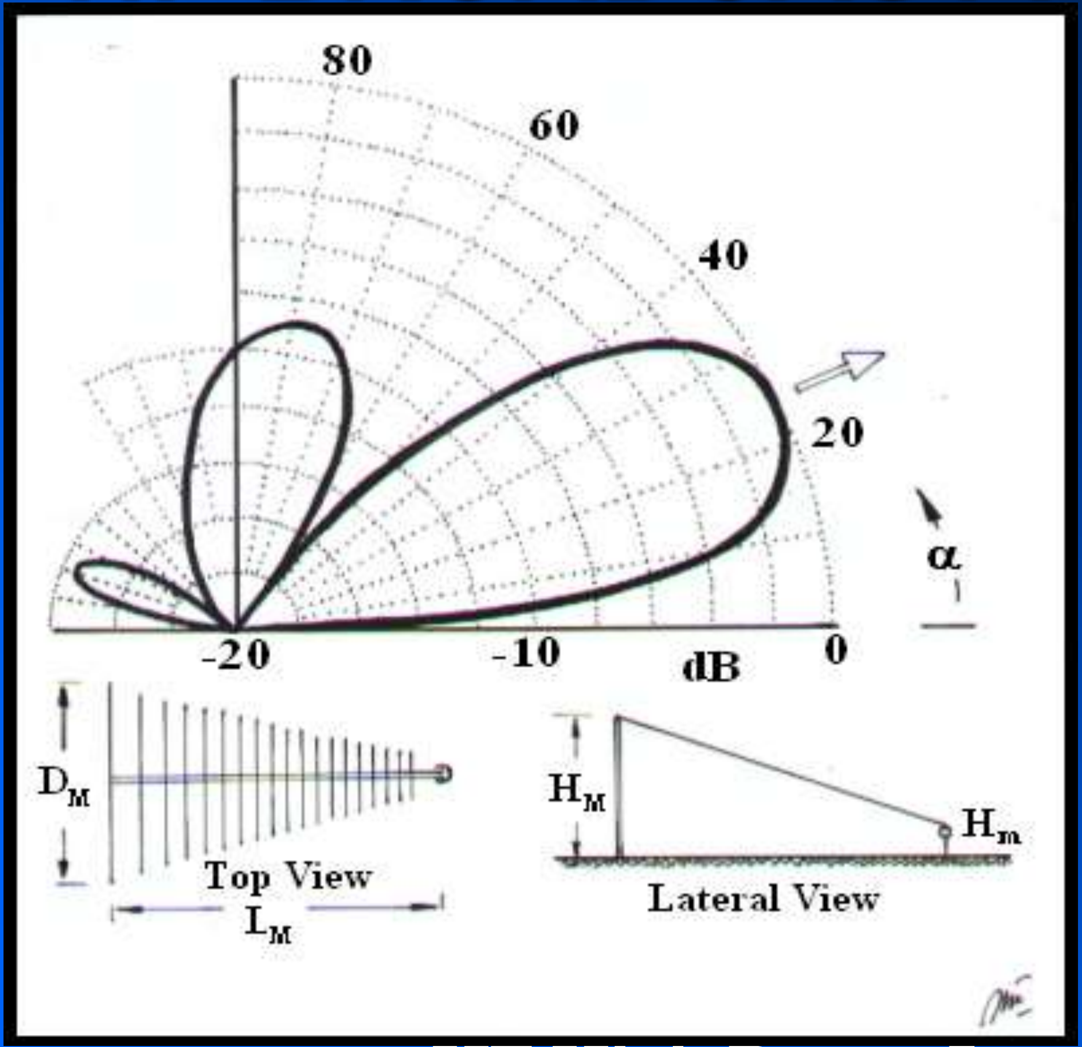
HF High Power Rhombic Antenna

HF BROADCAST ANTENNAS



HF High Power Log-Periodic Antenna

HF BROADCAST ANTENNAS



f = 9.5 MHz
τ = 0.92
Take off angle
$\alpha = 25^o$
$\alpha_m = 10^o$
$\alpha_M = 38^o$
$D_T = 12.7$ dBi

HF High Power Log-Periodic Antenna
Radiation pattern 31 m Band

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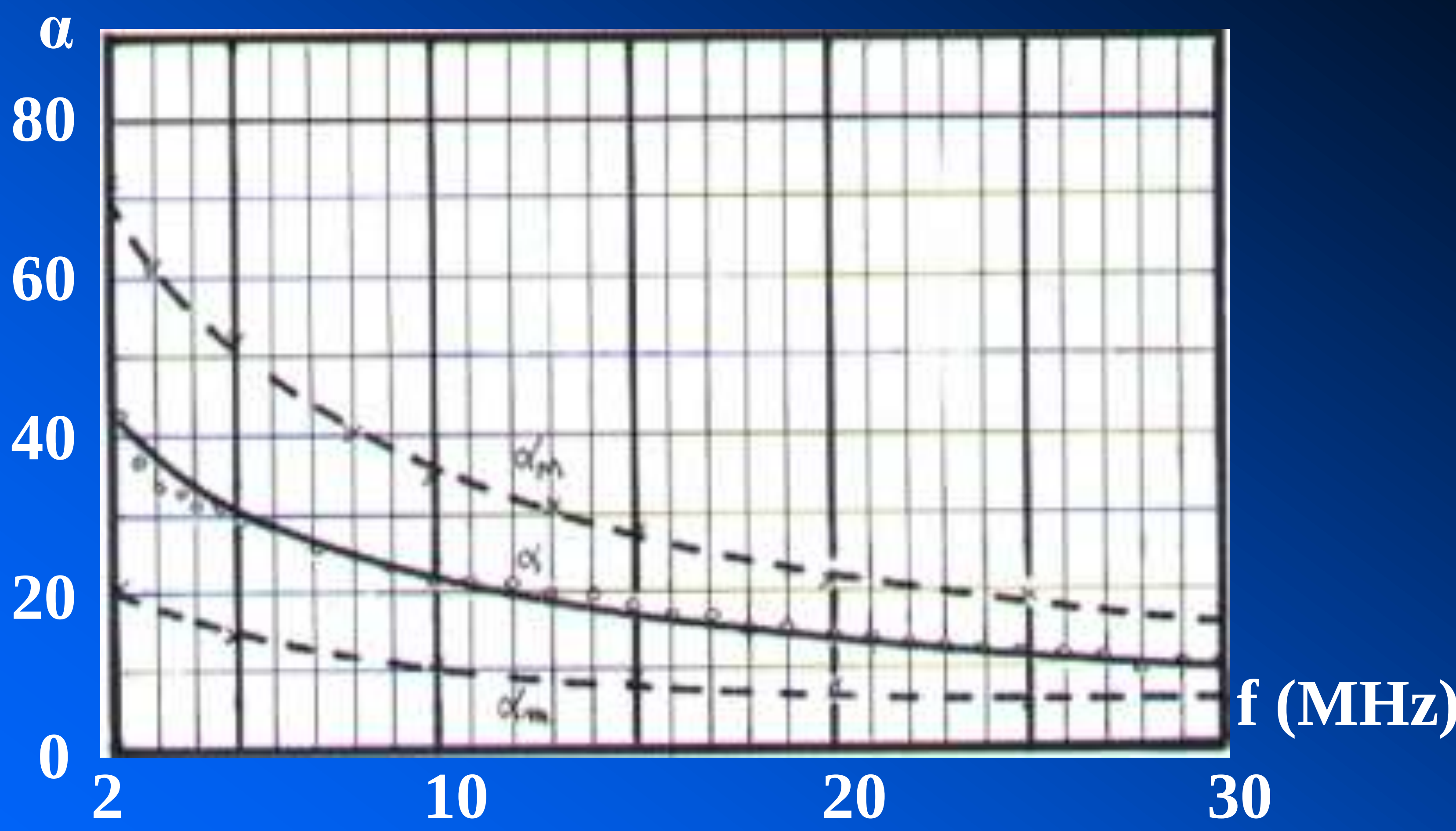
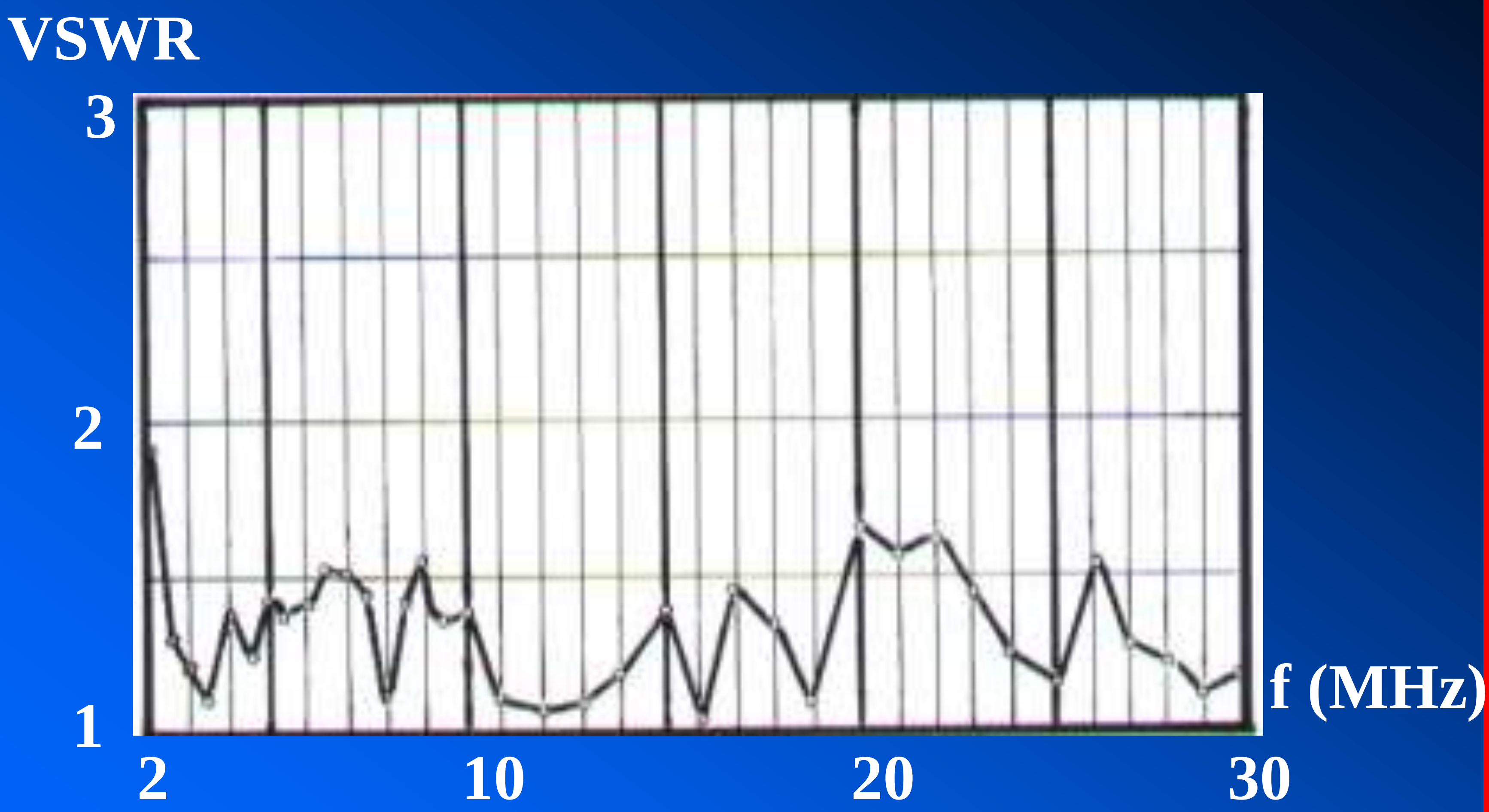
HF BROADCAST ANTENNAS



HF High Power Log-Periodic Antenna
2-30 MHz – Take off angle

HF BROADCAST ANTENNAS



HF High Power Log-Periodic Antenna
2-30 MHz – Standing wave ratio

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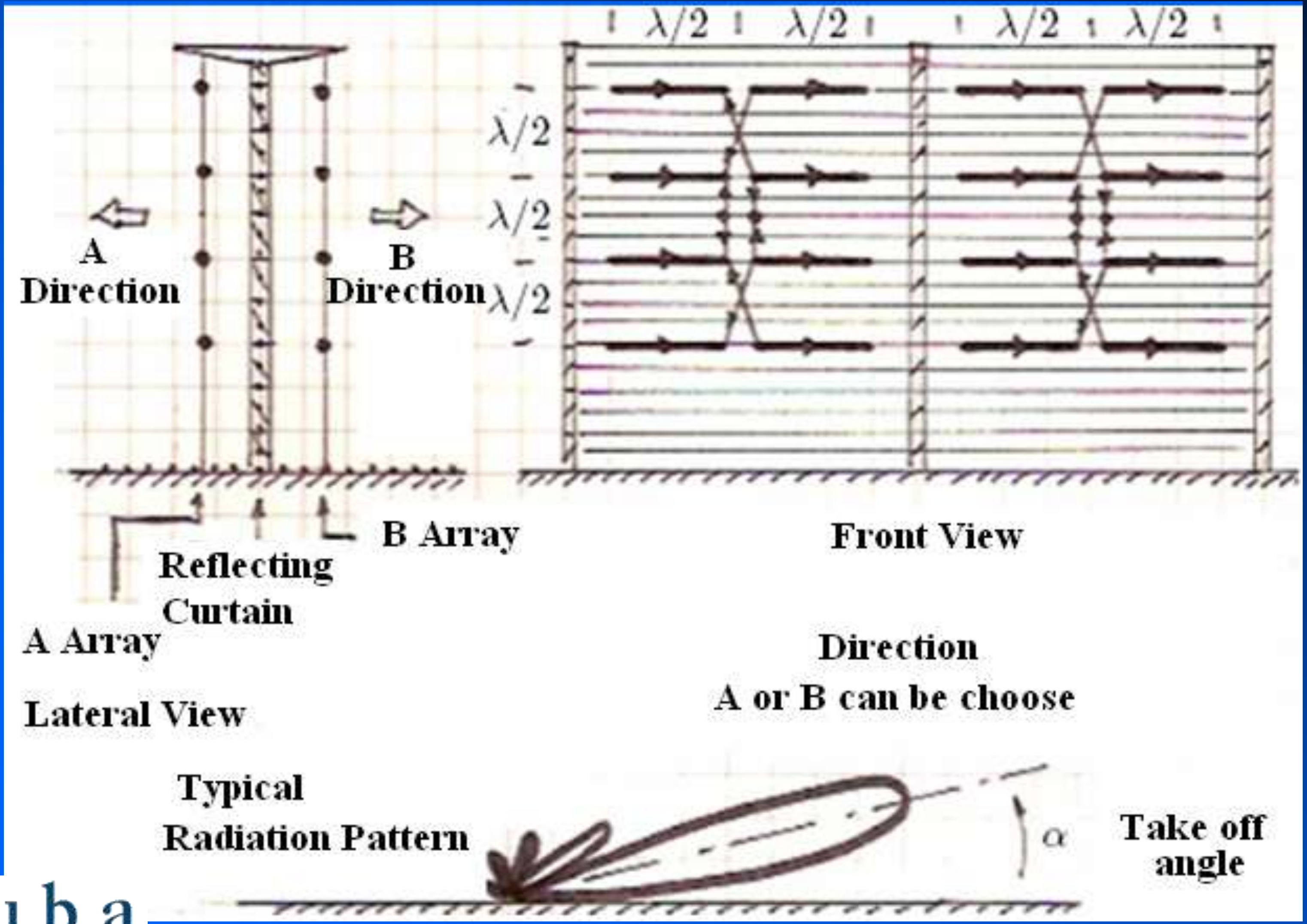
HF BROADCAST ANTENNAS

HF Directional Antenna



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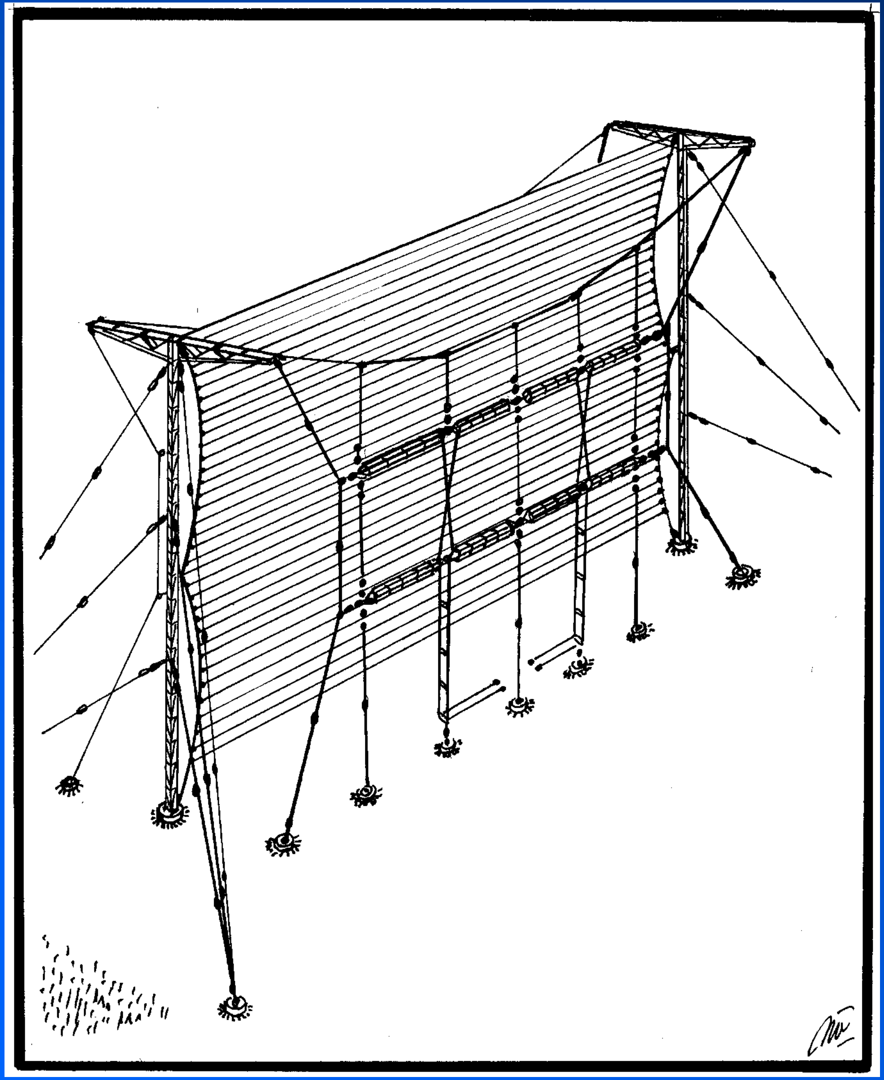
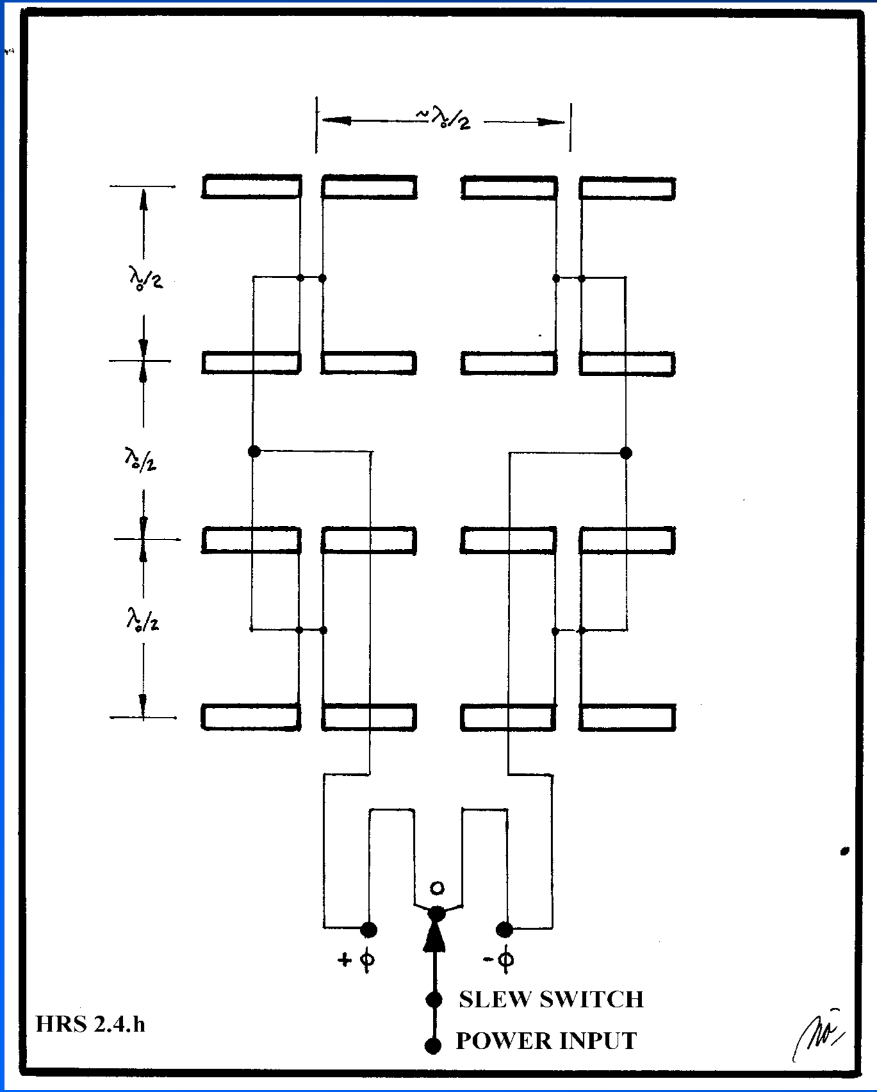
HF BROADCAST ANTENNAS



HF Dipole Curtain Array

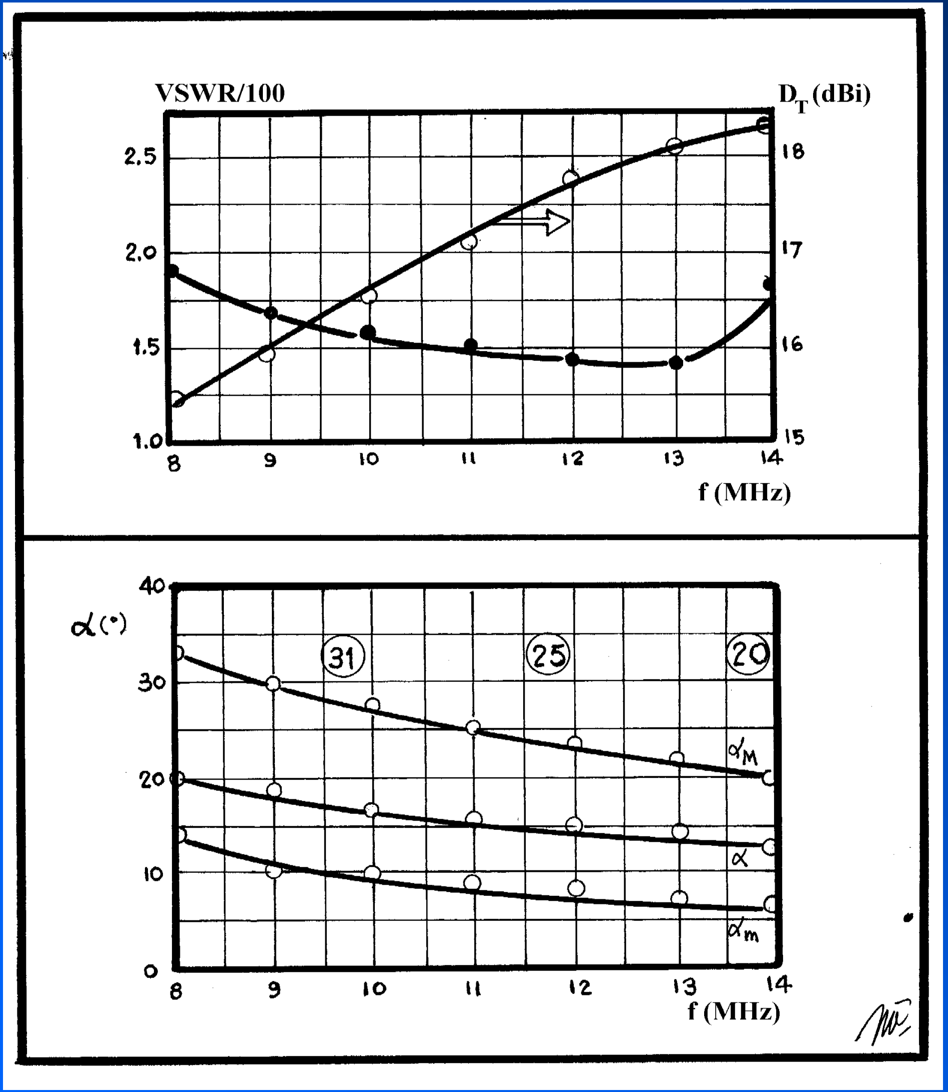
HF BROADCAST ANTENNAS



HF Dipole Curtain Array

HRS 2.4.h

HF BROADCAST ANTENNAS

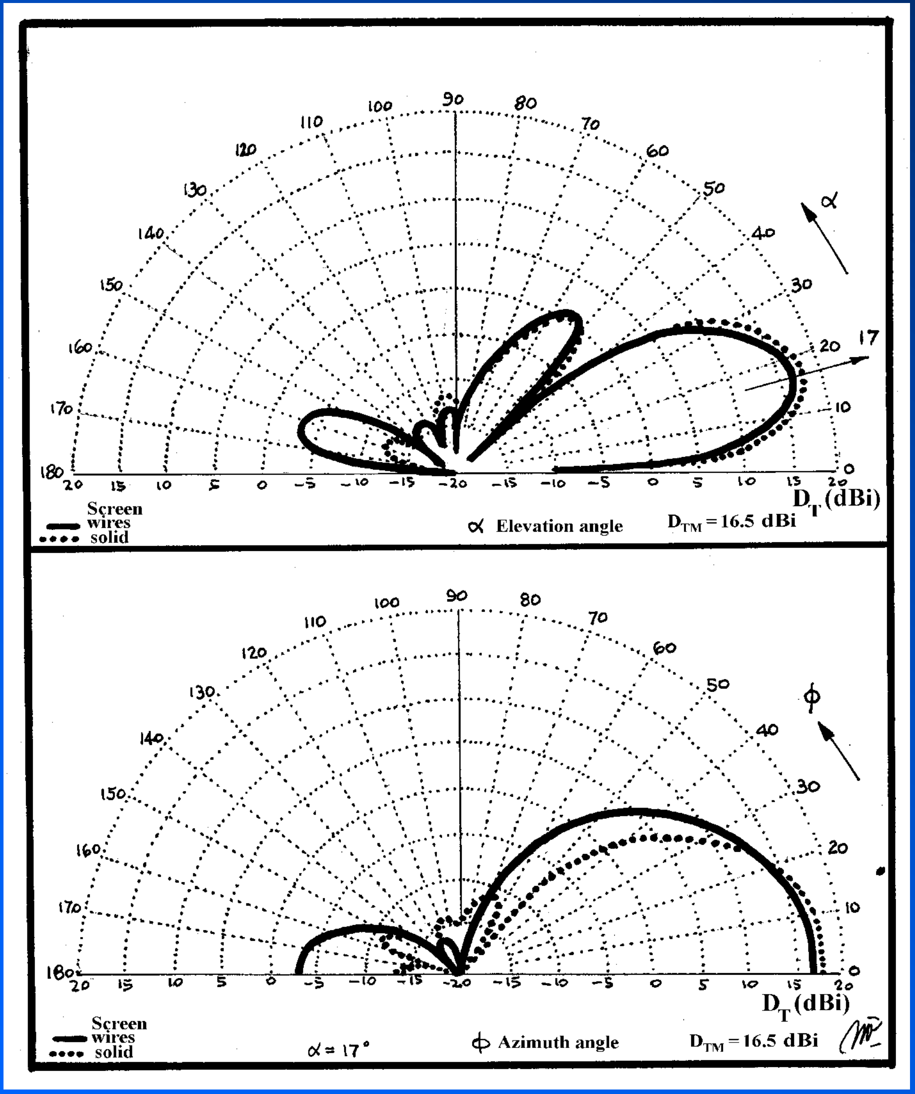


HF Dipole Curtain Array

HRRS 2.2.0,5

f_0 = 10 MHz

HF BROADCAST ANTENNAS



HF Dipole
Curtain Array
31 m

HRRS 2.2.0,5
f_0 = 10 MHz

Reflecting screen
60 x 45 m

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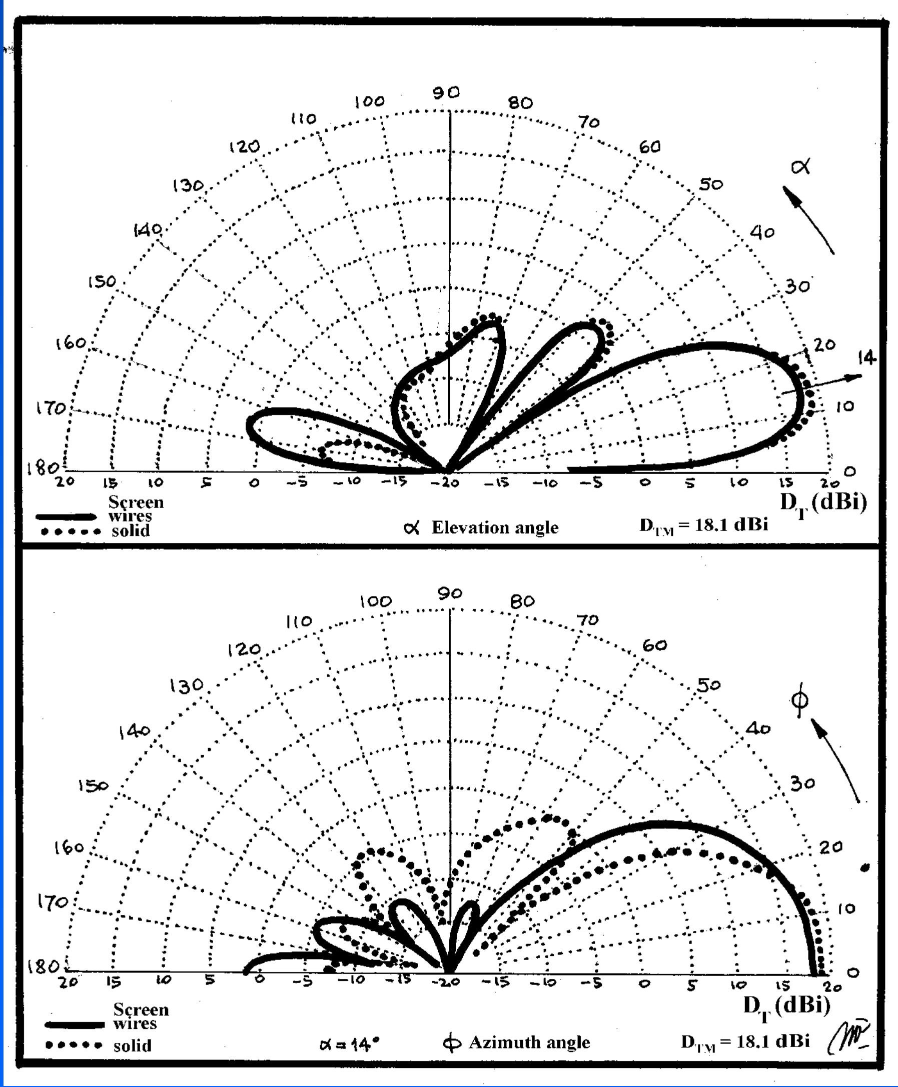
HF BROADCAST ANTENNAS



HF Dipole Curtain Array 25 m

HRRS 2.2.0,5

f_0 = 10 MHz

Reflecting screen 60 x 45 m

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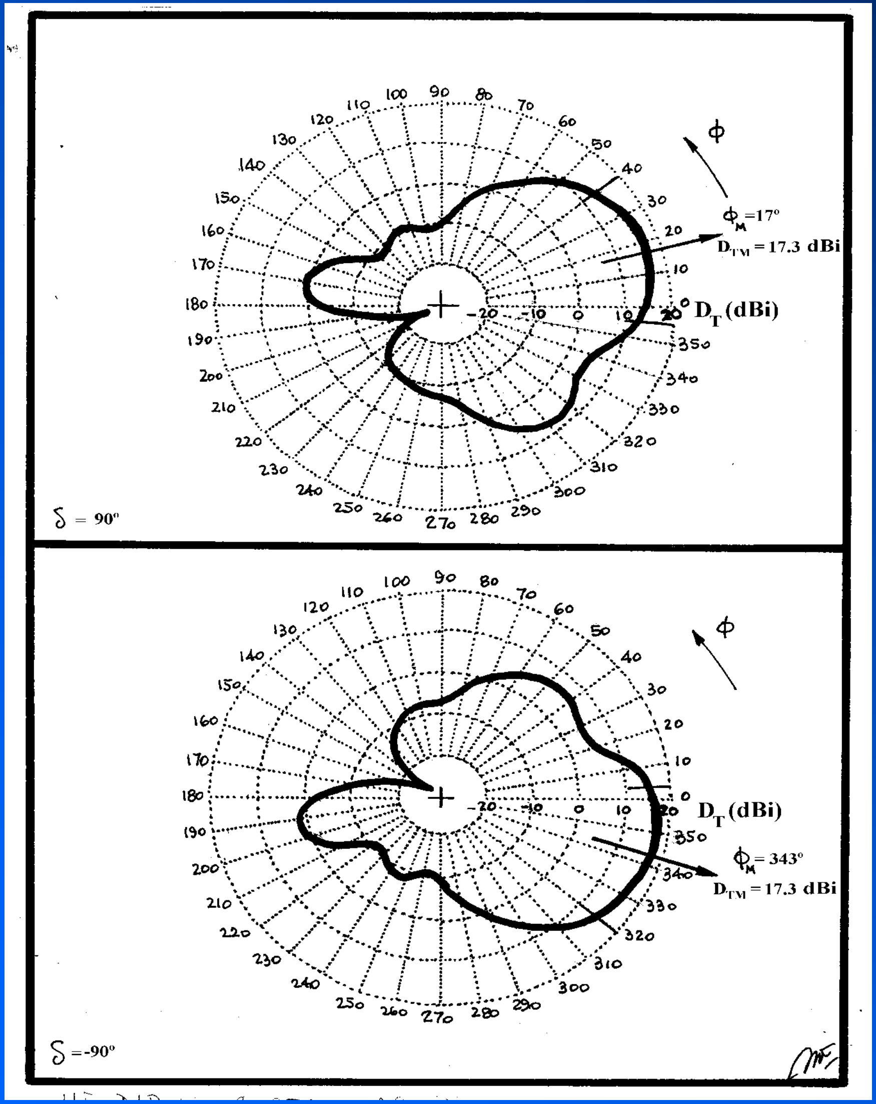
HF BROADCAST ANTENNAS



HF Dipole Curtain Array 25 m

HRRS 2.2.0,5

$f_0 = 10$ MHz

Reflecting screen 60 x 45 m

SLEW EFFECT

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HF BROADCAST ANTENNAS

Portugal
Deutsche
Welle
Rotatable
Shortwave
Antenna
(THALES)

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HF BROADCAST ANTENNAS

Portugal
Deutsche
Welle
Rotatable
Shortwave
Antenna
(THALES)

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HF BROADCAST ANTENNAS

Libya

Rotatable Shortwave Antenna (THALES)

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HF BROADCAST ANTENNAS

Libya

Rotatable Shortwave Antenna (THALES)

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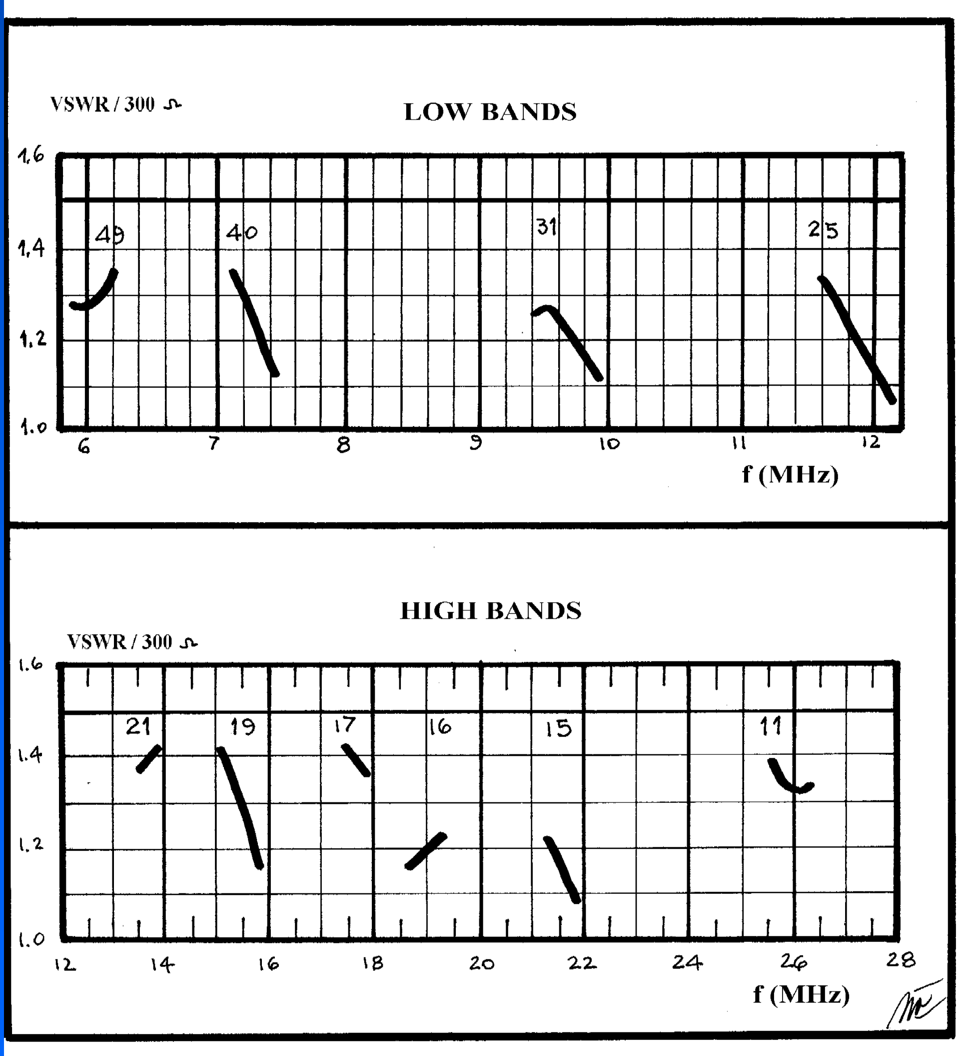
HF BROADCAST ANTENNAS



Rotatable Shortwave Antenna (THALES)

VSWR as a function of frequency

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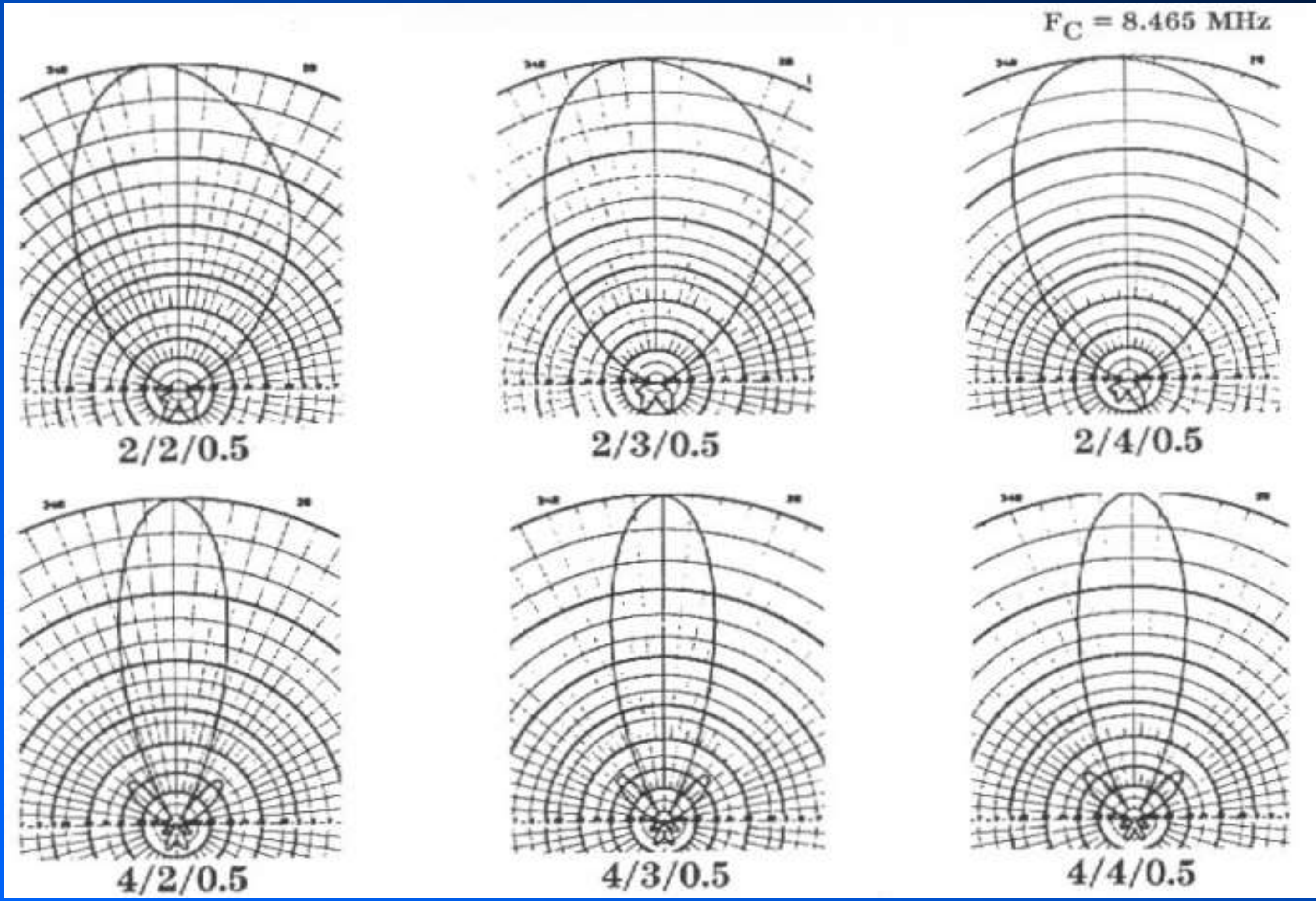
HF BROADCAST ANTENNAS



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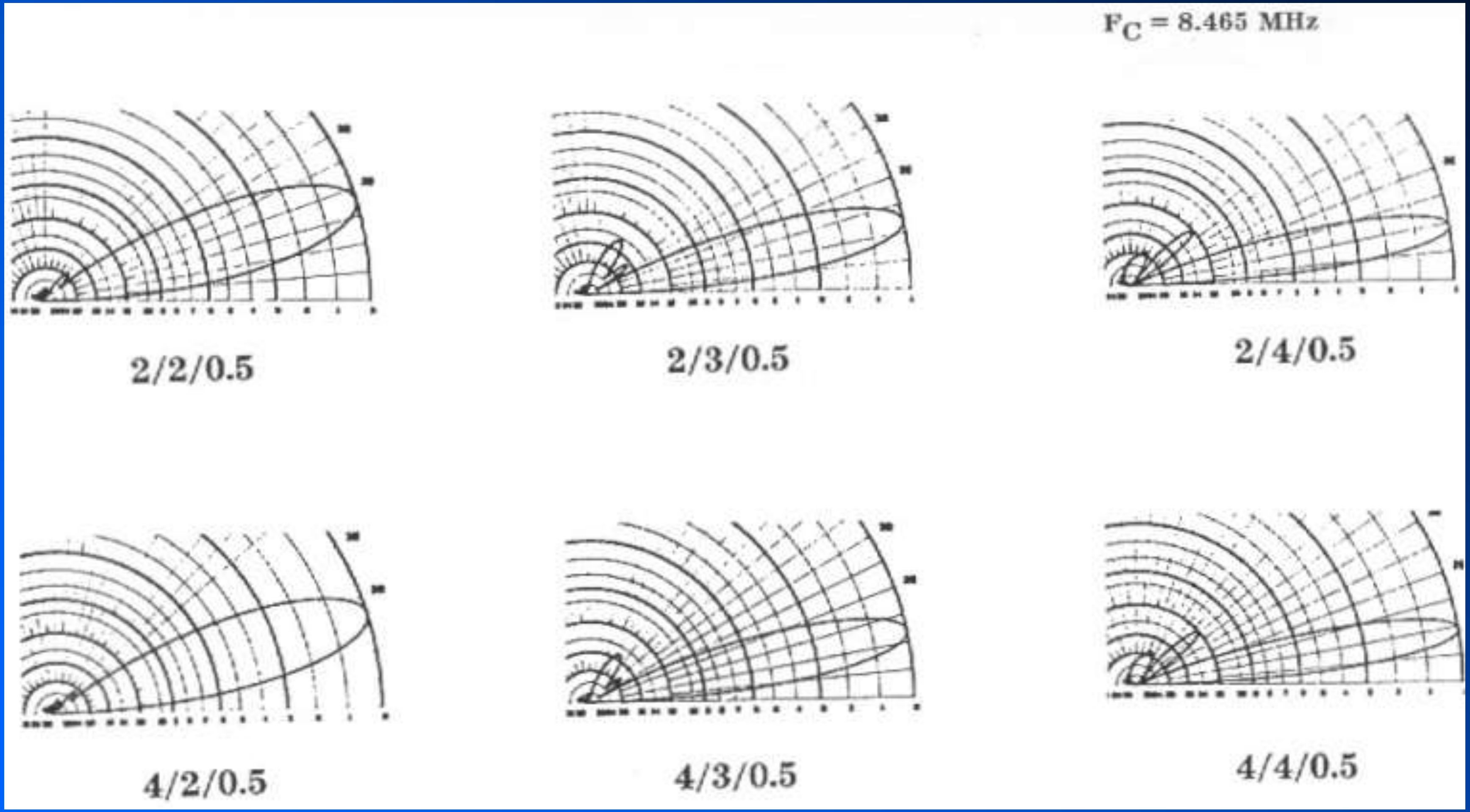
Horizontal radiation pattern
Rotatable Shortwave Antenna - Thales

HF BROADCAST ANTENNAS



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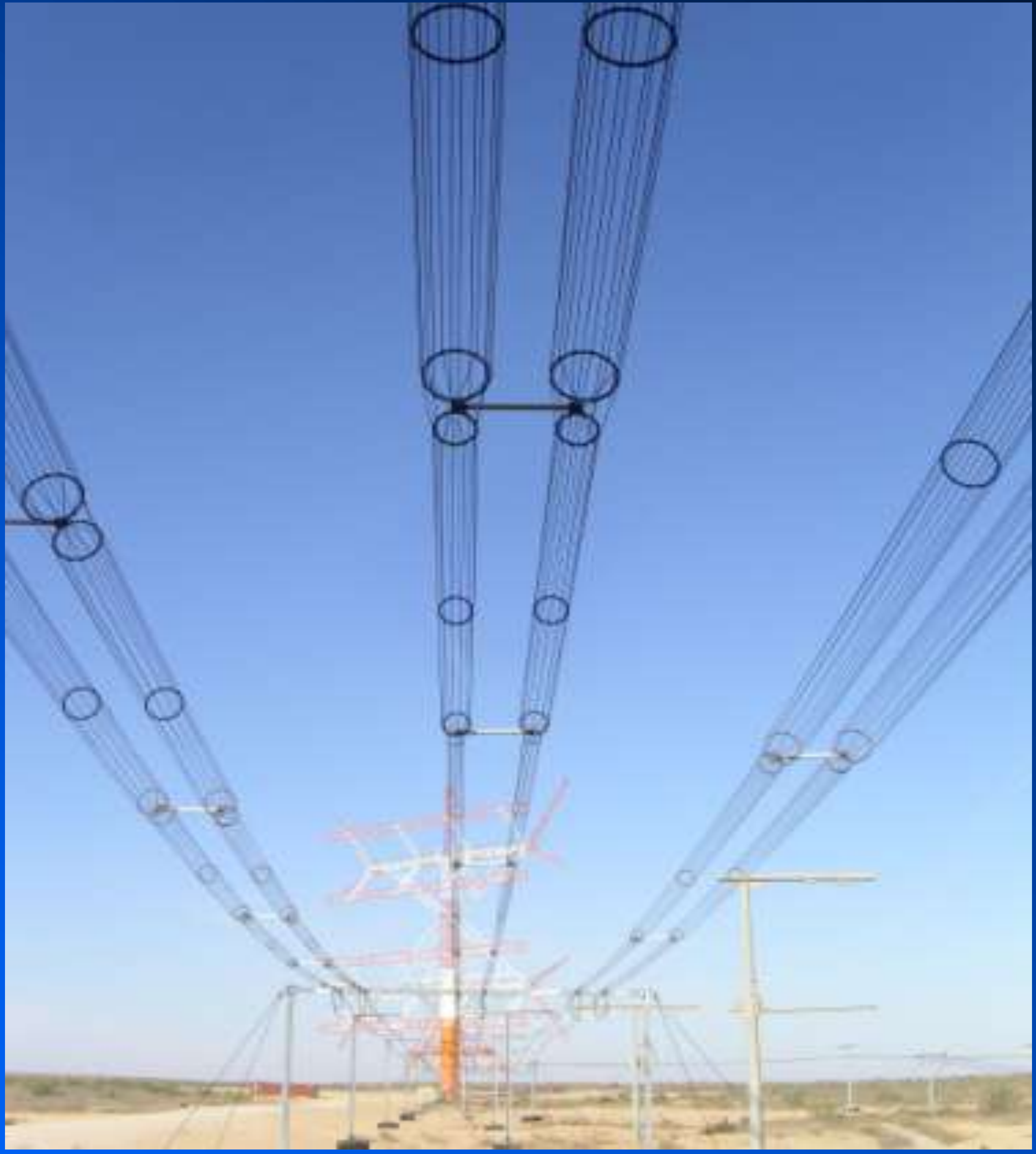
Vertical radiation pattern
Rotatable Shortwave Antenna - Thales

HF BROADCAST ANTENNAS



Libya

300 Ohm
Balanced SW
Feed Lines
500kW

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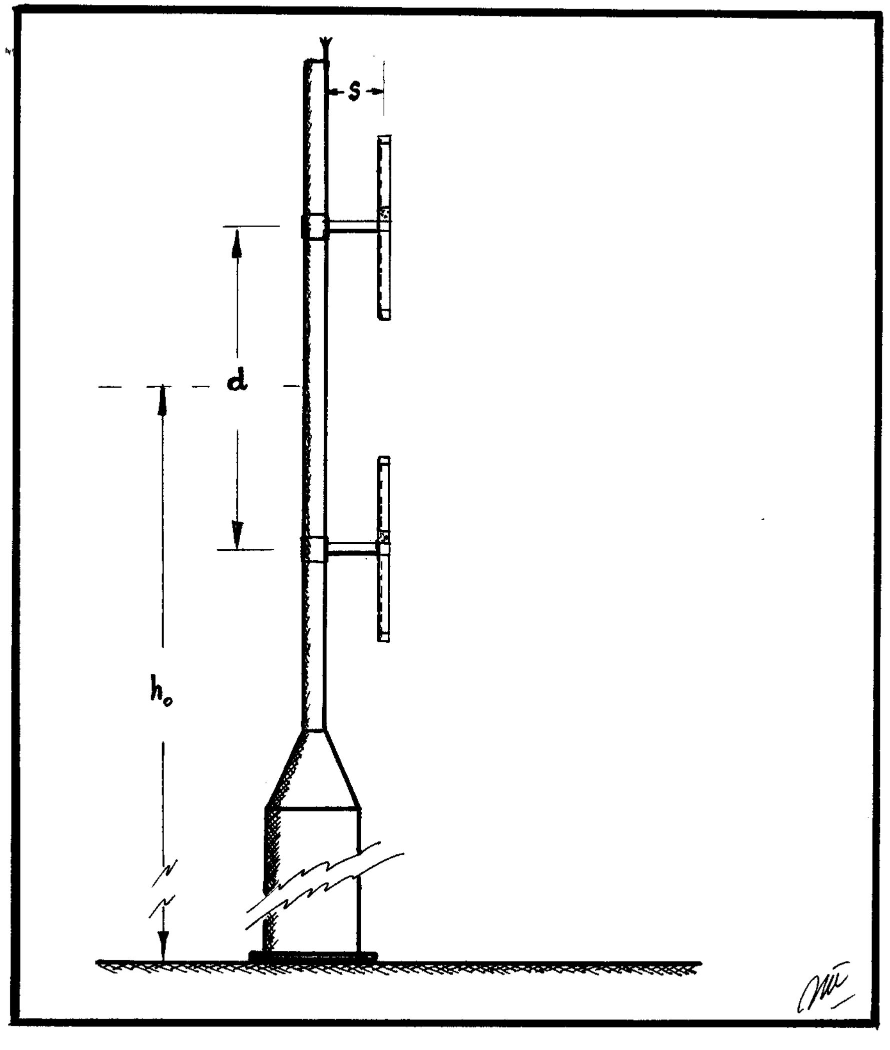
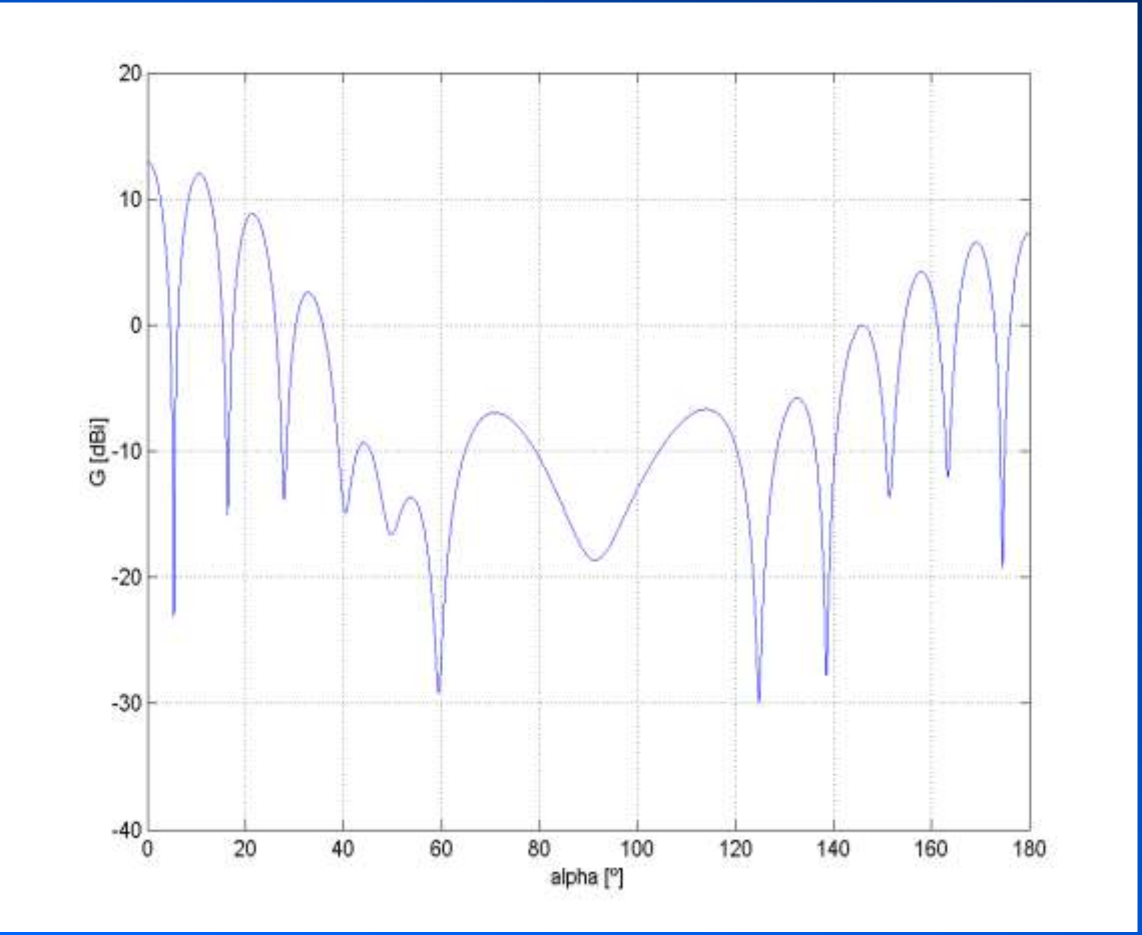
HF BROADCAST ANTENNAS



HF VERTICAL DIPOLE ARRAY

f = 26 MHz
(11 m BAND)

HF BROADCAST ANTENNAS



HF VERTICAL DIPOLE ARRAY

H_0 = 30 m

n = 2

GAIN

f = 26 MHz

(11 m BAND)

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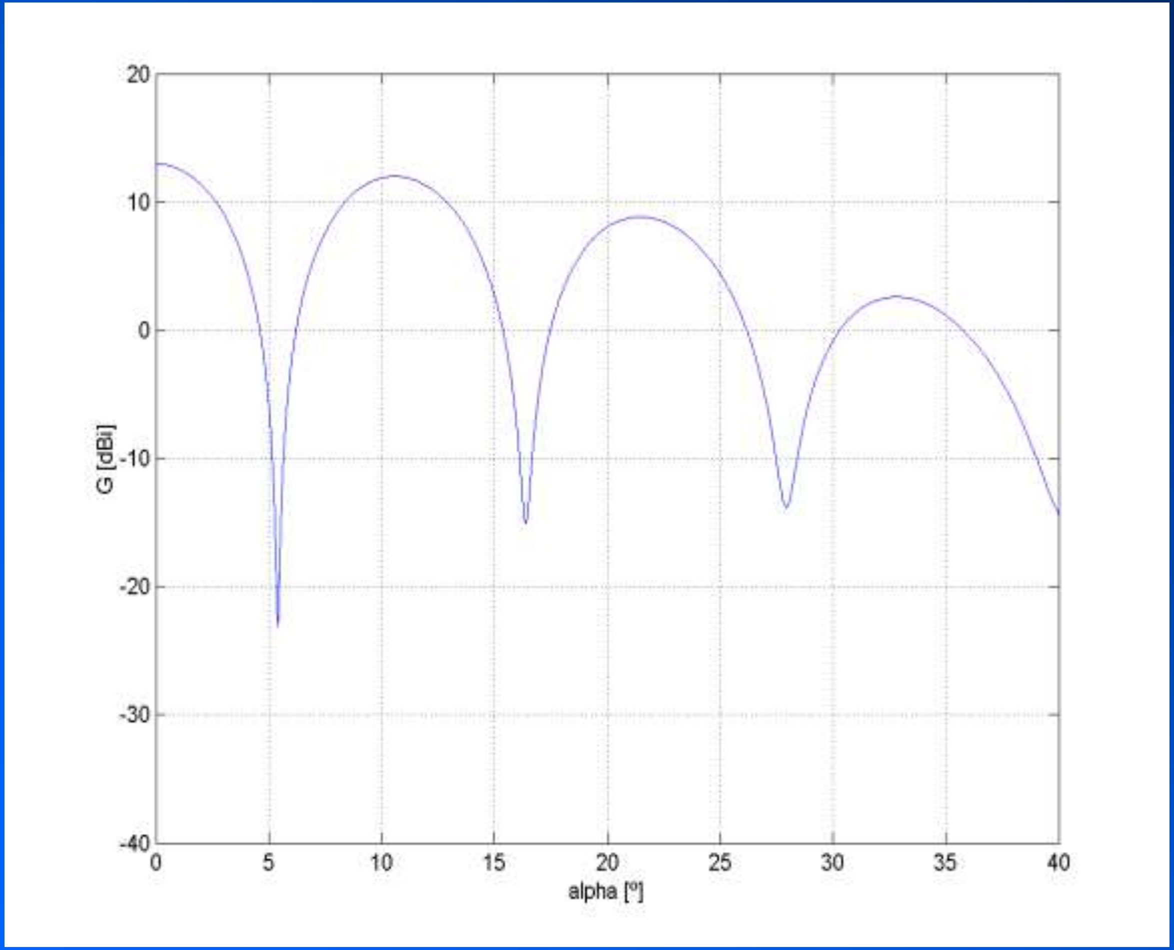
HF BROADCAST ANTENNAS



HF VERTICAL DIPOLE ARRAY

H_0 = 30 m

n = 2

GAIN

f = 26 MHz

(11 m BAND)

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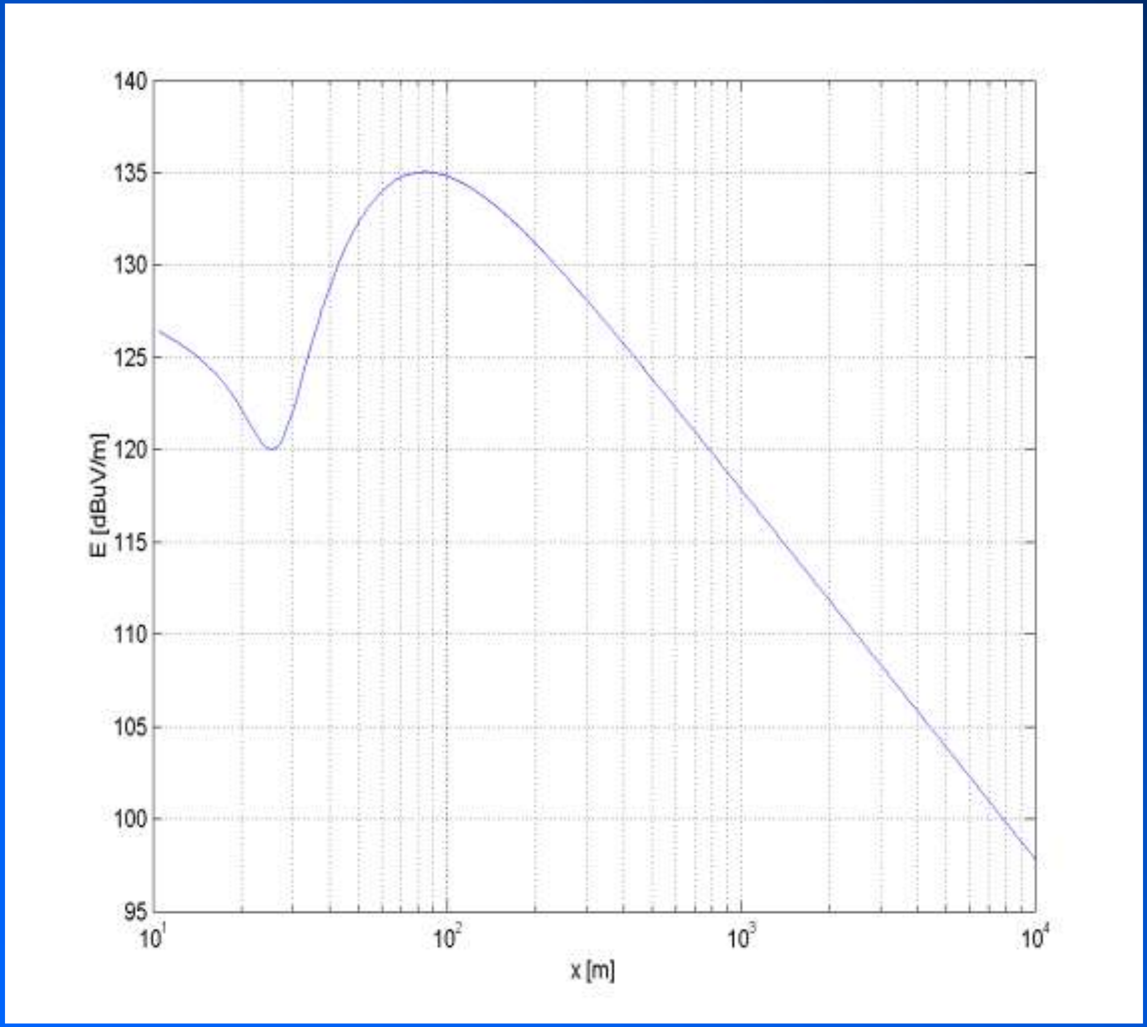
HF BROADCAST ANTENNAS



HF VERTICAL DIPOLE ARRAY

H_0 = 30 m

n = 2

W_T = 1kW

NEAR FIELD

z = 1.5 m

f = 26 MHz

(11 m BAND)

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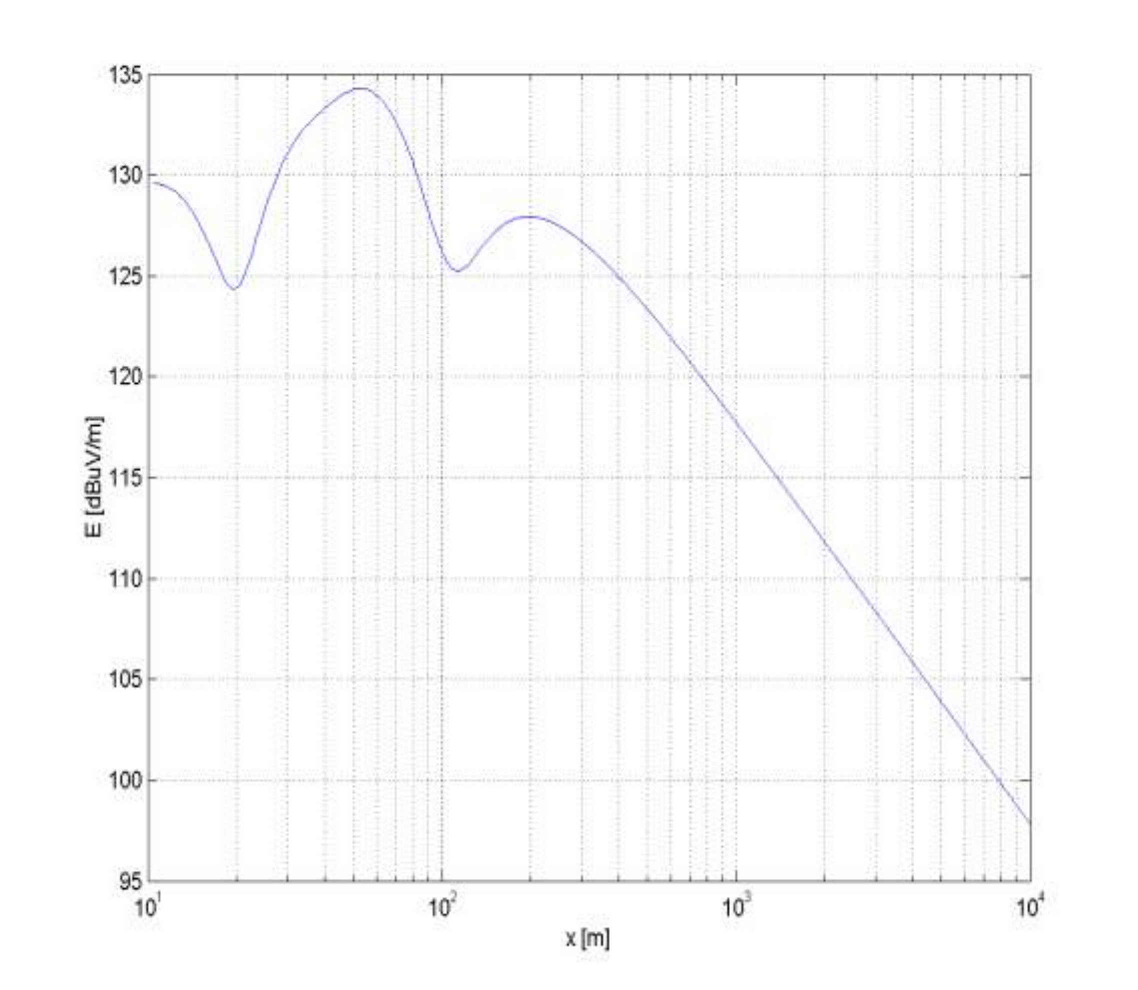
HF BROADCAST ANTENNAS



HF VERTICAL DIPOLE ARRAY

H_0 = 30 m

n = 2

W_T = 1kW

NEAR FIELD

z = 10 m

f = 26 MHz

(11 m BAND)

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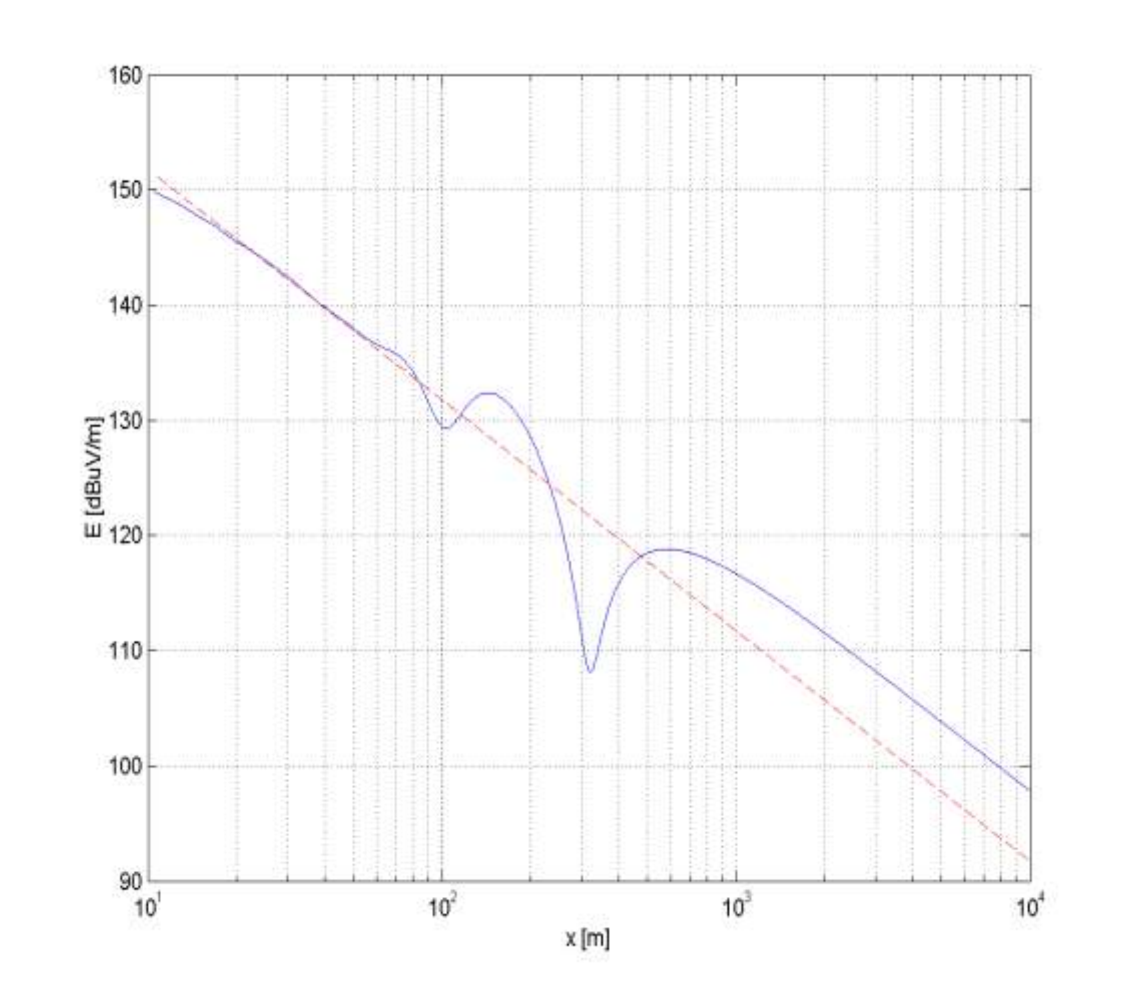
HF BROADCAST ANTENNAS



HF VERTICAL DIPOLE ARRAY

H_0 = 30 m

n = 2

W_T = 1kW

NEAR FIELD

z = 30 m

f = 26 MHz

(11 m BAND)

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VHF BROADCAST ANTENNAS

REQUIREMENTS

- DIRECTIVITY AND GAIN
- RADIATION PATTERN
- POLARIZATION
- POWER HANDLING
- BANDWIDTH

VHF BROADCAST ANTENNAS

- NEAR FIELD
- FAR FIELD
- RADIATED POWER
- RADIATION LEVEL
- IEEE STANDARD C95-1
- TRANSMISSION LINES

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VHF BROADCAST ANTENNAS

- FM and TV BROADCAST ANTENNAS
- Polarization:

Traditionally Horizontal Polarized (HP)

In the early 60´s Circular (CP) and Elliptical Polarization (EP) was introduced.

HP is Standard in US but CP and EP may be used if HP component is higher.

VHF BROADCAST ANTENNAS

- **Propagation:**

Almost no difference between day and night in the service area due to the spectrum employed (50-800 MHz).

This is valid for free Space Attenuation (A_{FS}) and other factors as Refraction, Reflection, Depolarization, Diffraction, Absorption, Scattering, Fresnel Zone Clearance, Grazing and Brewster Angle.

VHF BROADCAST ANTENNAS

- Propagation:
- Free Space Propagation Loss
- $A_{FS} = (4 \pi r / \lambda)^2$
- $A_{FS}(dB) = 21.98 + 20 \log r(m) - 20 \log \lambda(m)$
- $A_{FS}(dB) = 32.44 + 20 \log r(km) + 20 \log f\ (MHz)$
- FCC Chart of Coverage is FCC 50/50 curves
- Receiving Antenna at 9 m over ground.
- Raising the Receiving Antenna from 1.5 m to 9 m signal increase is around 10 dB.

VHF BROADCAST ANTENNAS

- Propagation:
- ERP Effective Radiated Power is referred to a Theoretical Half Wave Dipole [D_T = 1.64 (2.15 dBi)]
- EIRP Effective Isotropically Radiated Power is referred to an Isotropic Source
- [D_T = 1 (0 dBi)]

VHF BROADCAST ANTENNAS

- FM Required Signal Strength

- Rural Areas E=0.05 mV/m (34 dBμV/m)
- Suburban E=1.00 mV/m (60 dBμV/m)
- Urban E=3.16 mV/m (70 dBμV/m)
- High Pop. E= 25 mV/m (88 dBμV/m)
- Blanketing E=577 mV/m (115 dBμV/m)
- These levels must be achieved at 9 m AG

VHF BROADCAST ANTENNAS

- FM Antenna Element:
- Cylindrical Dipole (HP)
- Turnstile Cylindrical Dipole (HP)
- Ring (HP)
- “V” Dipole (HP)
- Twist Ring (EP)
- Ring Stub (EP)
- Shunt Fed Slanted Dipole (CP)
- Series Fed Slanted Dipole (CP)

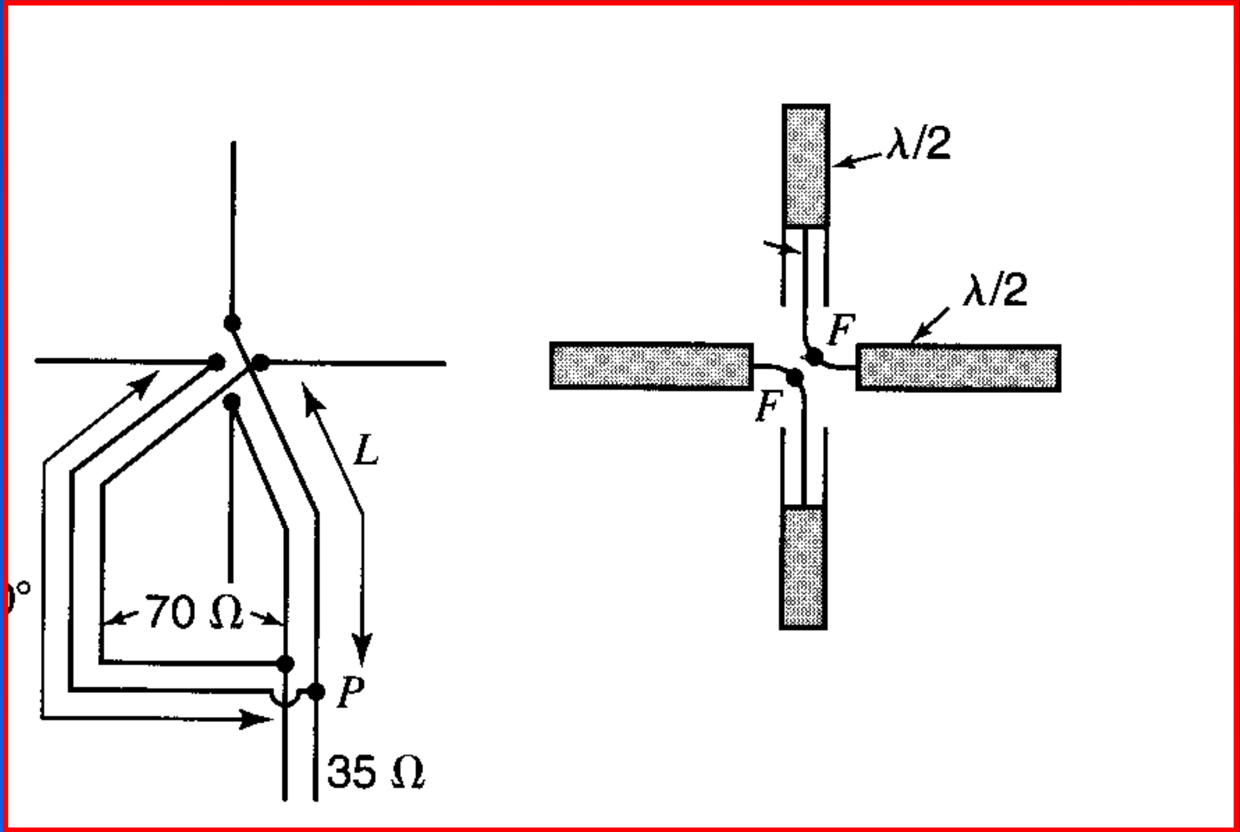
VHF BROADCAST ANTENNAS

- FM Antenna Element:

- Flat Panel Cylindrical Dipole (HP or VP)
- Flat Panel Crossed Dipole (CP)
- Flat Panel Wide Band Dipole (HP or VP)
- Cavity Backed Crossed Dipole (CP)

VHF BROADCAST ANTENNAS

TURNSTILE ANTENNA (Dr. G. H. BROWN 1936)



Cylindrical Dipole Antenna
Horizontal Plane Omnidirectional

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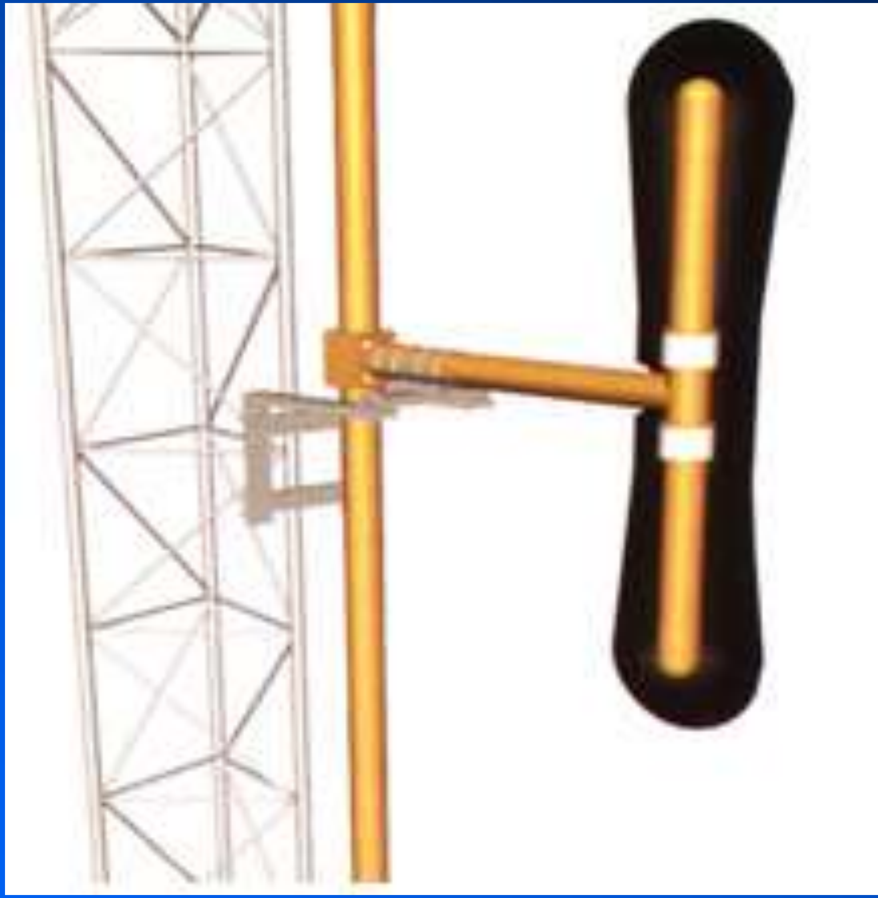
VHF BROADCAST ANTENNAS



Cylindrical Dipole Antenna
Horizontal Plane Quasi -Omnidirectional
VERTICAL POLARIZATION

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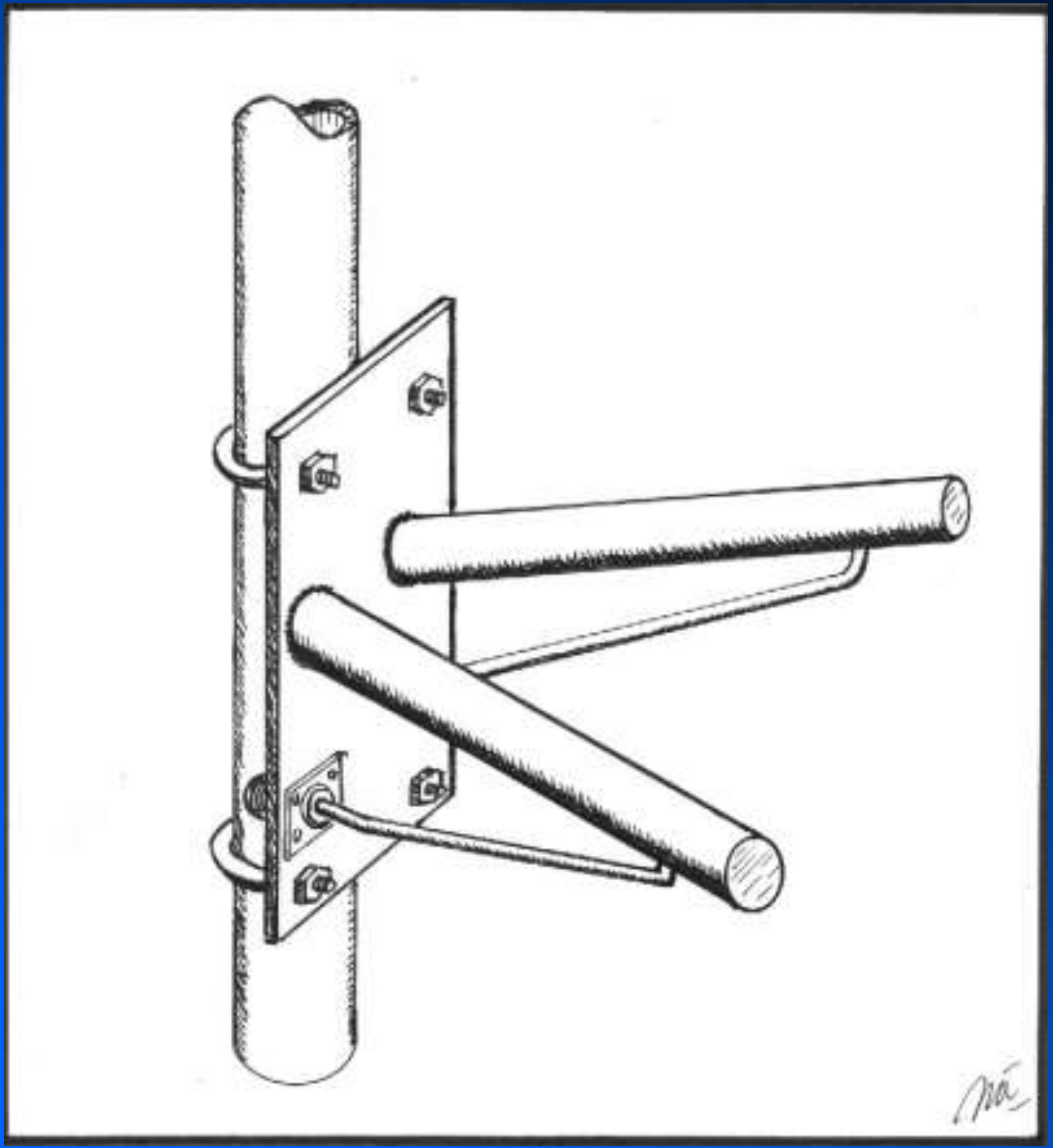
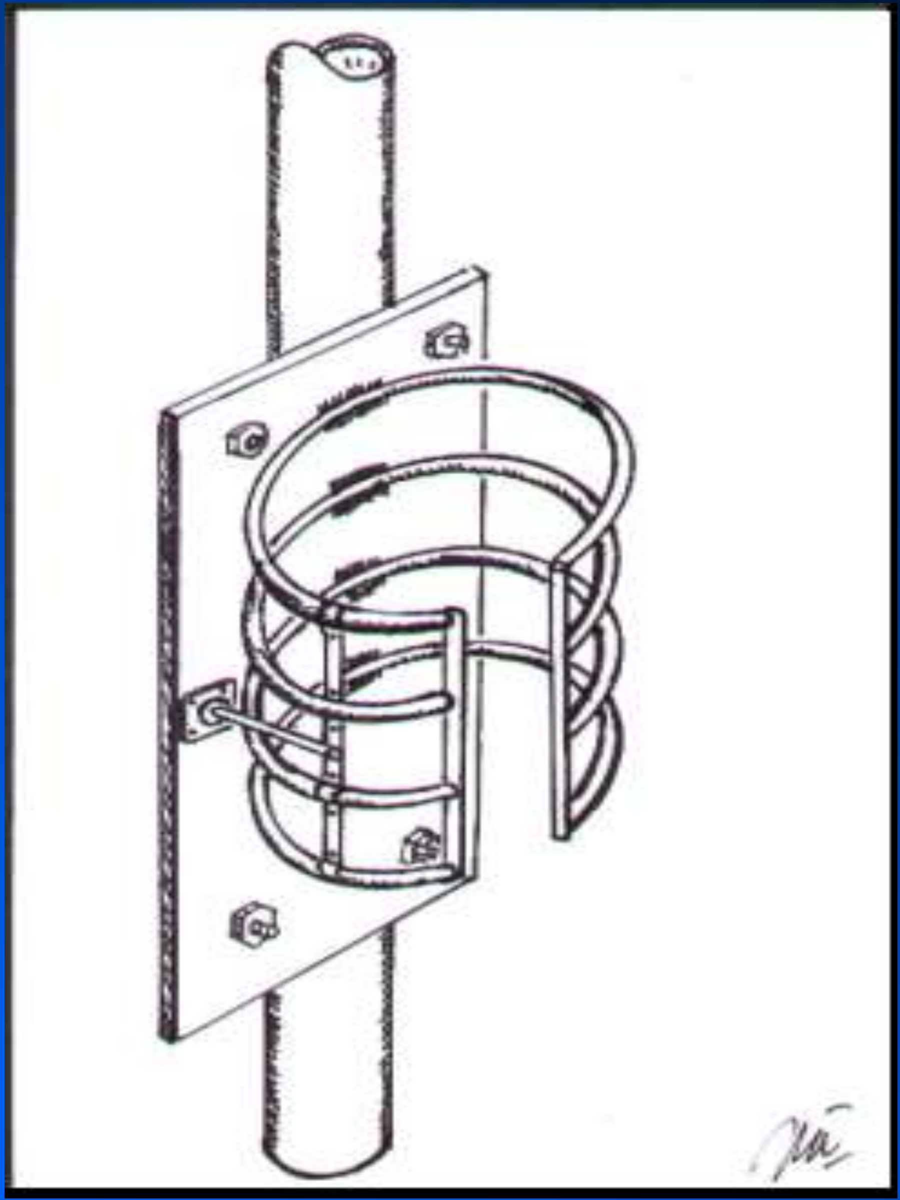
VHF BROADCAST ANTENNAS

"V" Dipole Element



VHF BROADCAST ANTENNAS

Ring
Element



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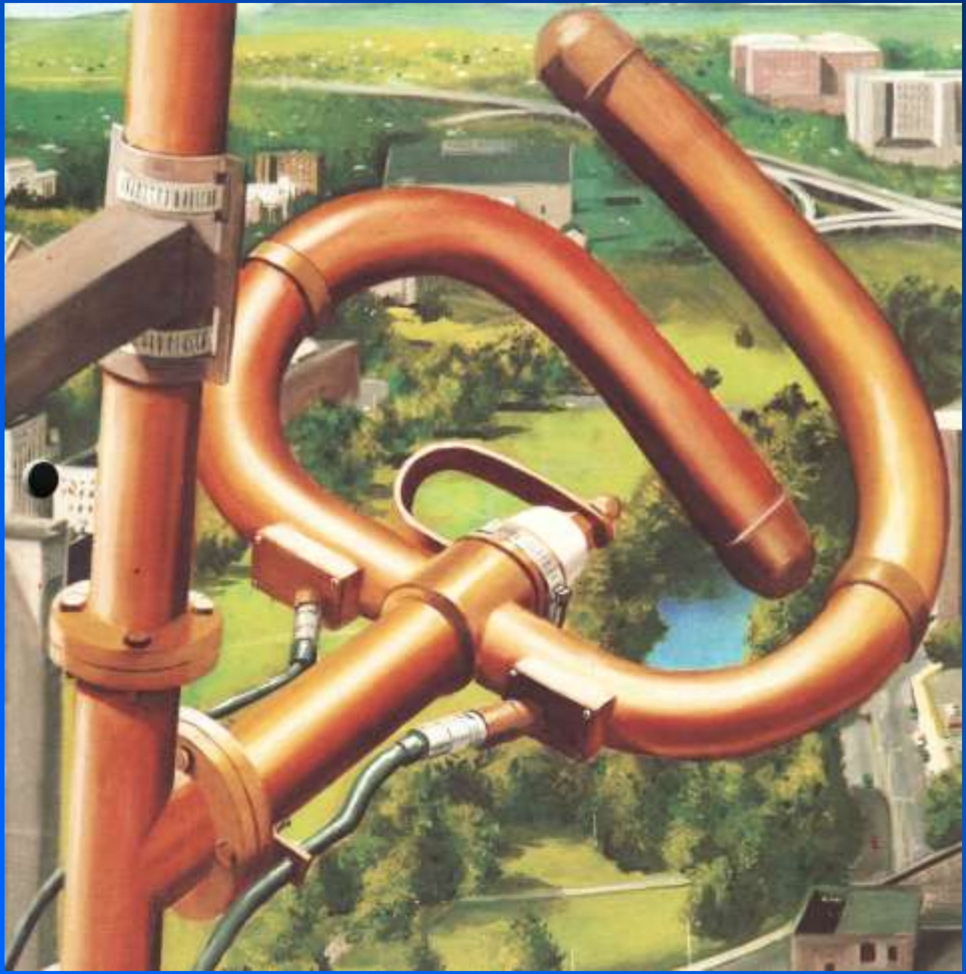
VHF BROADCAST ANTENNAS

Quasi –Omnidirectional Dipolar Element

Linear Horizontal Polarization

VHF BROADCAST ANTENNAS



Twist Ring Element

Horizontal Plane
Quasi -Omnidirectional

Elliptical
Polarization

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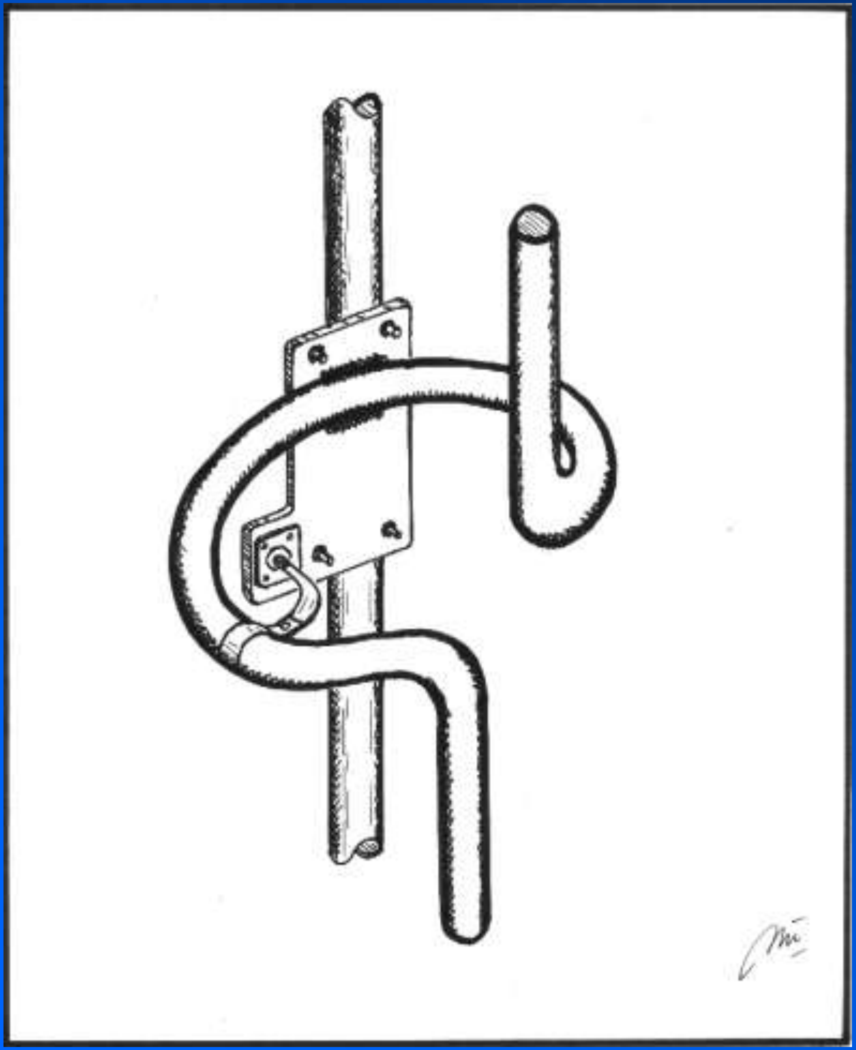
VHF BROADCAST ANTENNAS



Ring Stub Element

Horizontal Plane
Quasi -Omnidirectional

Elliptical
Polarization

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VHF BROADCAST ANTENNAS

Ring Stub Element

Horizontal Plane
Quasi -Omnidirectional

Circular Polarization

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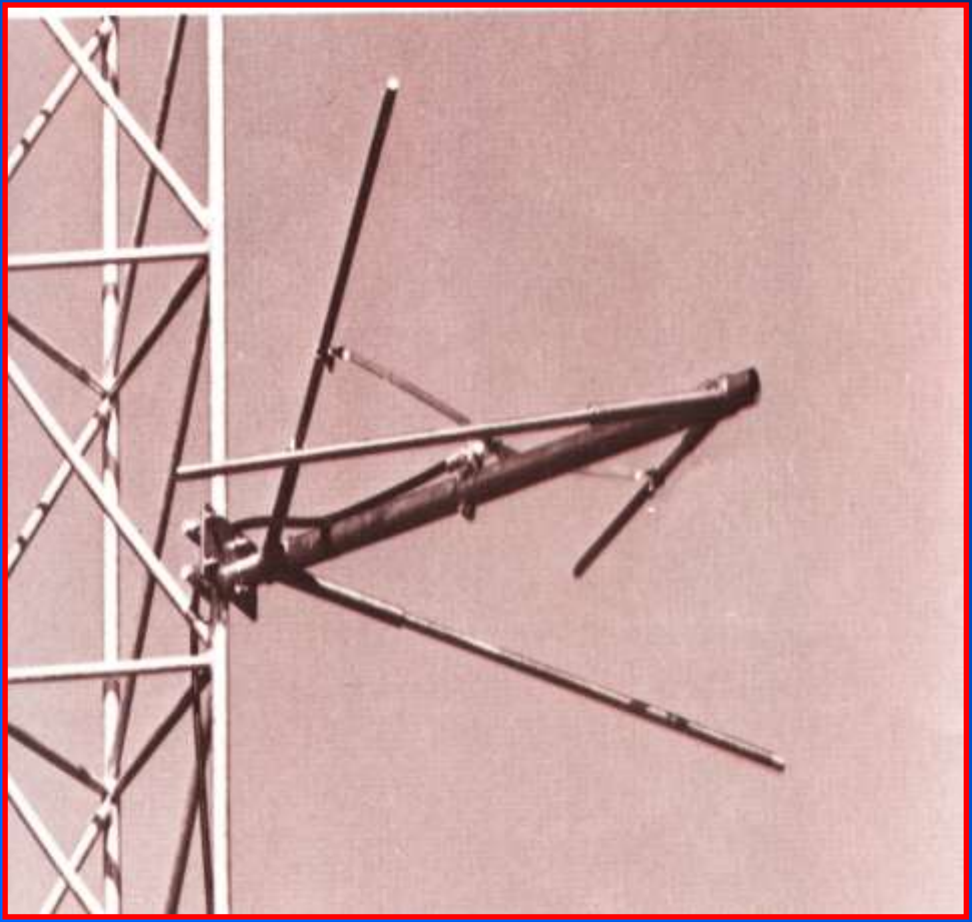
VHF BROADCAST ANTENNAS

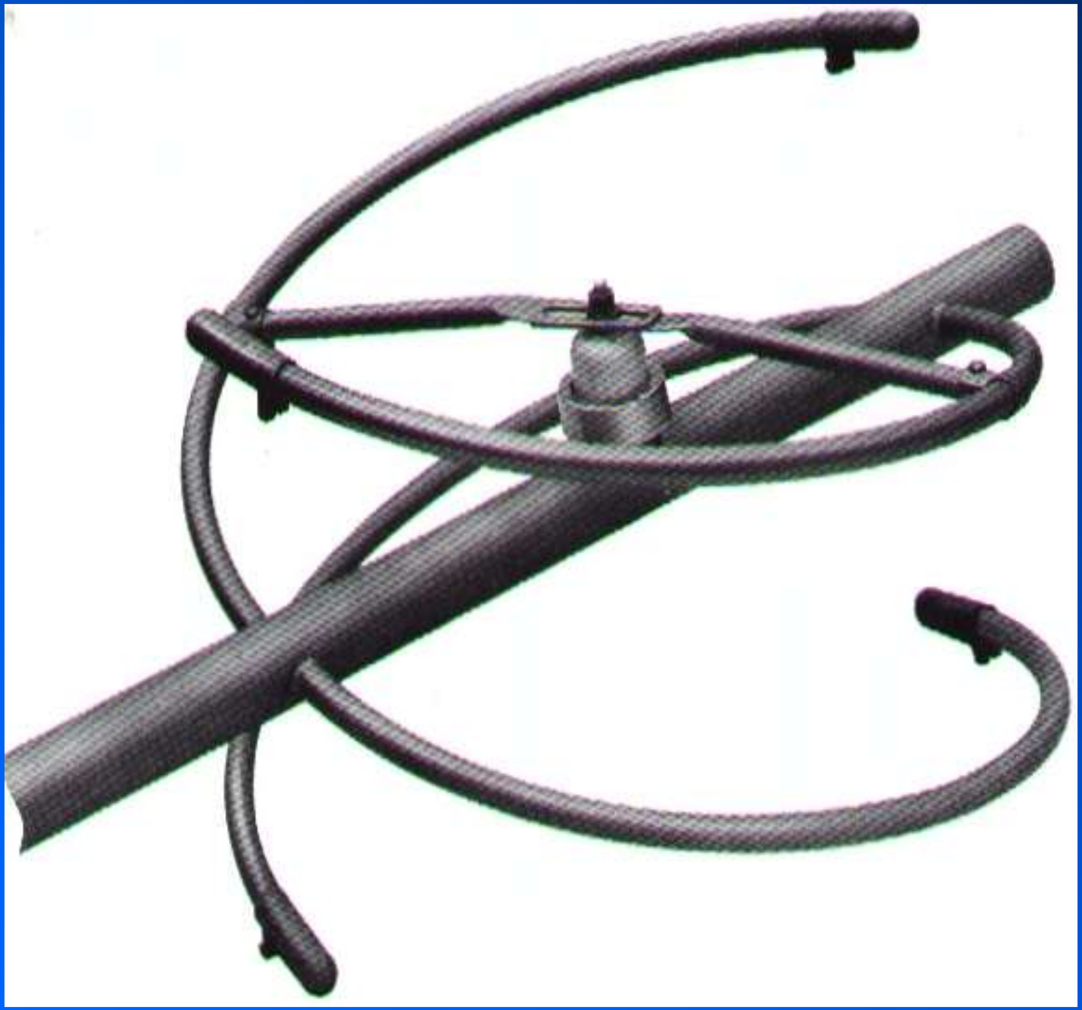


Shunt Fed Slanted Dipole

Two Half Wave Dipole Desplazed 90º In Space (Penetrator)

Circular Polarization

VHF BROADCAST ANTENNAS



Element of Two Dipole Antennas
90º between them in Space

Circular Polarization

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VHF BROADCAST ANTENNAS

Element of Two Dipole Antennas
90º between them in Space

Rotatiller

Circular Polarization

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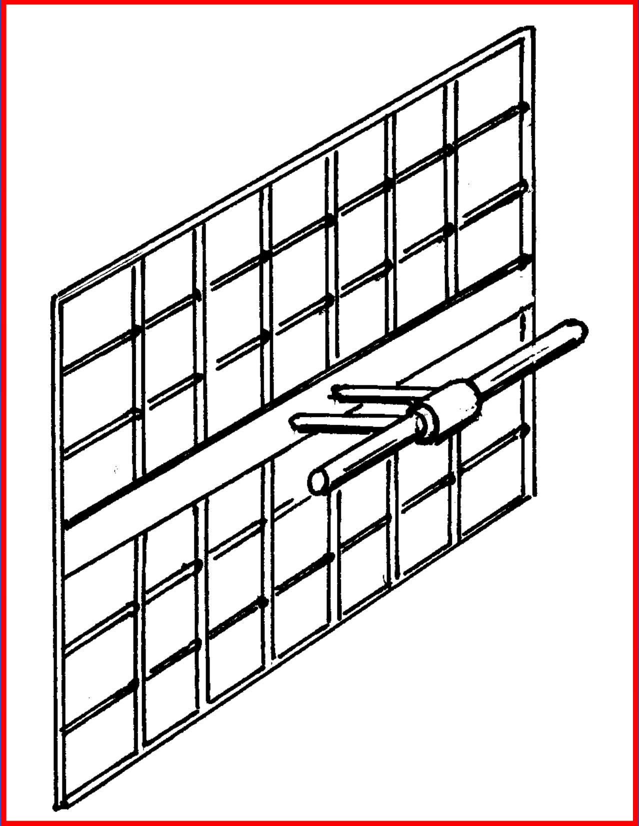
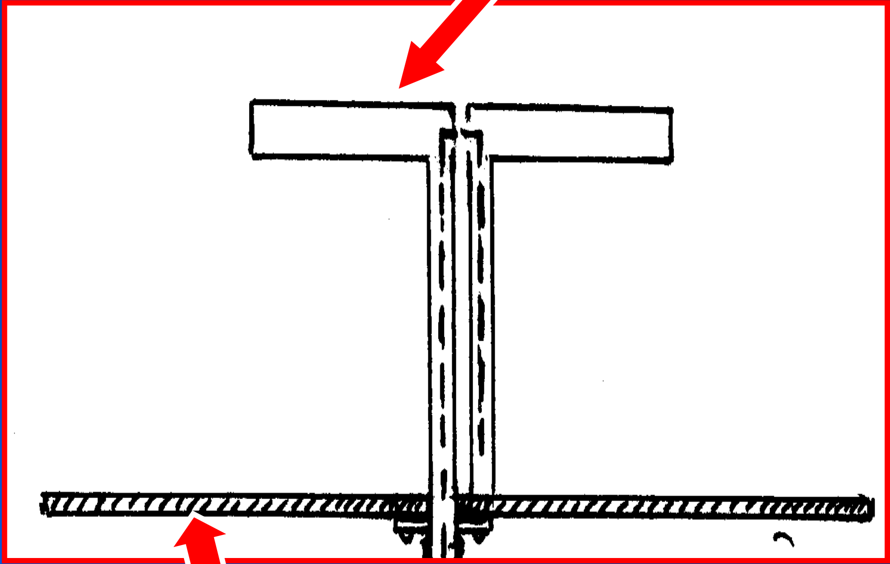
VHF BROADCAST ANTENNAS

Flat Panel Cylindrical Dipole



Dipole Detail

Dipole



Reflector

Directional Linear Polarization

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VHF BROADCAST ANTENNAS

Flat Panel Crossed Dipole

Directional Circular Polarization

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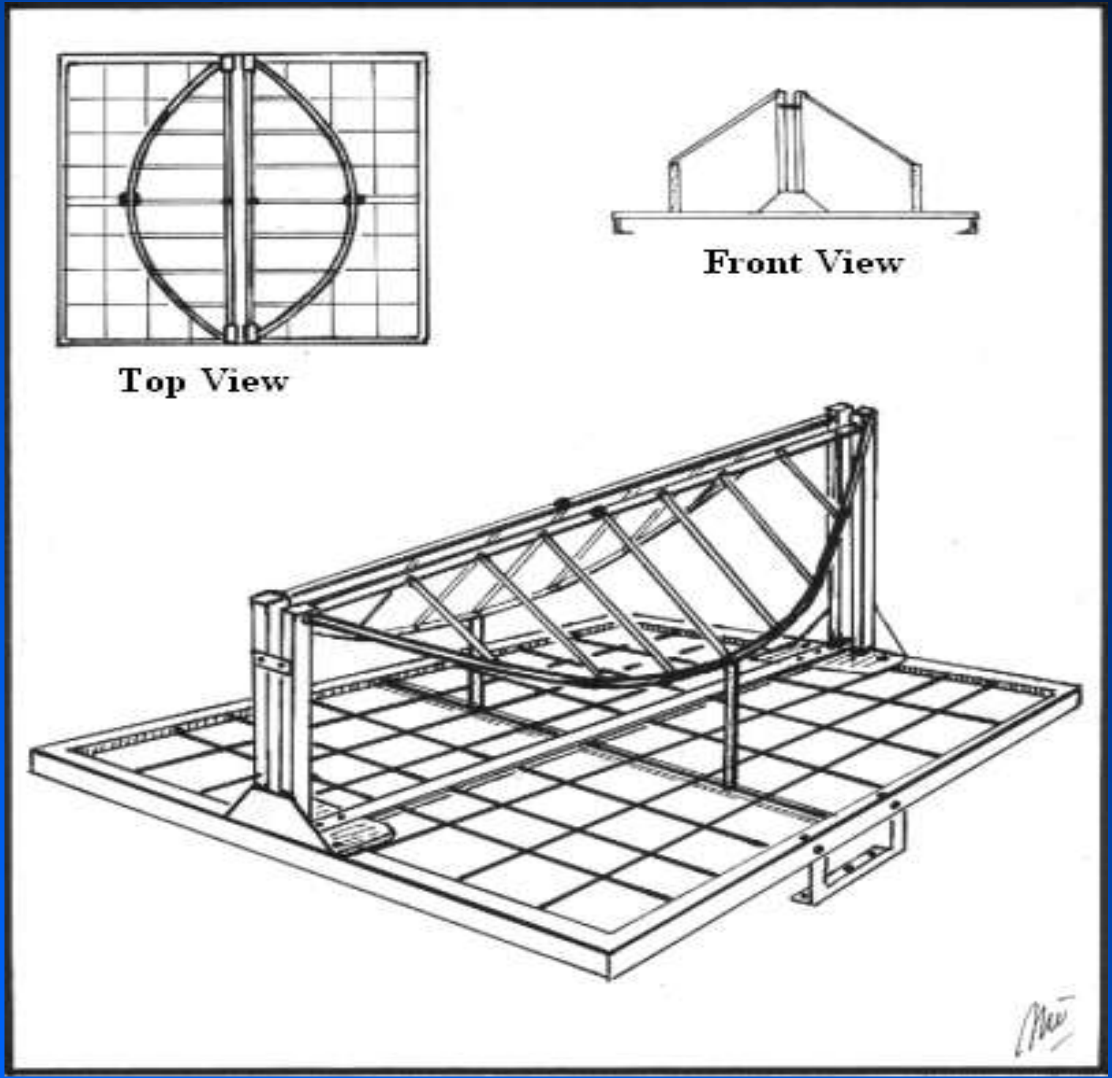
VHF BROADCAST ANTENNAS

Flat Panel Wide Band Dipole



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VHF BROADCAST ANTENNAS
Flat Panel Wide Band Dipole

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VHF BROADCAST ANTENNAS

Flat Panel Wide Band Dipole

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VHF BROADCAST ANTENNAS

Cavity Backed Dual Dipole

Directional Circular Polarization

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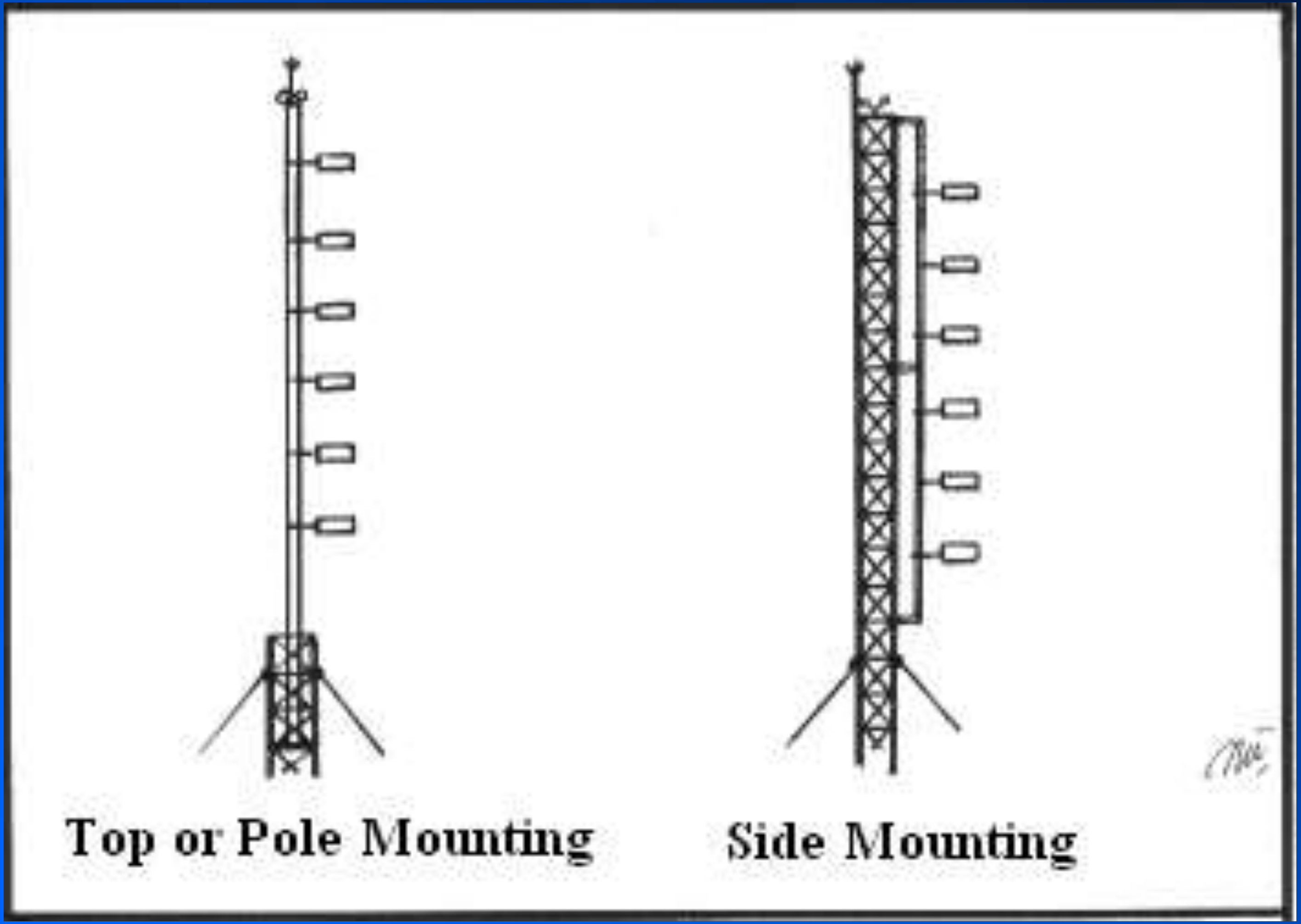
VHF BROADCAST ANTENNAS

FM Antenna Array Installation



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VHF BROADCAST ANTENNAS

FM Antenna Array Installation

Alabama 600 m Height Tower
Supporting Tower Guys

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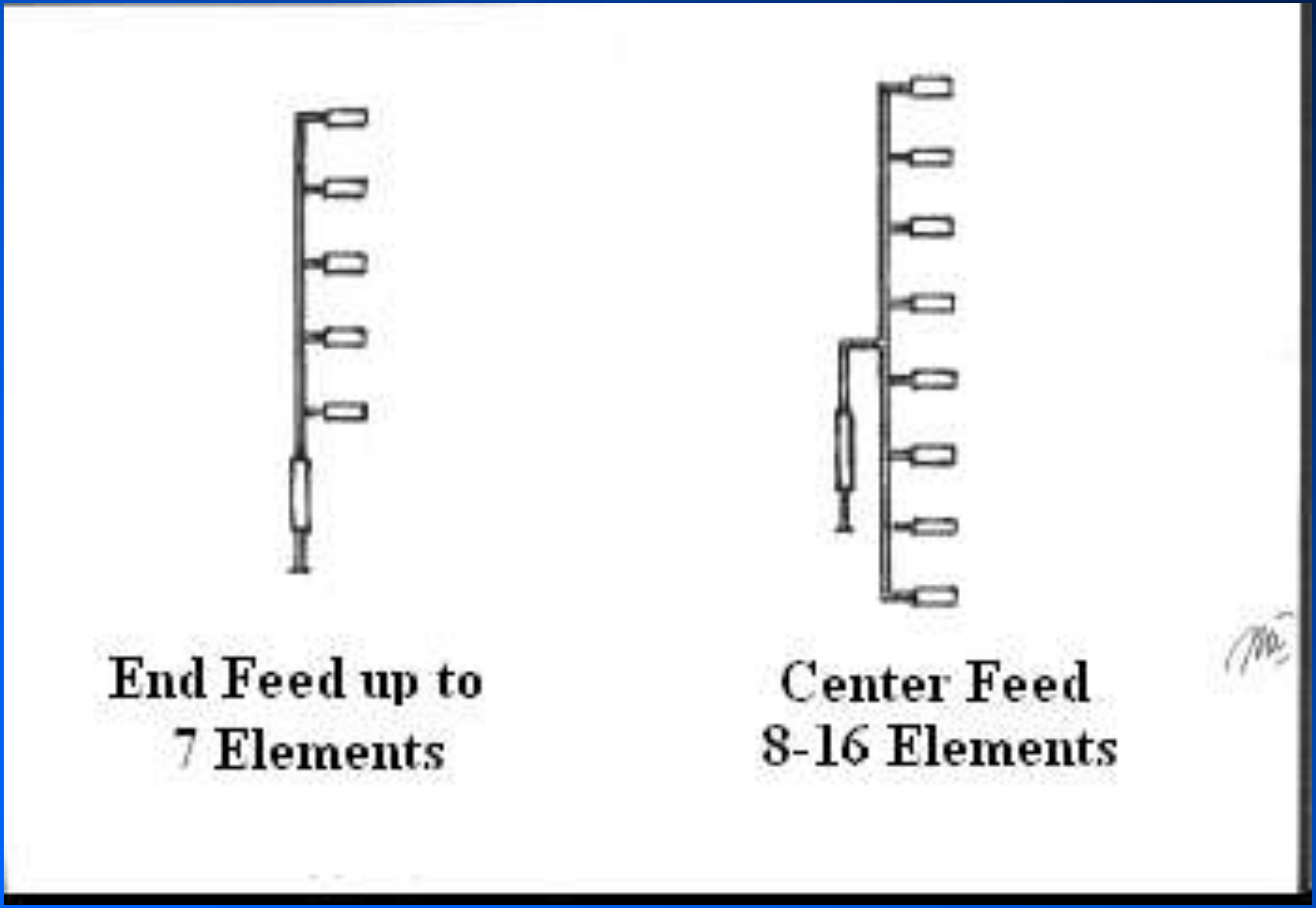
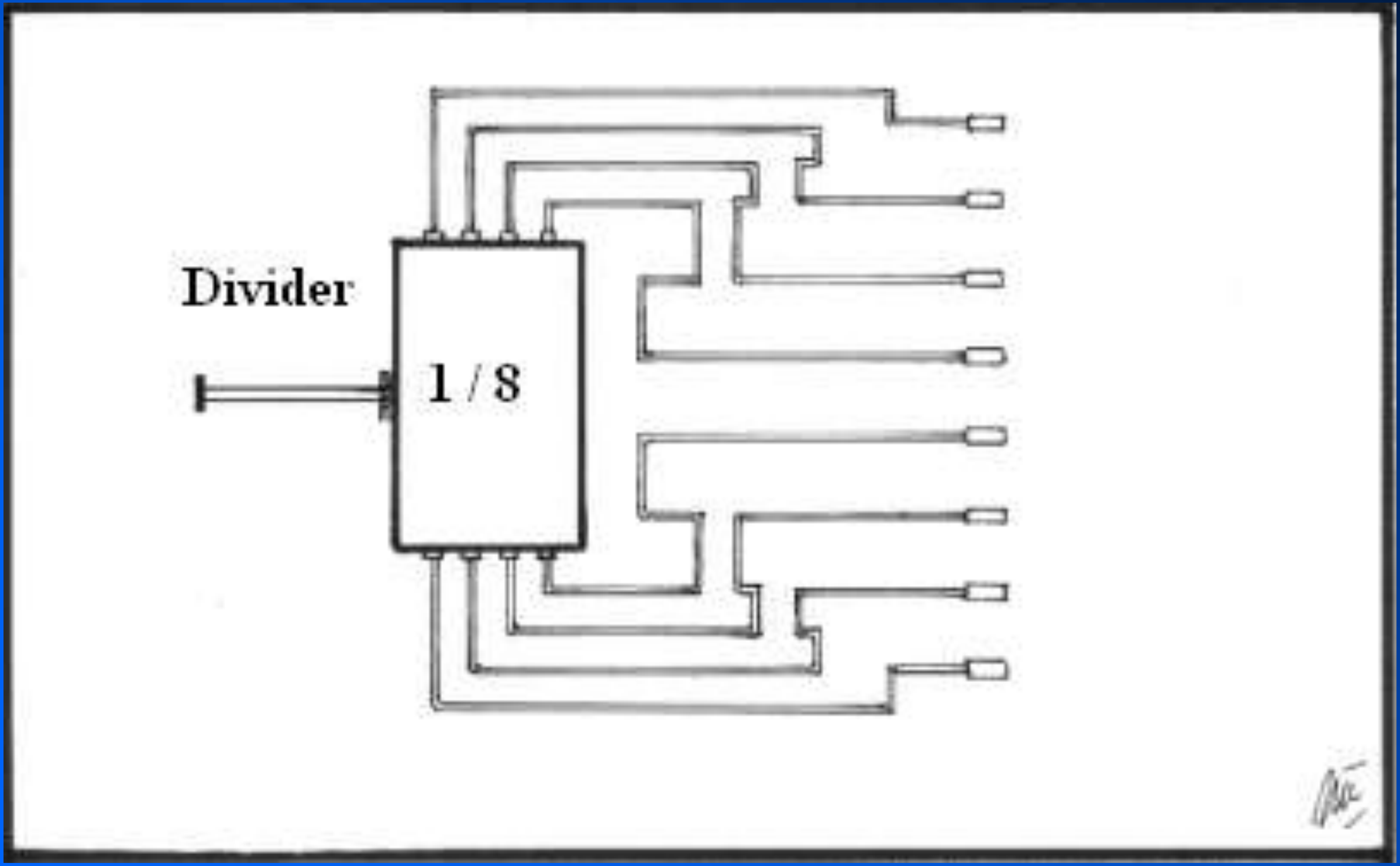
VHF BROADCAST ANTENNAS

FM Antenna Array Feed



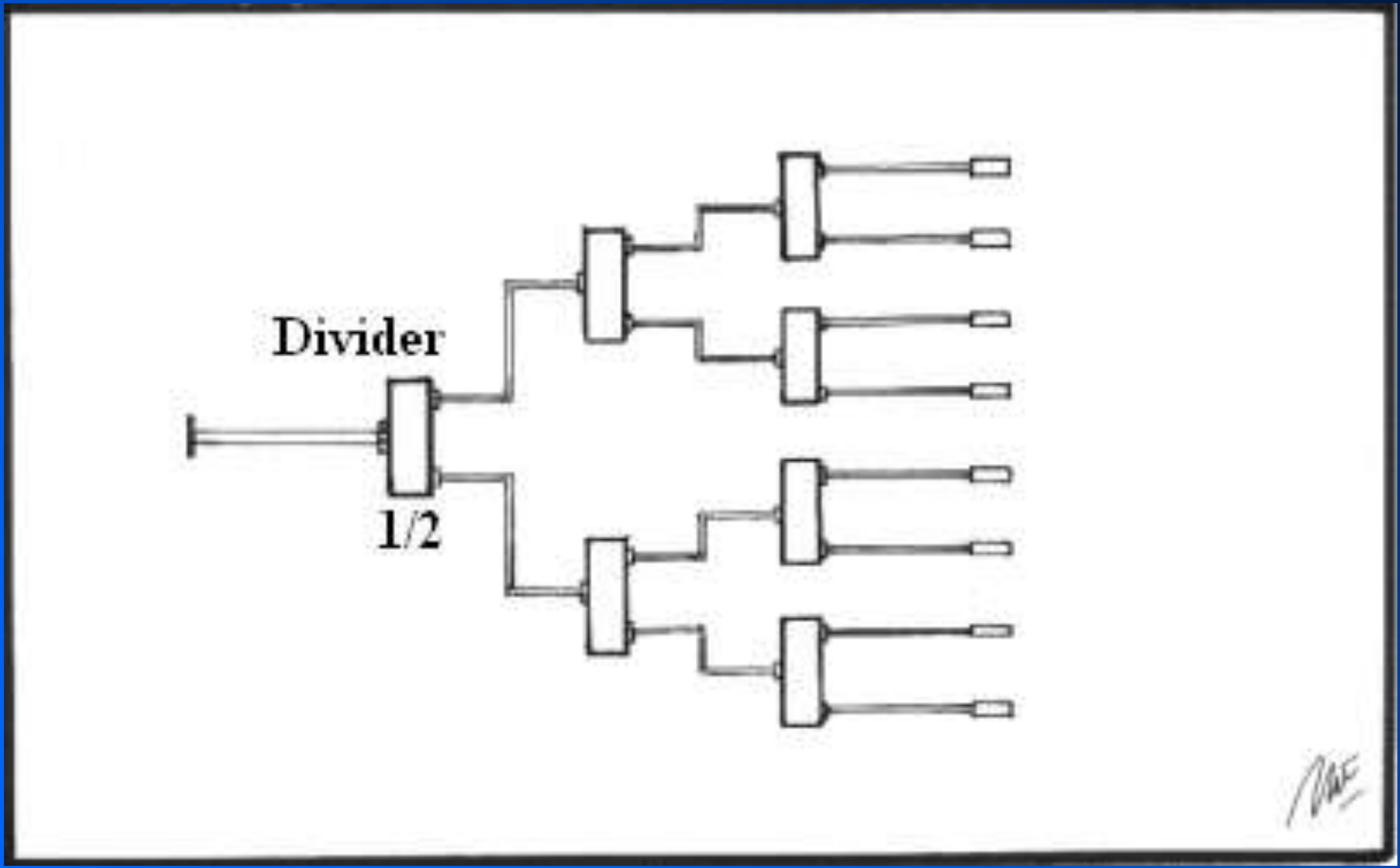
VHF BROADCAST ANTENNAS

FM Antenna Array Branch Feed System



VHF BROADCAST ANTENNAS

FM Antenna Array Branch Feed System



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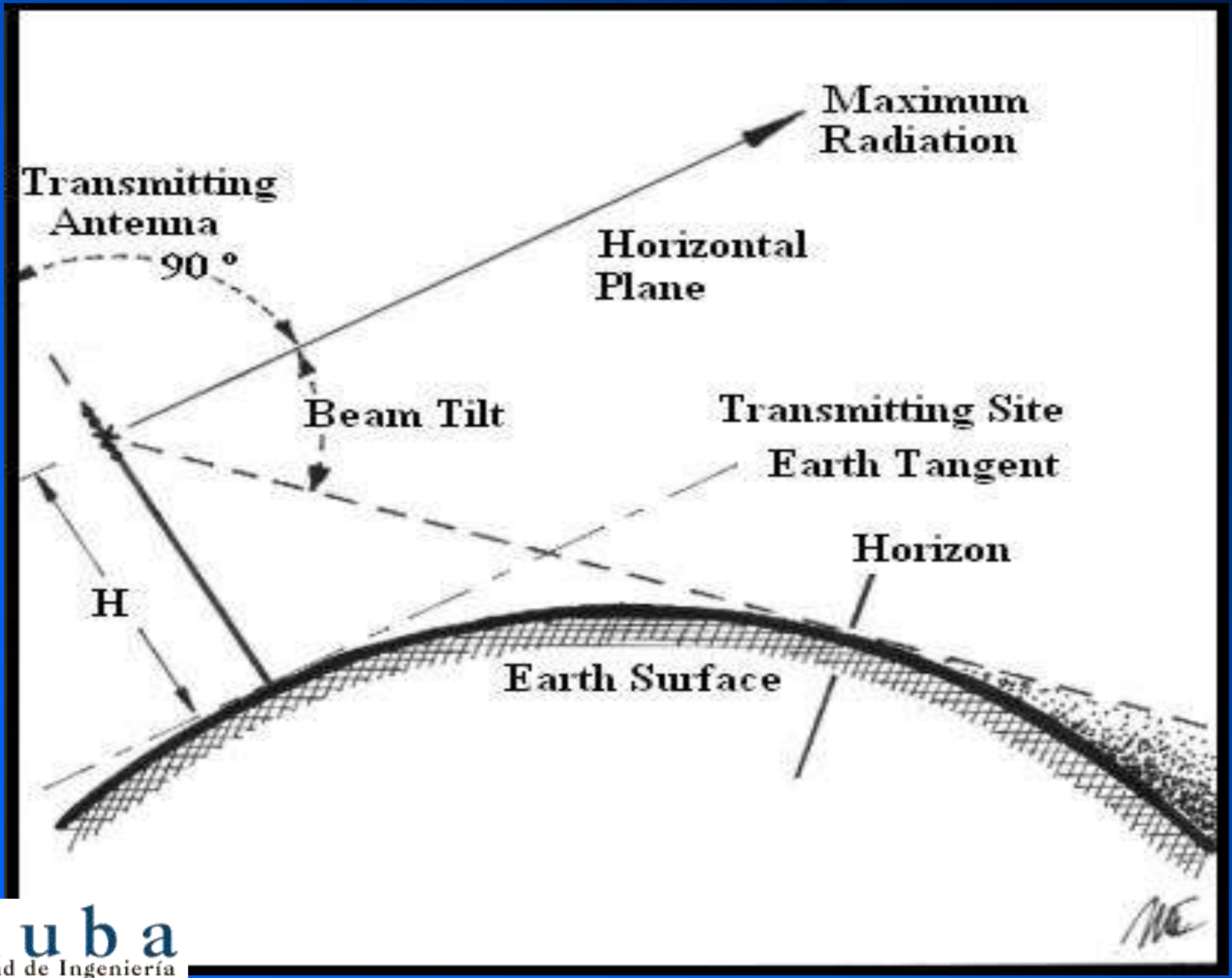
VHF AND UHF BROADCAST ANTENNAS



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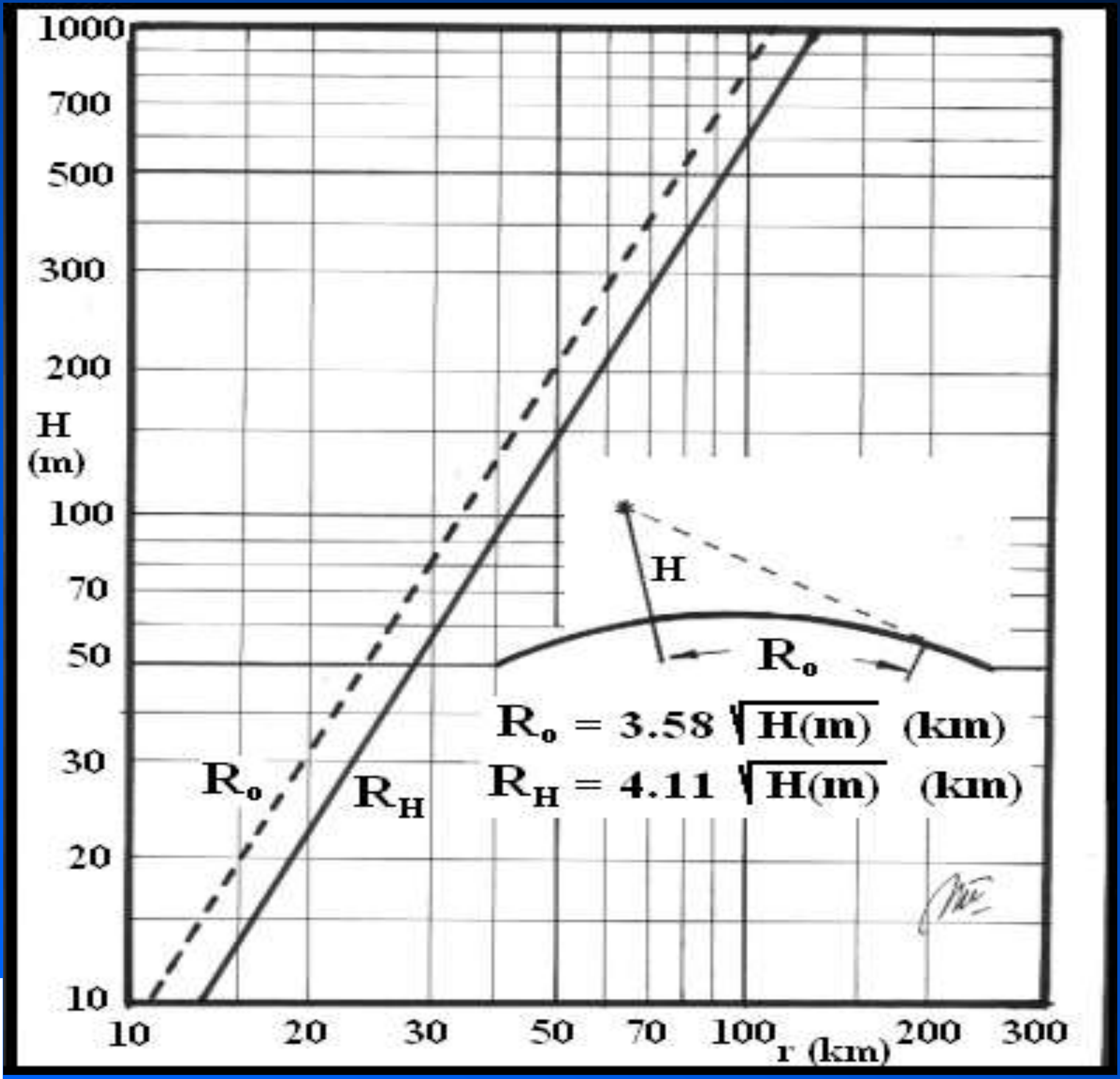
VHF AND UHF BROADCAST ANTENNAS



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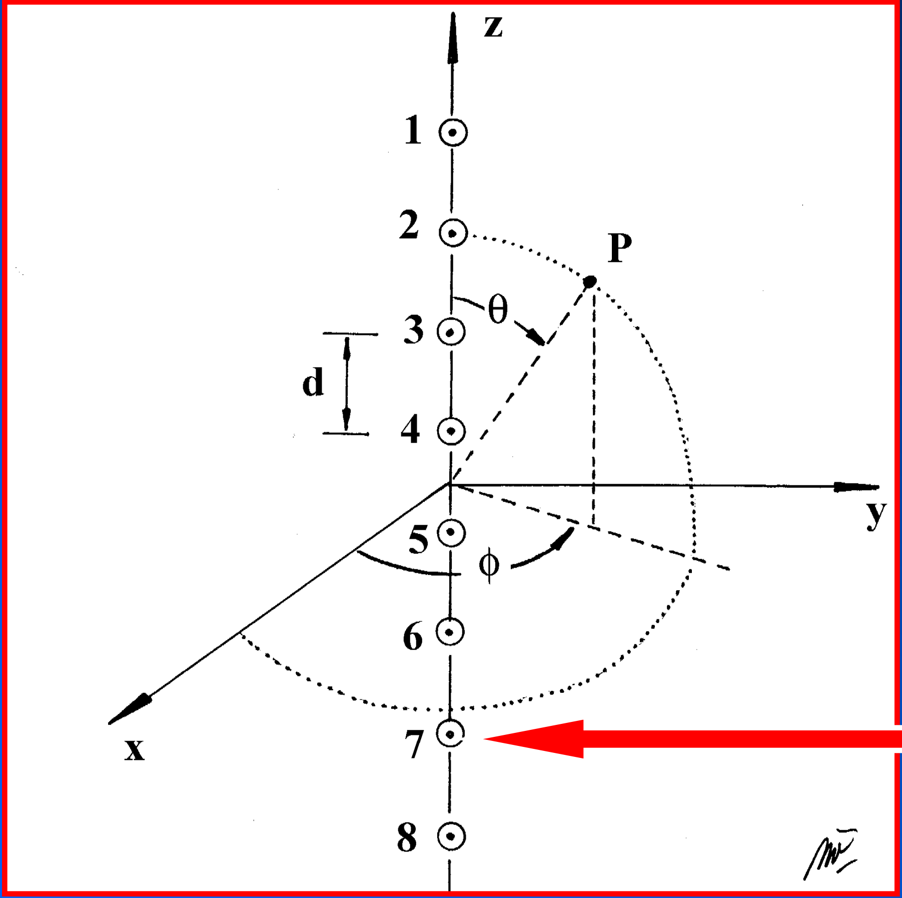
VHF AND UHF BROADCAST ANTENNAS

DIRECTIONAL ARRAYS



VERTICAL ARRAYS OR HORIZONTAL ARRAYS

VHF DIRECTIONAL ARRAY FOR FM or TV

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VHF AND UHF BROADCAST ANTENNAS

DIRECTIONAL ARRAYS

n HALF WAVE VERTICAL DIPOLE ARRAY IN THE VERTICAL PLANE

ELECTRICO FIELD EQUATION

$$\mathbf{E} = \mathbf{E}_1 + \mathbf{E}_2 + \mathbf{E}_3 + \mathbf{E}_4 + \ldots\ldots$$

$$\mathbf{E} = \mathrm{n}\mathbf{E}_0 \frac{\operatorname{sen}\left(n\frac{\beta d}{2}\cos(\theta) + \frac{\delta}{2}\right)}{\operatorname{sen}\left(\frac{\beta d}{2}\cos(\theta) + \frac{\delta}{2}\right)} \cdot \frac{\cos\left(\frac{\pi}{2}\cos(\theta)\right)}{\operatorname{sen}\theta}$$

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n EQUAL CURRENT IN EACH ELEMERT

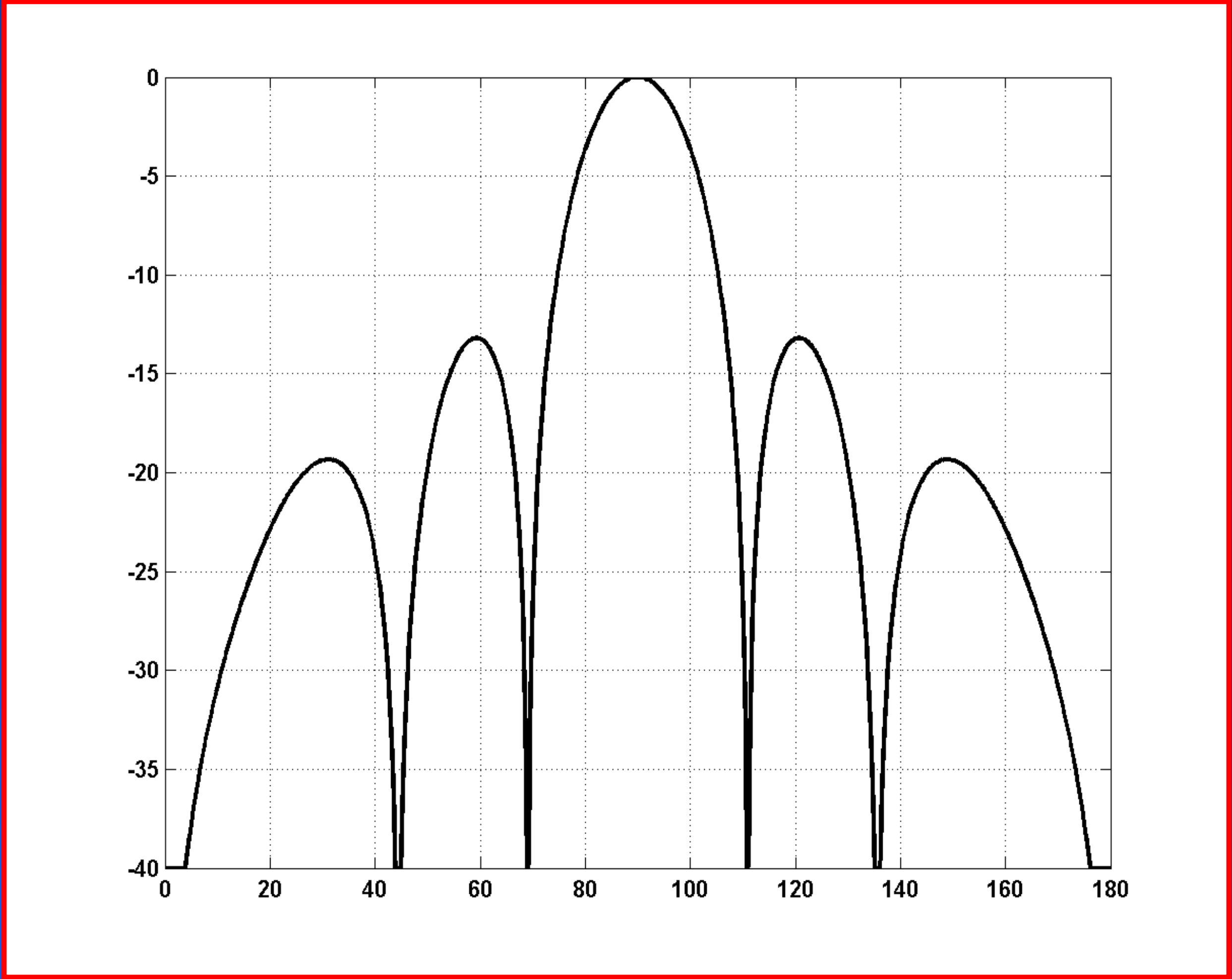
δ TIME RELATIVE PHASE BETWEEN ELEMENTS

VHF AND UHF BROADCAST ANTENNAS

DIRECTIONAL ARRAYS

Erel [dB]

$\delta = 0^o$



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4 VERTICAL DIPOLE RADIATION PATTERN

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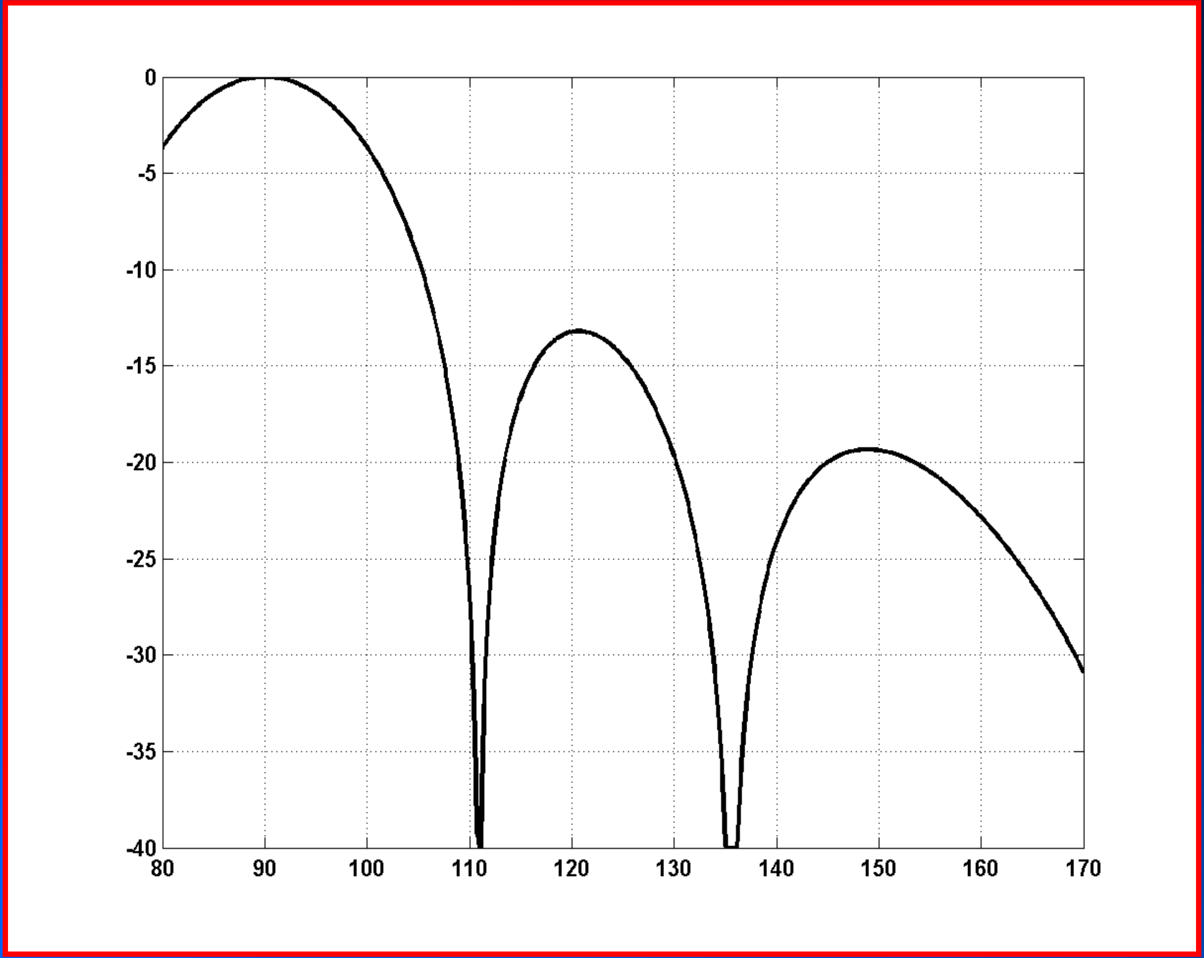
VHF AND UHF BROADCAST ANTENNAS

DIRECTIONAL ARRAYS

Erel [dB]

$\delta = 0^o$



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4 VERTICAL DIPOLE RADIATION PATTERN

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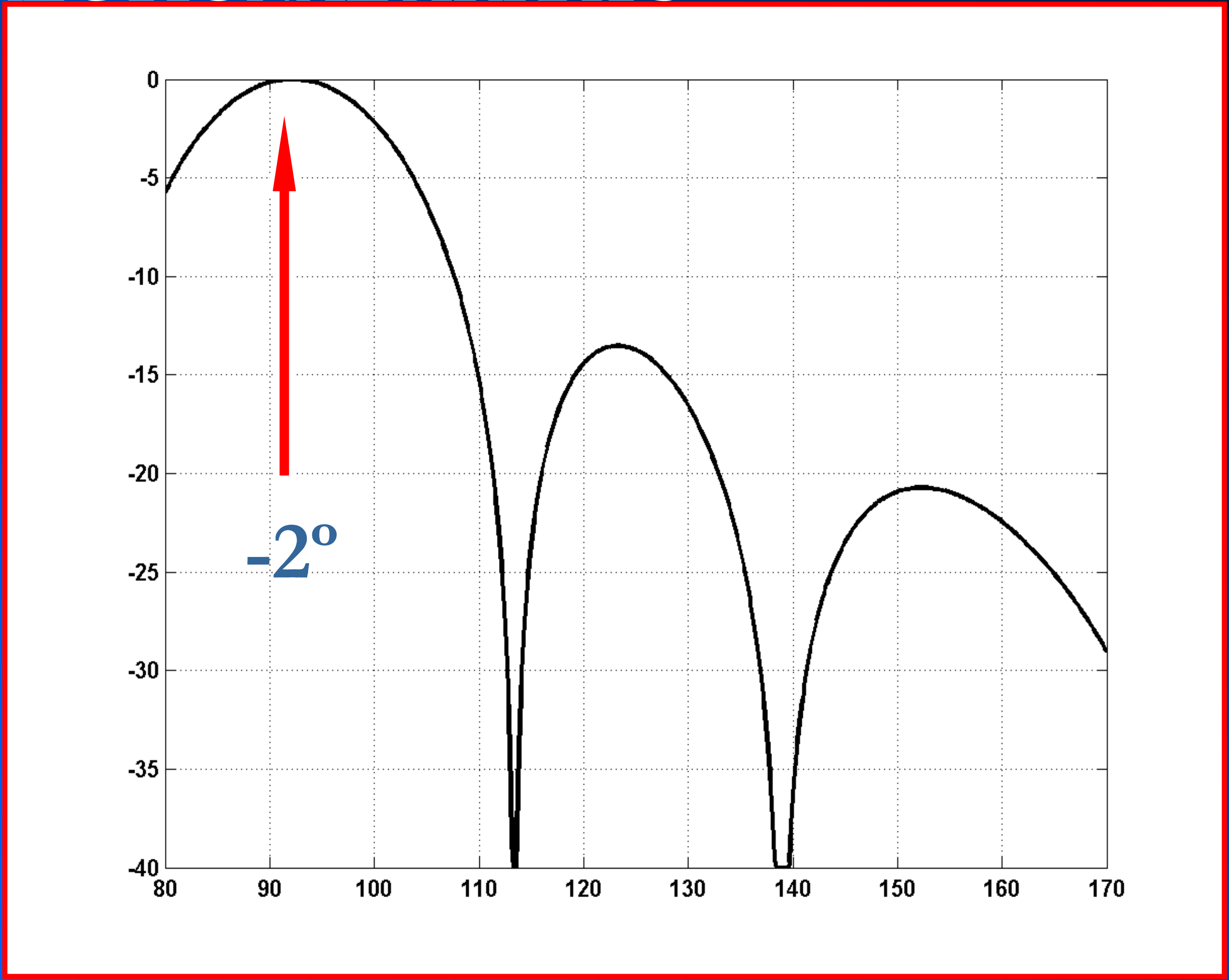
VHF AND UHF BROADCAST ANTENNAS

DIRECTIONAL ARRAYS

Erel [dB]

$\delta = 10º$



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4 VERTICAL DIPOLE RADIATION PATTERN

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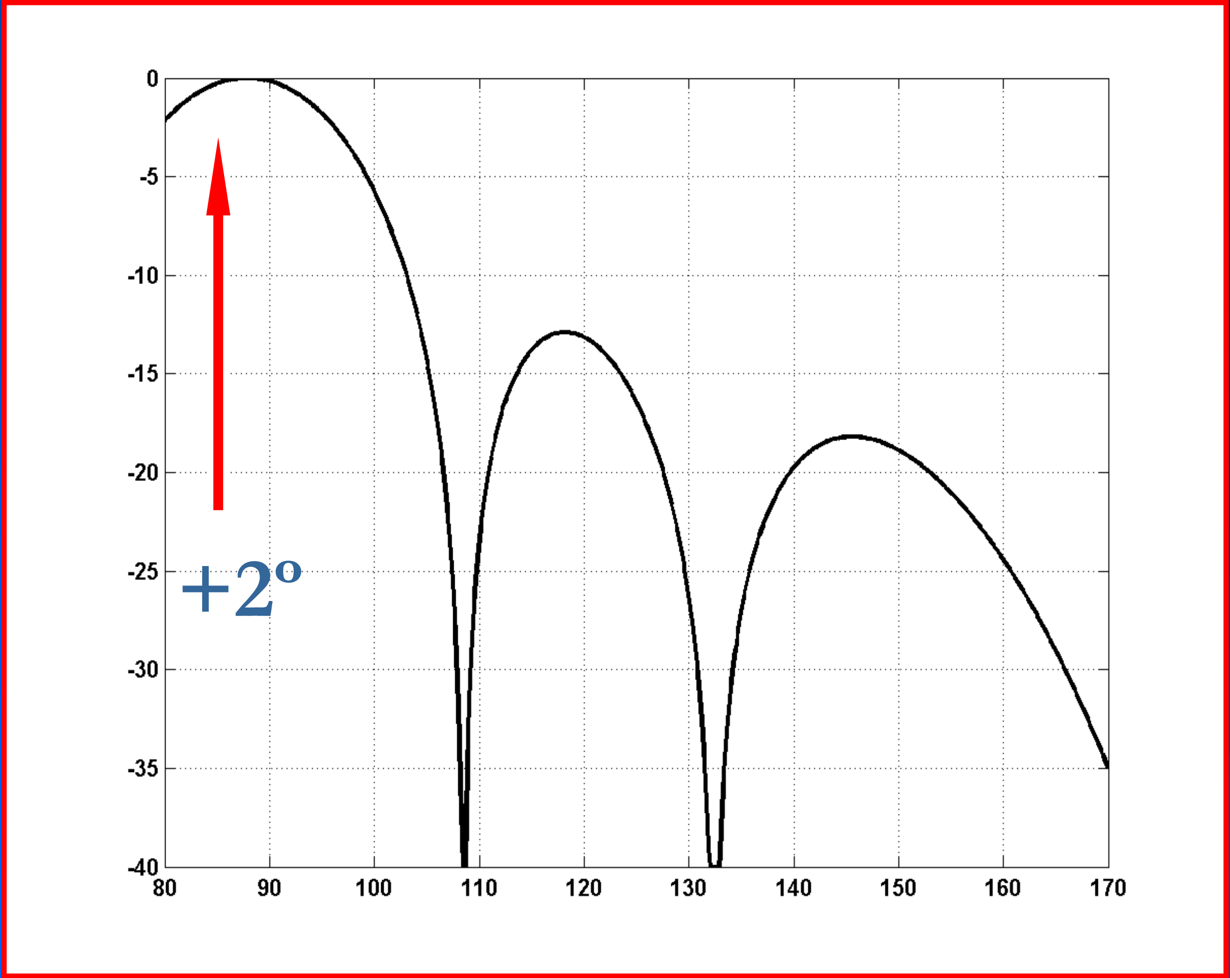
VHF AND UHF BROADCAST ANTENNAS
DIRECTIONAL ARRAYS

Erel [dB]

$\delta = -10^{\circ}$



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4 VERTICAL DIPOLE RADIATION PATTERN

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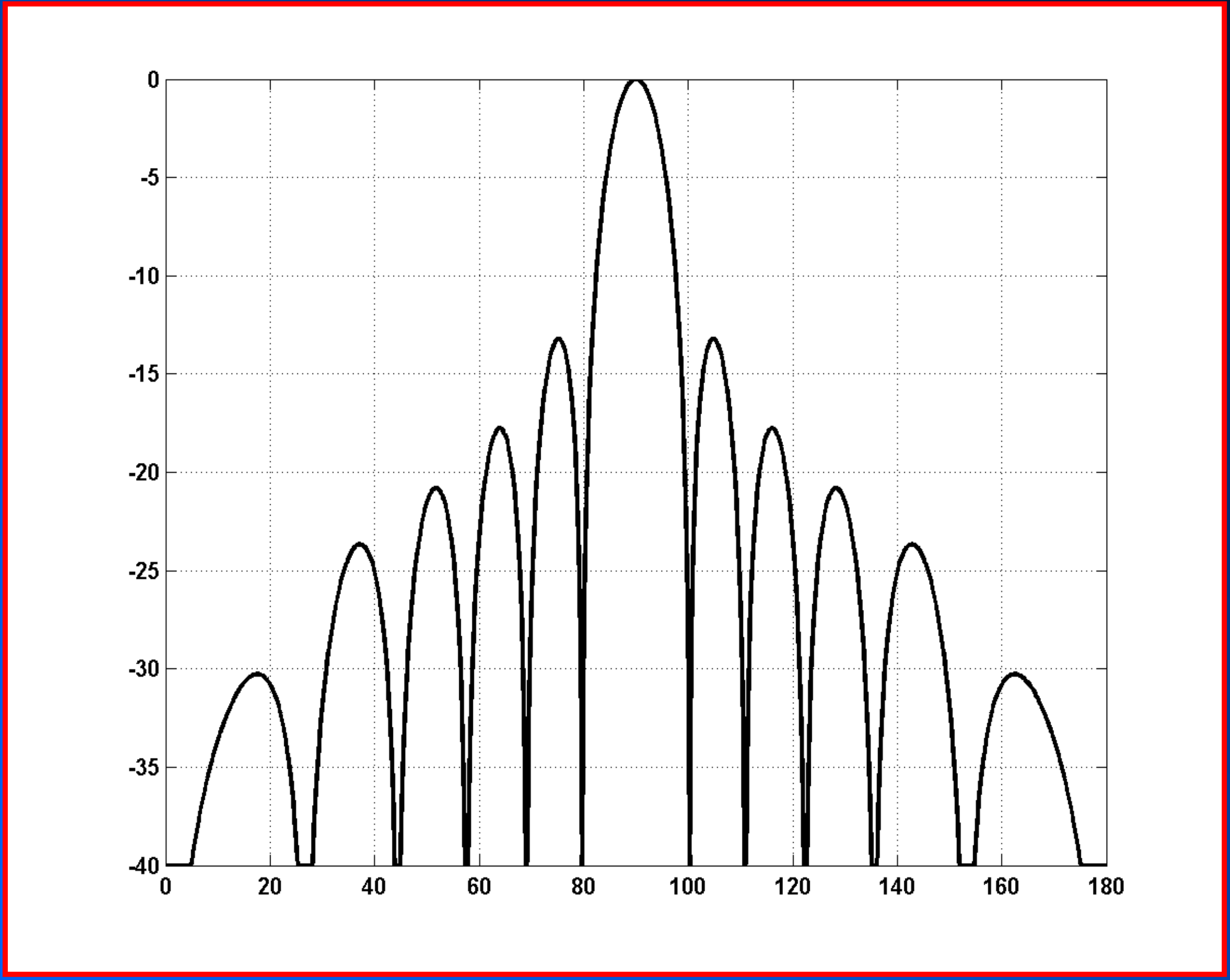
VHF AND UHF BROADCAST ANTENNAS

DIRECTIONAL ARRAYS

Erel [dB]

$\delta = 0^o$



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8 VERTICAL DIPOLE RADIATION PATTERN

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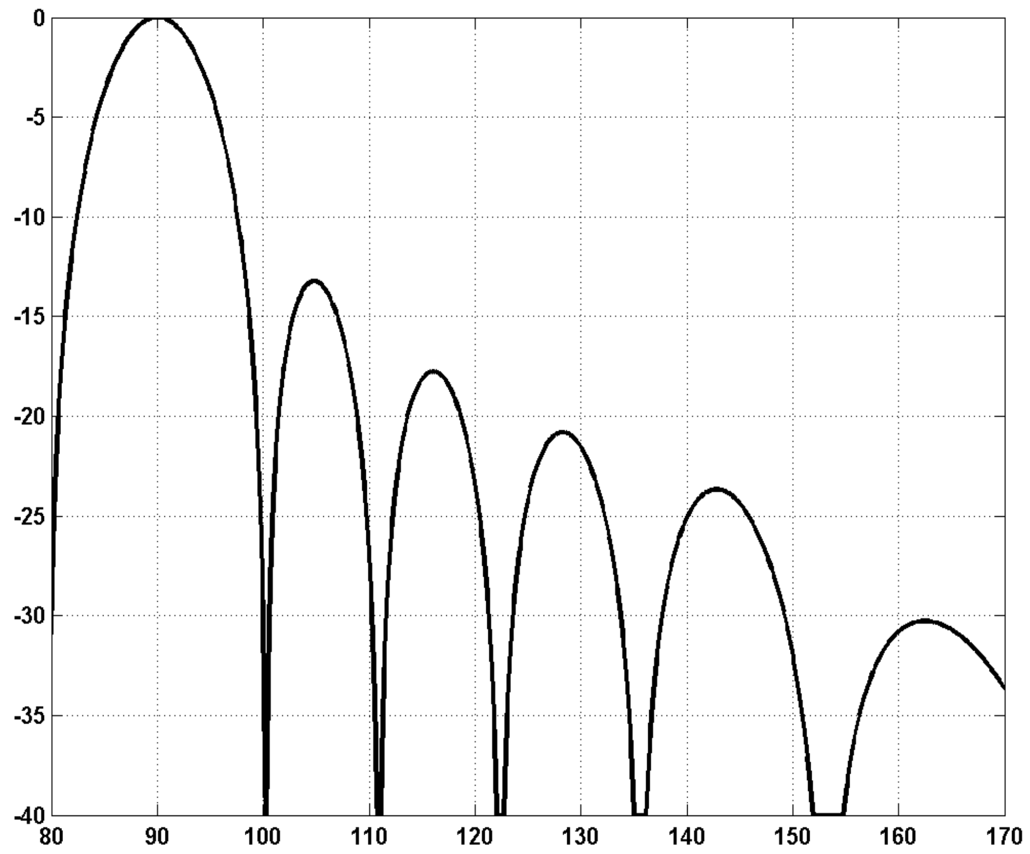
VHF AND UHF BROADCAST ANTENNAS

DIRECTIONAL ARRAYS

Erel [dB]

$\delta = 0^o$



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8 VERTICAL DIPOLE RADIATION PATTERN

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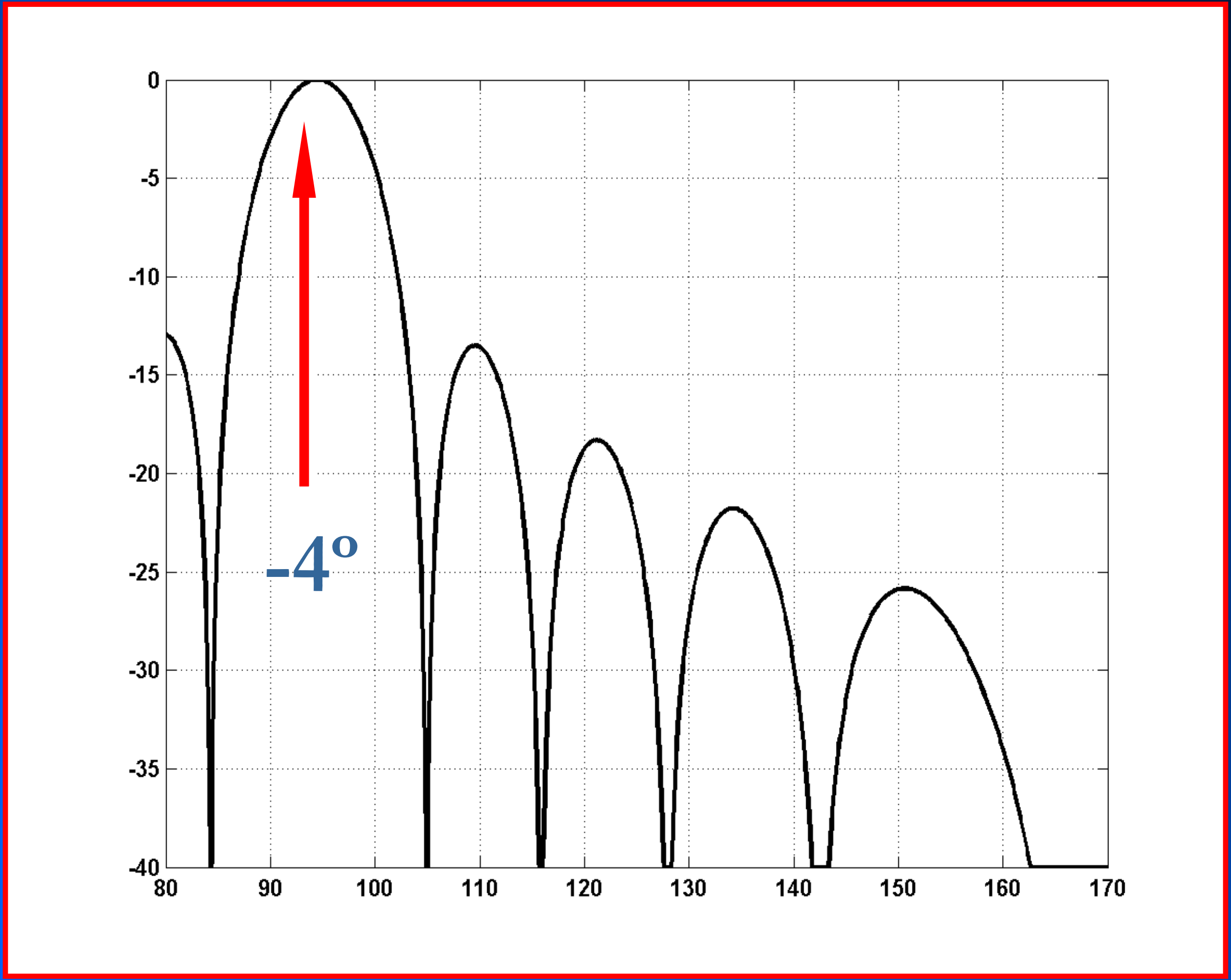
VHF AND UHF BROADCAST ANTENNAS

DIRECTIONAL ARRAYS

Erel [dB]

$\delta = 20^o$



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8 VERTICAL DIPOLE RADIATION PATTERN

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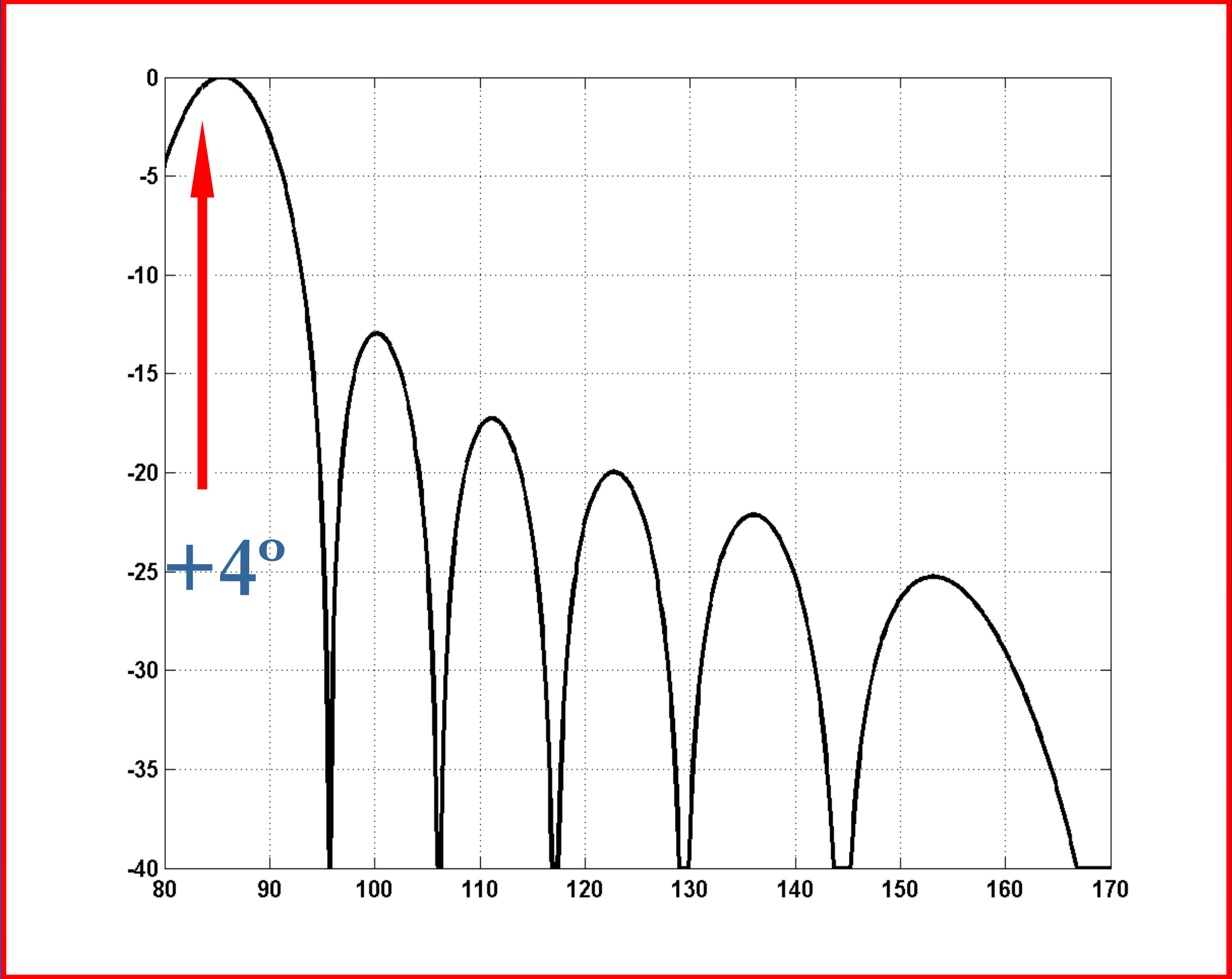
VHF AND UHF BROADCAST ANTENNAS
DIRECTIONAL ARRAYS

Erel [dB]

$\delta = -20º$



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8 VERTICAL DIPOLE RADIACION PATTERN

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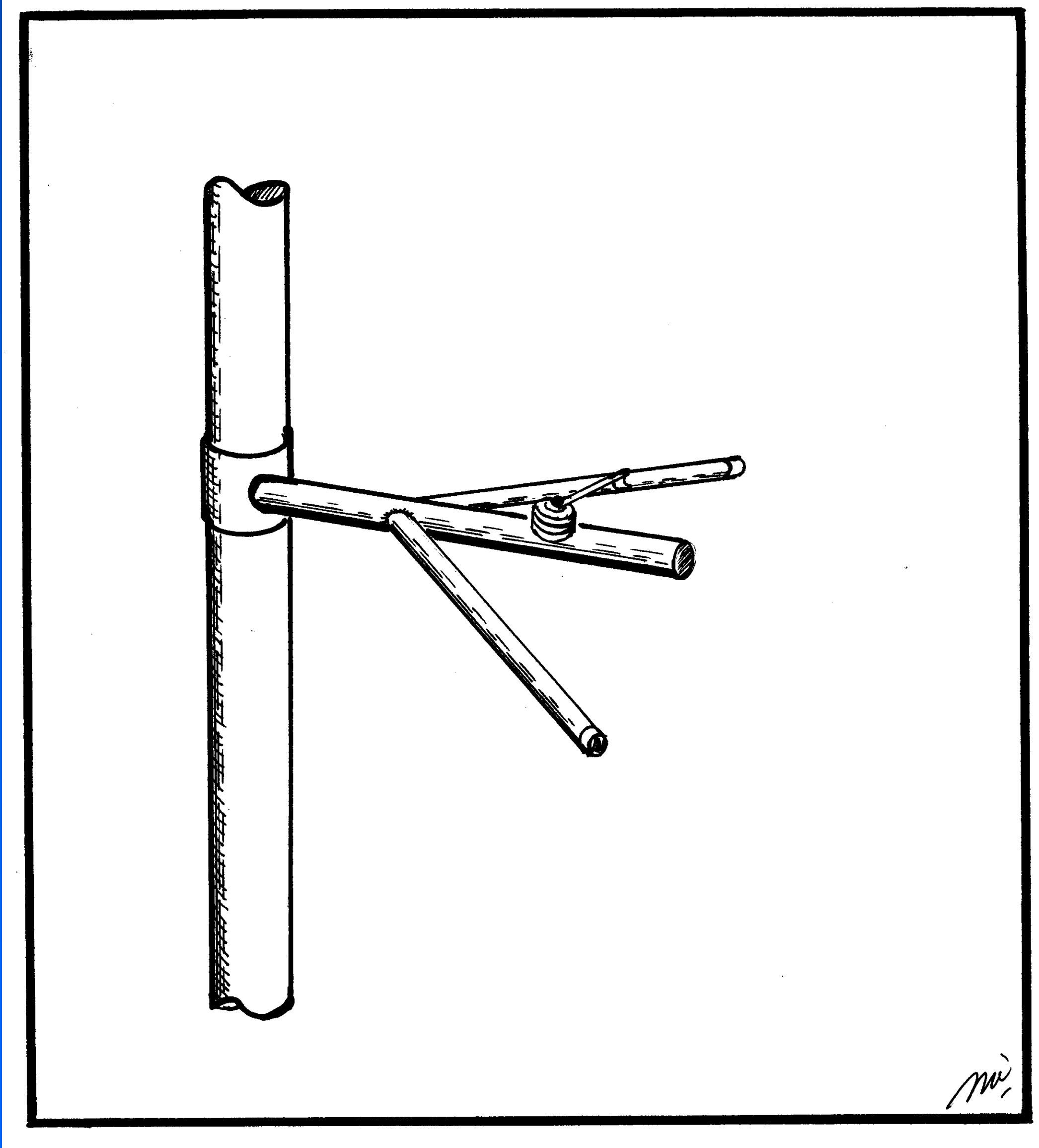
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA HORIZONTALLY POLARIZED

f = 100 MHz

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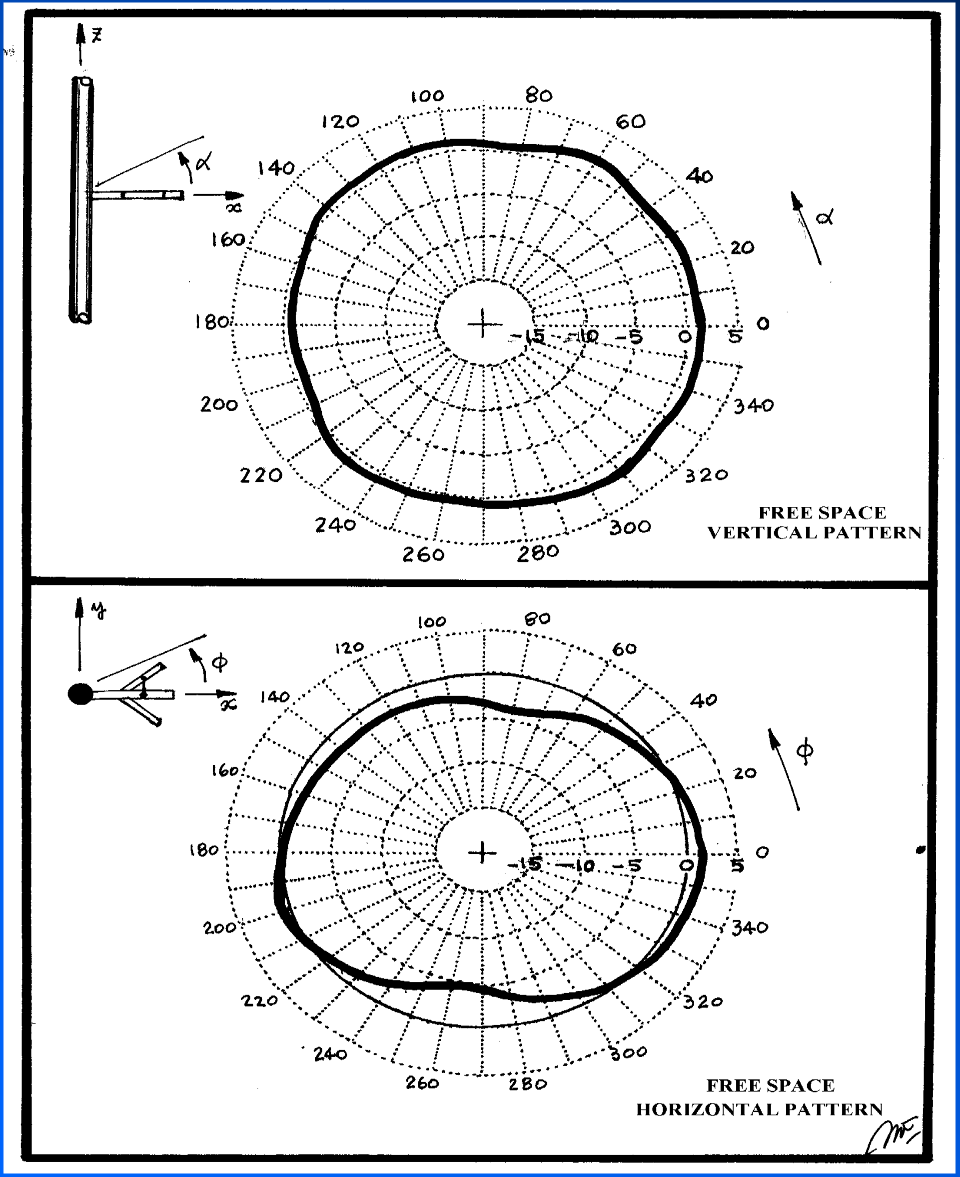
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE
ANTENNA
HORIZONTALLY
POLARIZED
f = 100 MHz

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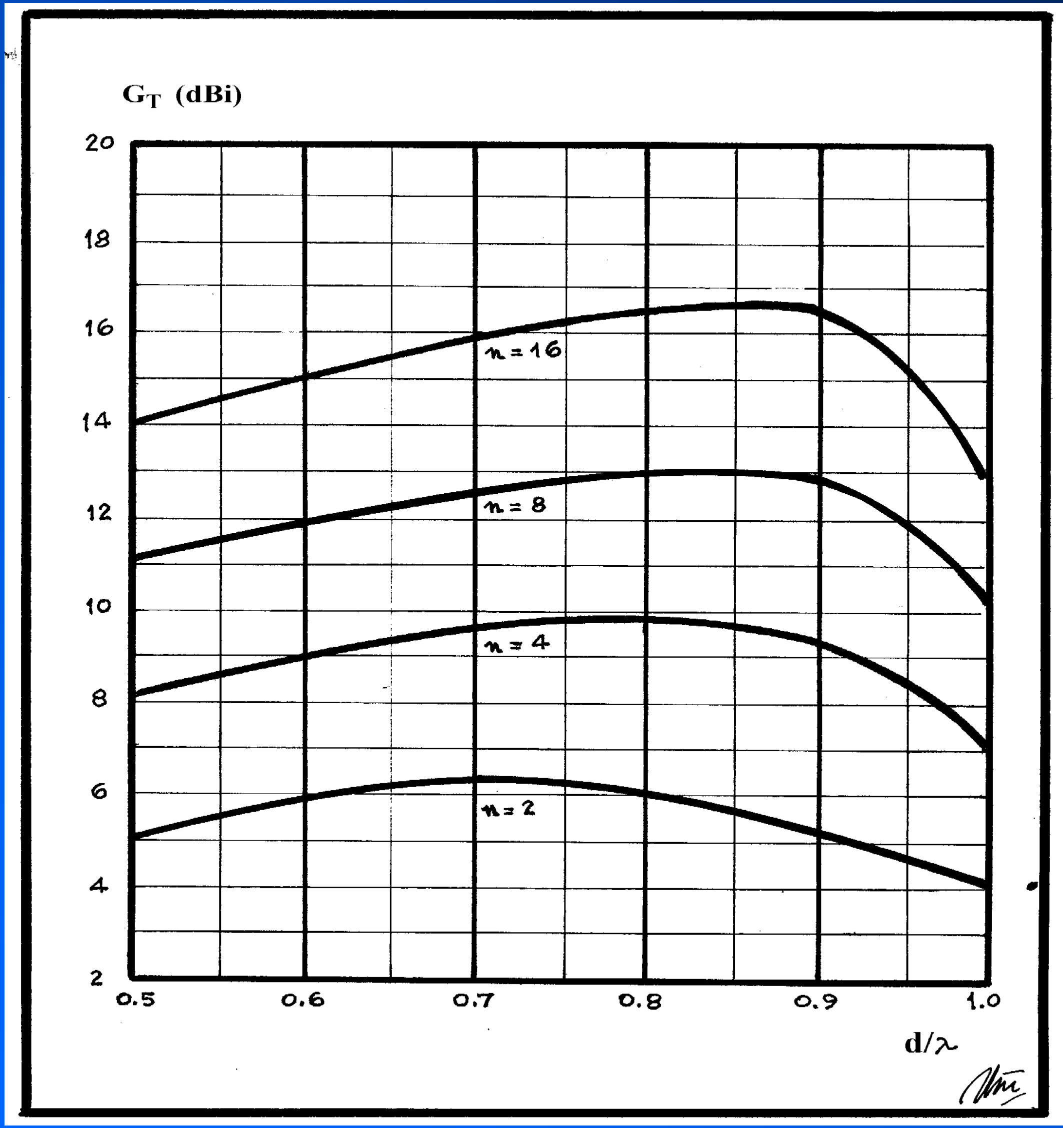
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED
f = 100 MHz

GAIN IN FREE SPACE

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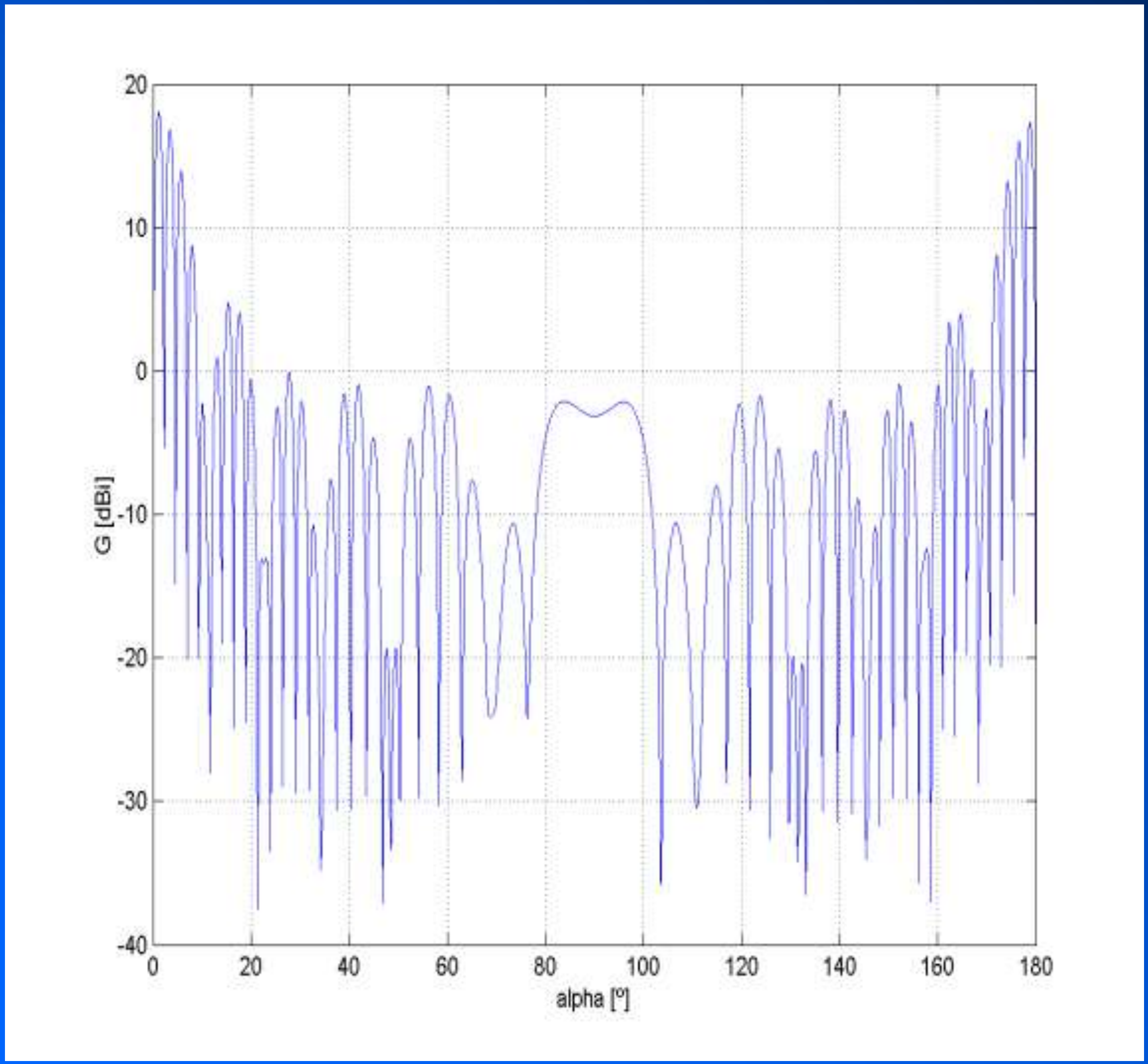
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

$f = 100$ MHz

$H_0 = 37$ m

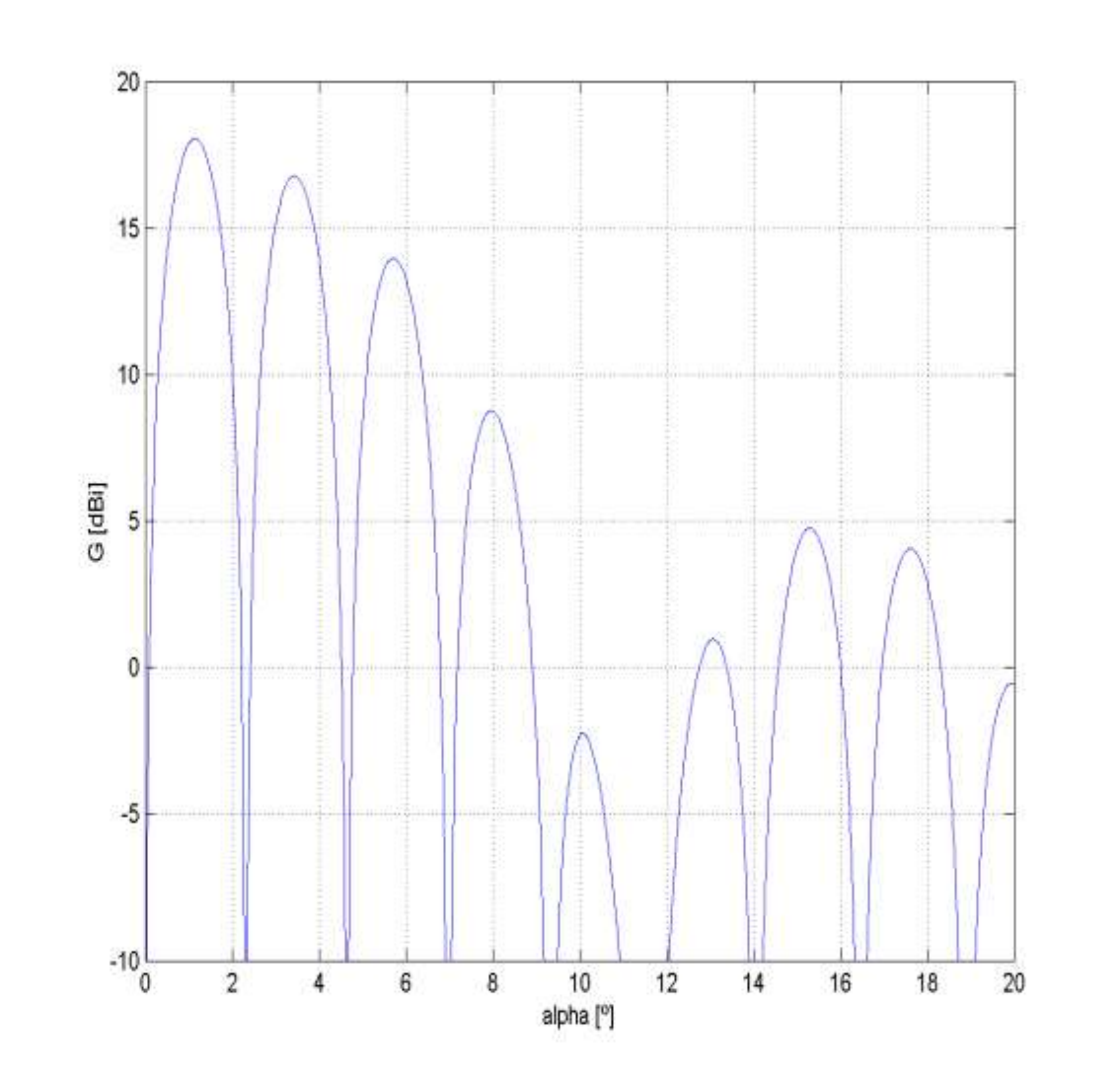
$Wt = 1$ kW

GAIN OVER PERFECT GROUND

$n = 8$

$d = 0.7\ \lambda$

VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

f = 100 MHz

H_0 = 37 m

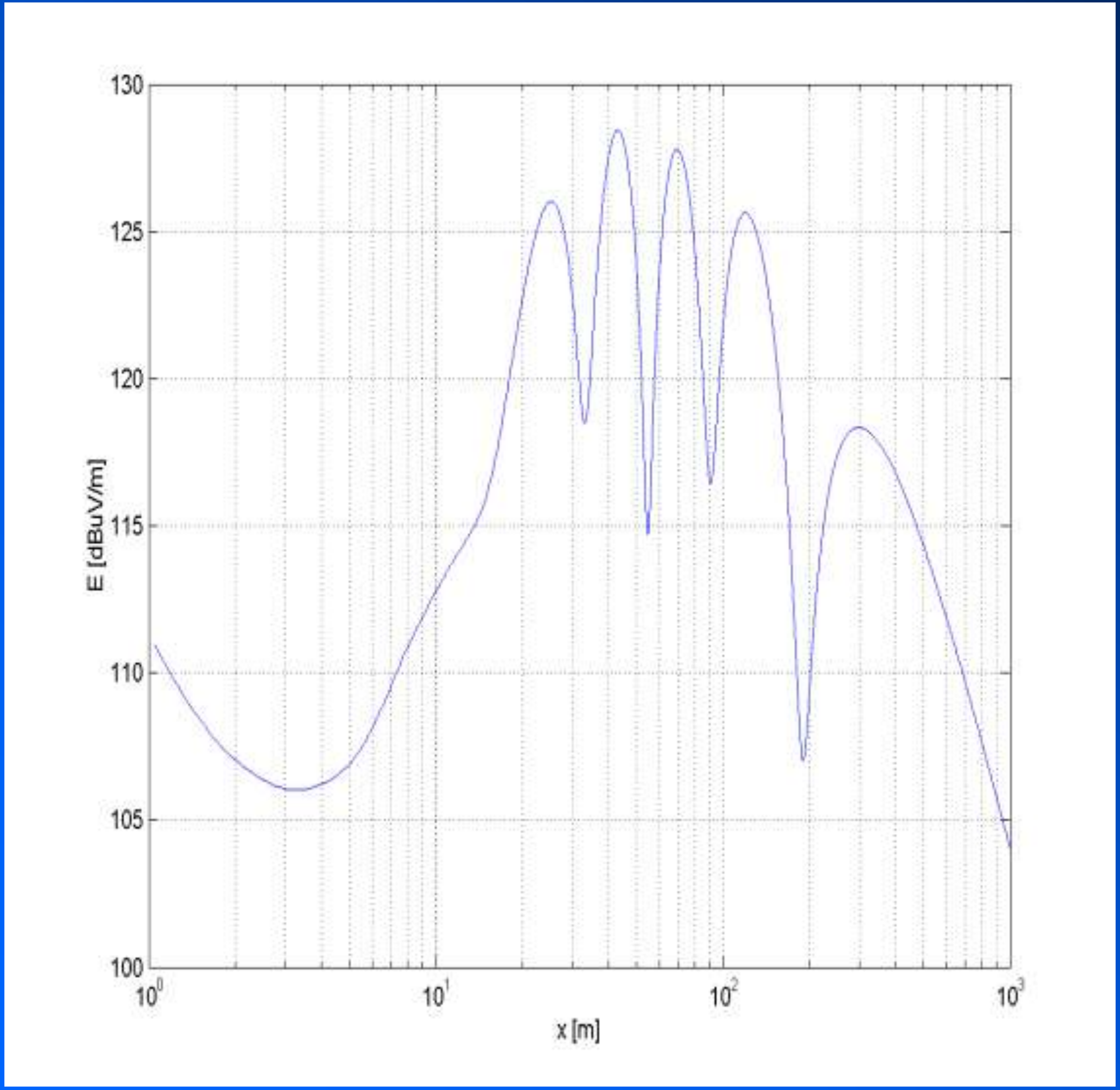
Wt = 1 kW

GAIN OVER PERFECT GROUND

n = 8

d = 0.7 λ

VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

f = 100 MHz

H_0 = 37 m

Wt = 1 kW

NEAR E FIELD OVER PERFECT GROUND

n = 8

d = 0.7 λ

z = 1.5 m

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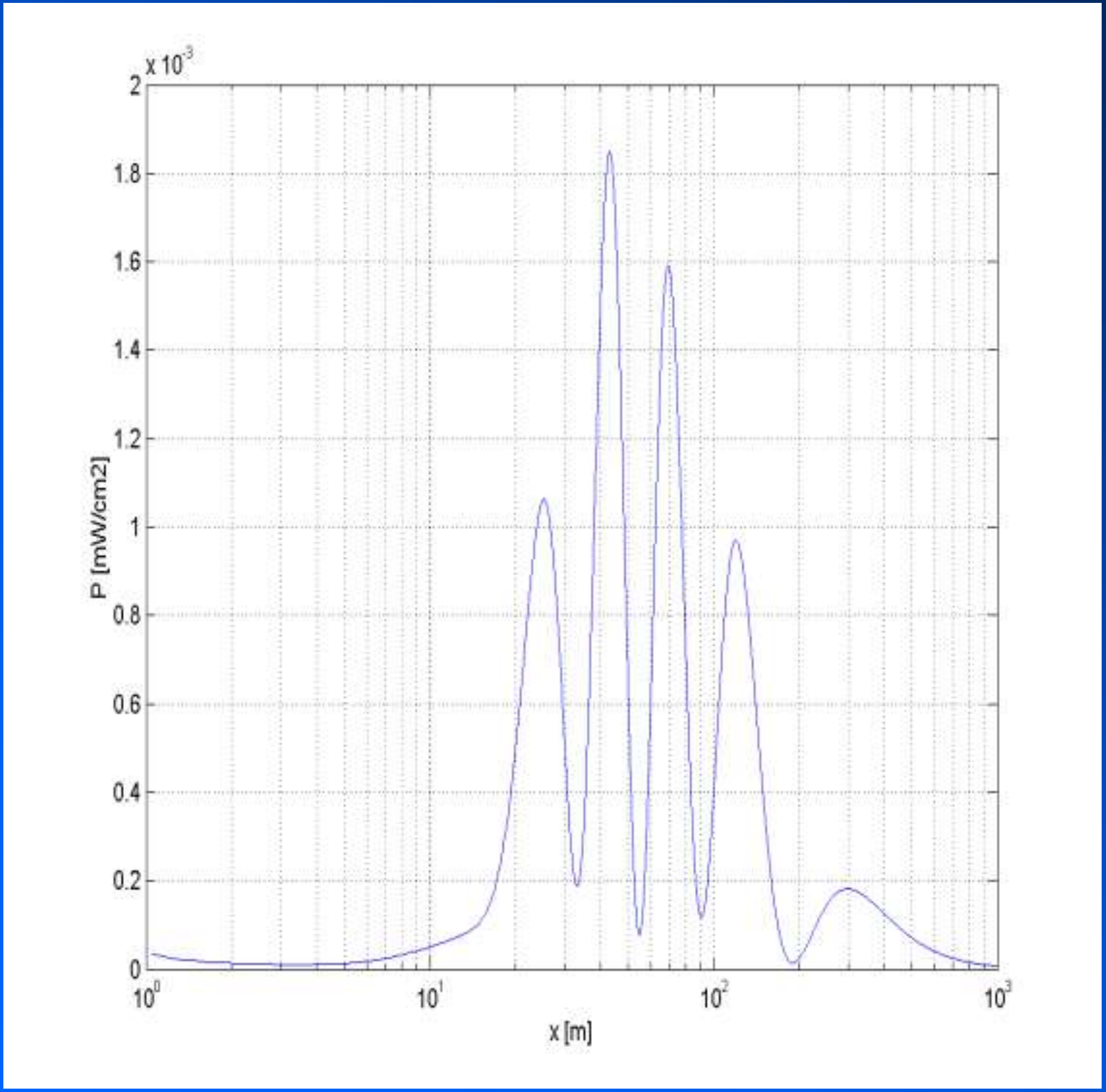
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

$f = 100$ MHz

$H_0 = 37$ m

$Wt = 1$ kW

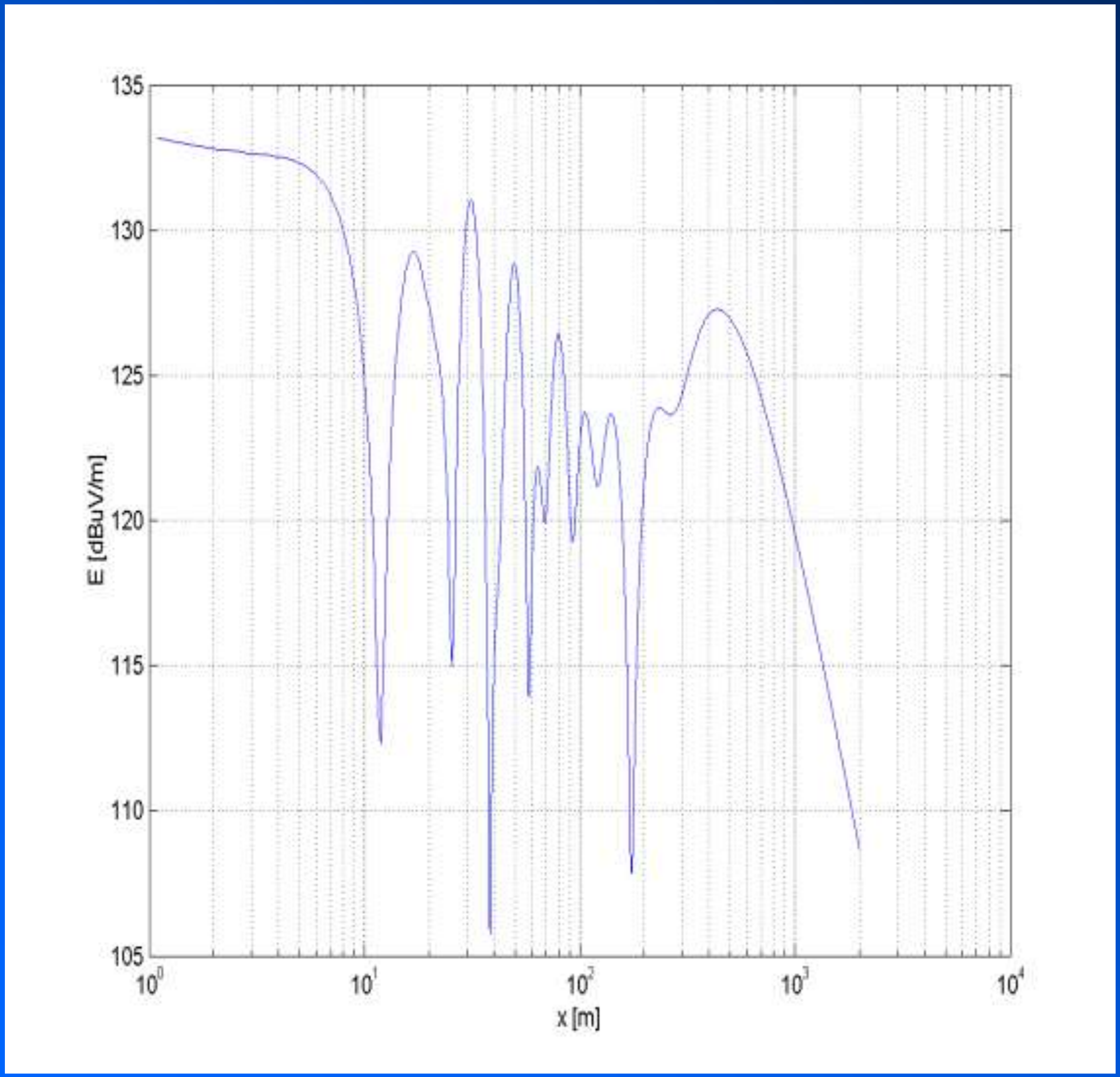
NEAR POWER DENSITY OVER PERFECT GROUND

$n = 8$

$d = 0.7\ \lambda$

$z = 1.5$ m

VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

$f = 100$ MHz

$H_0 = 37$ m

$Wt = 1$ kW

NEAR E FIELD OVER PERFECT GROUND

$n = 8$

$d = 0.7\ \lambda$

$z = 10$ m

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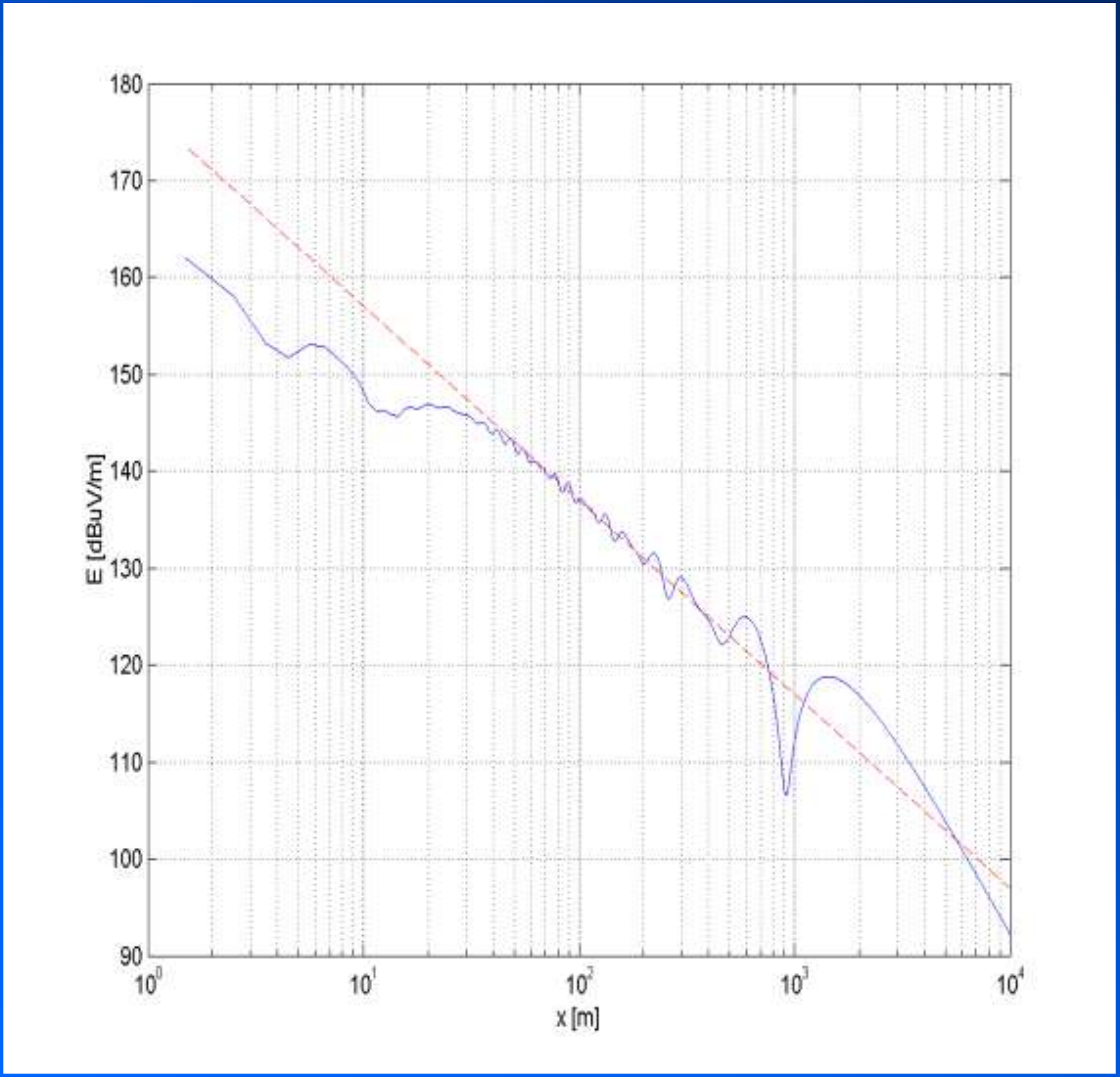
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

f = 100 MHz

H_0 = 37 m

Wt = 1 kW

NEAR E FIELD OVER PERFECT GROUND

n = 8

d = 0.7 λ

z = 37 m

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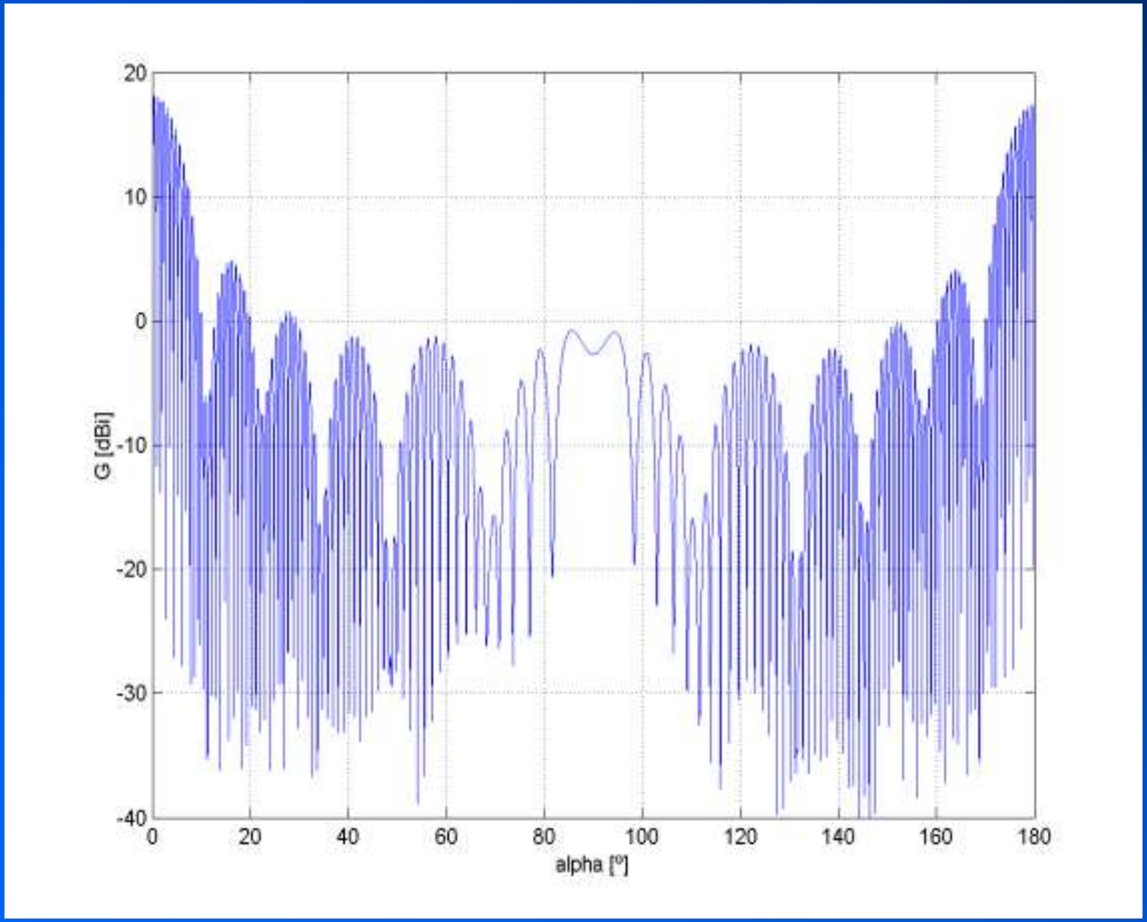
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

f = 100 MHz

H_0 = 100 m

Wt = 1 kW

GAIN OVER PERFECT GROUND

n = 8

d = 0.7 λ

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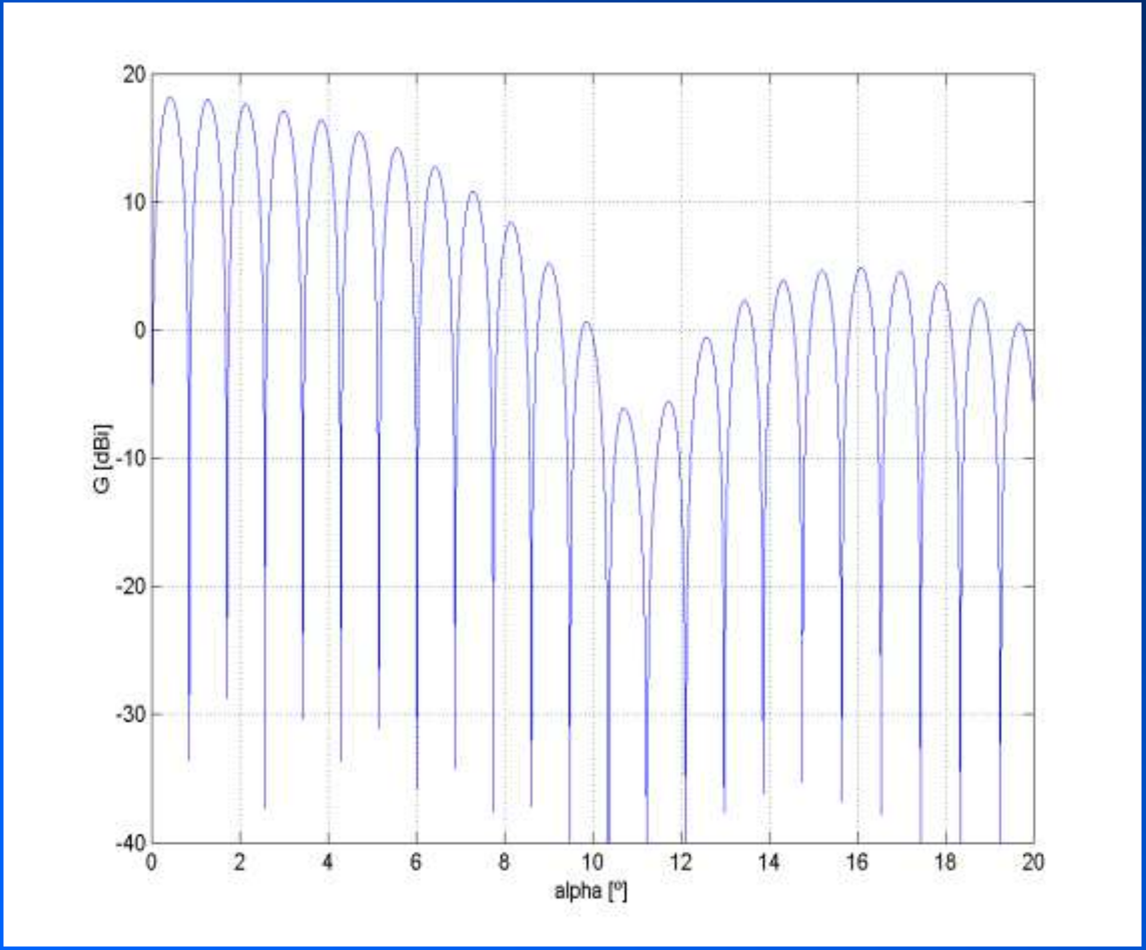
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

$f = 100$ MHz

$H_0 = 100$ m

$Wt = 1$ kW

GAIN OVER PERFECT GROUND

$n = 8$

$d = 0.7\ \lambda$

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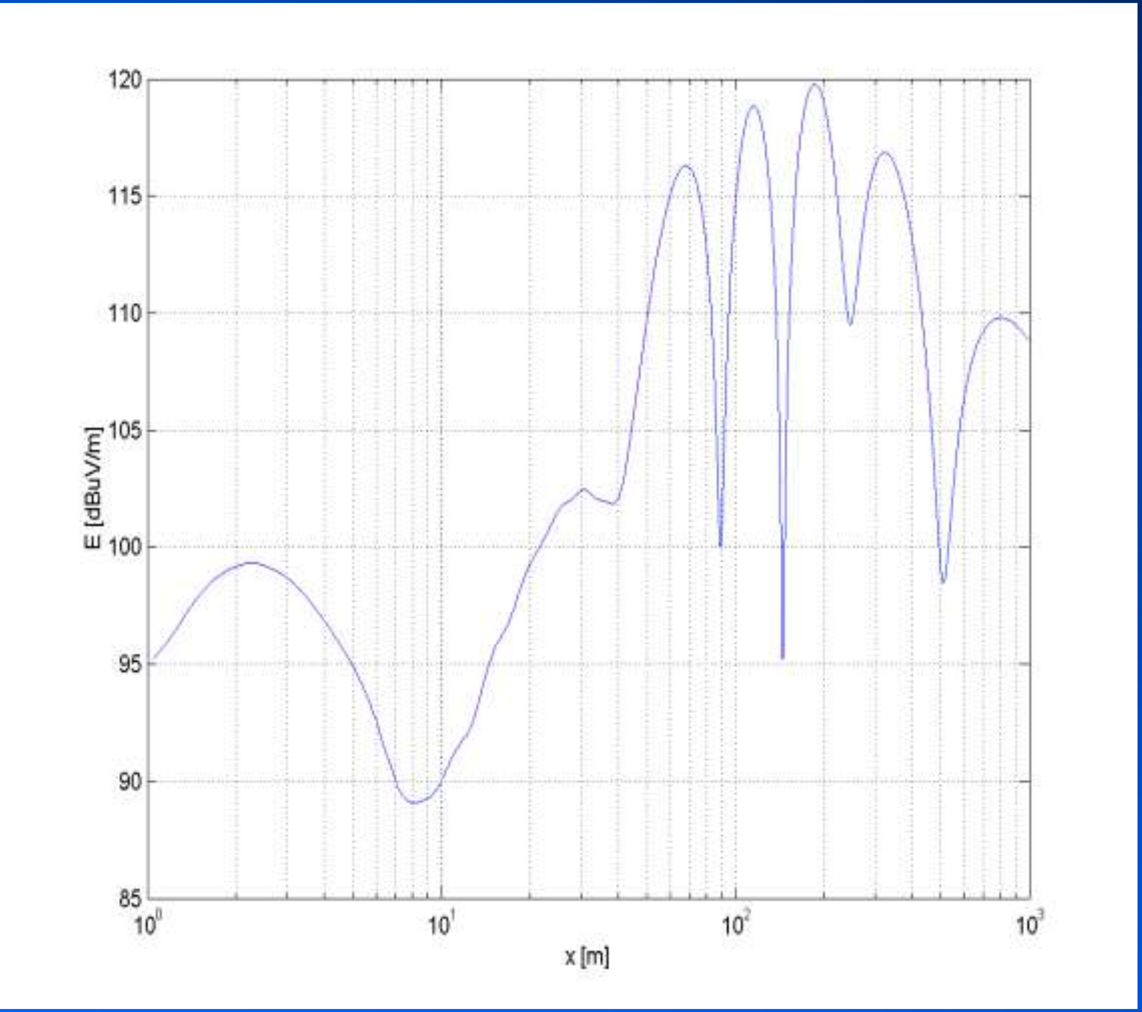
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

$f = 100$ MHz

$H_0 = 100$ m

$Wt = 1$ kW

NEAR E FIELD OVER PERFECT GROUND

$n = 8$

$d = 0.7\ \lambda$

$z = 1.5$ m

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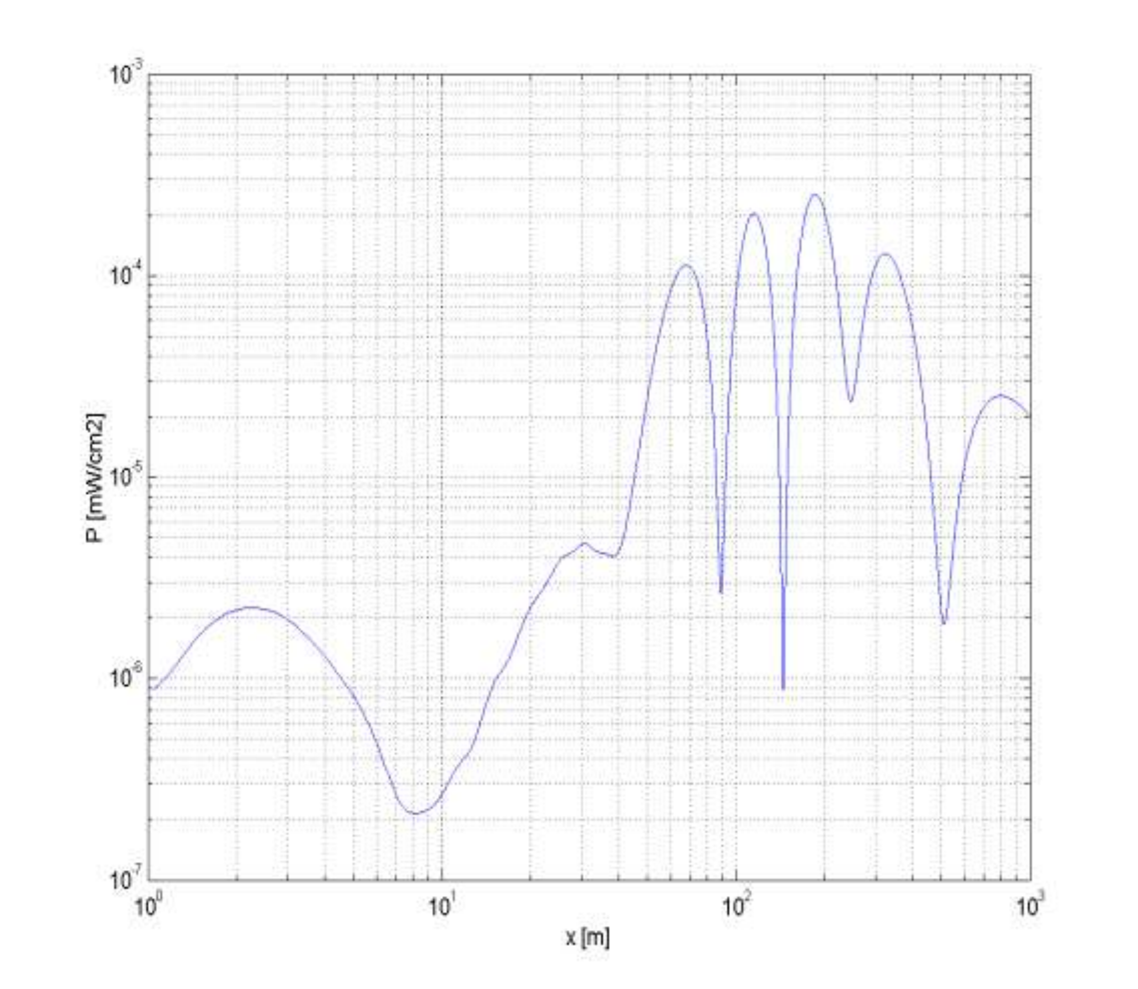
VHF AND UHF BROADCAST ANTENNAS



FM “V” DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

f = 100 MHz

H_0 = 100 m

Wt = 1 kW

NEAR POWER DENSITY OVER PERFECT GROUND

n = 8

d = 0.7 λ

z = 1.5 m

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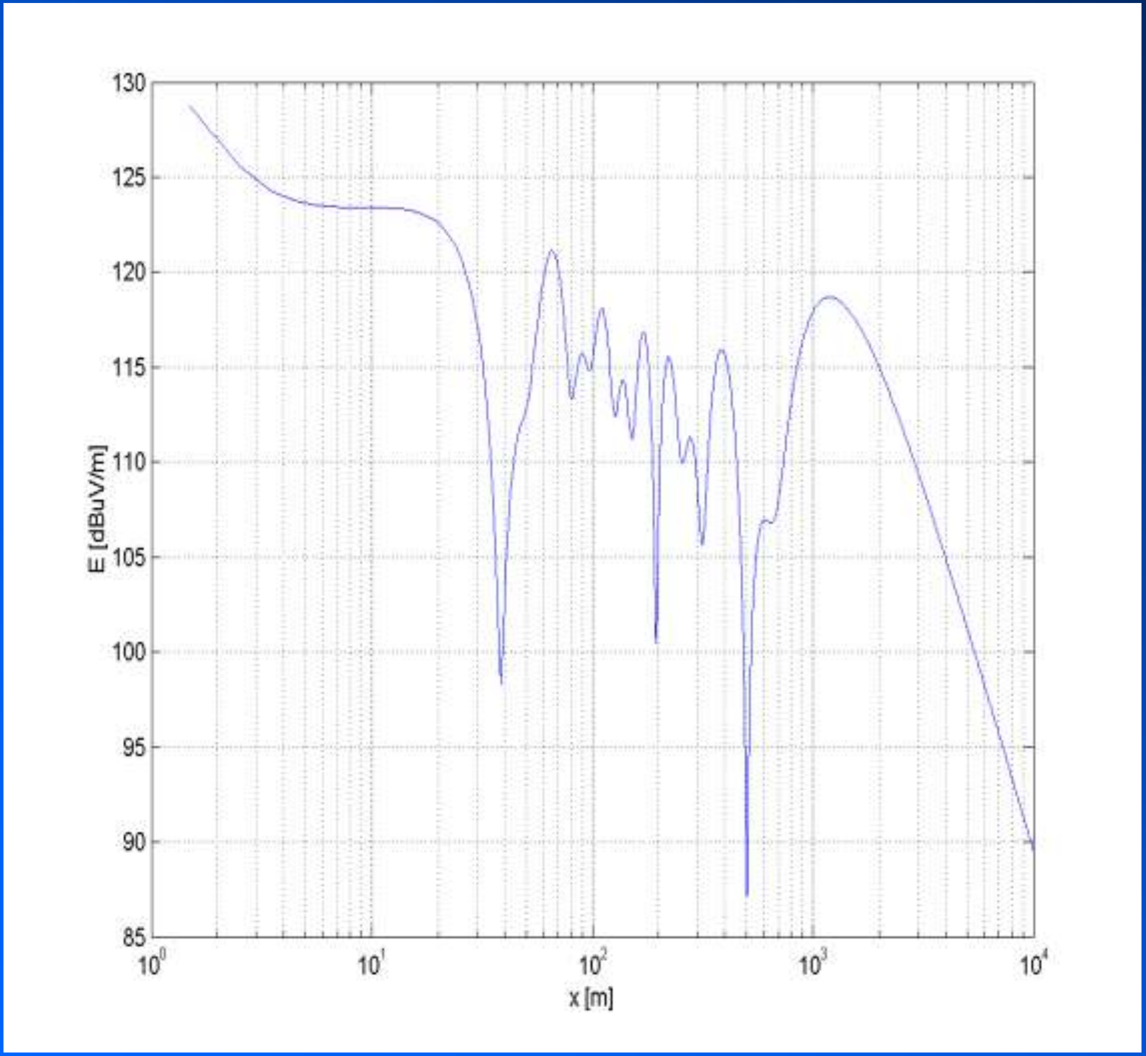
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

f = 100 MHz

H_0 = 100 m

Wt = 1 kW

NEAR E FIELD OVER PERFECT GROUND

n = 8

d = 0.7 λ

z = 10 m

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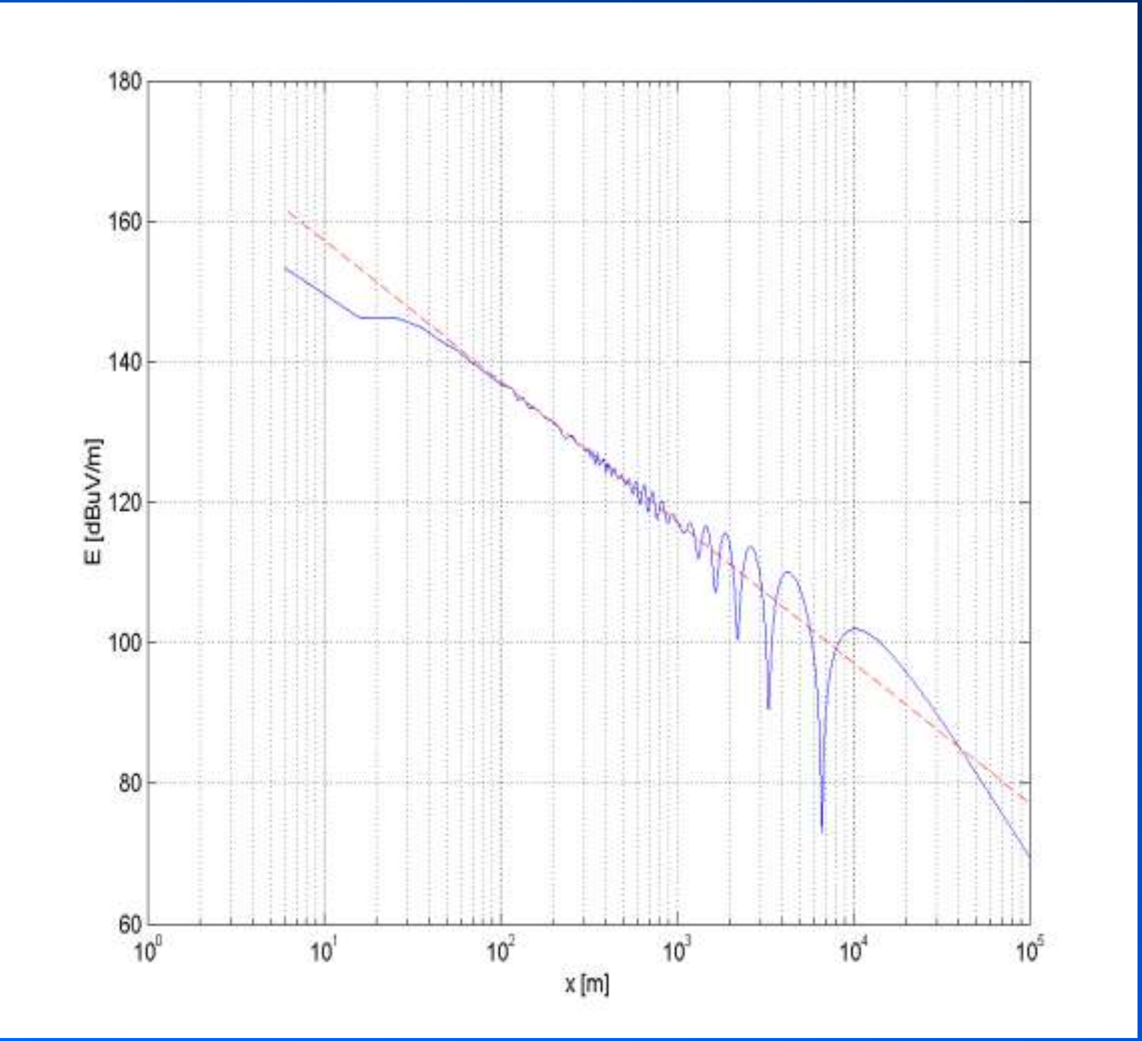
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

$f = 100$ MHz

$H_0 = 100$ m

$Wt = 1$ kW

NEAR E FIELD OVER PERFECT GROUND

$n = 8$

$d = 0.7\ \lambda$

$z = 100$ m

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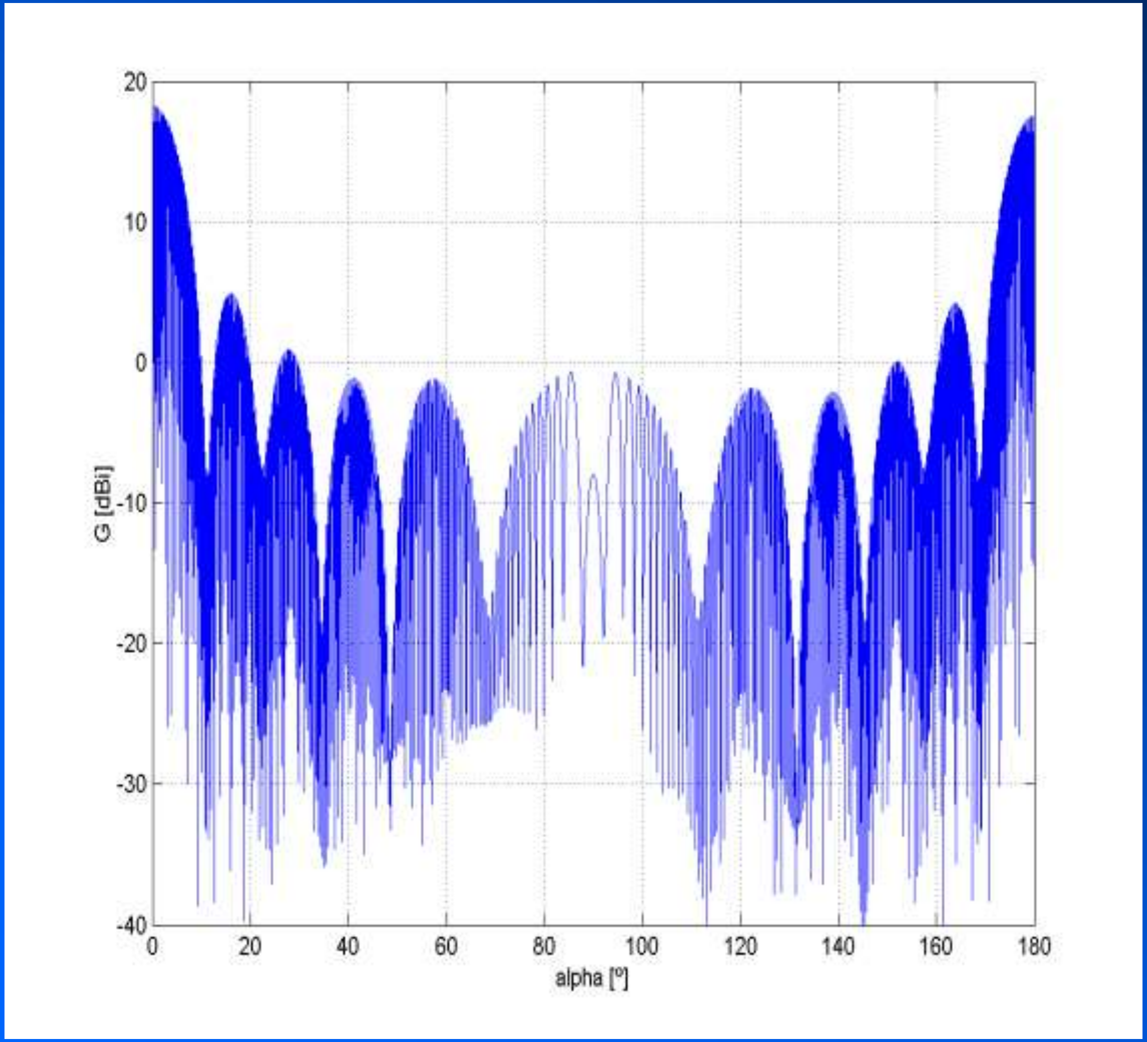
VHF AND UHF BROADCAST ANTENNAS



FM “V” DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

$f = 100$ MHz

$H_0 = 300$ m

$Wt = 1$ kW

GAIN OVER PERFECT GROUND

$n = 8$

$d = 0.7\ \lambda$

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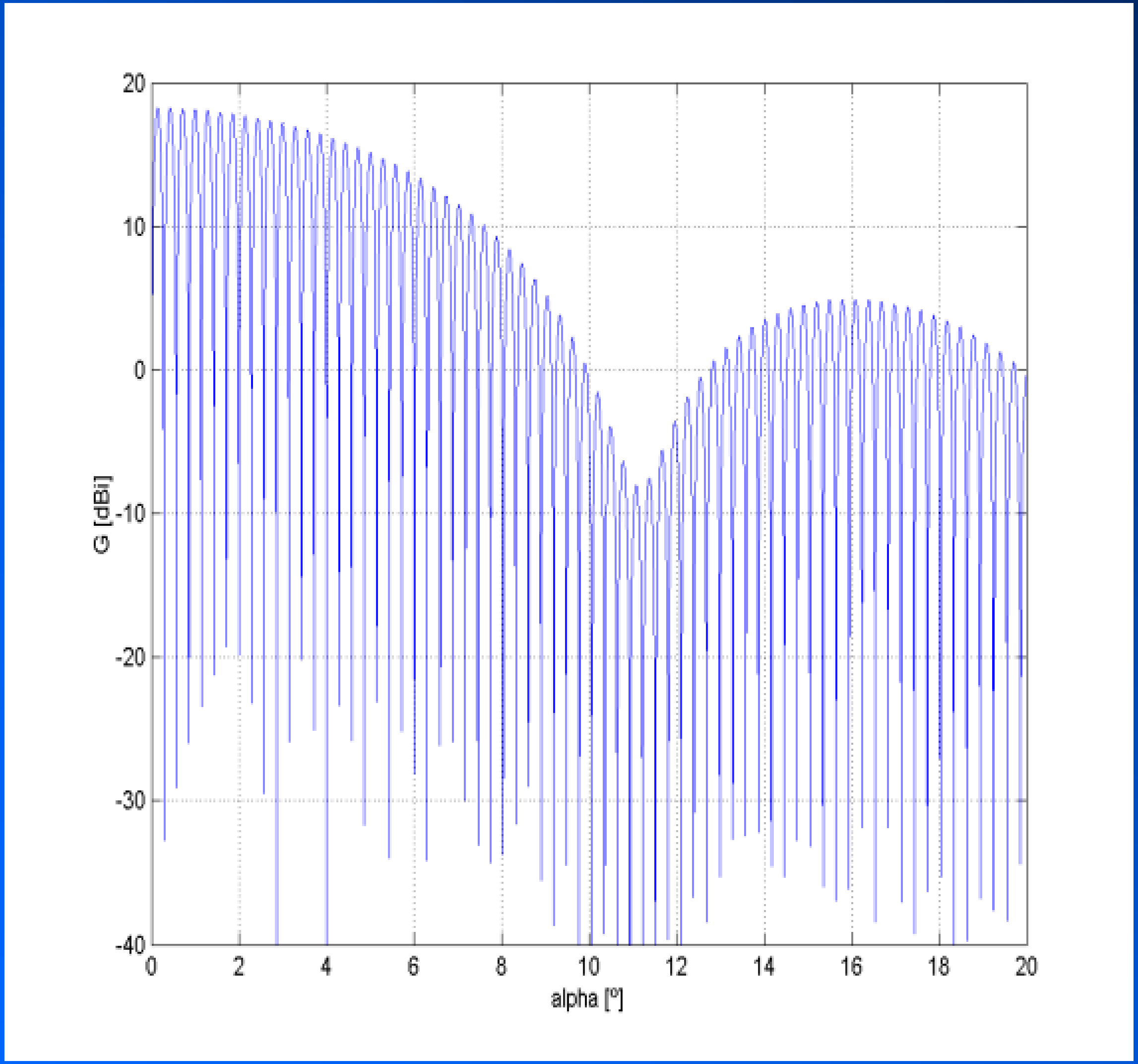
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

f = 100 MHz

H_0 = 300 m

Wt = 1 kW

GAIN OVER PERFECT GROUND

n = 8

d = 0.7 λ

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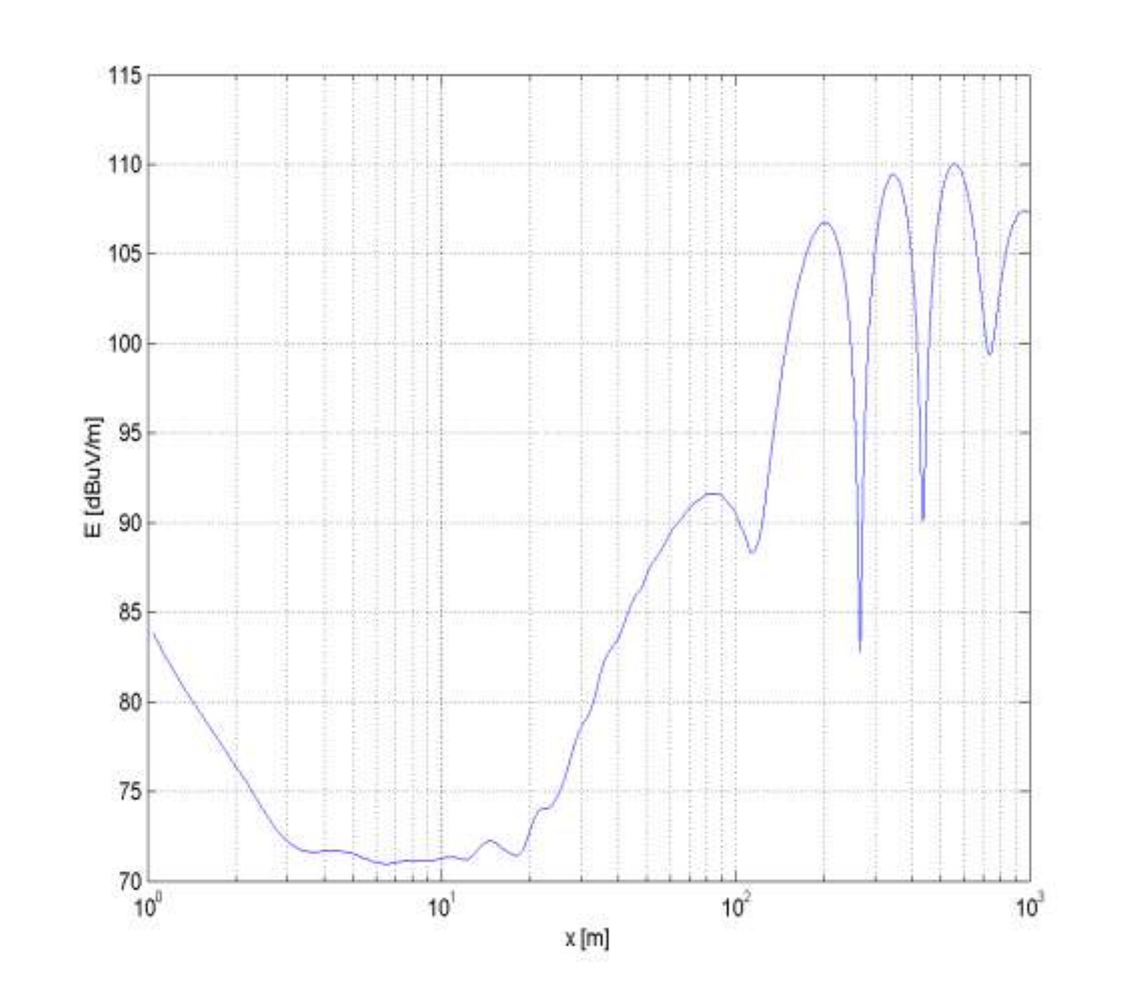
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

f = 100 MHz

H_0 = 300 m

Wt = 1 kW

NEAR E FIELD OVER PERFECT GROUND

n = 8

d = 0.7 λ

z = 1.5 m

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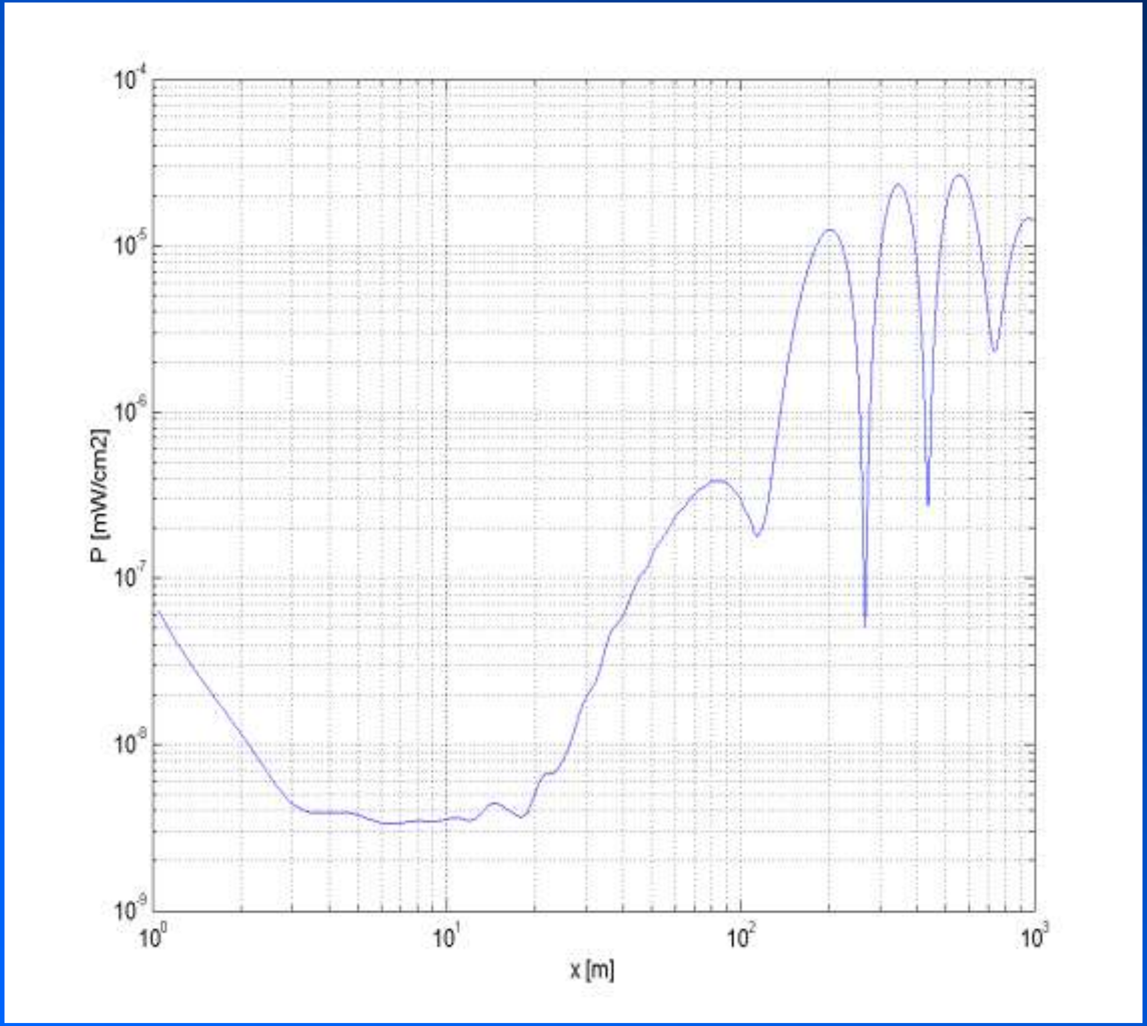
VHF AND UHF BROADCAST ANTENNAS



FM "V" DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

$f = 100$ MHz

$H_0 = 300$ m

$Wt = 1$ kW

NEAR POWER DENSITY OVER PERFECT GROUND

$n = 8$

$d = 0.7\ \lambda$

$z = 1.5$ m

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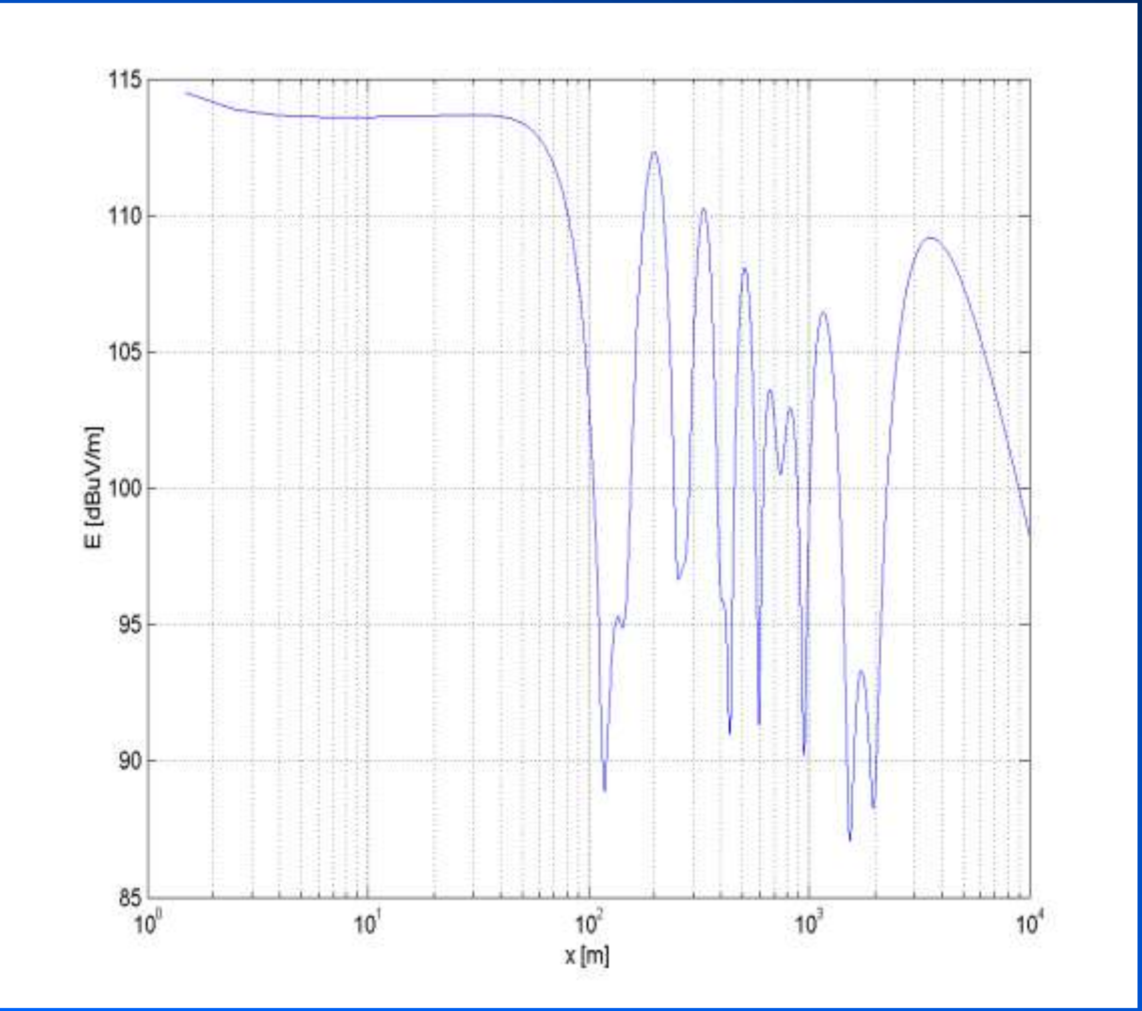
VHF AND UHF BROADCAST ANTENNAS



FM “V” DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

$f = 100$ MHz

$H_0 = 300$ m

$Wt = 1$ kW

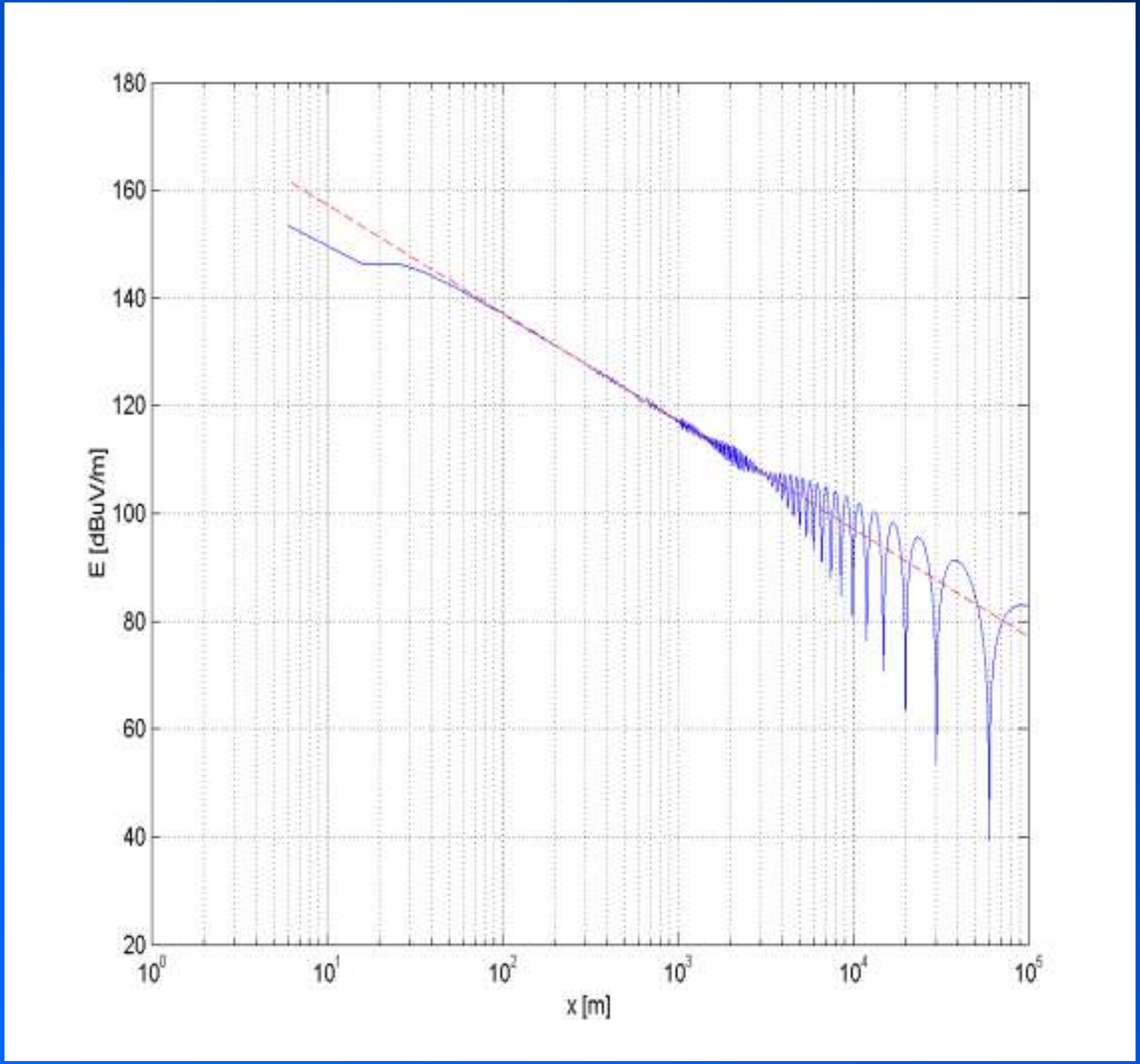
NEAR E FIELD OVER PERFECT GROUND

$n = 8$

$d = 0.7\ \lambda$

$z = 10$ m

VHF AND UHF BROADCAST ANTENNAS



FM “V” DIPOLE ANTENNA ARRAY HORIZONTALLY POLARIZED

$f = 100$ MHz

$H_0 = 300$ m

$Wt = 1$ kW

NEAR E FIELD OVER PERFECT GROUND

$n = 8$

$d = 0.7\ \lambda$

$z = 300$ m

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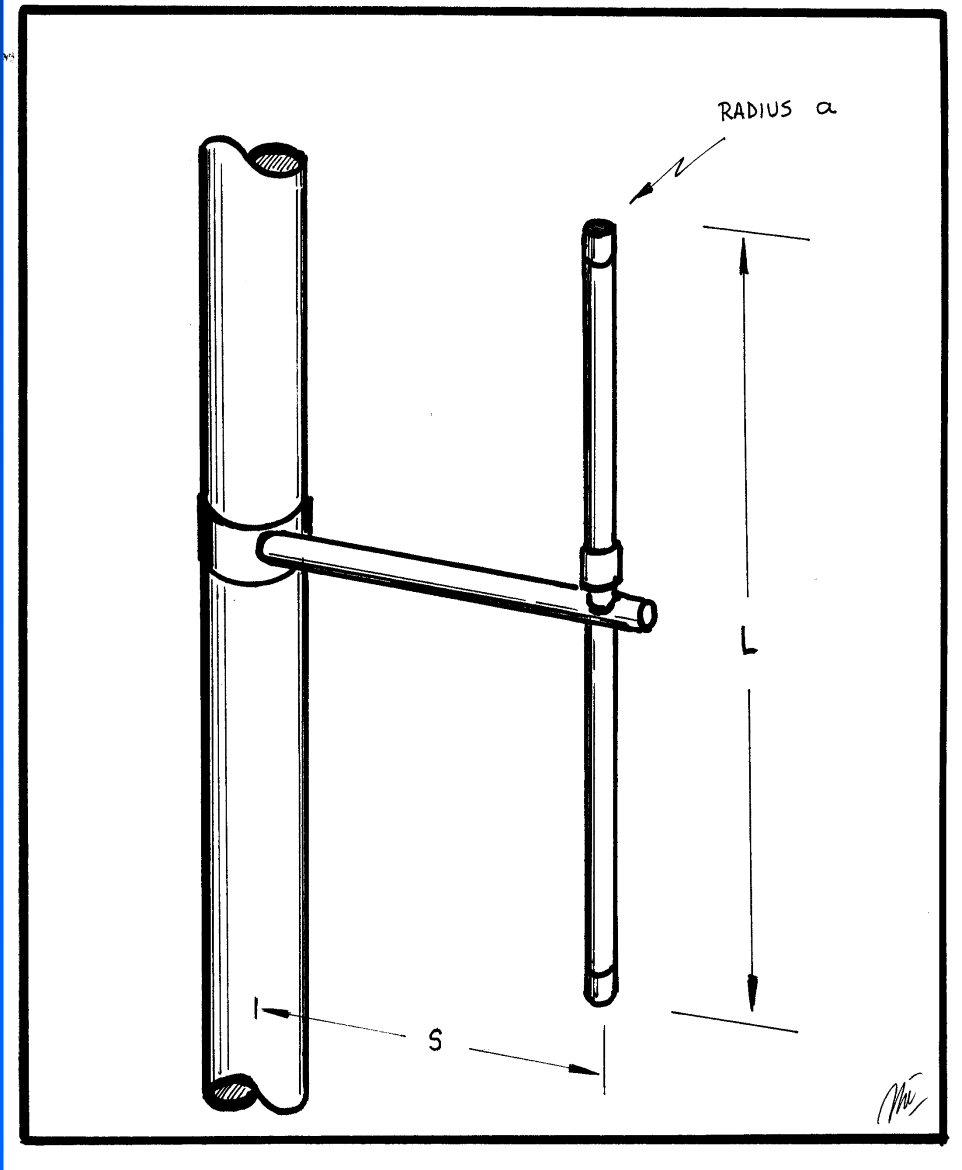
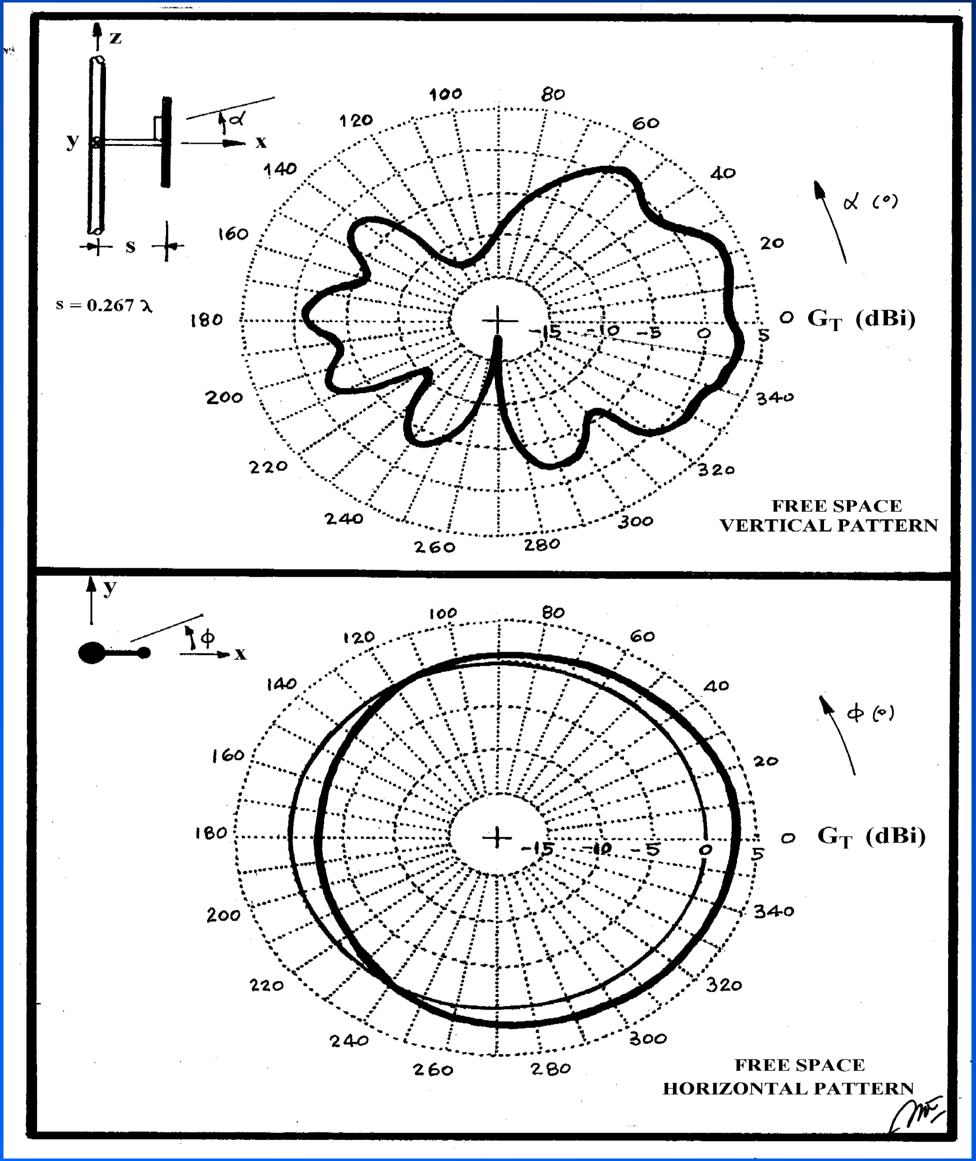
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE
ANTENNA
VERTICALLY
POLARIZED

GAIN
FREE SPACE

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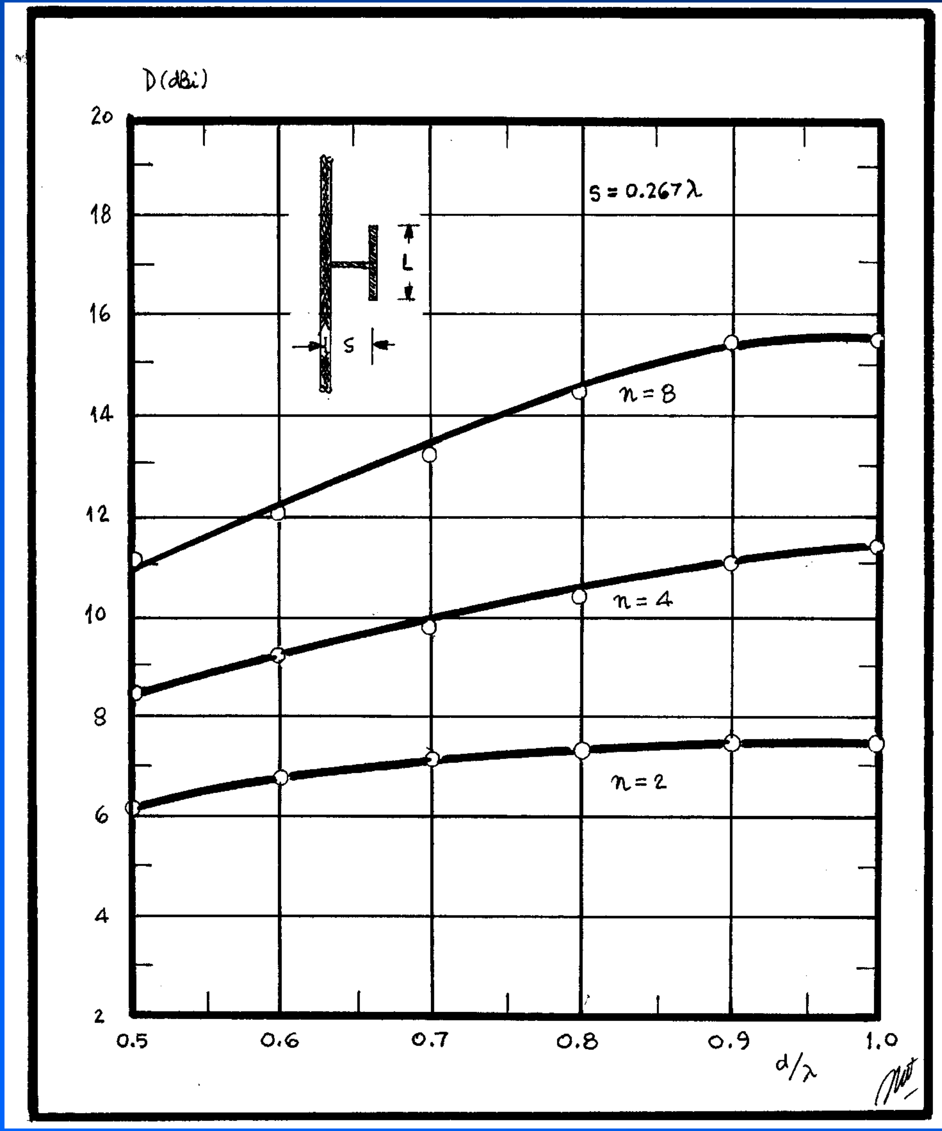
VHF AND UHF BROADCAST ANTENNAS

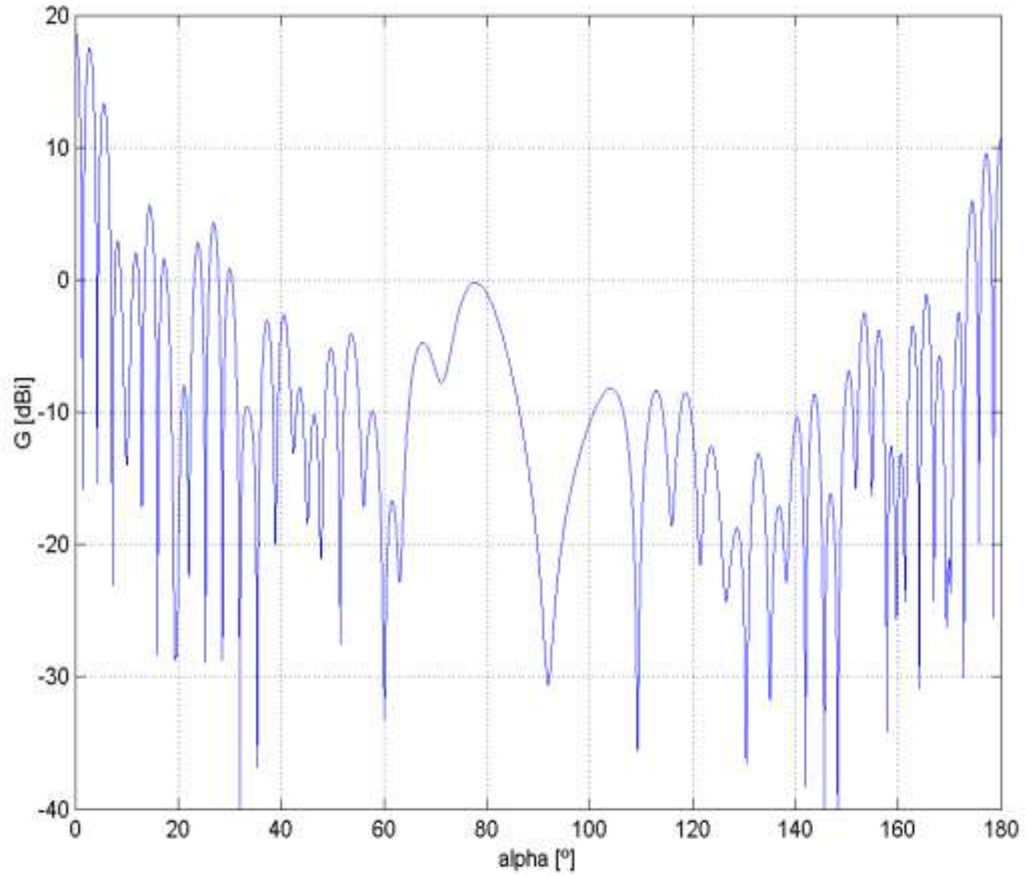


FM DIPOLE ANTENNA VERTICALLY POLARIZED

GAIN FREE SPACE

f = 100 MHz
FBR = 5.63 dB

VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

H = 30 m

GAIN OVER PERFECT GROUND

n = 8

D_{TM} = 11.14 dBi

FBR = 7.56 dB

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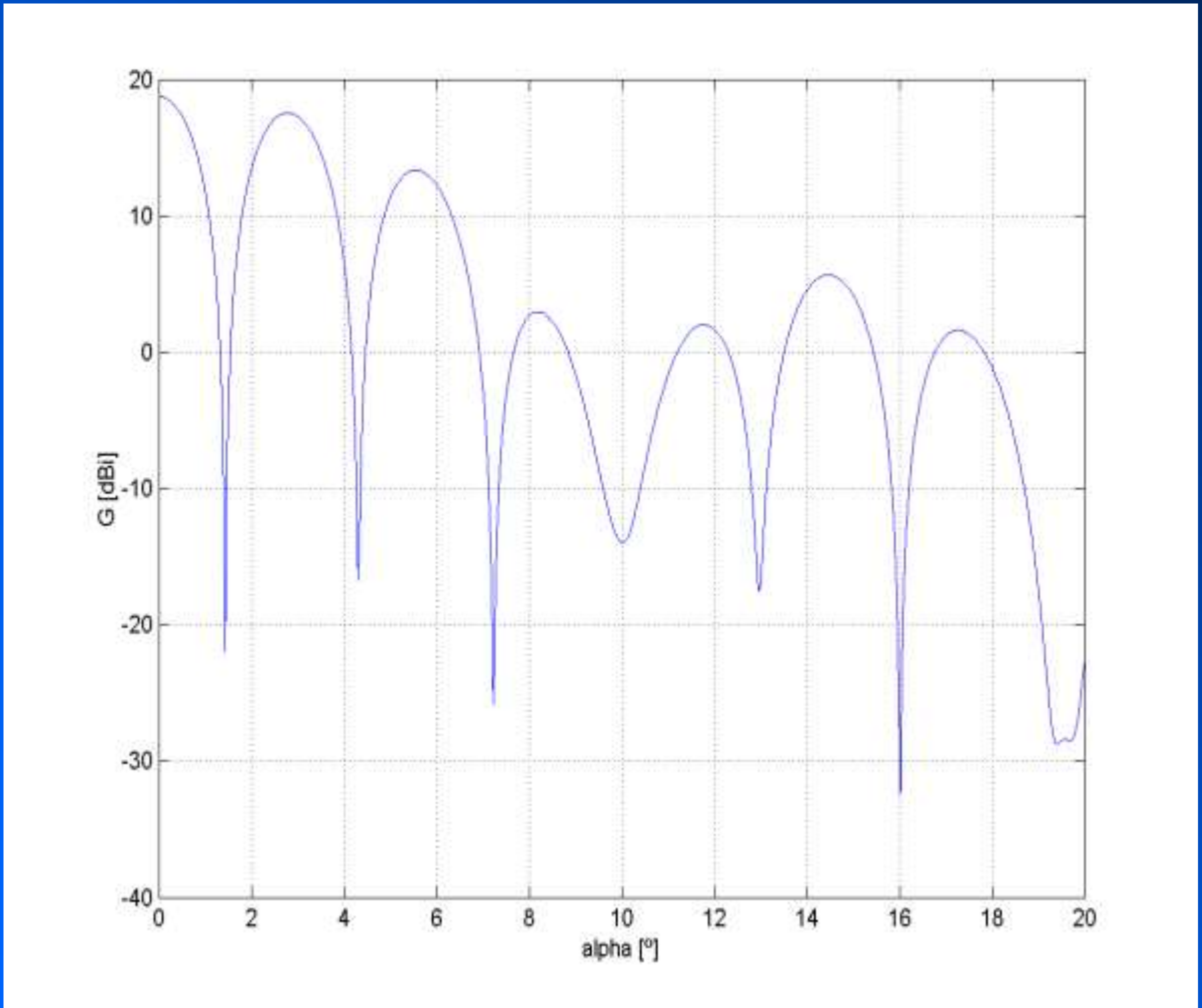
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

H = 30 m

GAIN OVER PERFECT GROUND

n = 8

D_{TM} = 11.14 dBi

FBR = 7.56 dB

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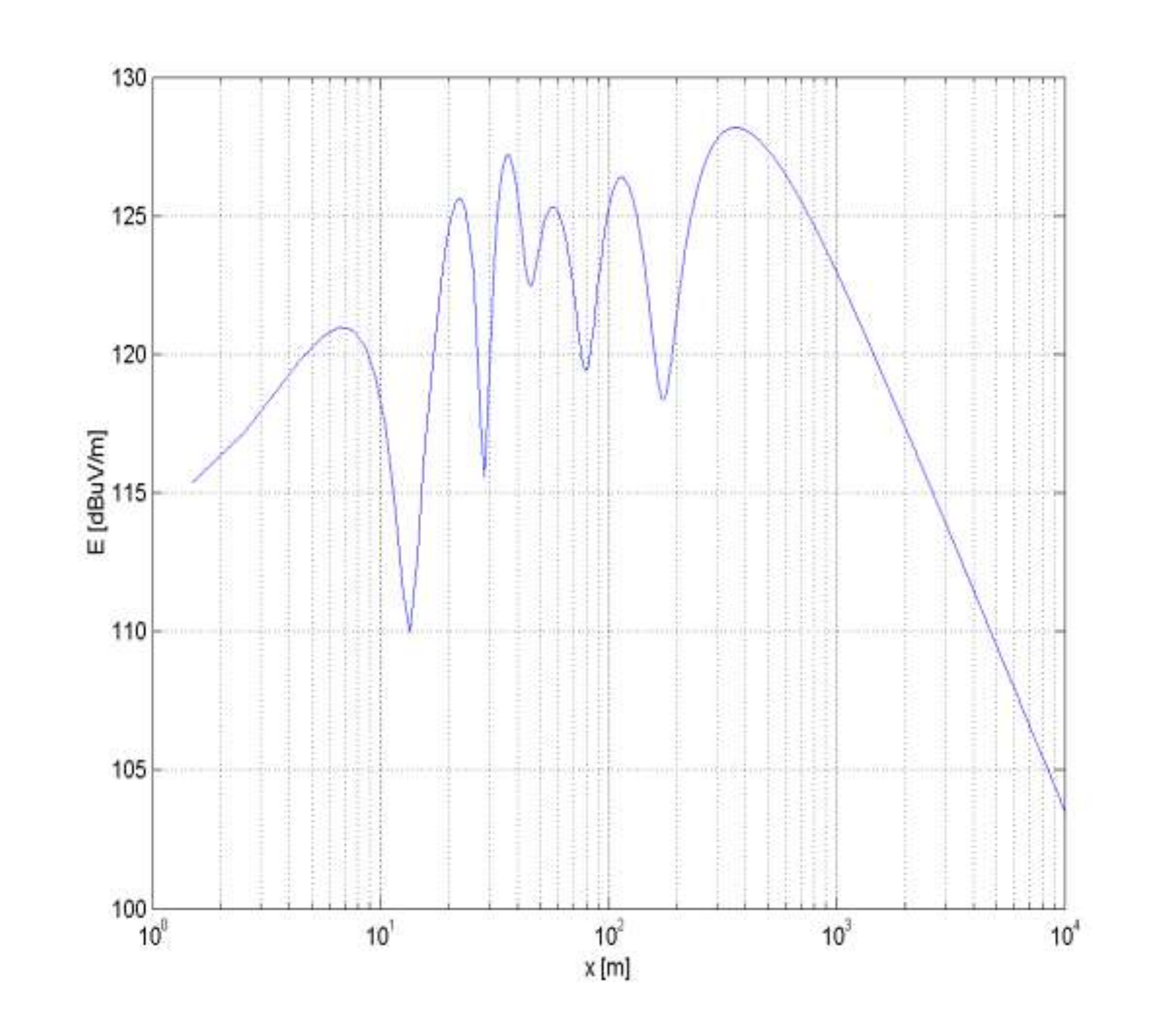
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

H = 30 m

NEAR FIELD OVER PERFECT GROUND

n = 8

W_T = 1 kW

z = 1.5 m

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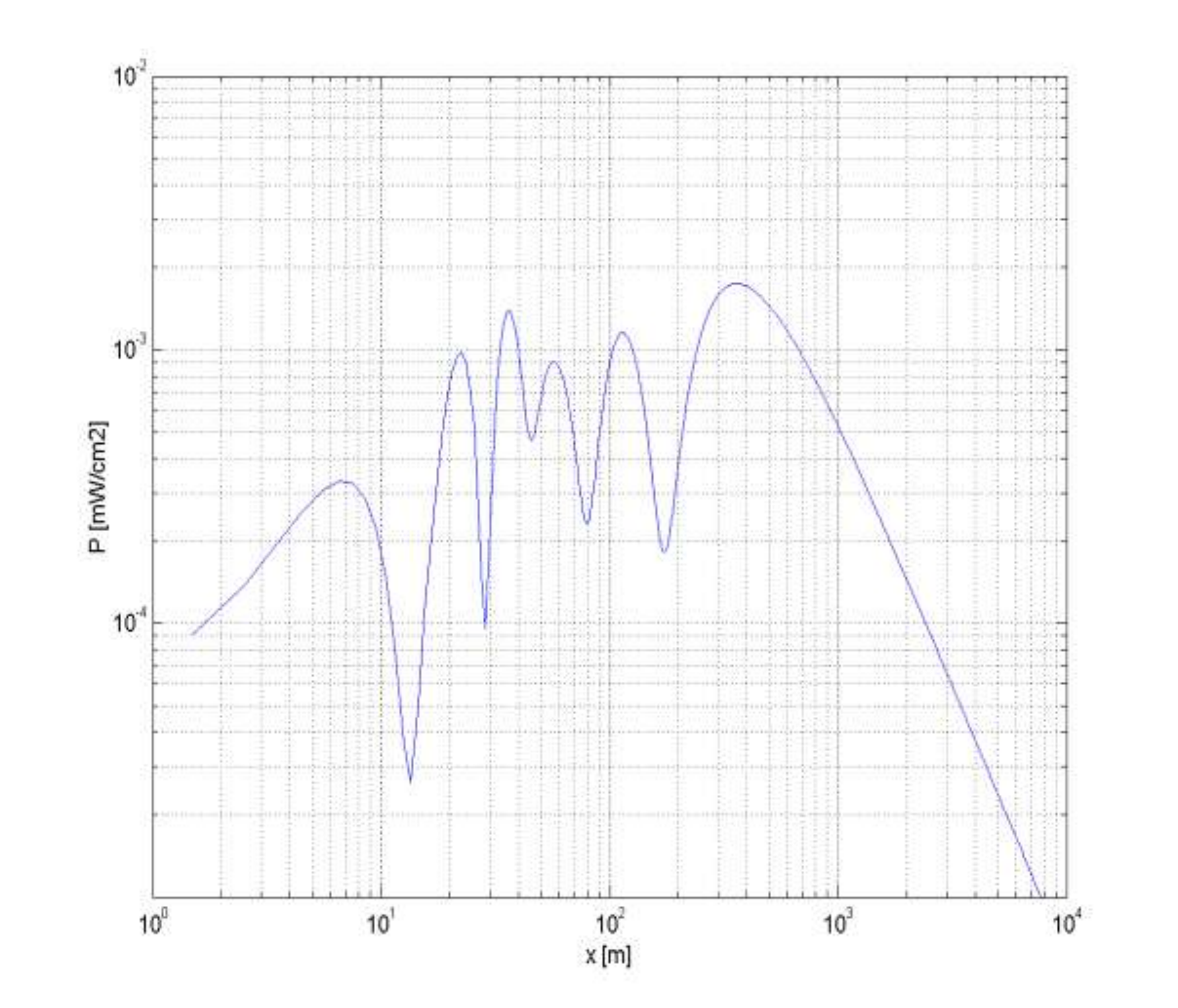
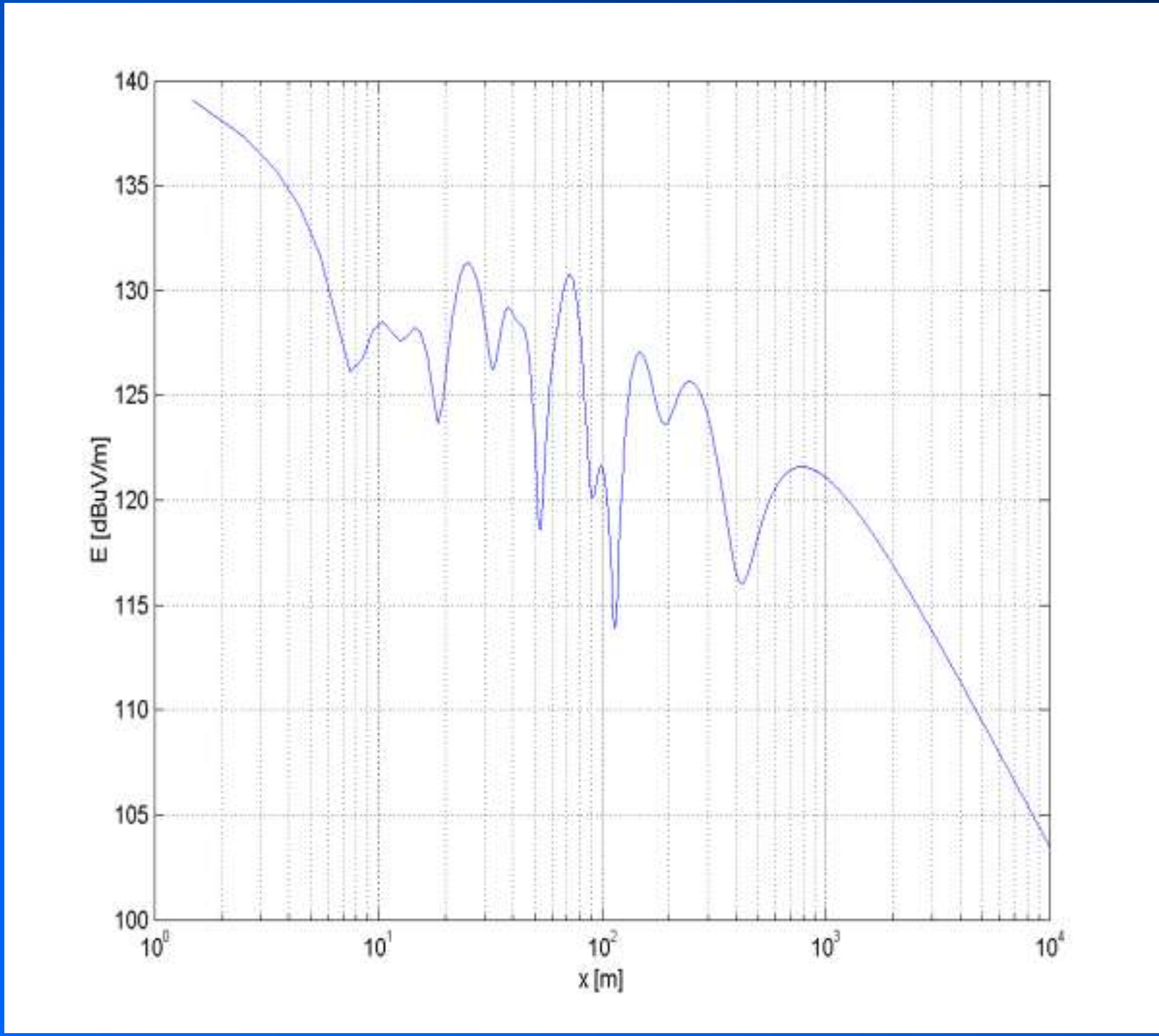
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED
H = 30 m
POWER DENSITY OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 1.5 m

VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

H = 30 m

NEAR FIELD OVER PERFECT GROUND

n = 8

W_T = 1 kW

z = 10 m

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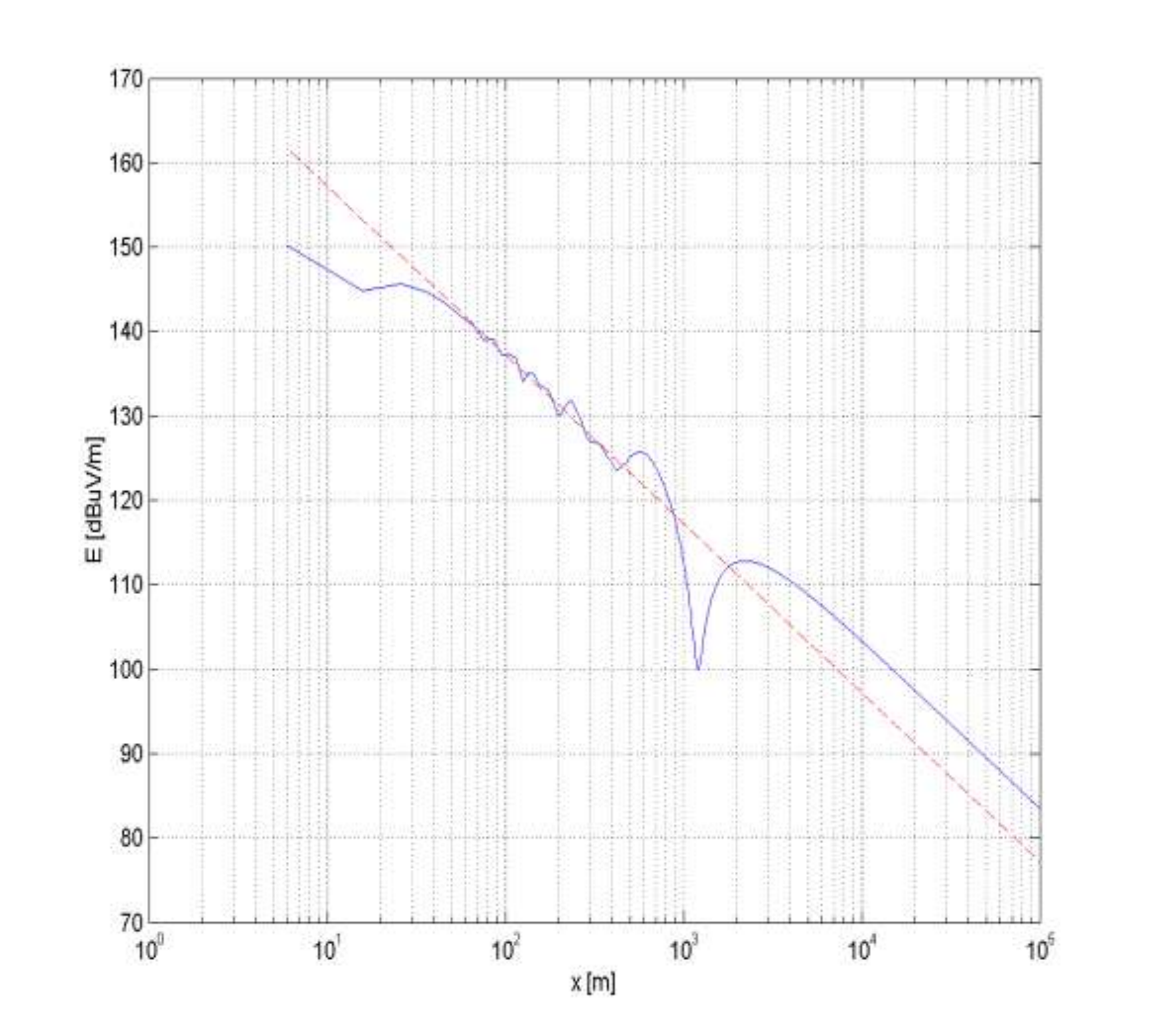
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

H = 30 m

NEAR FIELD OVER PERFECT GROUND

n = 8

W_T = 1 kW

z = 30 m

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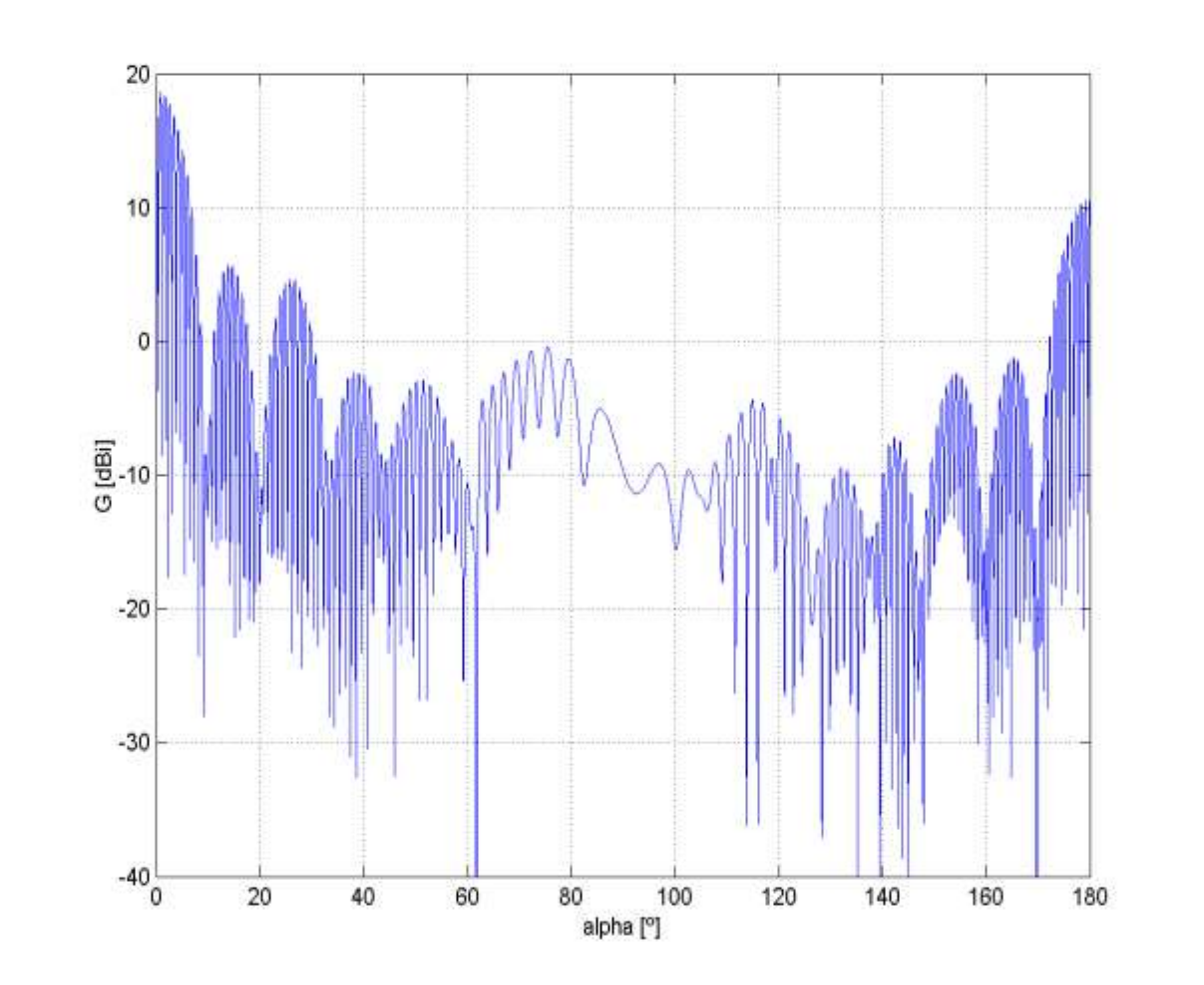
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

H = 100 m

GAIN OVER PERFECT GROUND

n = 8

D_{TM} = 18.8 dBi

FBR = 7.6 dB

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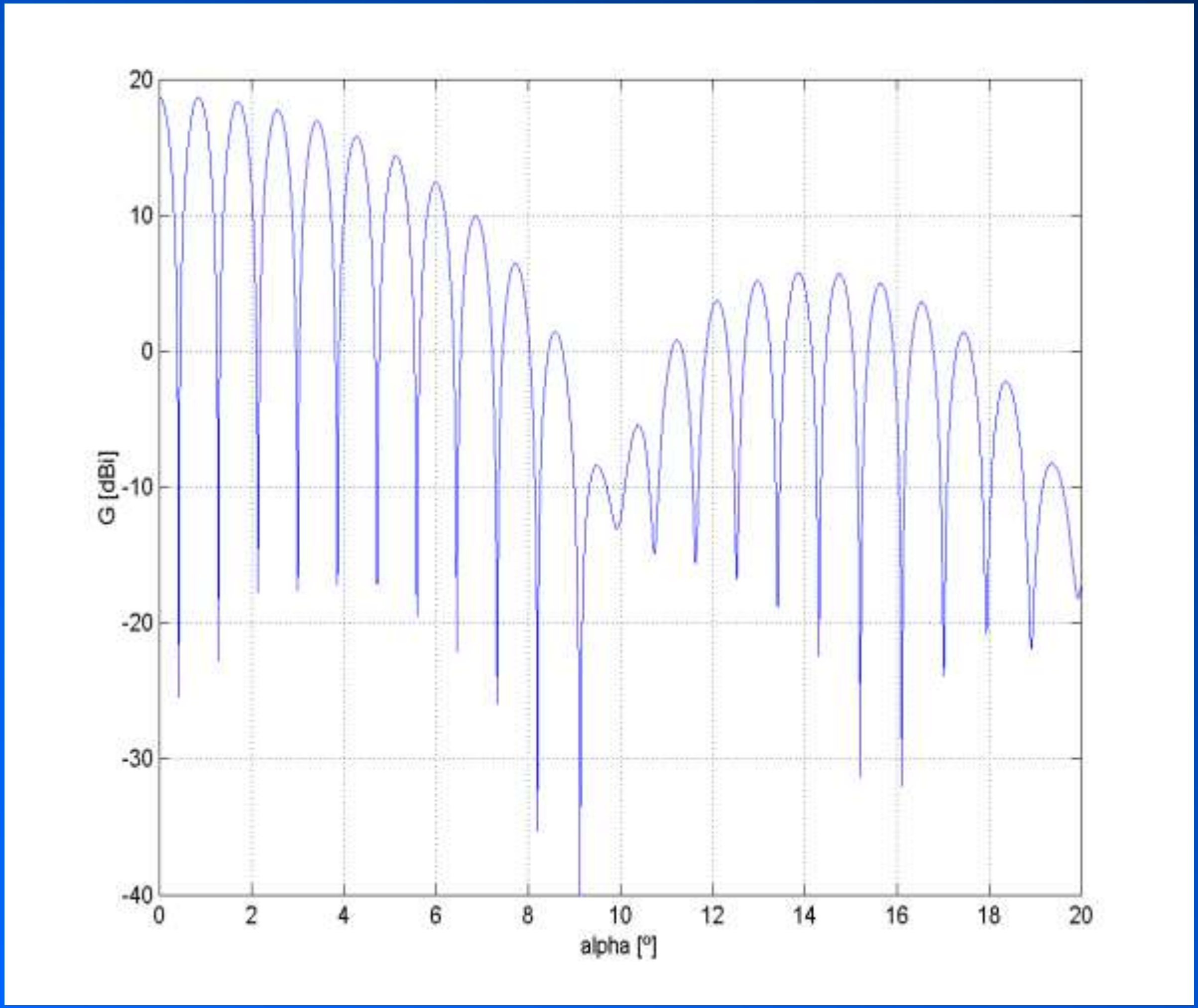
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

H = 100 m

GAIN OVER PERFECT GROUND

n = 8

D_{TM} = 18.8 dBi

FBR = 7.6 dB

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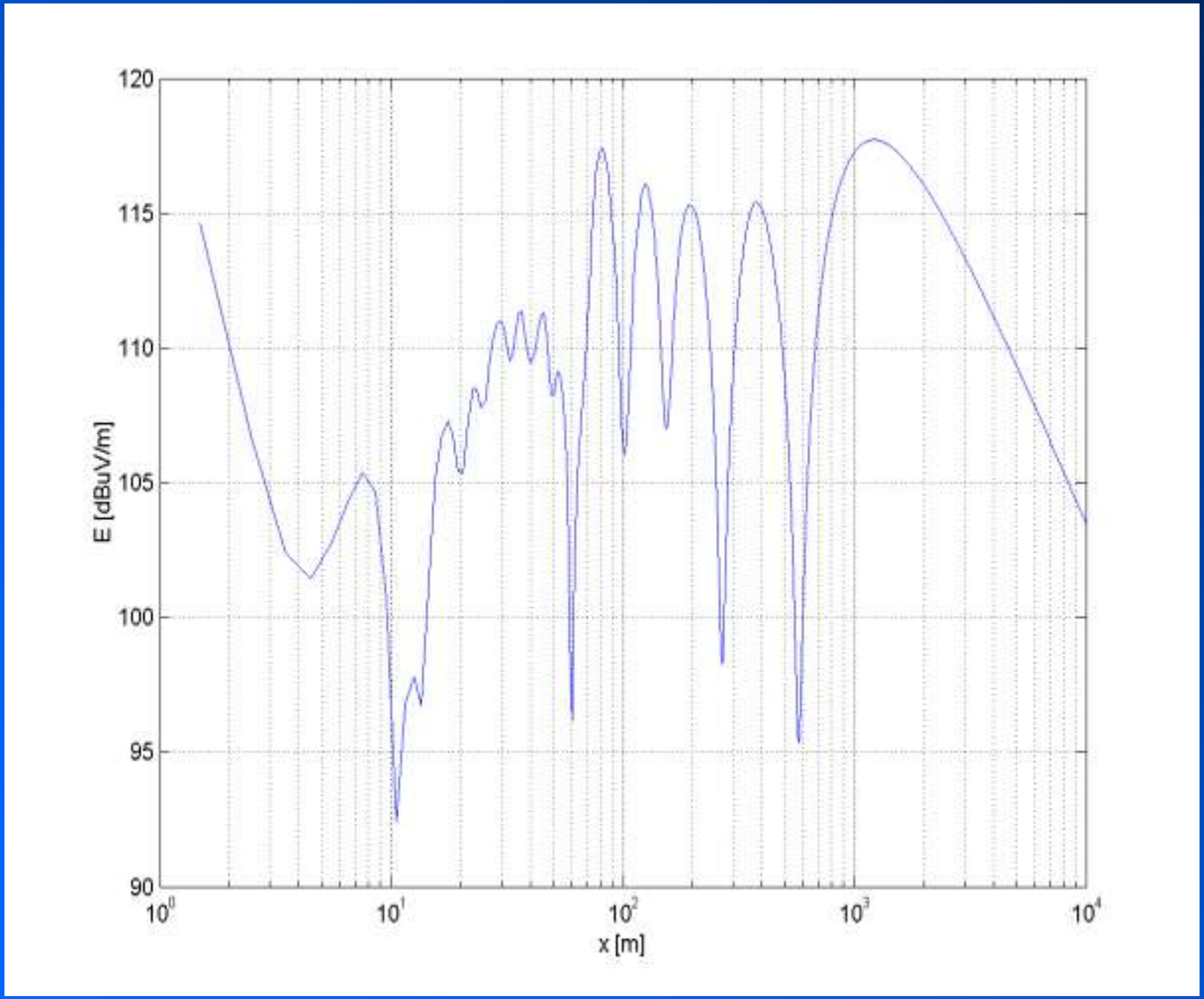
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED
H = 100 m
NEAR FIELD OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 1.5 m

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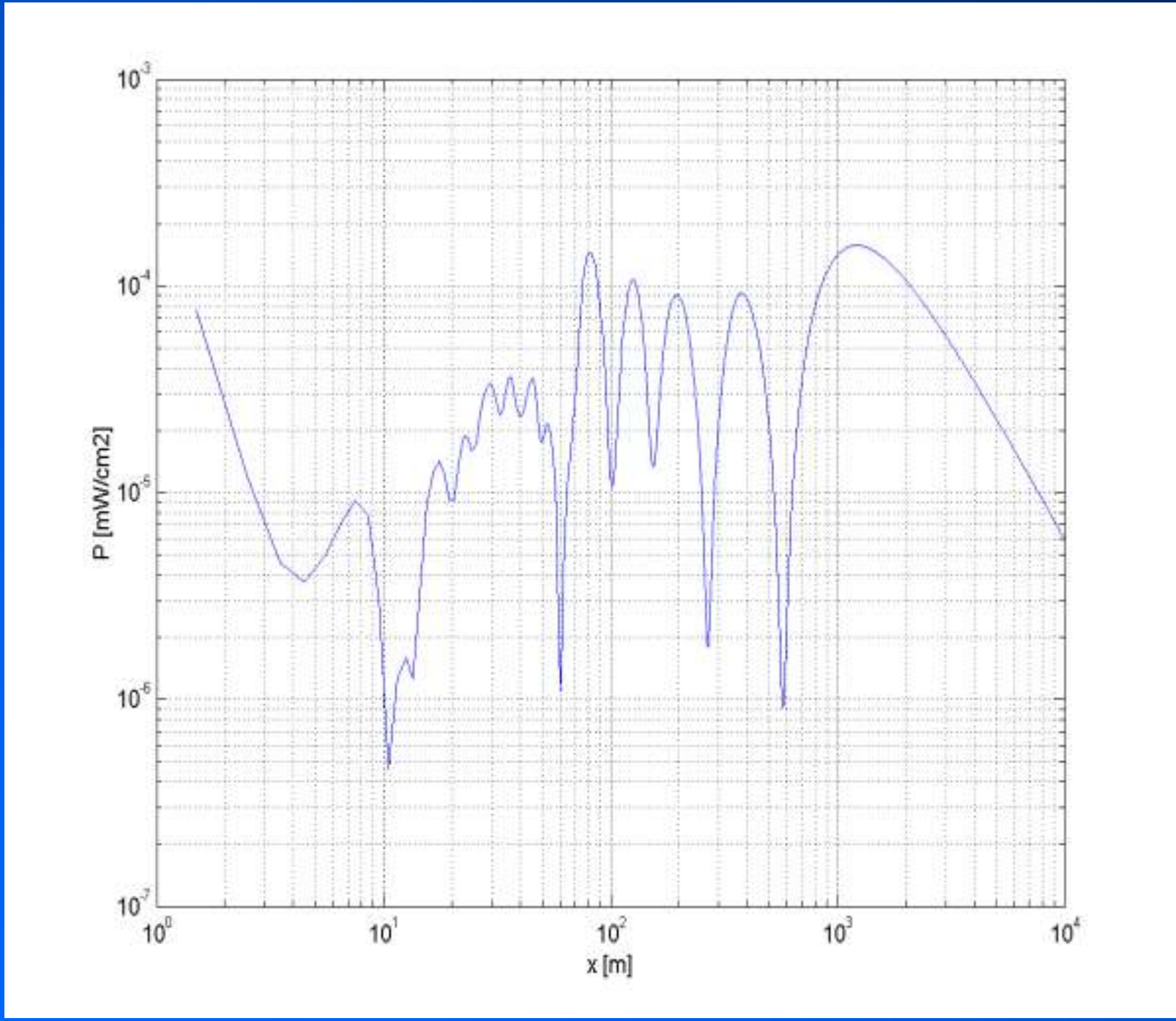
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED
H = 100 m
POWER DENSITY OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 1.5 m

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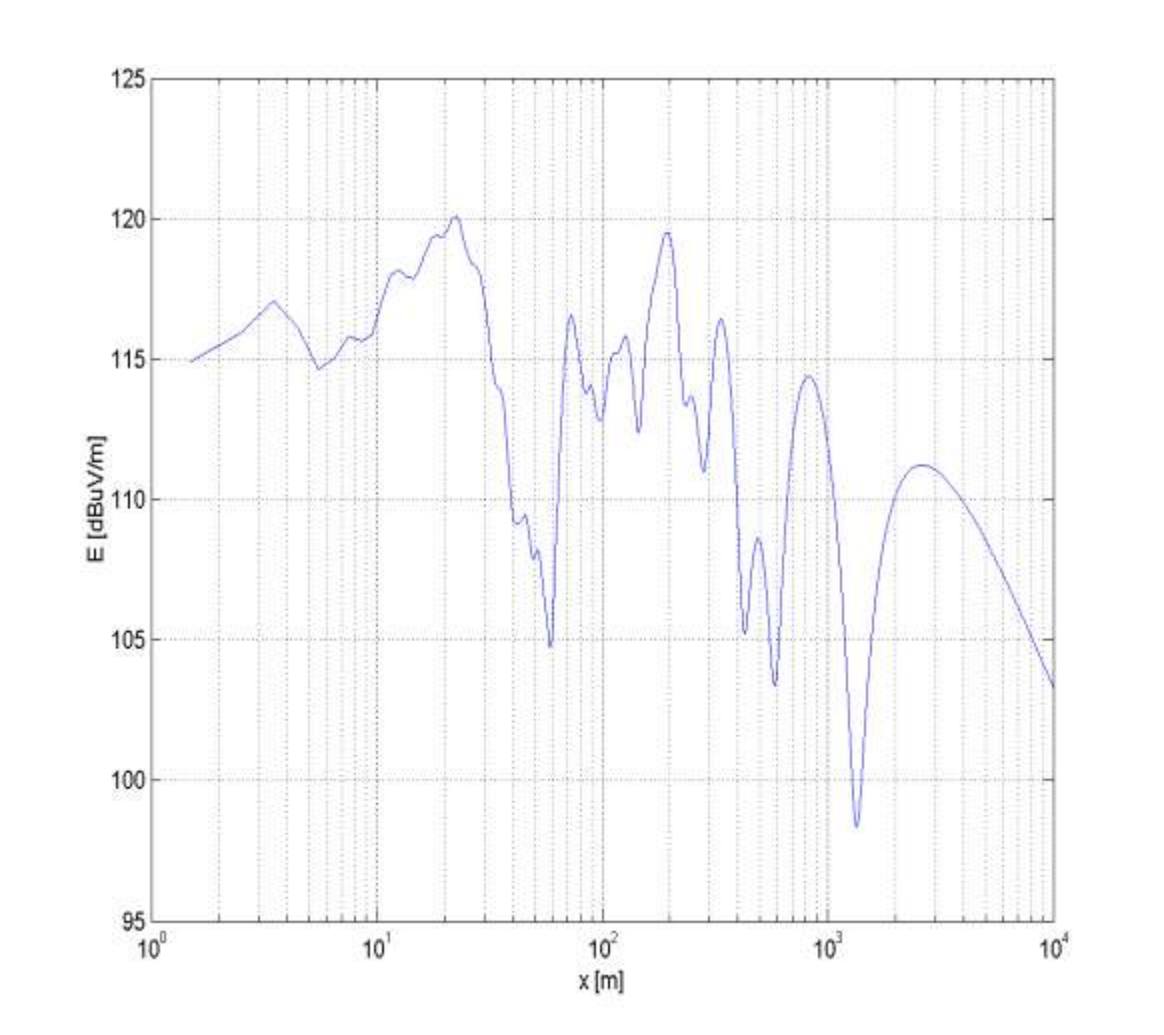
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED
H = 100 m
NEAR FIELD OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 10 m

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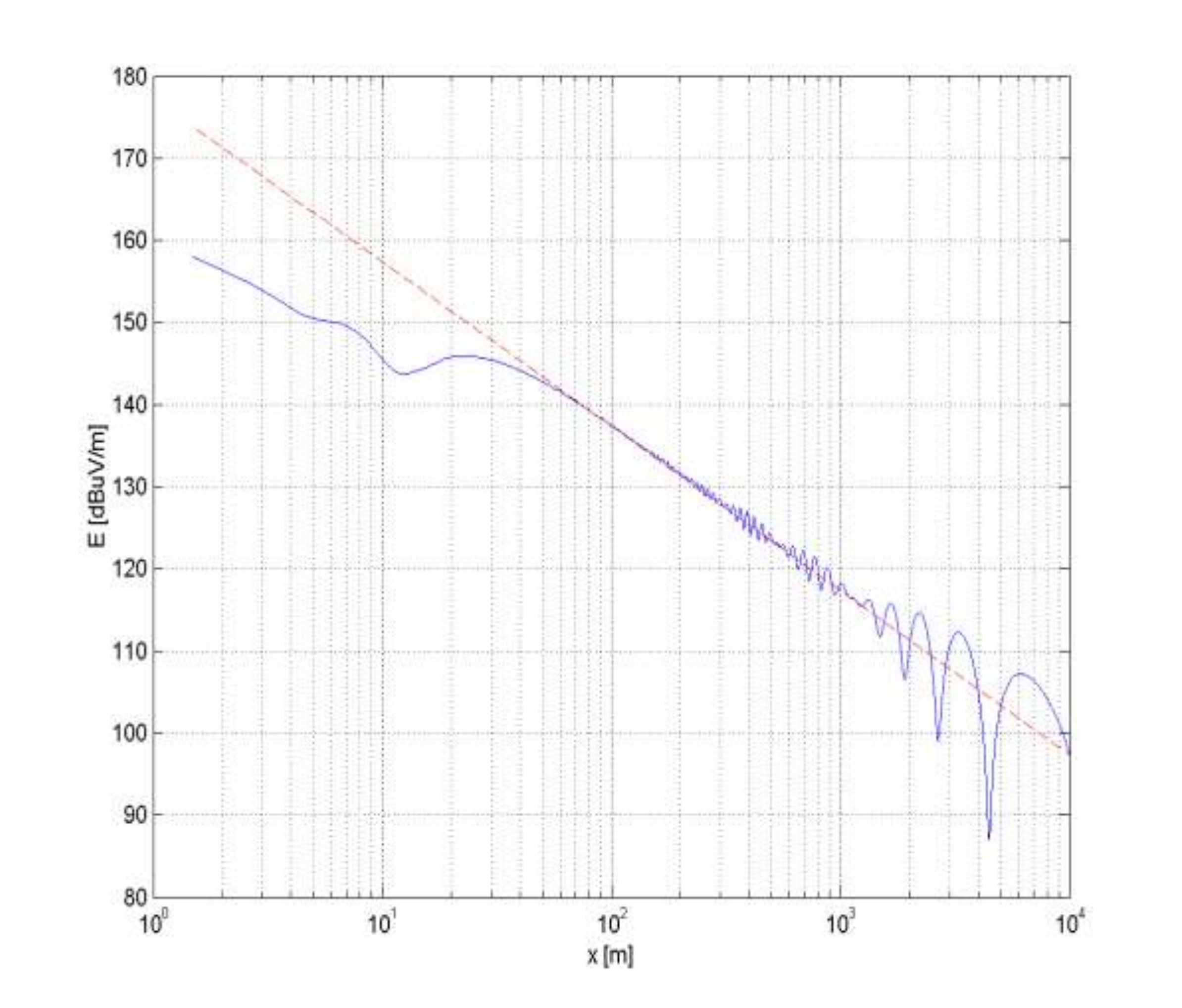
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED
H = 100 m
NEAR FIELD OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 100 m

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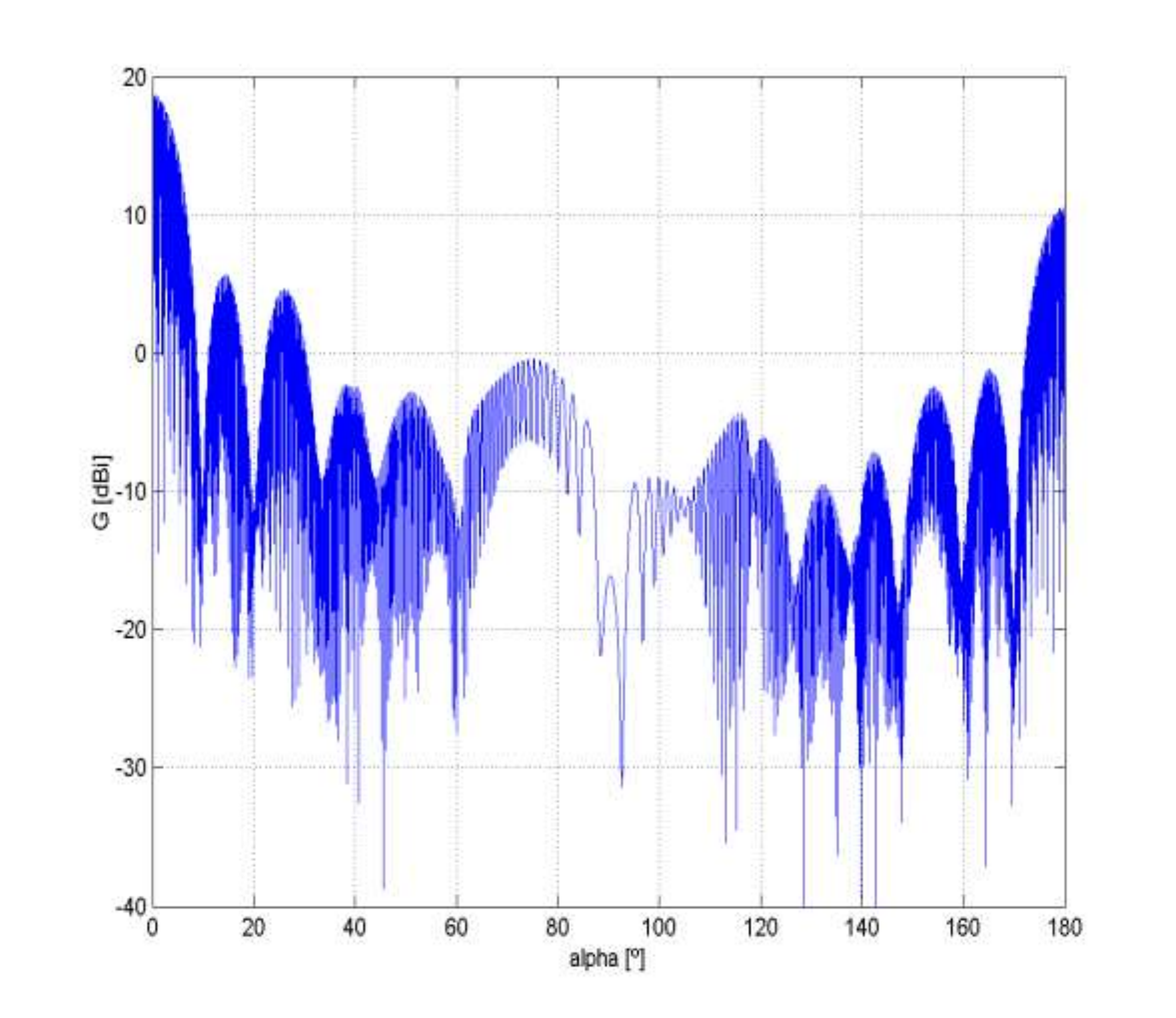
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

H = 300 m

GAIN OVER PERFECT GROUND

n = 8

D_{TM} = 18.8 dBi

FBR = 7.6 dB

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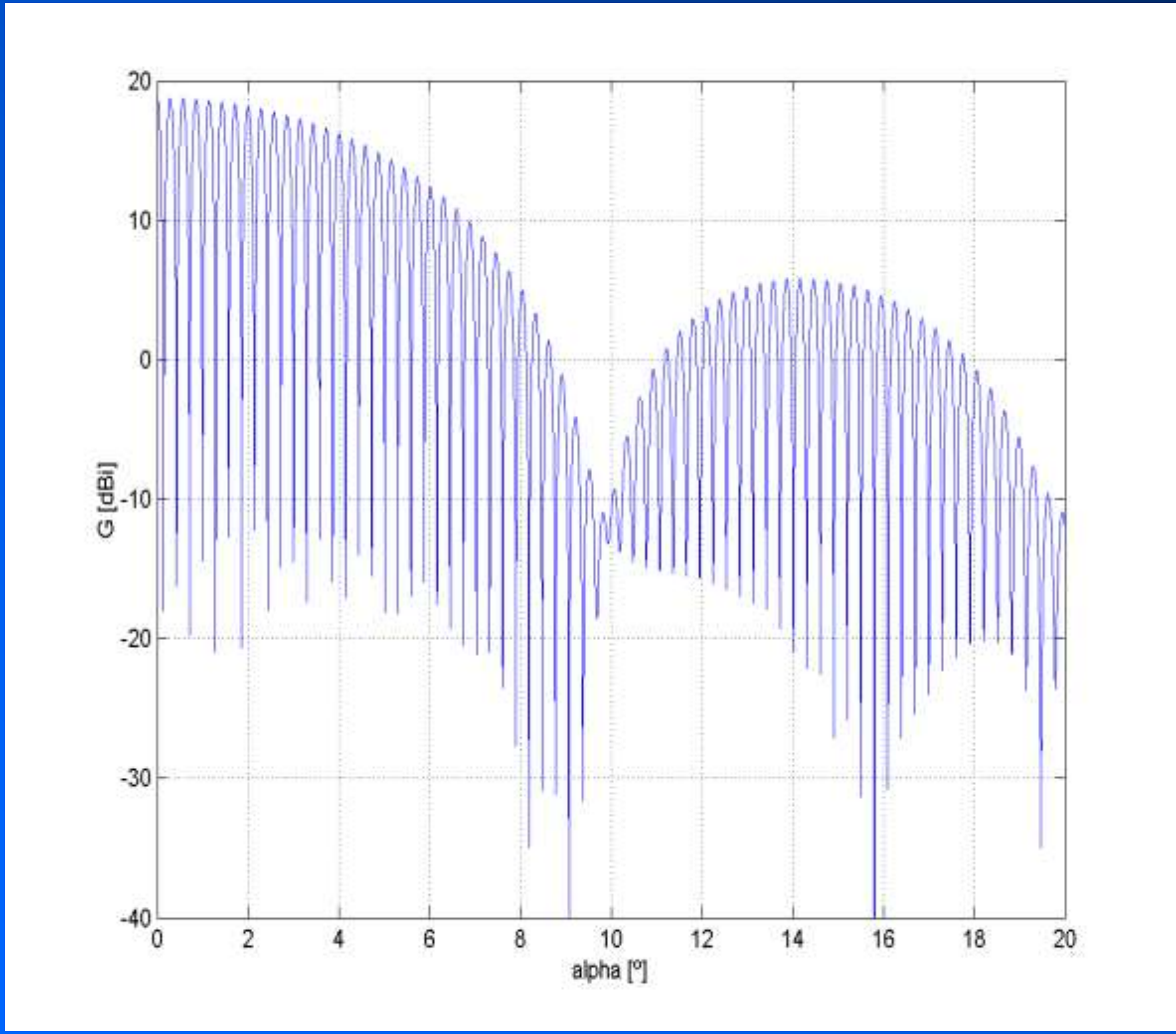
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

H = 300 m

GAIN OVER PERFECT GROUND

n = 8

D_{TM} = 18.8 dBi

FBR = 7.6 dB

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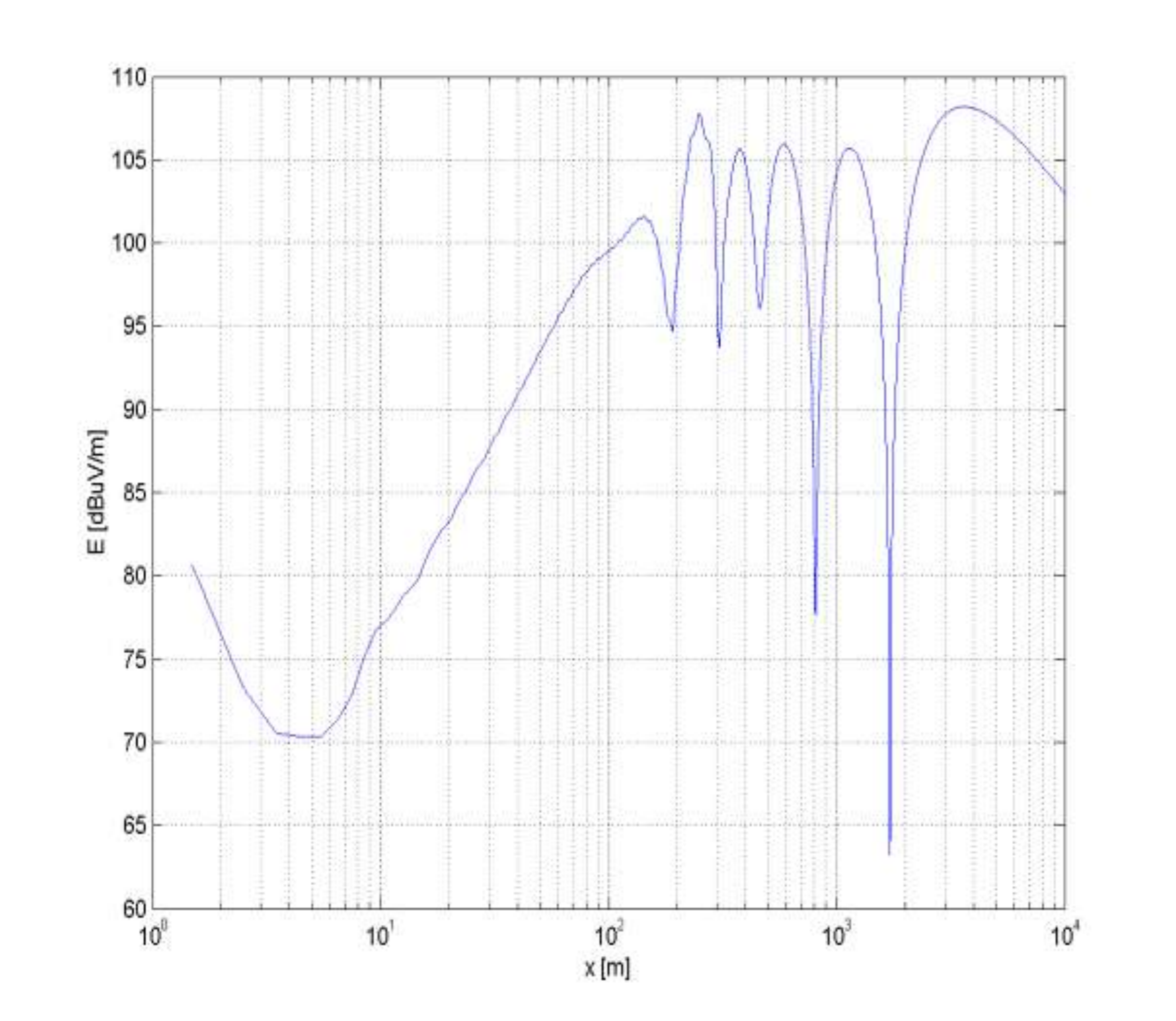
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

H = 300 m

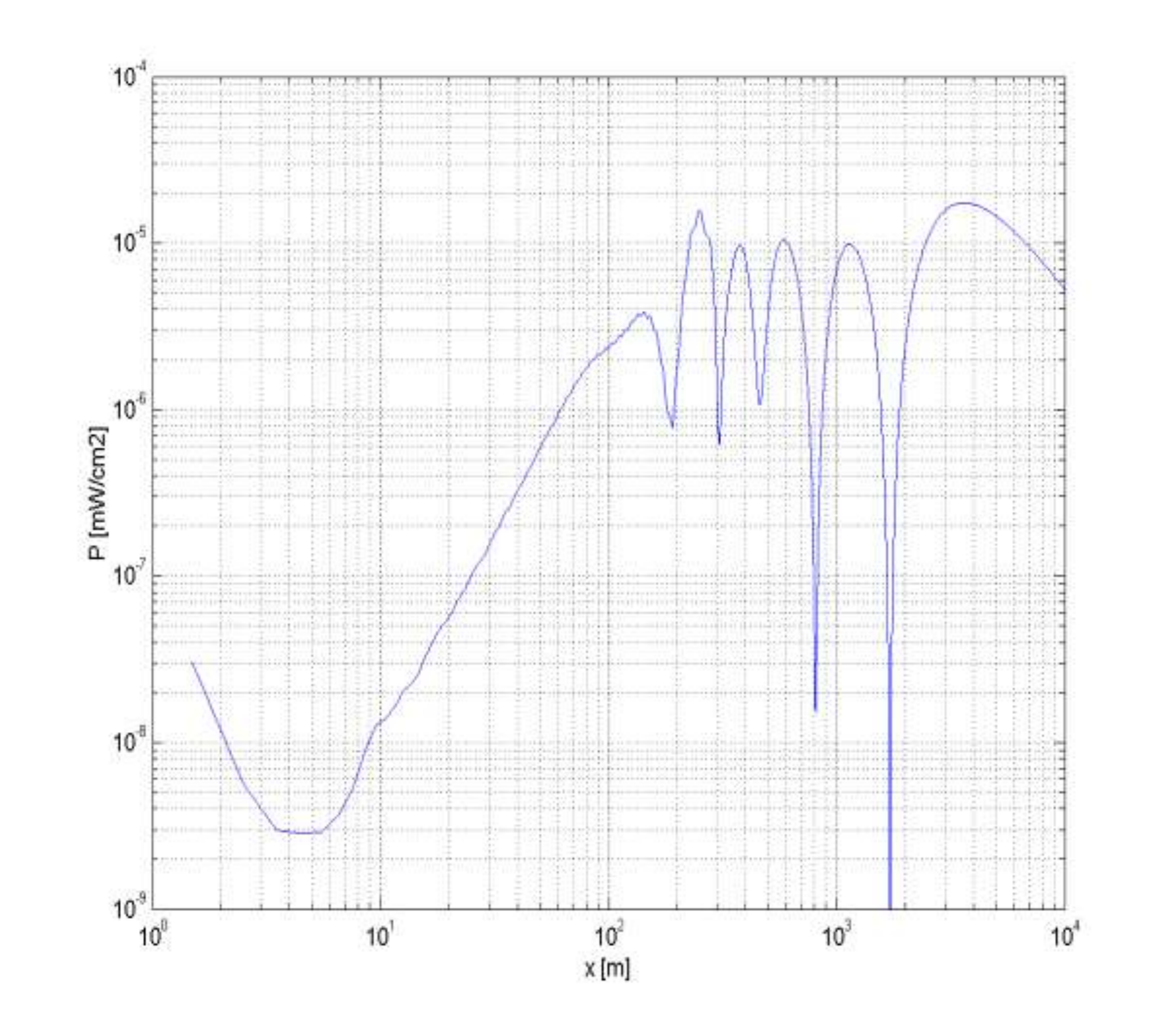
NEAR FIELD OVER PERFECT GROUND

n = 8

W_T = 1 kW

z = 1.5 m

VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED
H = 300 m
POWER DENSITY OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 1.5 m

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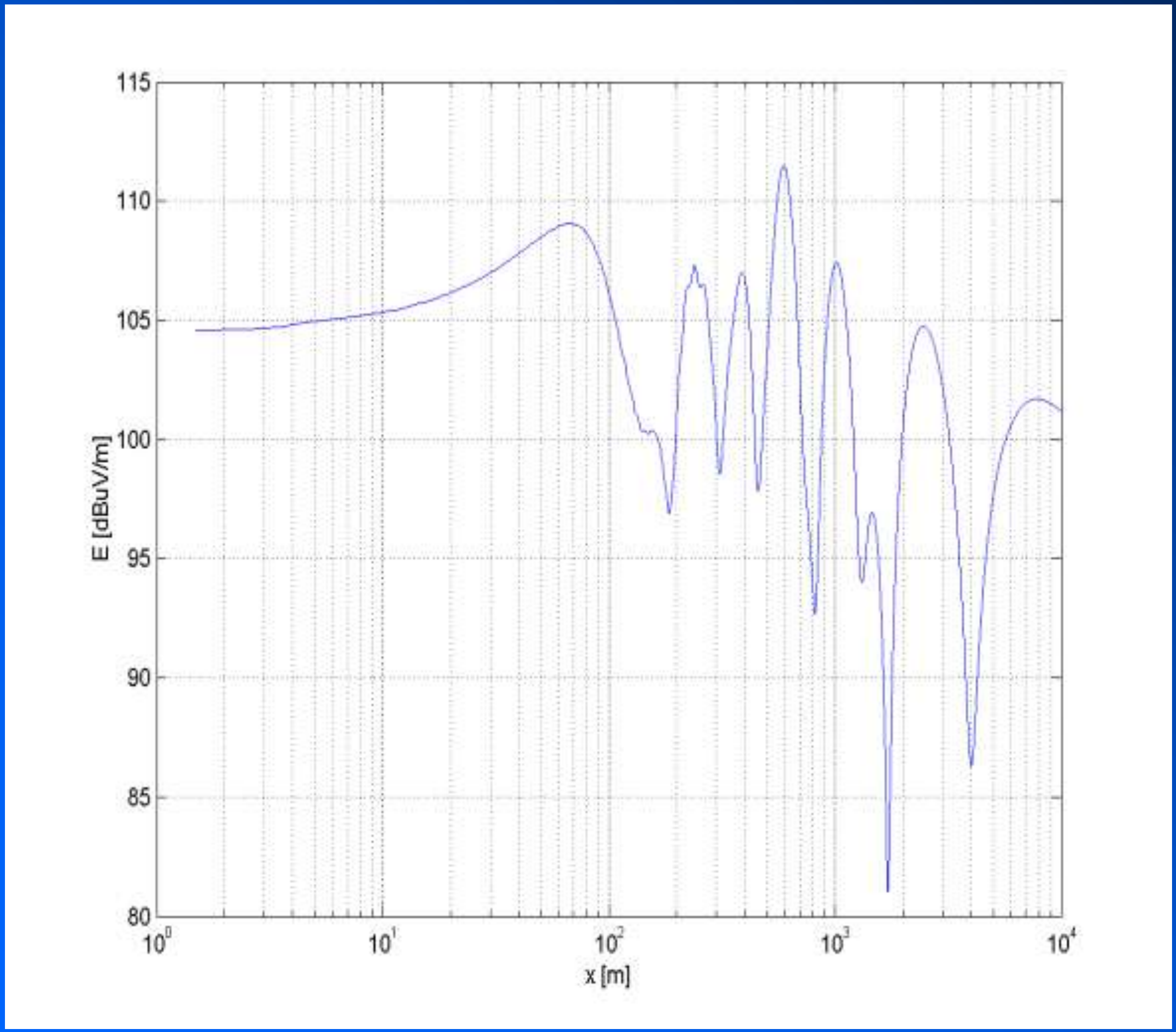
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED
H = 300 m
NEAR FIELD OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 10 m

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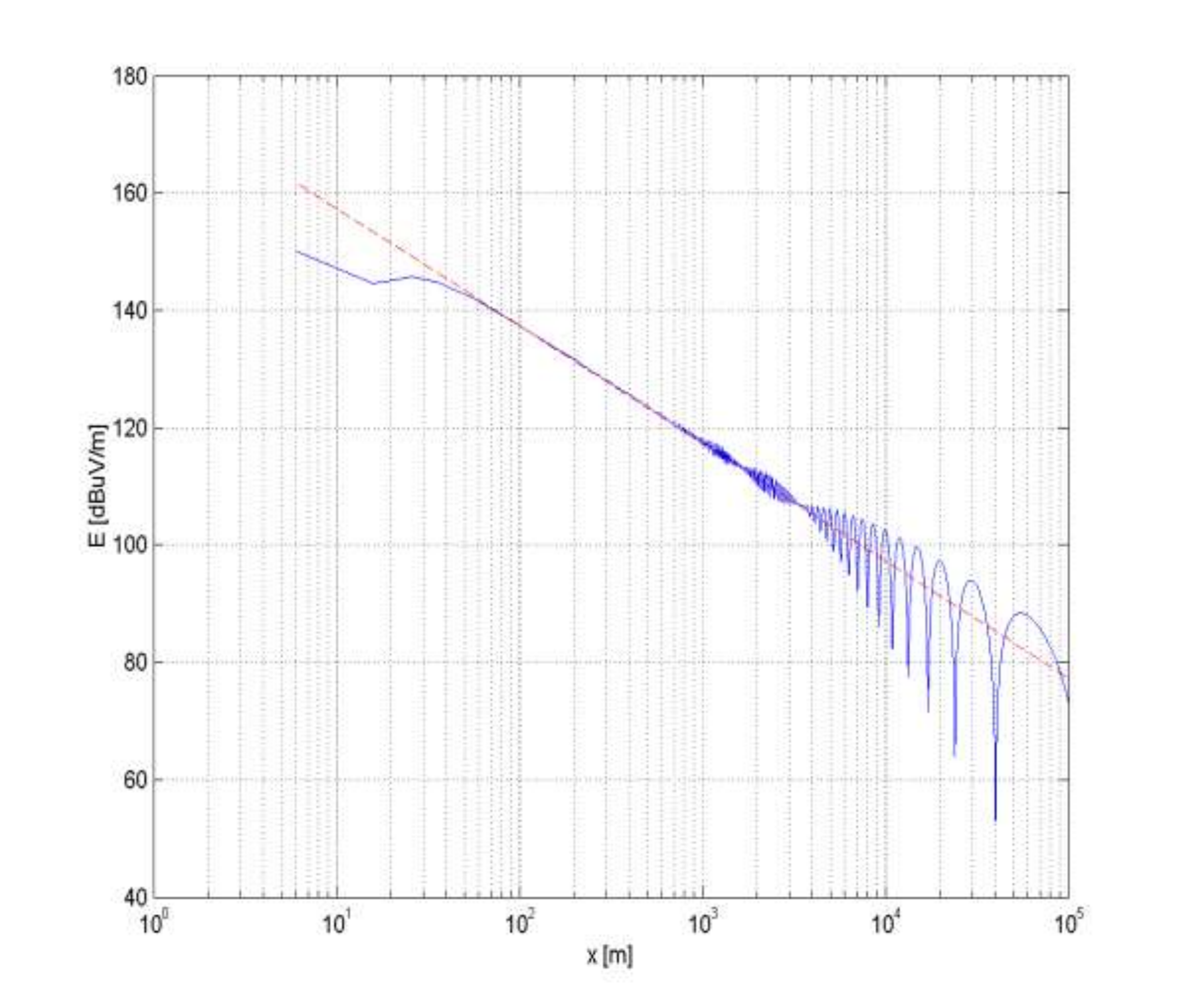
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA VERTICALLY POLARIZED

H = 300 m

NEAR FIELD OVER PERFECT GROUND

n = 8

W_T = 1 kW

z = 300 m

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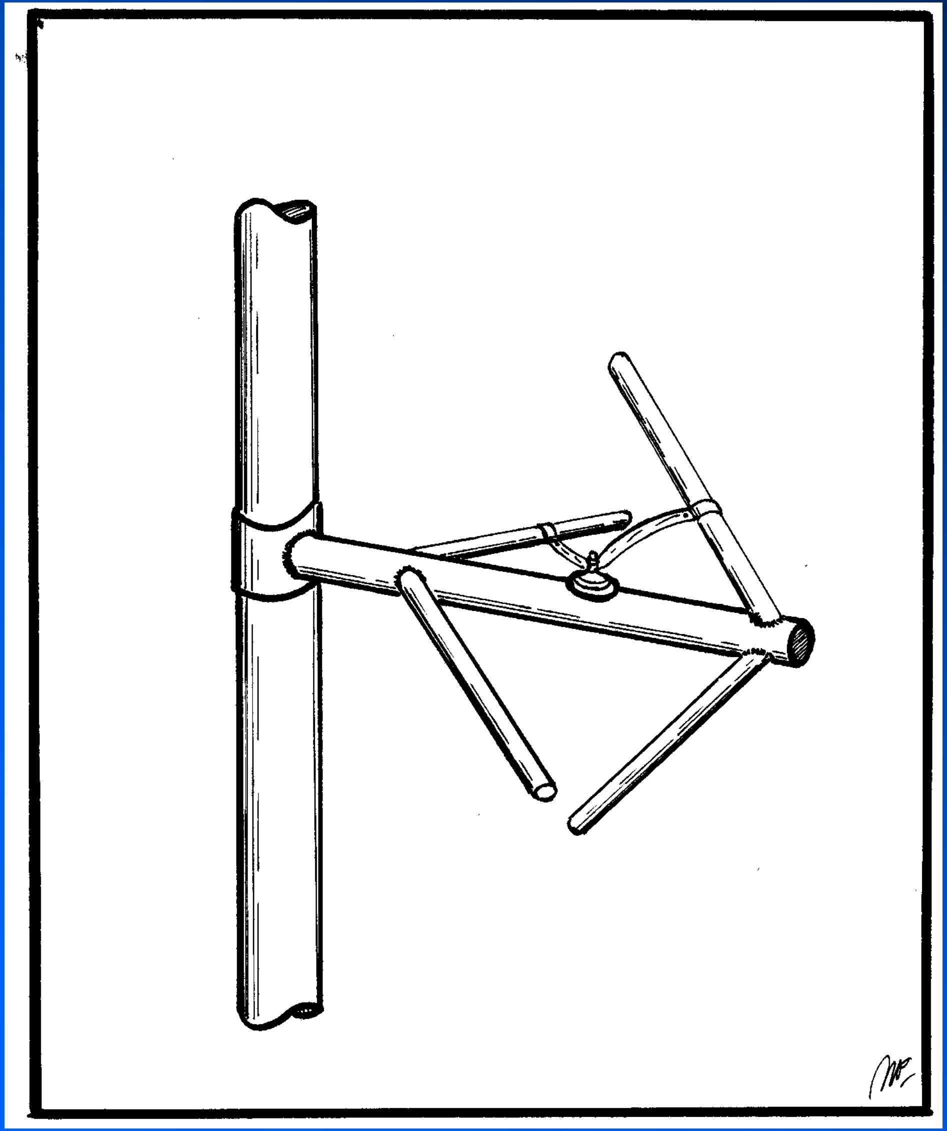
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED

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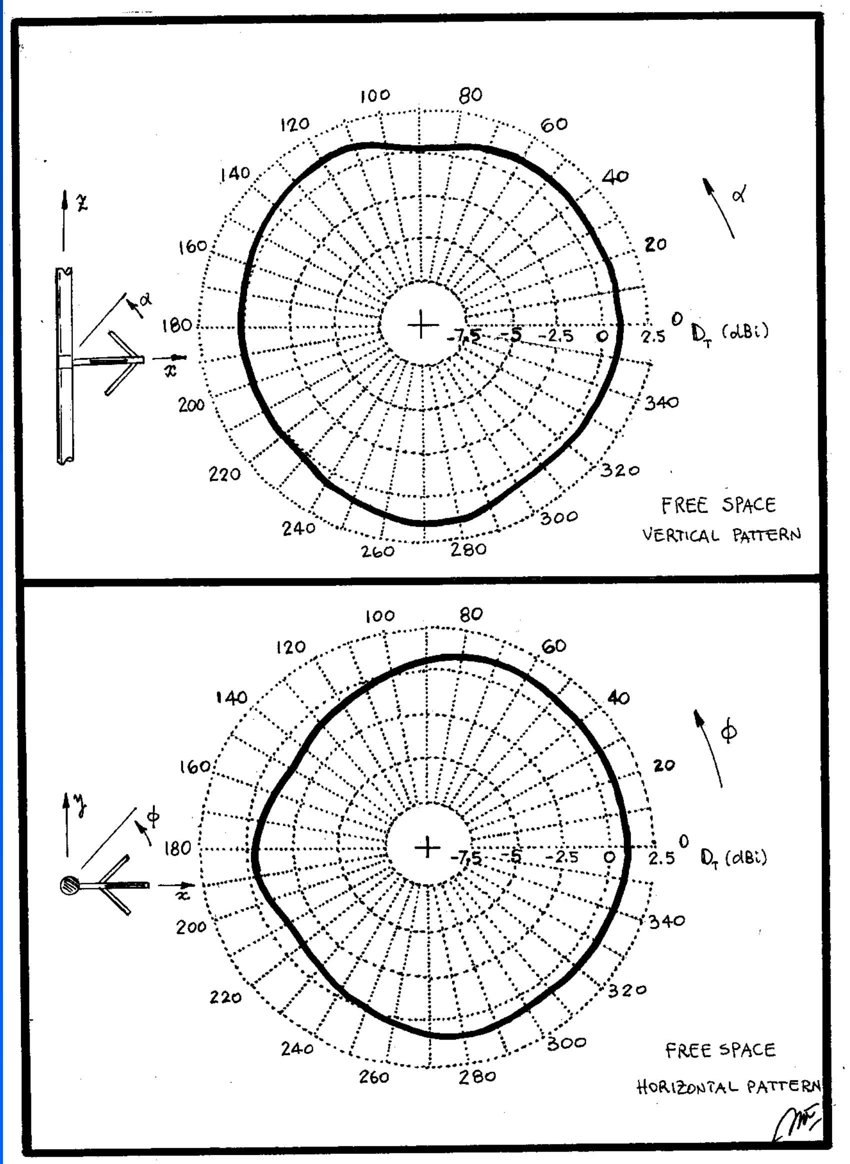
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED

GAIN FREE SPACE

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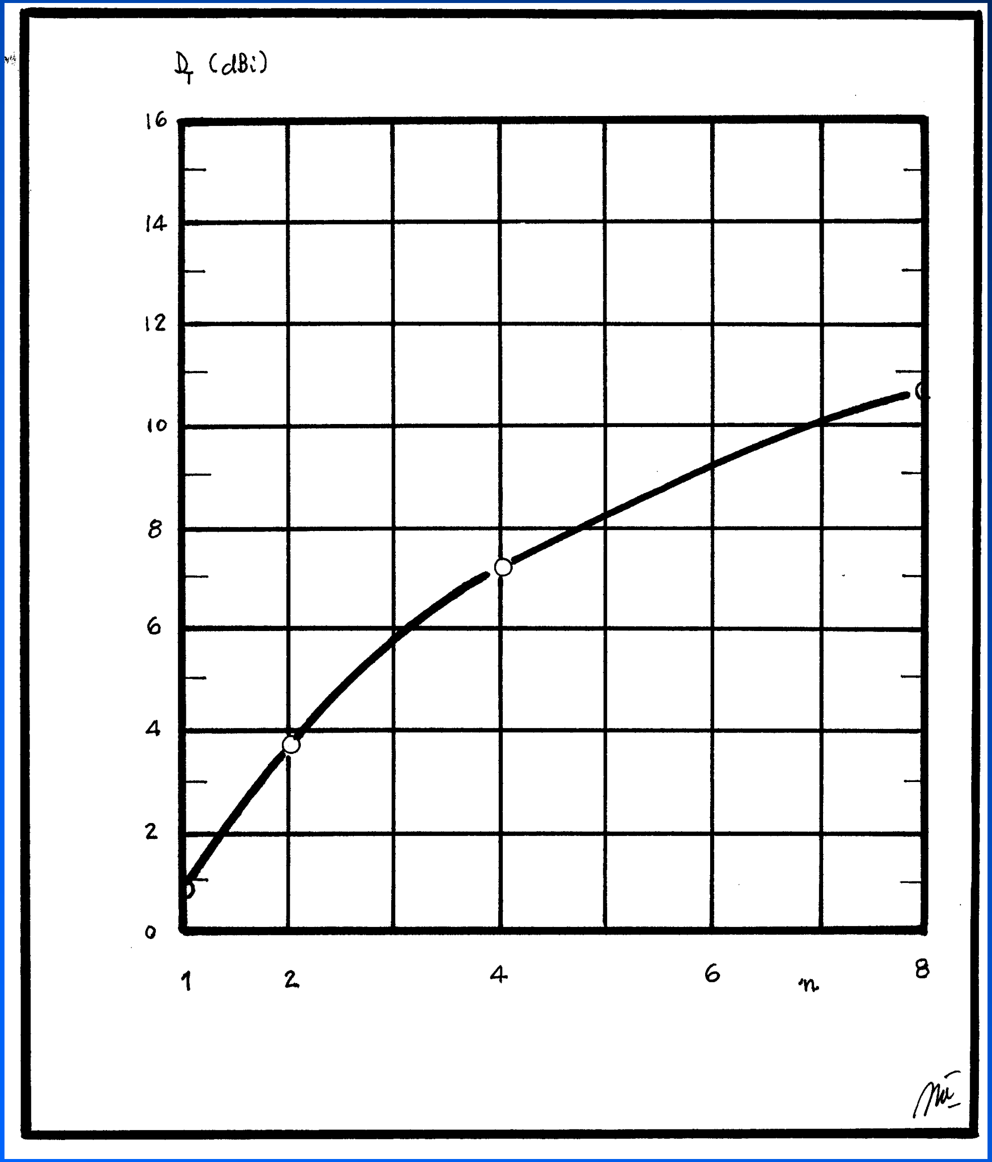
VHF AND UHF BROADCAST ANTENNAS

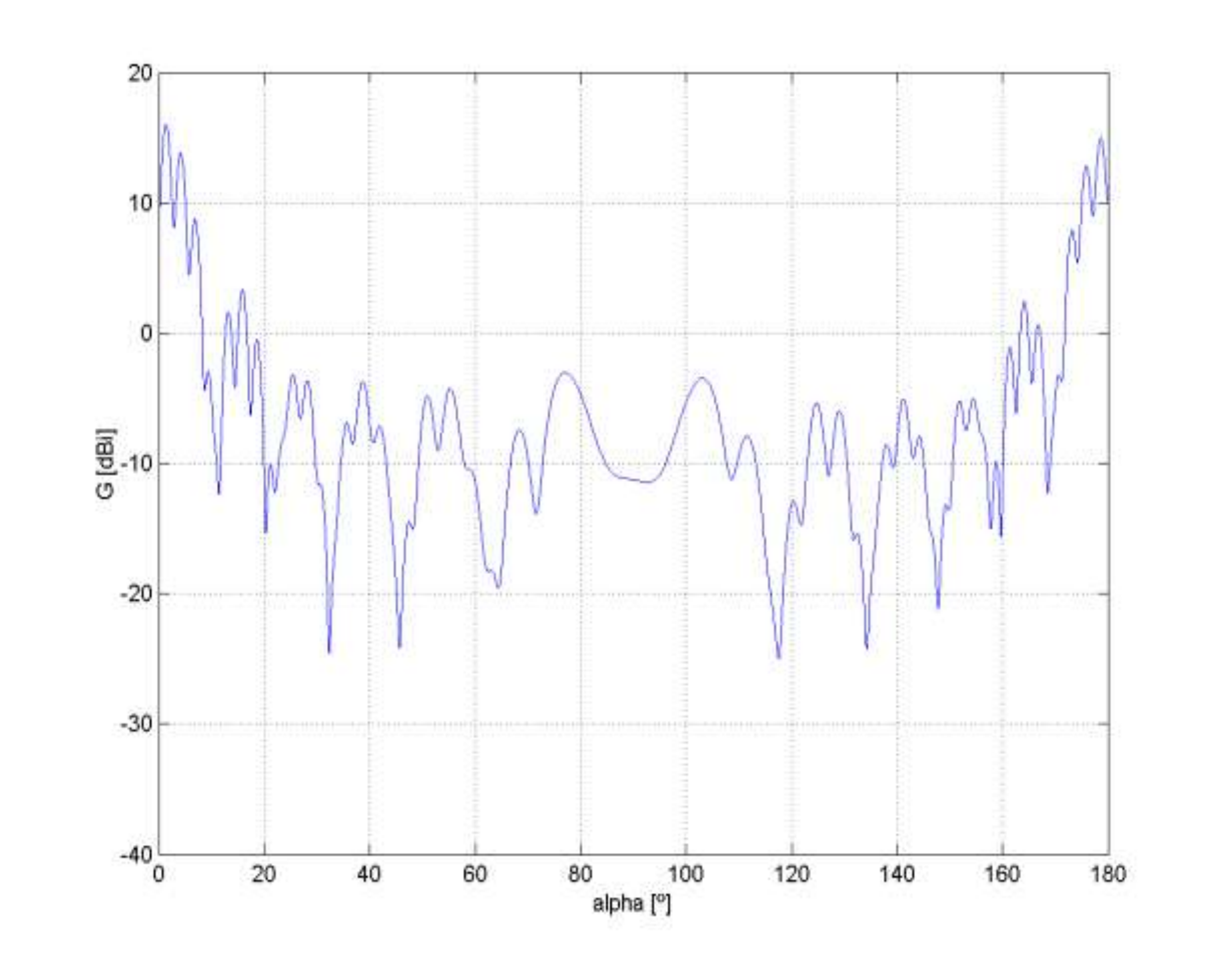


FM DIPOLE ANTENNA CIRCULARLY POLARIZED IN FREE SPACE

DIRECTIVITY AS A FUNCTION OF ELEMENT NUMBER

f = 100 MHz
d = 0.7 λ

VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED

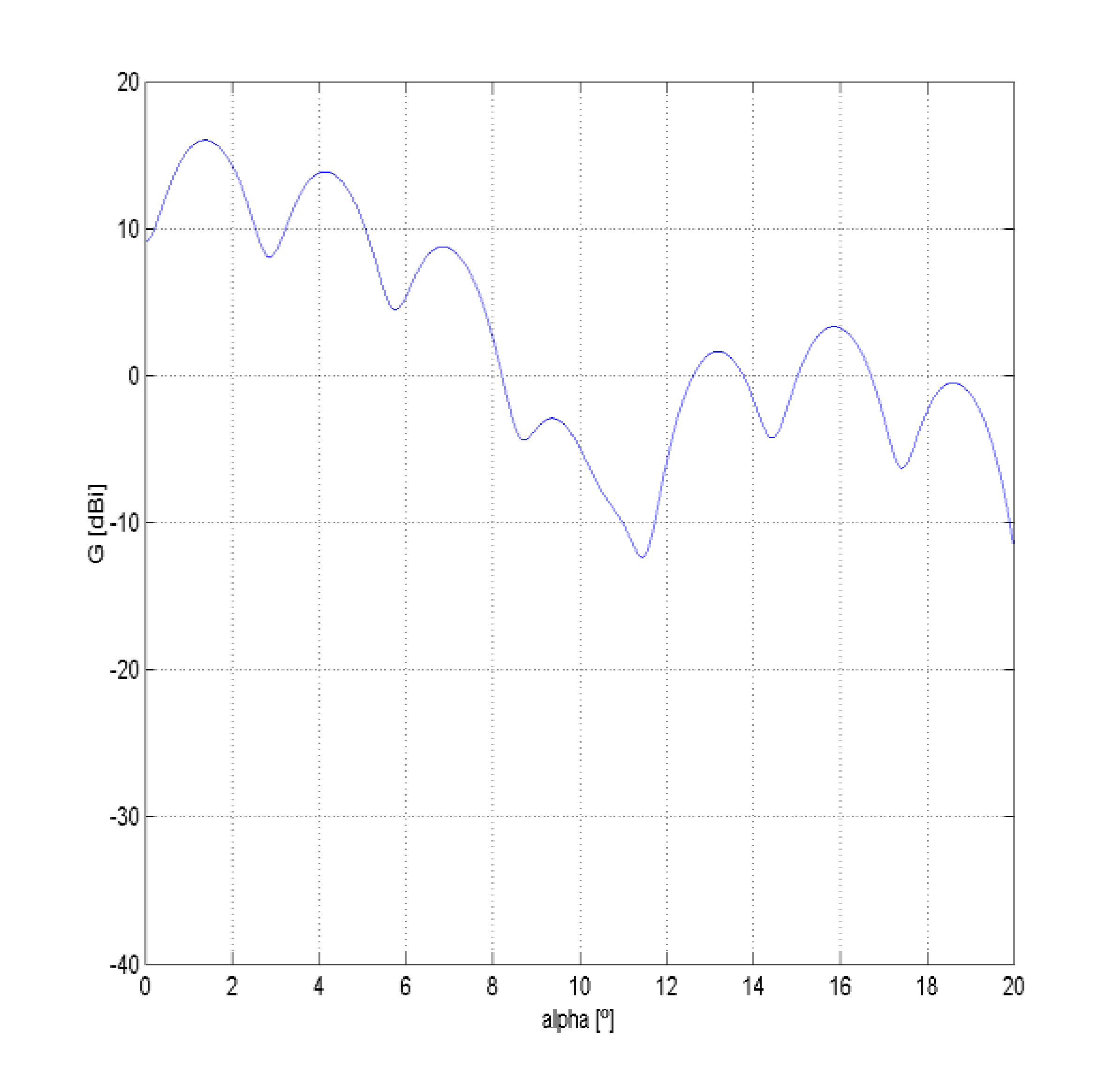
H = 30 m

GAIN OVER PERFECT GROUND

n = 8

D_{TM} = 16 dBi

VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED

H = 30 m

GAIN OVER PERFECT GROUND

n = 8

D_{TM} = 16 dBi

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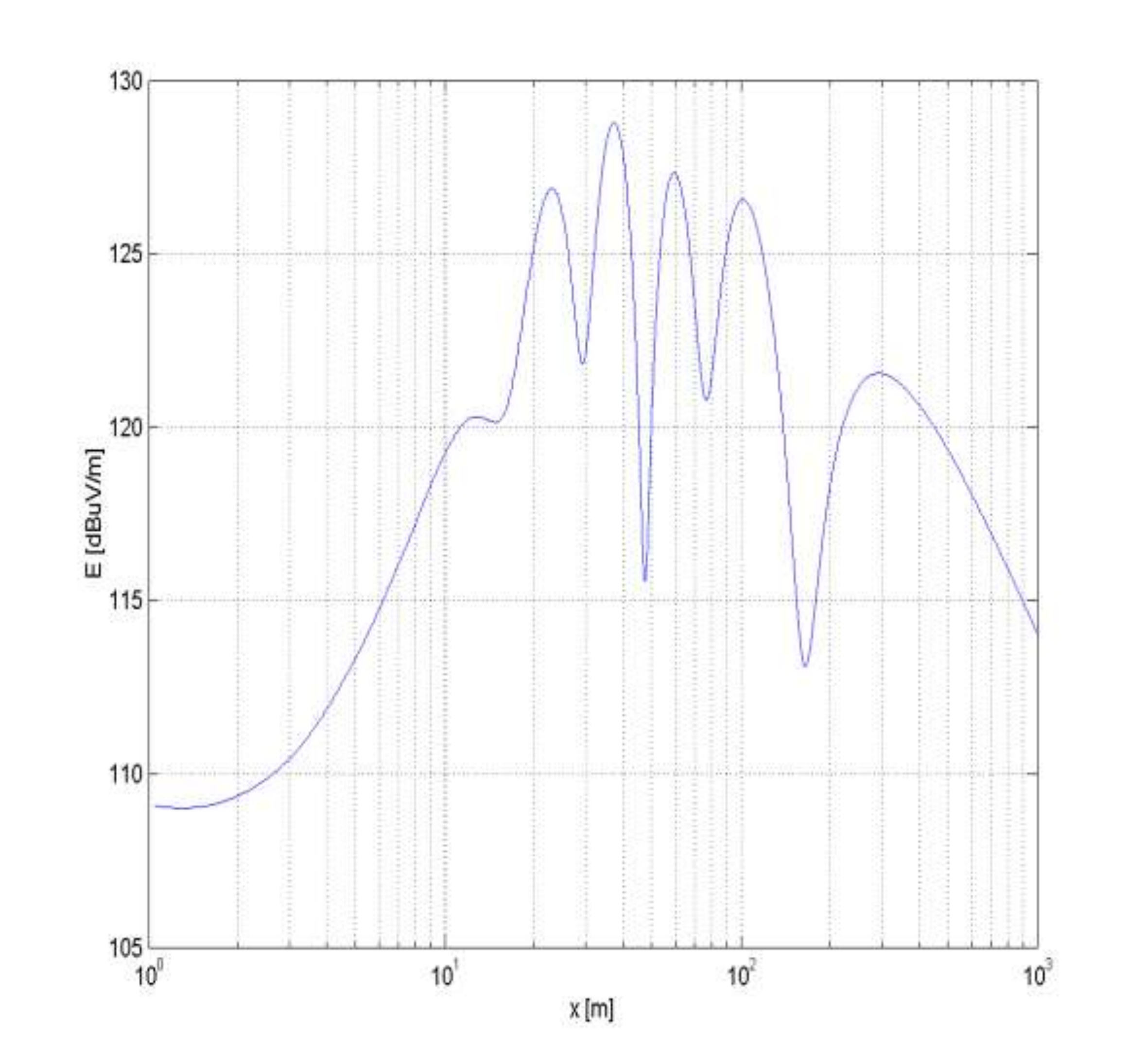
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED

H = 30 m

NEAR FIELD OVER PERFECT GROUND

n = 8

W_T = 1 kW

z = 1.5 m

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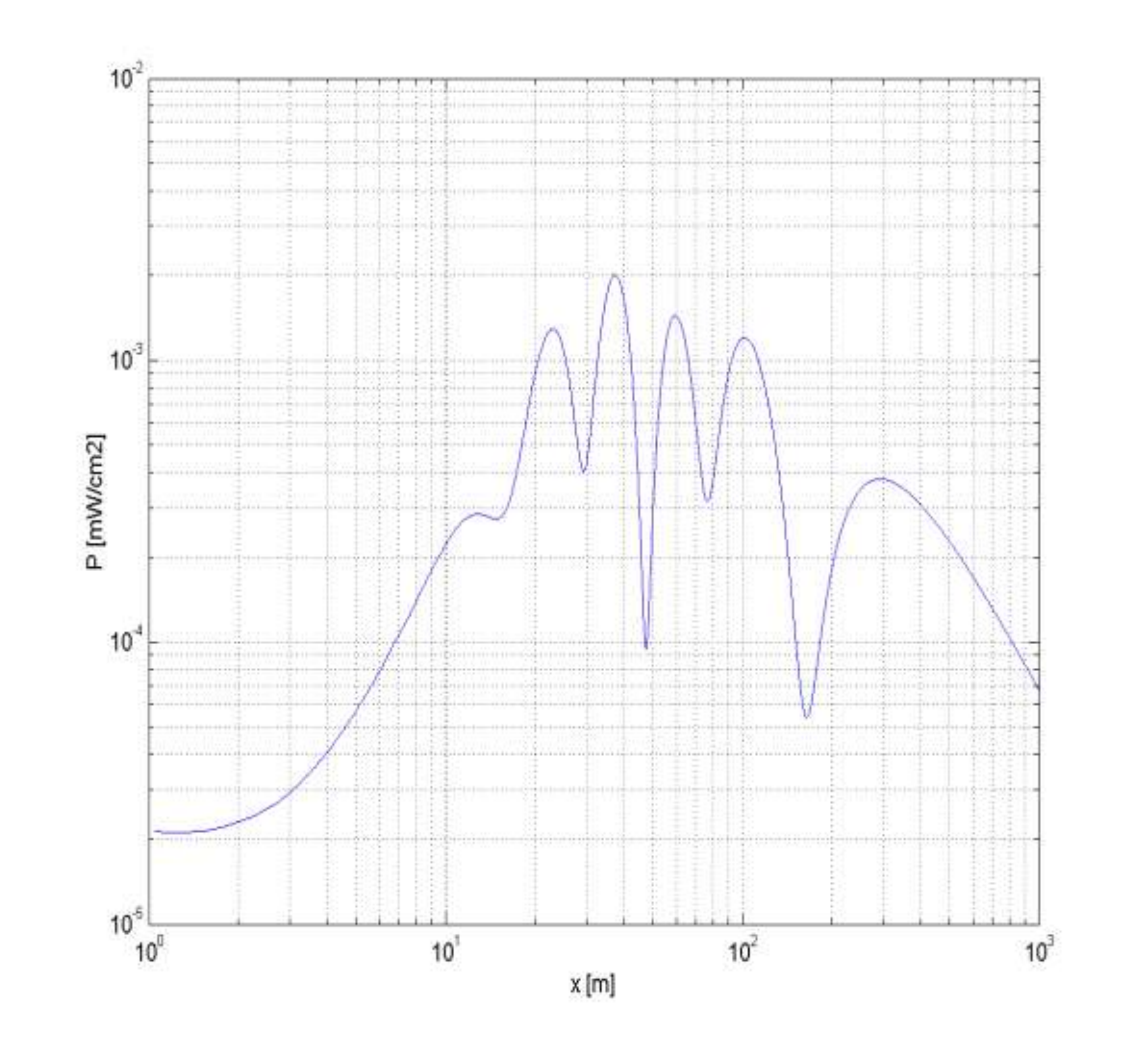
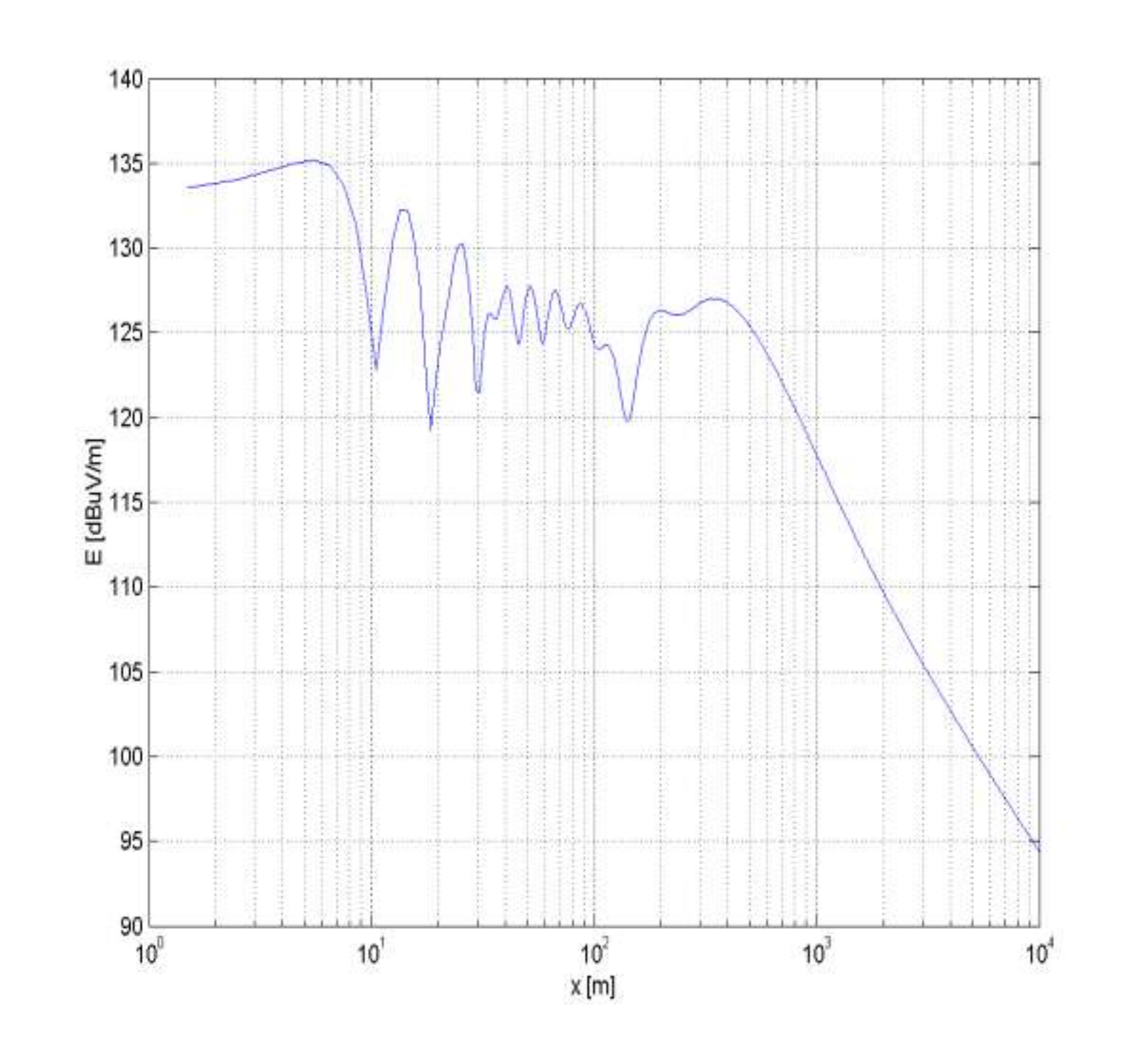
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED
H = 30 m
POWER DENSITY OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 1.5 m

VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED
H = 30 m
NEAR FIELD OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 10 m

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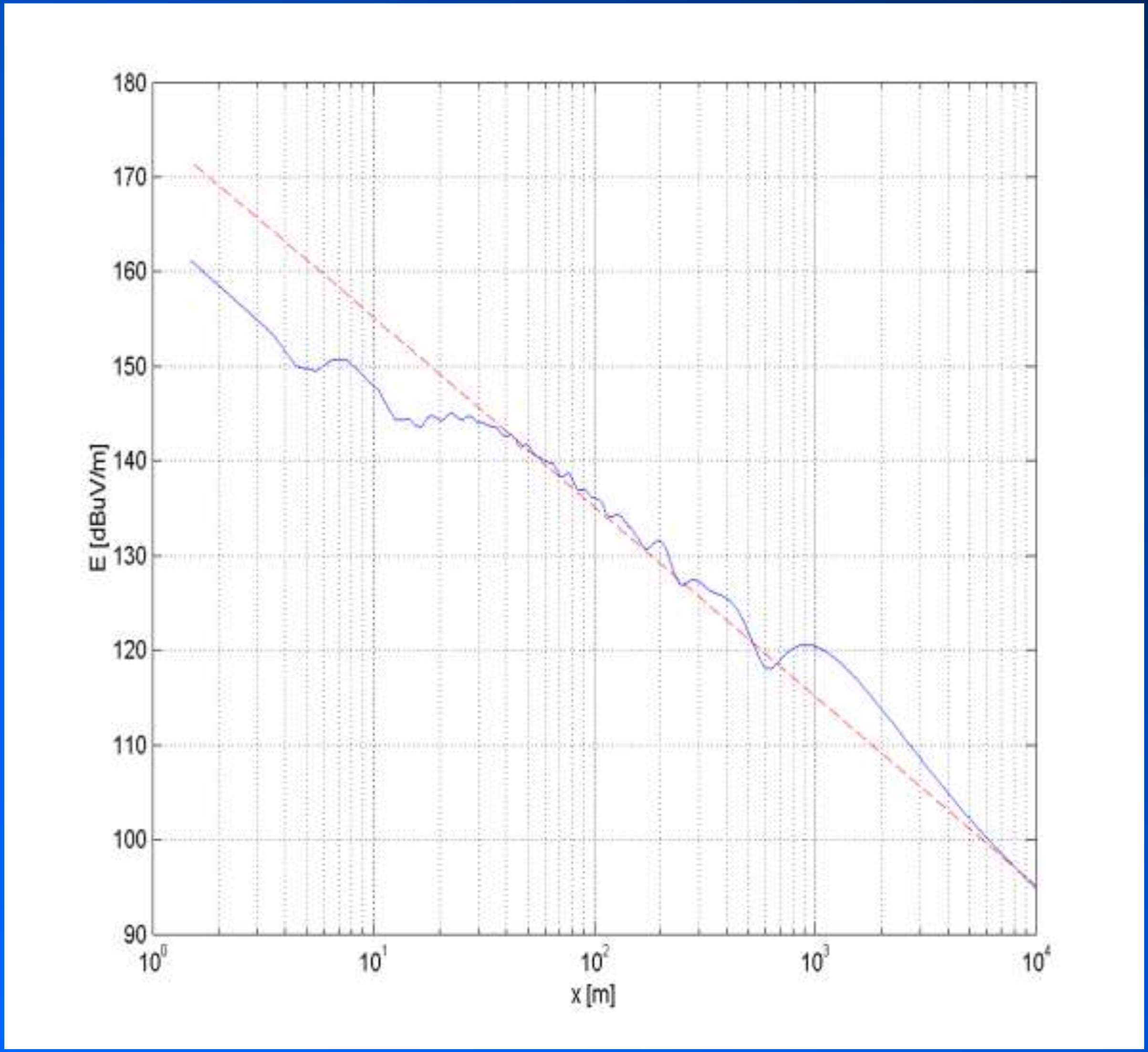
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED

H = 30 m

NEAR FIELD OVER PERFECT GROUND

n = 8

W_T = 1 kW

z = 30 m

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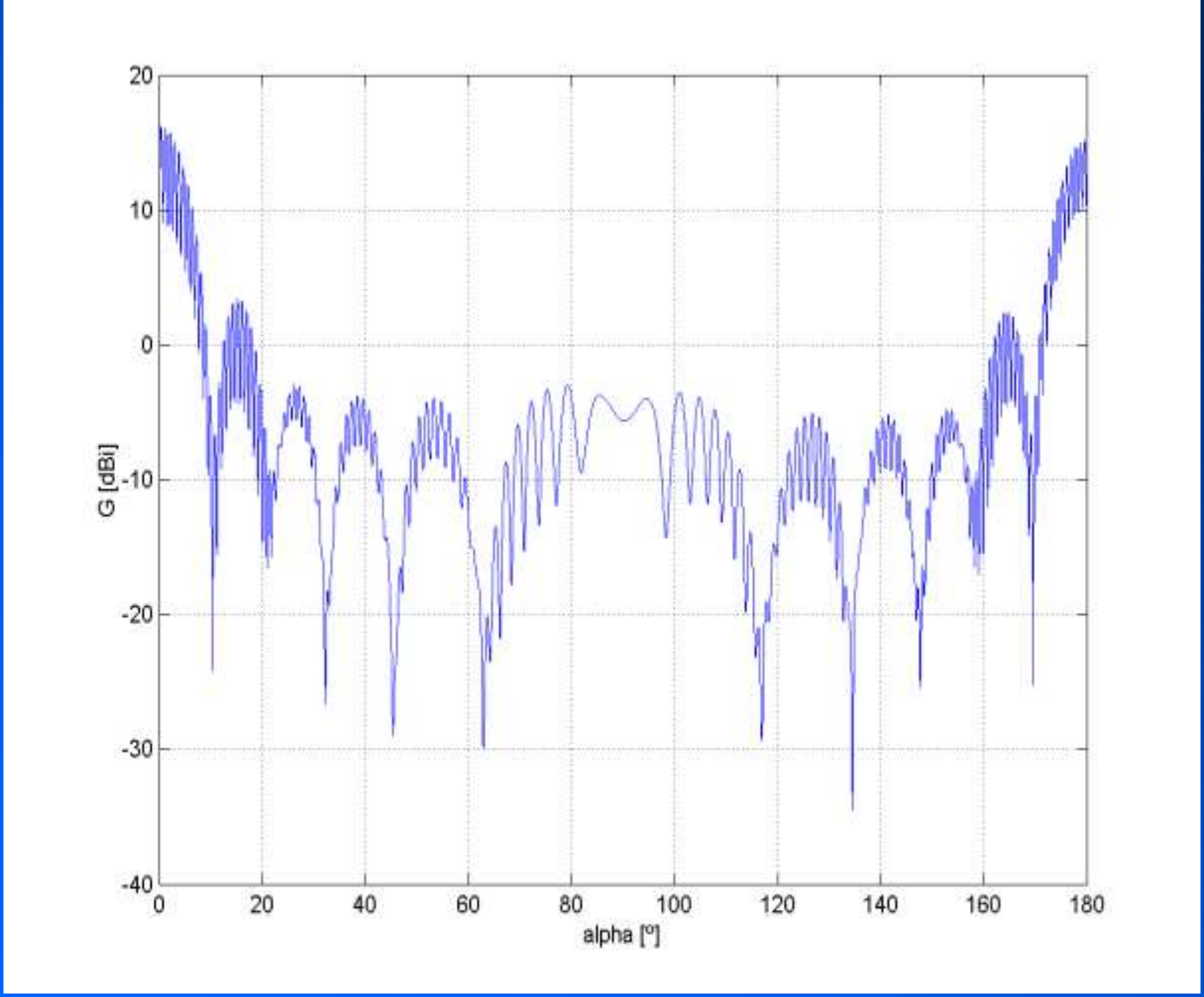
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED H = 100 m GAIN OVER PERFECT GROUND

n = 8

D_{TM} = 16 dBi

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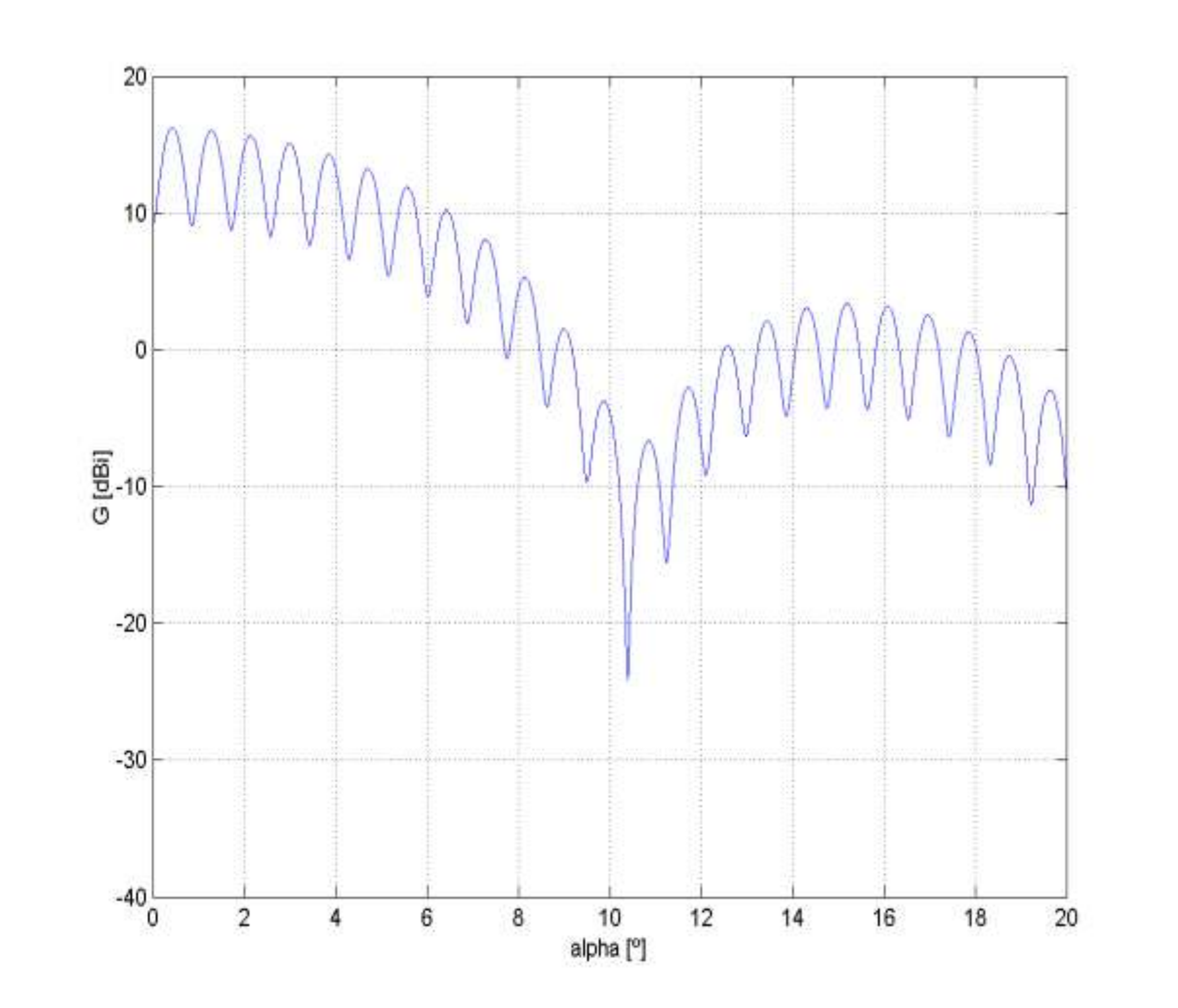
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED
H = 100 m
GAIN OVER PERFECT GROUND

n = 8
D_{TM} = 16 dBi

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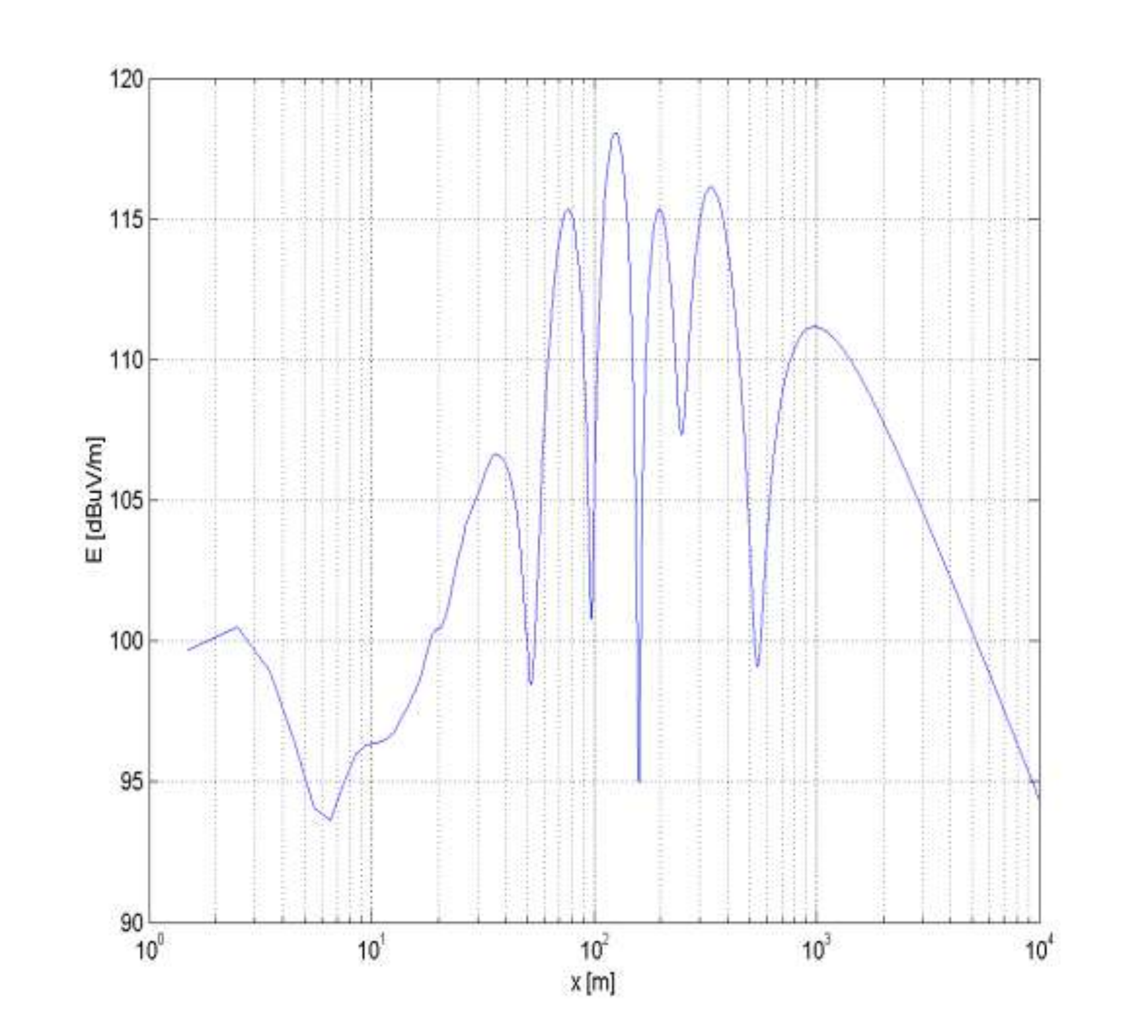
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED

H = 100 m

NEAR FIELD OVER PERFECT GROUND

n = 8

W_T = 1 kW

z = 1.5 m

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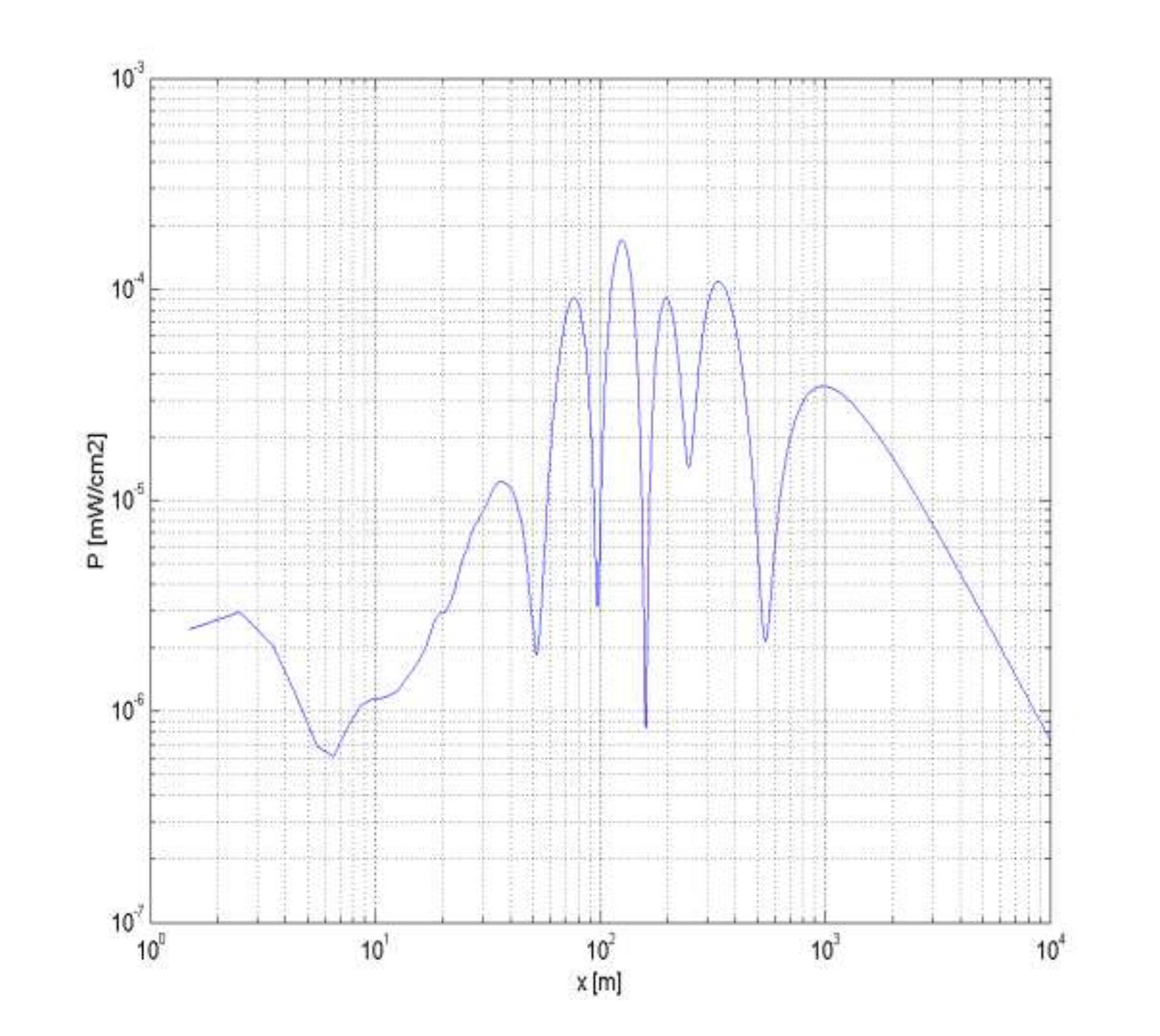
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED
H = 100 m
POWER DENSITY OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 1.5 m

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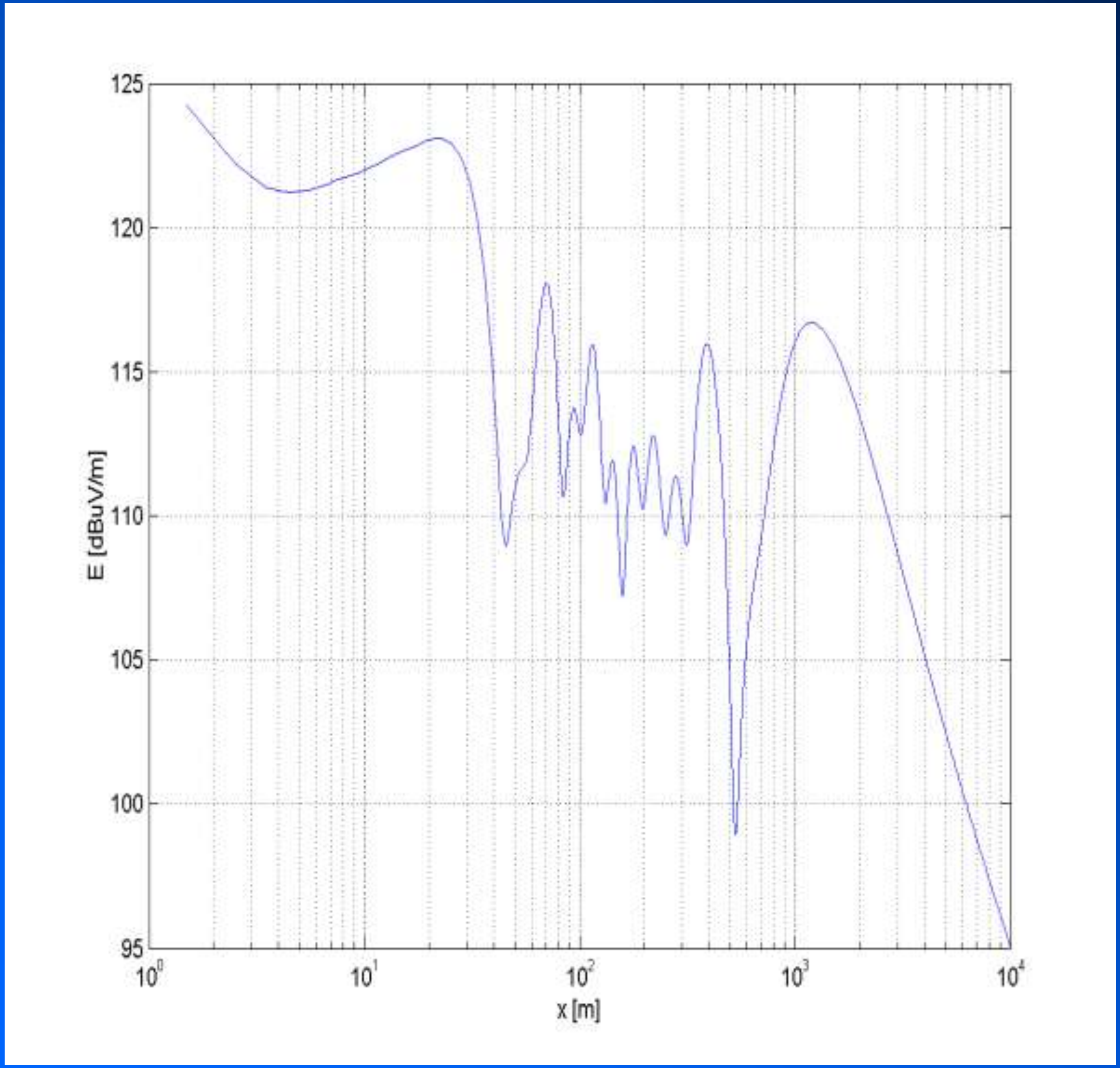
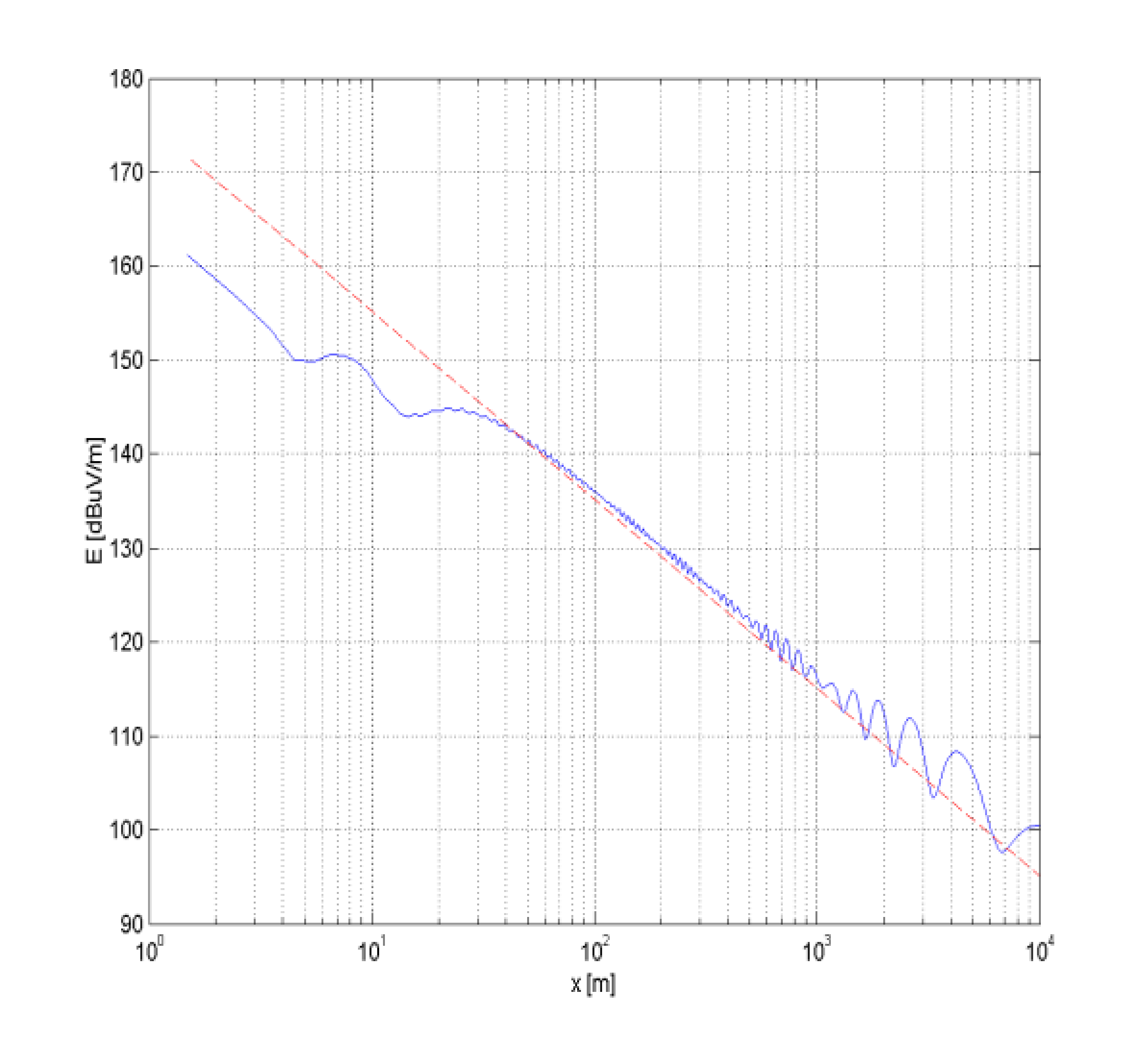
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED
H = 100 m
NEAR FIELD OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 10 m

VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED

H = 300 m

NEAR FIELD OVER PERFECT GROUND

n = 8

W_T = 1 kW

z = 100 m

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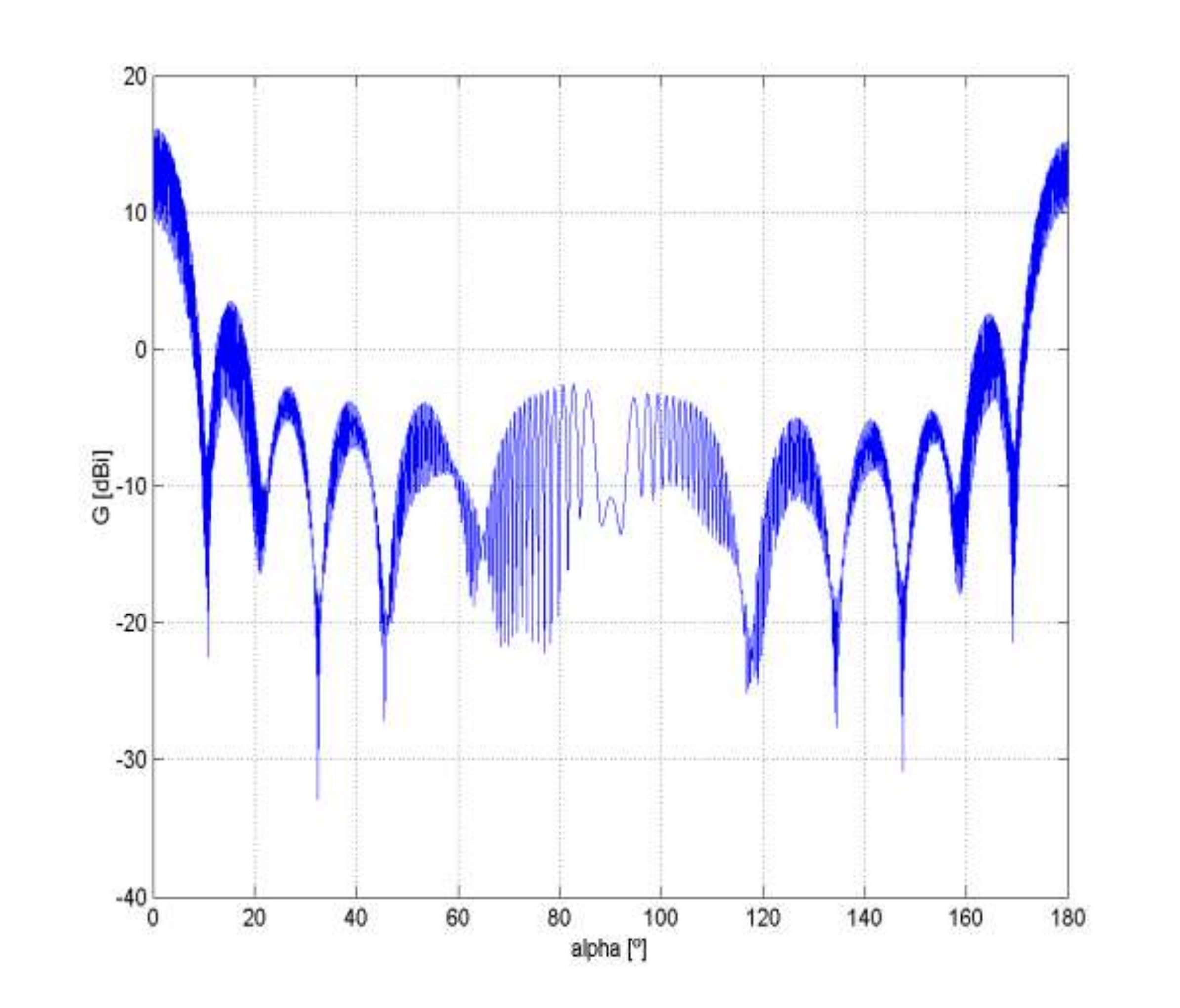
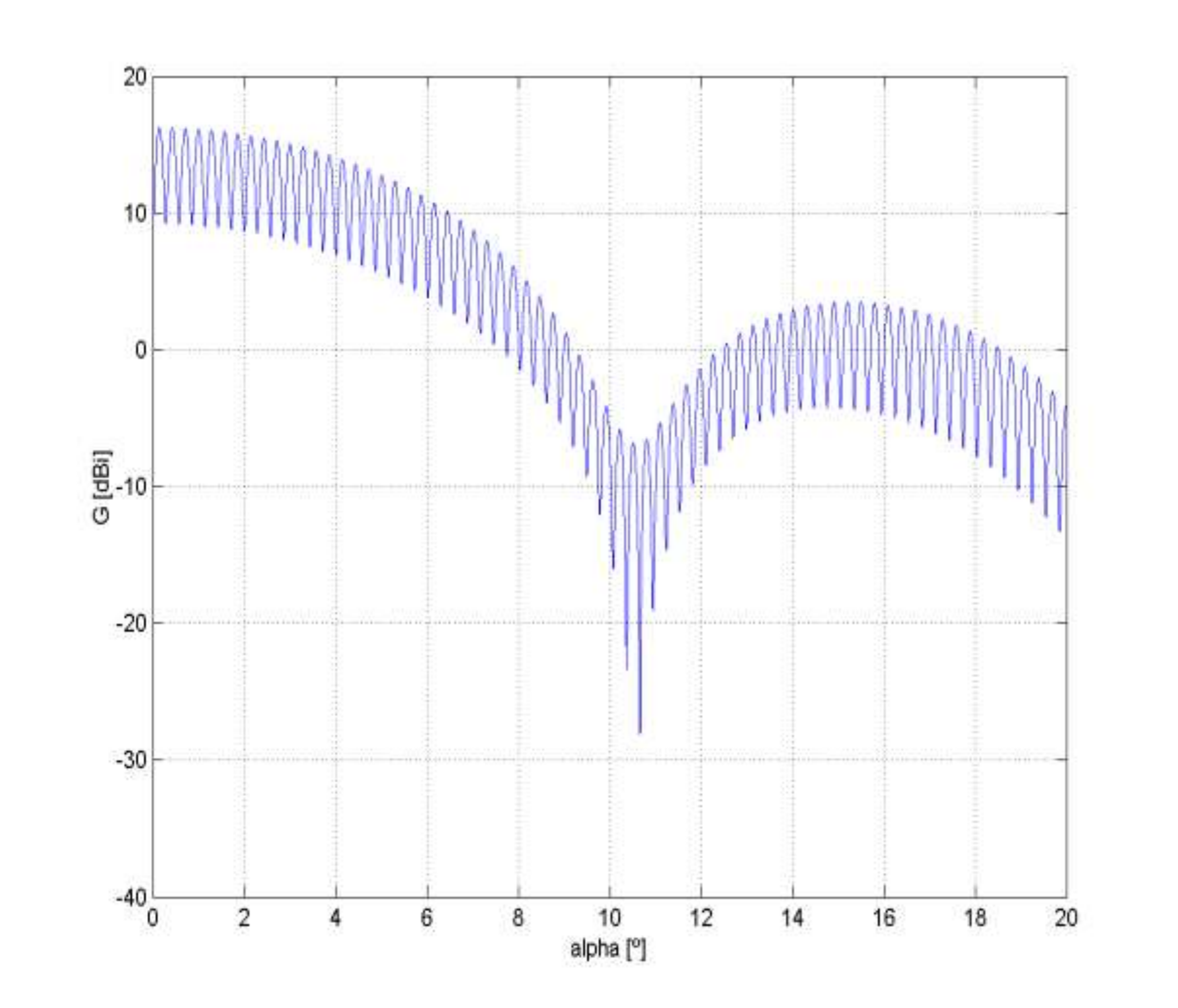
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED
H = 300 m
GAIN OVER PERFECT GROUND

n = 8
D_{TM} = 16 dBi

VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED

H = 300 m

GAIN OVER PERFECT GROUND

n = 8

D_{TM} = 16 dBi

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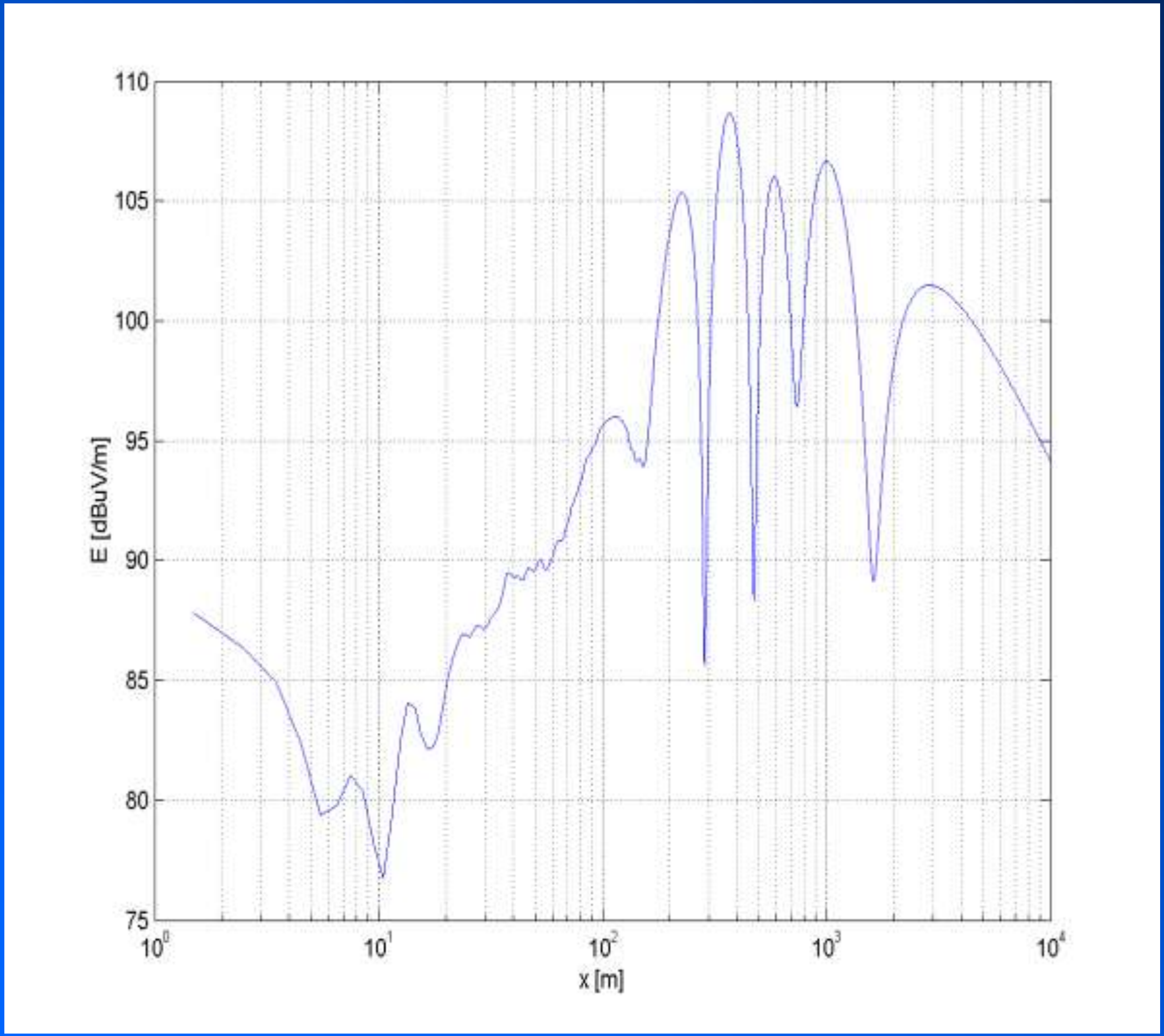
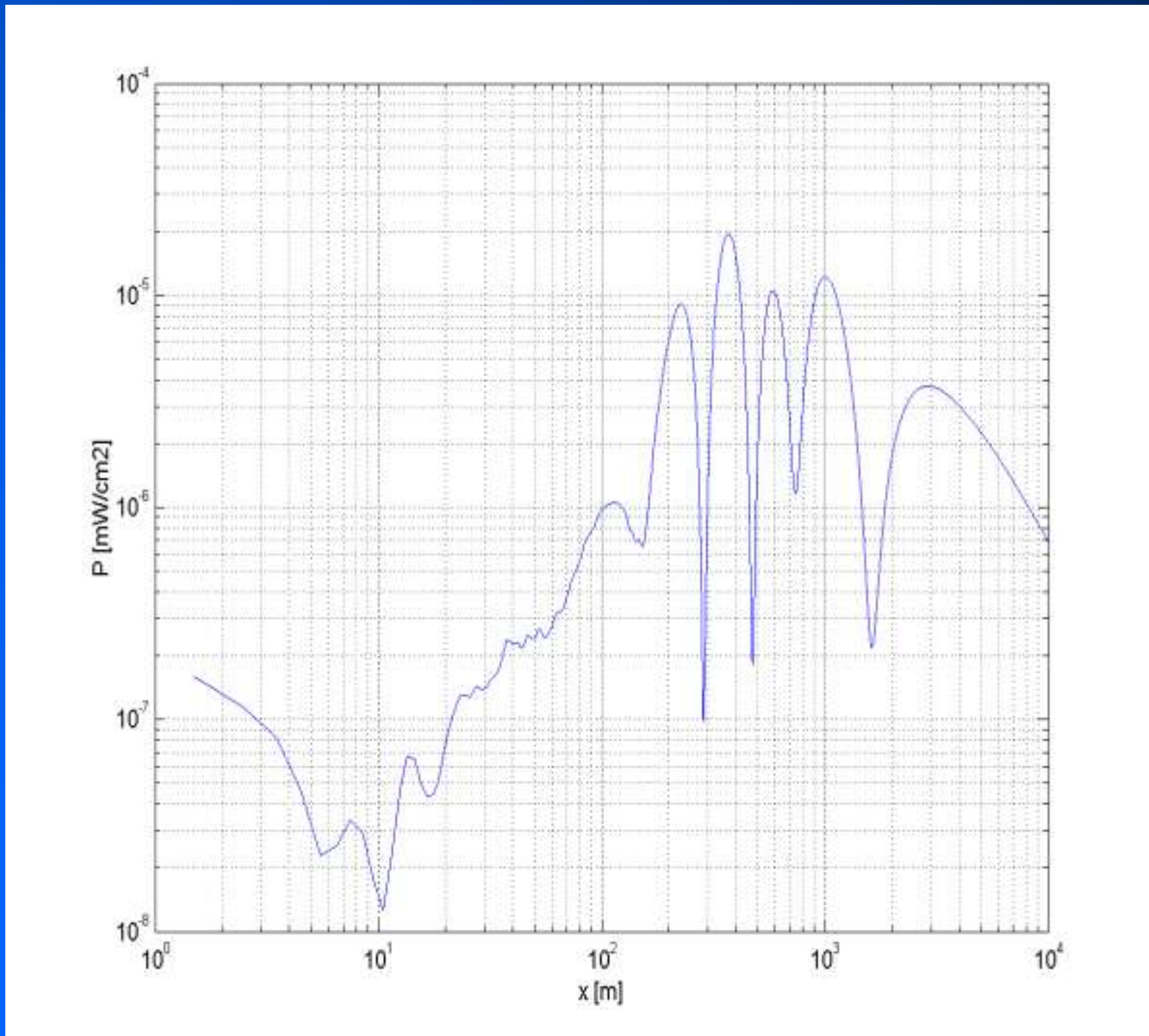
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED
H = 300 m
NEAR FIELD OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 1.5 m

VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED H = 300 m POWER DENSITY OVER PERFECT GROUND

n = 8

W_T = 1 kW

z = 1.5 m

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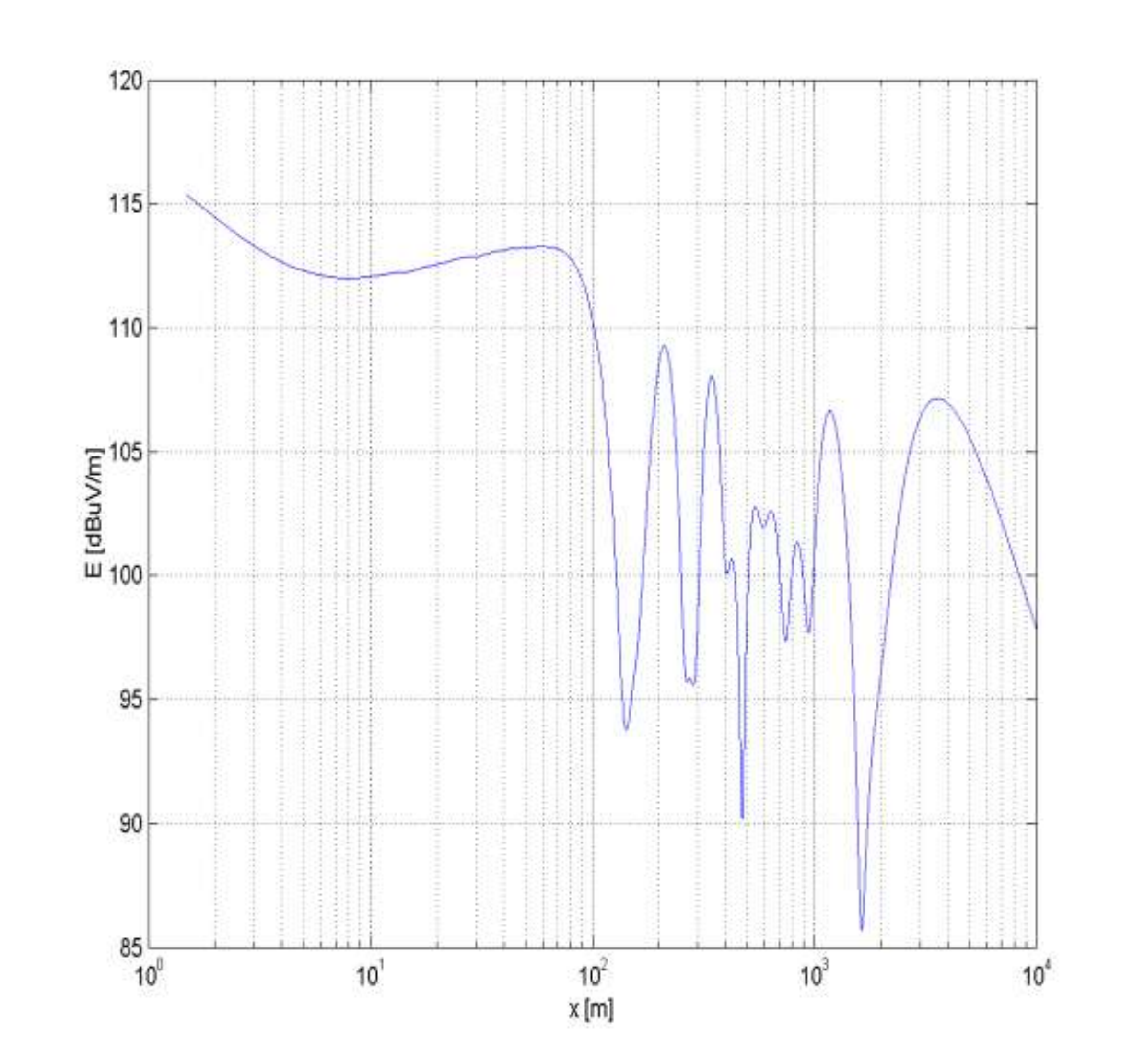
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED
H = 300 m
NEAR FIELD OVER PERFECT GROUND

n = 8
W_T = 1 kW
z = 10 m

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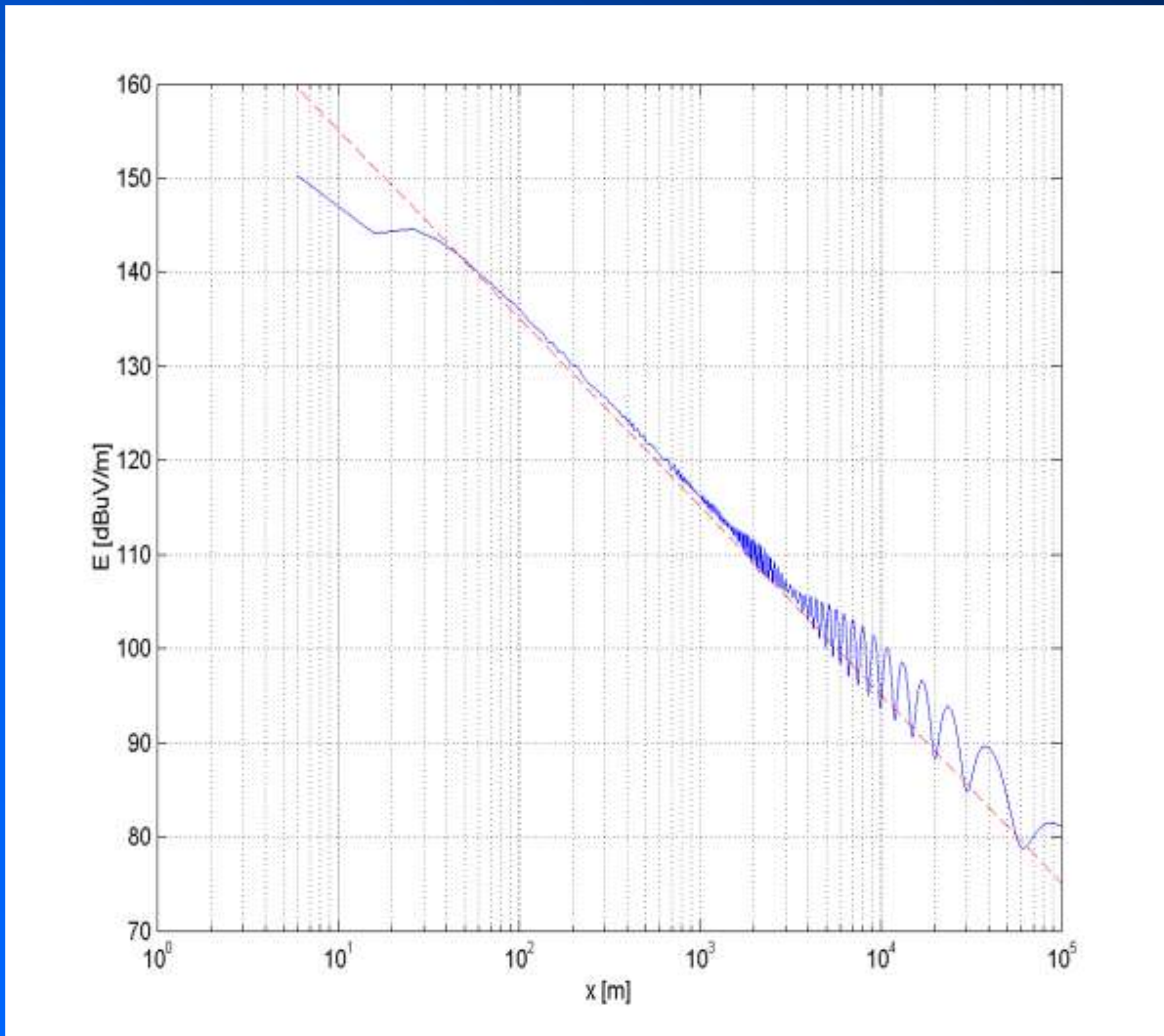
VHF AND UHF BROADCAST ANTENNAS



FM DIPOLE ANTENNA CIRCULARLY POLARIZED

H = 300 m

NEAR FIELD OVER PERFECT GROUND

n = 8

W_T = 1 kW

z = 300 m

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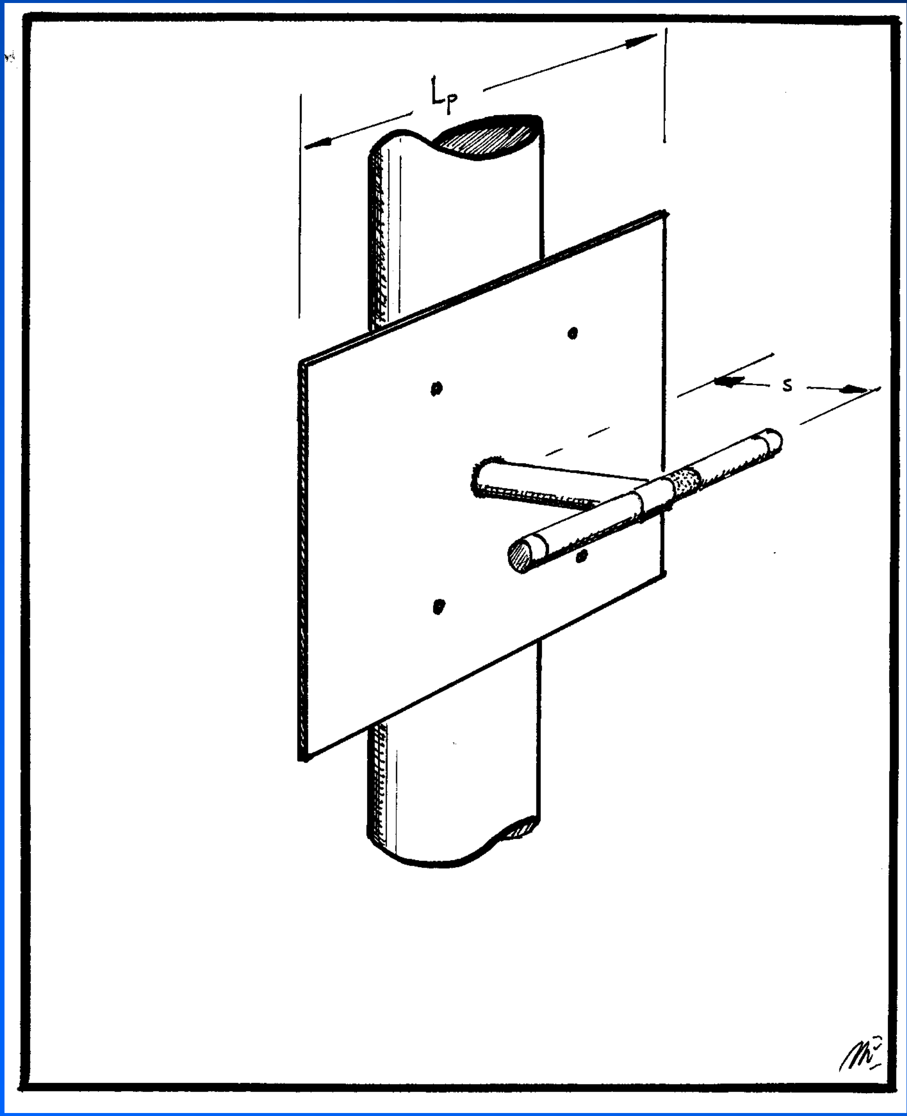
VHF AND UHF BROADCAST ANTENNAS

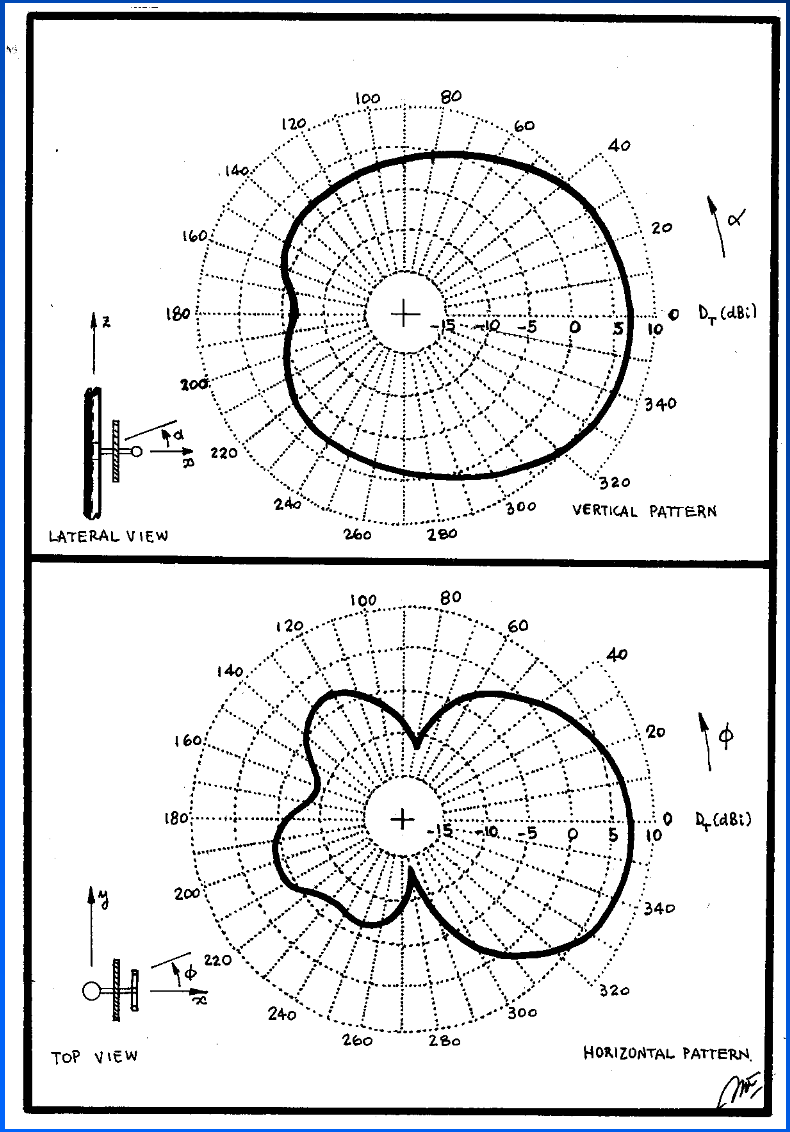


FM OR TV PANEL DIPOLE ANTENNA

HORIZONTALLY POLARIZED

$L_p = 0.667\ \lambda$
$S = 0.25\ \lambda$

VHF AND UHF BROADCAST ANTENNAS



FM OR TV PANEL DIPOLE ANTENNA ONE ELEMENT RADIATION PATTERN

F = 200 MHz
D_{TM} = 6.78 dBi
HORIZONTALLY POLARIZED

Lp = 0.667 λ
S = 0.25 λ

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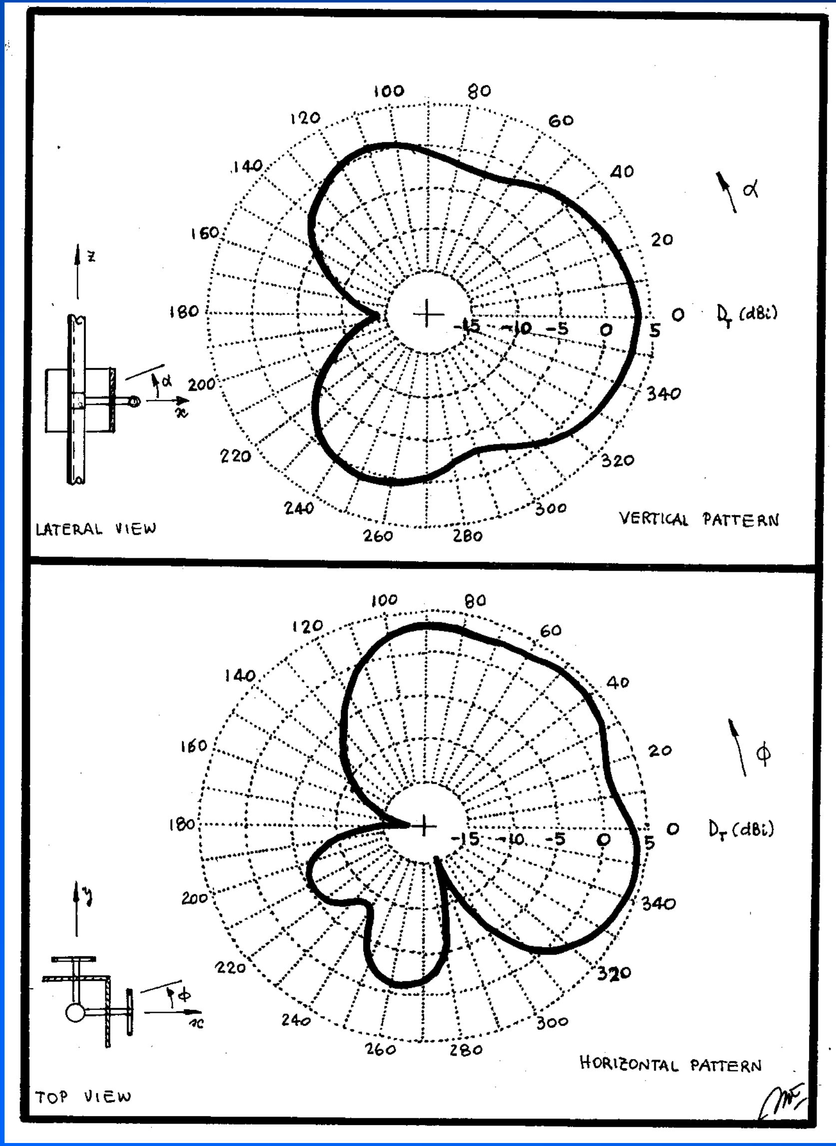
VHF AND UHF BROADCAST ANTENNAS

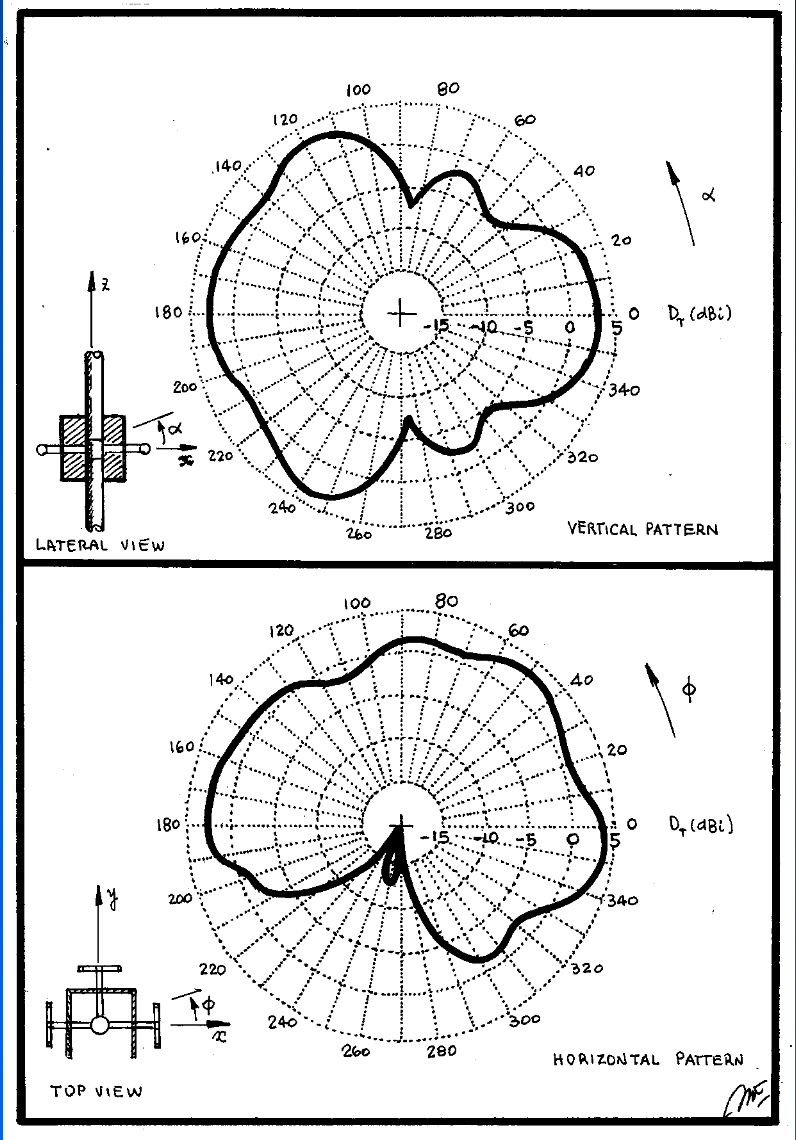


FM OR TV PANEL DIPOLE ANTENNA TWO ELEMENT RADIATION PATTERN

F = 200 MHz
D_{TM} = 4.40 dBi
HORIZONTALLY POLARIZED

Lp = 0.667 λ
S = 0.25 λ

VHF AND UHF BROADCAST ANTENNAS



FM OR TV PANEL DIPOLE ANTENNA THREE ELEMENT RADIATION PATTERN

F = 200 MHz

D_{TM} = 3.95 dBi

HORIZONTALLY POLARIZED

Lp = 0.667 λ

S = 0.25 λ

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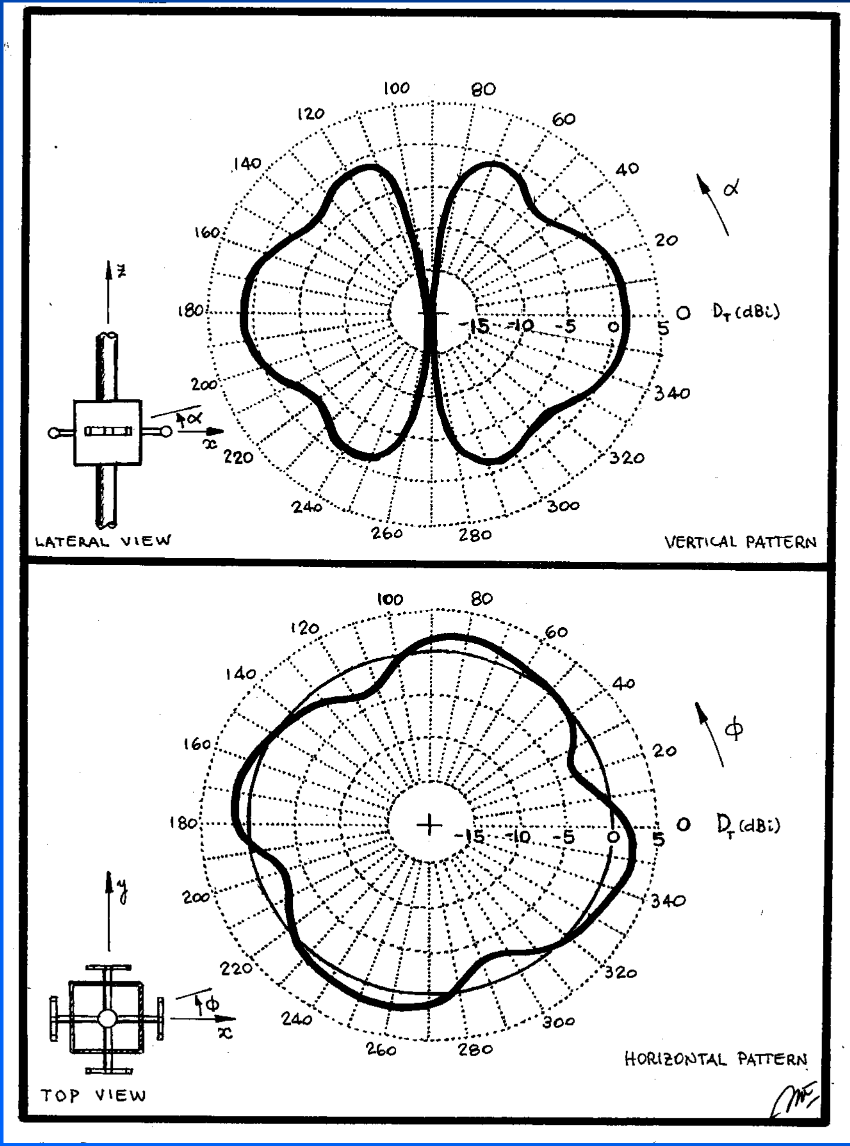
VHF AND UHF BROADCAST ANTENNAS



FM OR TV PANEL DIPOLE ANTENNA FOUR ELEMENT RADIATION PATTERN

F = 200 MHz

D_{TM} = 2 dBi

HORIZONTALLY POLARIZED

Lp = 0.667 λ

S = 0.25 λ

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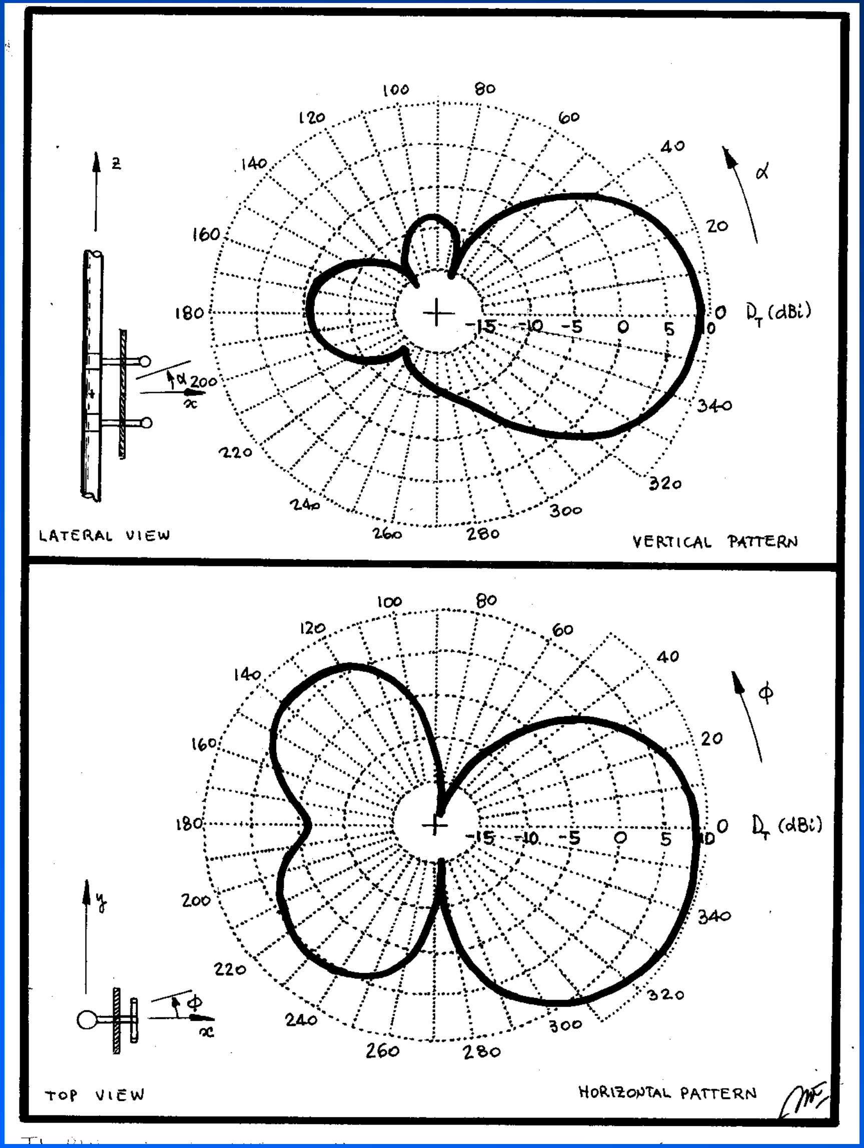
VHF AND UHF BROADCAST ANTENNAS



FM OR TV PANEL DIPOLE ANTENNA ONE ELEMENT TWO BAY RADIATION PATTERN

F = 200 MHz
D_{TM} = 9.4 dBi
HORIZONTALLY POLARIZED
d = 0. 5 λ
Lp = 0.667 λ
S = 0.25 λ

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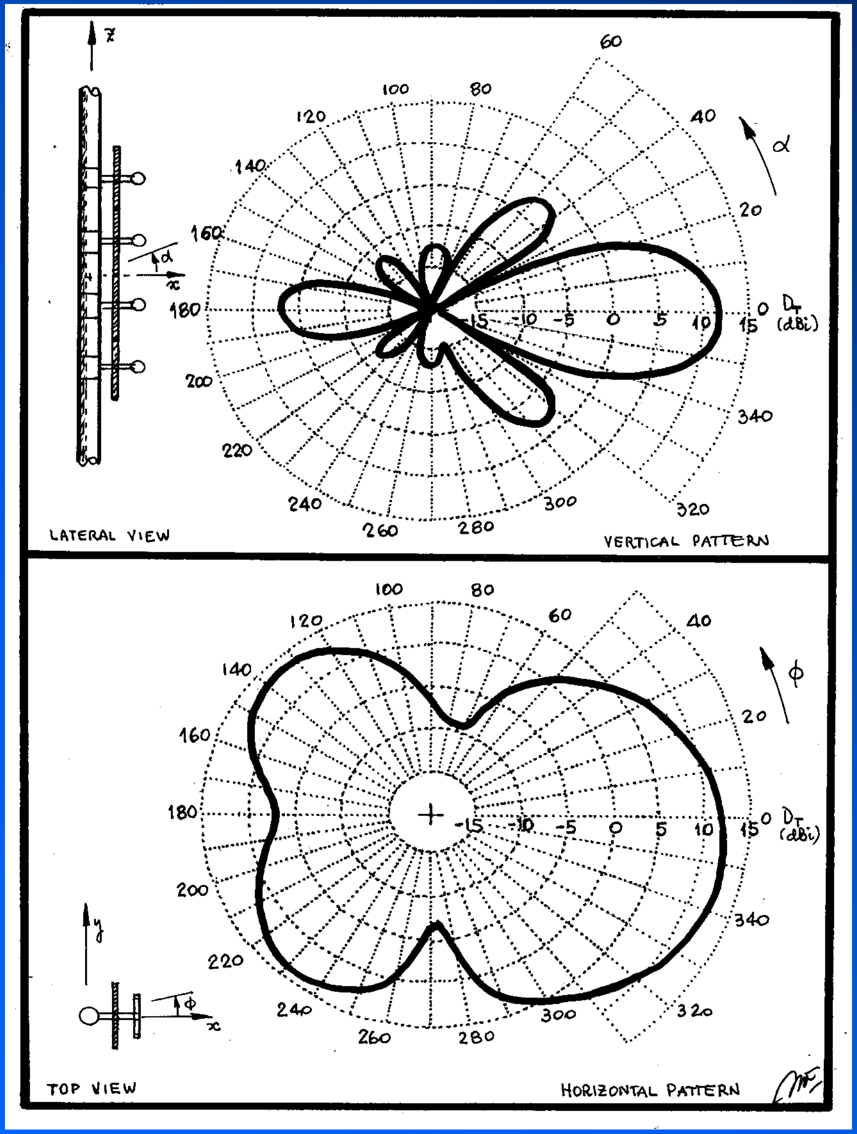
VHF AND UHF BROADCAST ANTENNAS



FM OR TV PANEL DIPOLE ANTENNA ONE ELEMENT FOUR BAY RADIATION PATTERN

F = 200 MHz

D_{TM} = 12.2 dBi

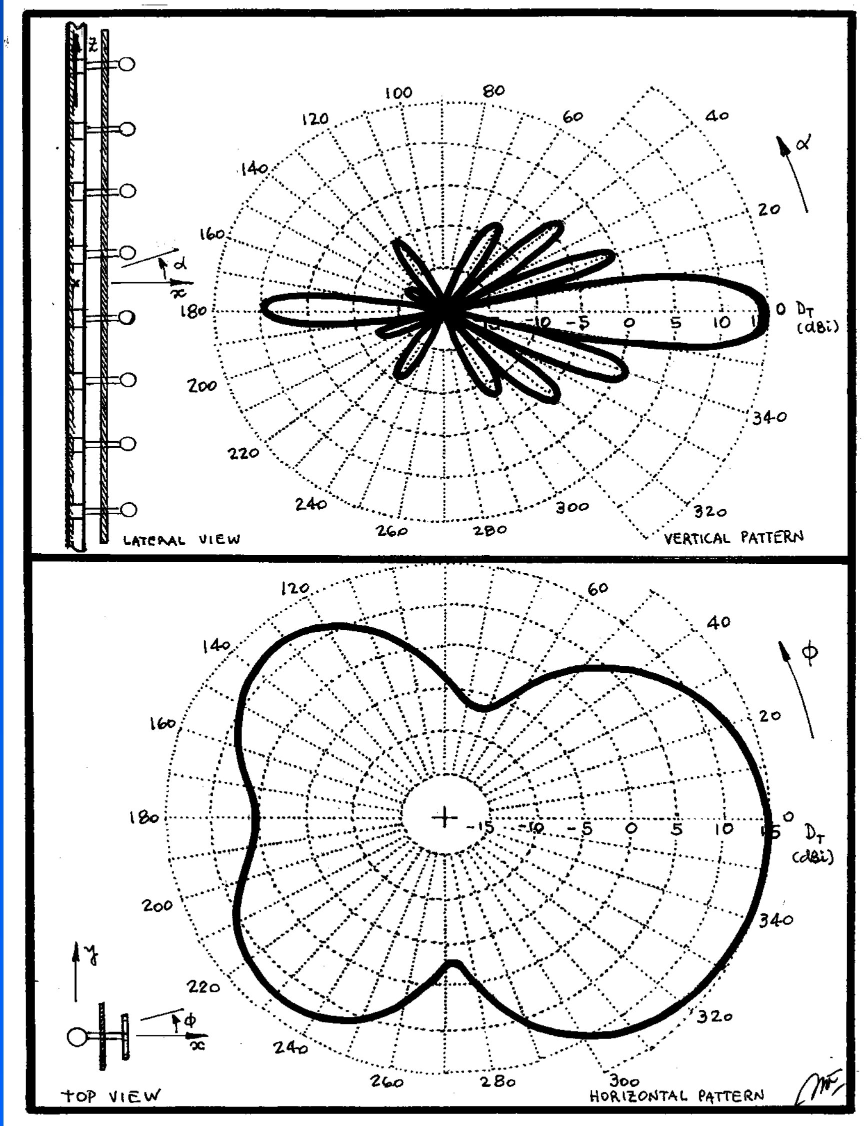
HORIZONTALLY POLARIZED

d = 0. 5 λ

Lp = 0.667 λ

S = 0.25 λ

VHF AND UHF BROADCAST ANTENNAS



FM OR TV PANEL DIPOLE ANTENNA ONE ELEMENT EIGHT BAY RADIATION PATTERN

F = 200 MHz

D_{TM} = 15.2 dBi

HORIZONTALLY POLARIZED

d = 0. 5 λ

Lp = 0.667 λ

S = 0.25 λ

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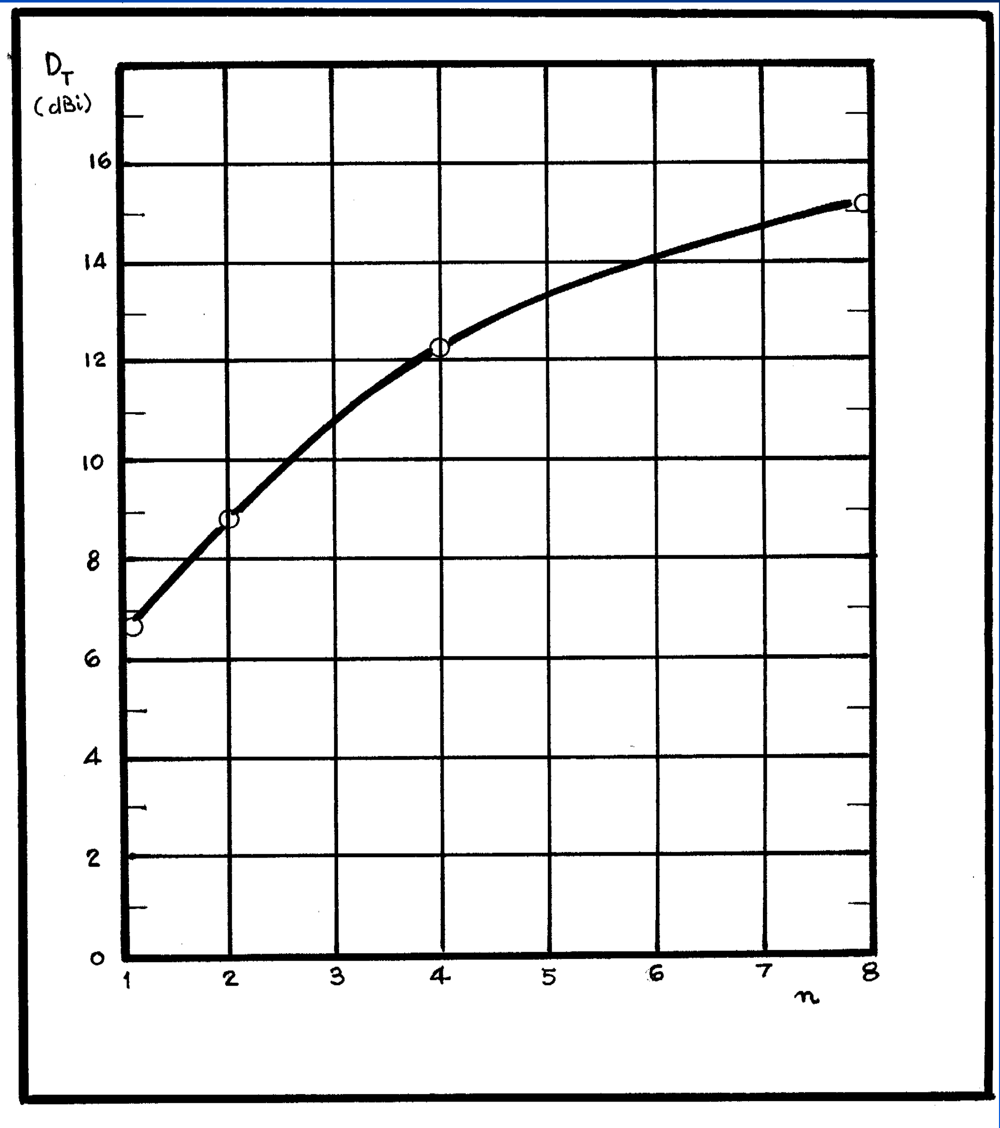
VHF AND UHF BROADCAST ANTENNAS



FM OR TV ONE ELEMENT PANEL DIPOLE ANTENNA DIRECTIVITY AS A FUNCTION OF BAY NUMBER FREE SPACE

HORIZONTALLY POLARIZED

F = 200 MHz

d = 0. 5 λ

Lp = 0.667 λ

S = 0.25 λ

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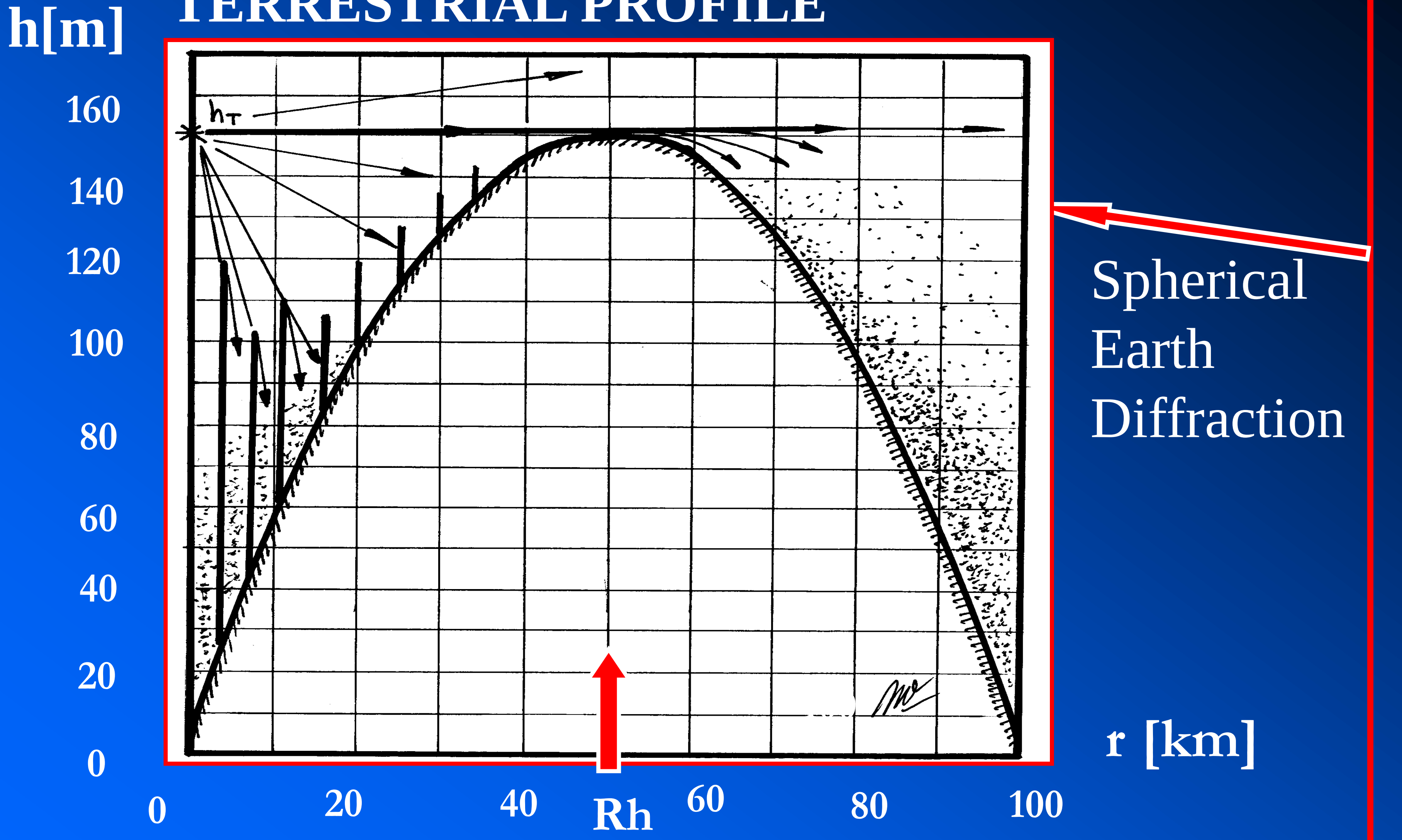
VHF AND UHF BROADCAST ANTENNAS

TERRESTRIAL PROFILE



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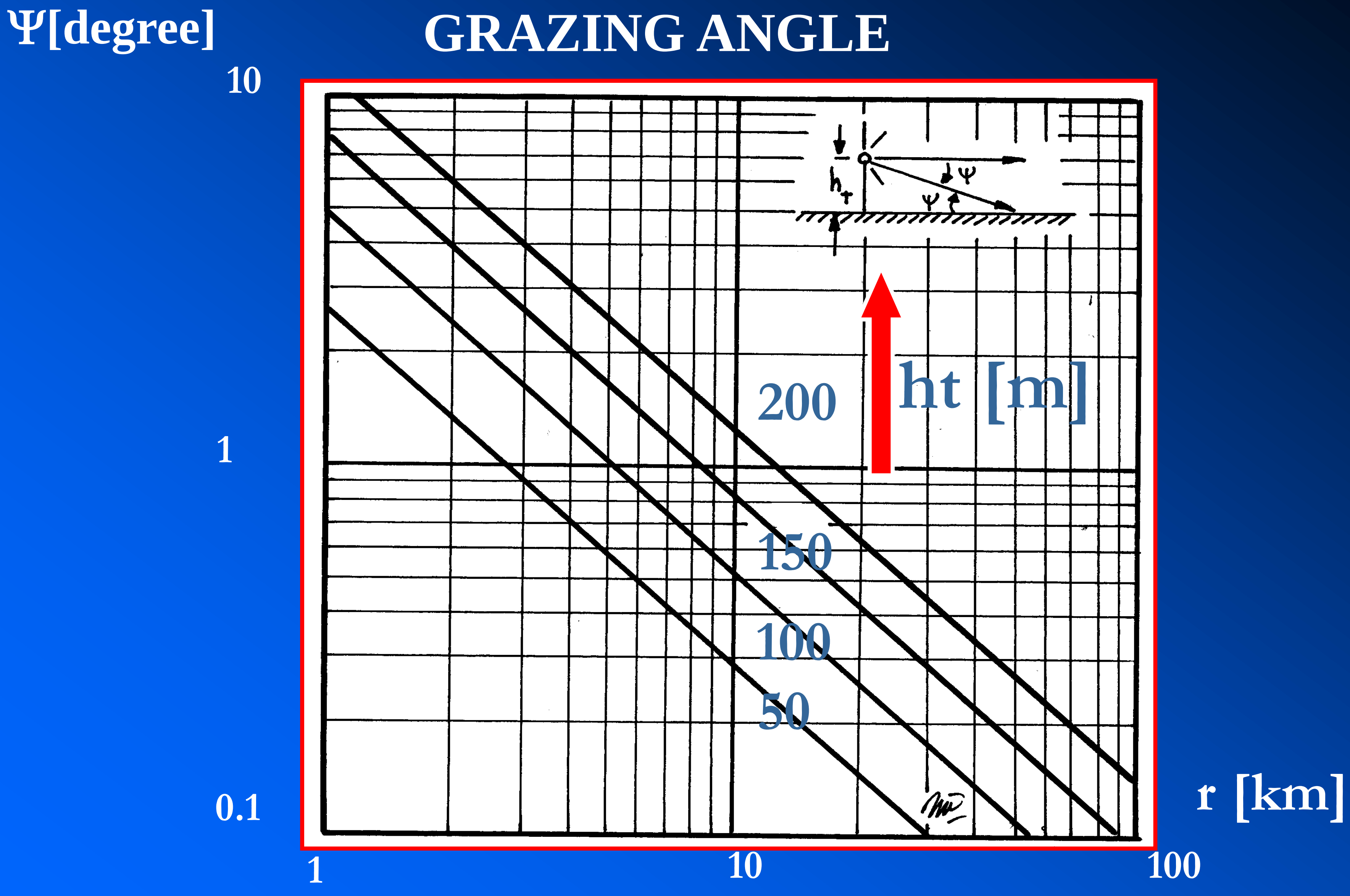
VHF AND UHF BROADCAST ANTENNAS

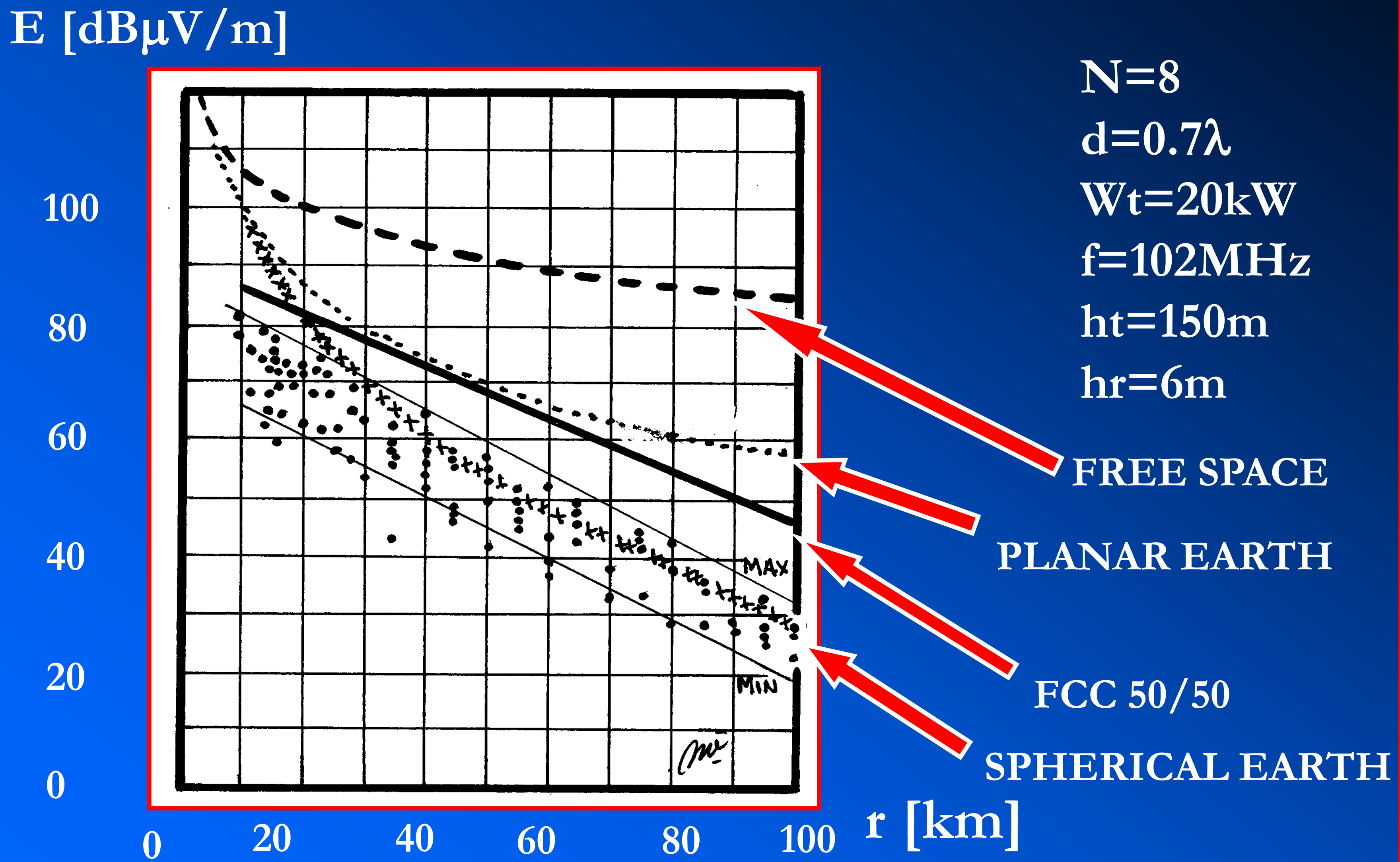
GRAZING ANGLE



VHF BROADCAST ANTENNAS

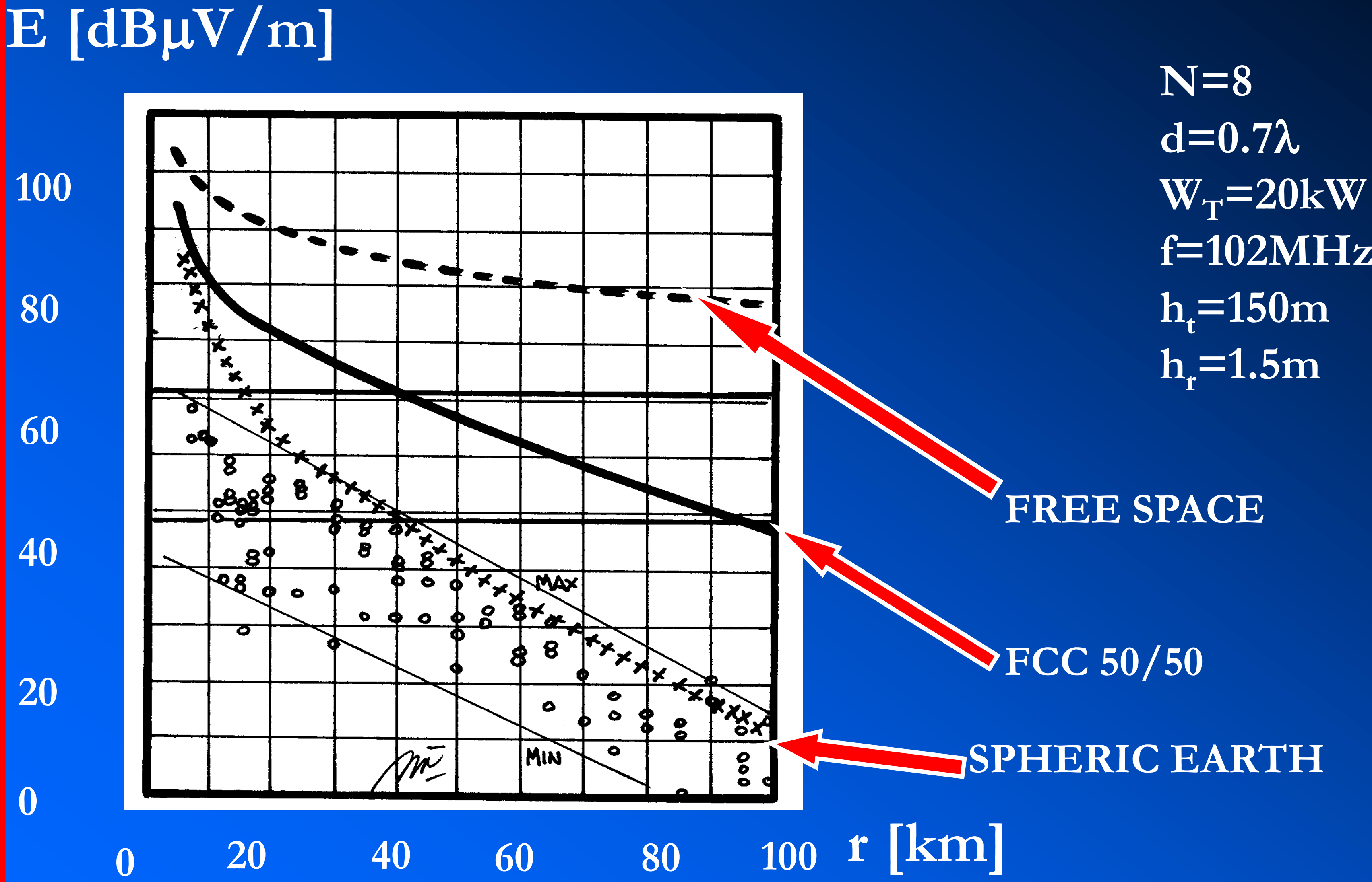
8 VERTICAL DIPOLE ARRAY

N=8
d=0.7λ
Wt=20kW
f=102MHz
ht=150m
hr=6m



VHF BROADCAST ANTENNAS

8 VERTICAL DIPOLE ARRAY



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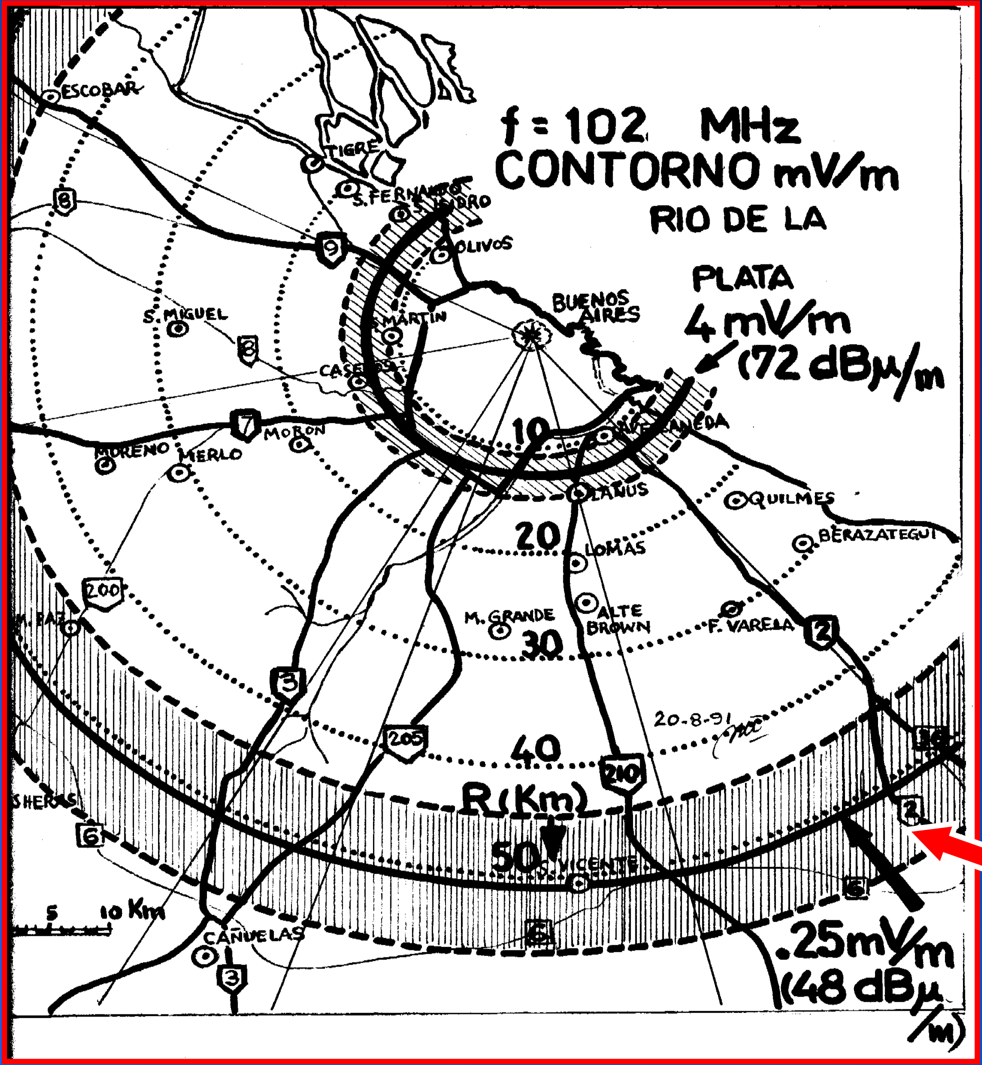
VHF AND UHF BROADCAST ANTENNAS

8 VERTICAL DIPOLE ARRAY



N=8

d=0.7λ

W_T=20kW

f=102MHz

h_t=150m

h_r=6m

STATION SERVICE AREA

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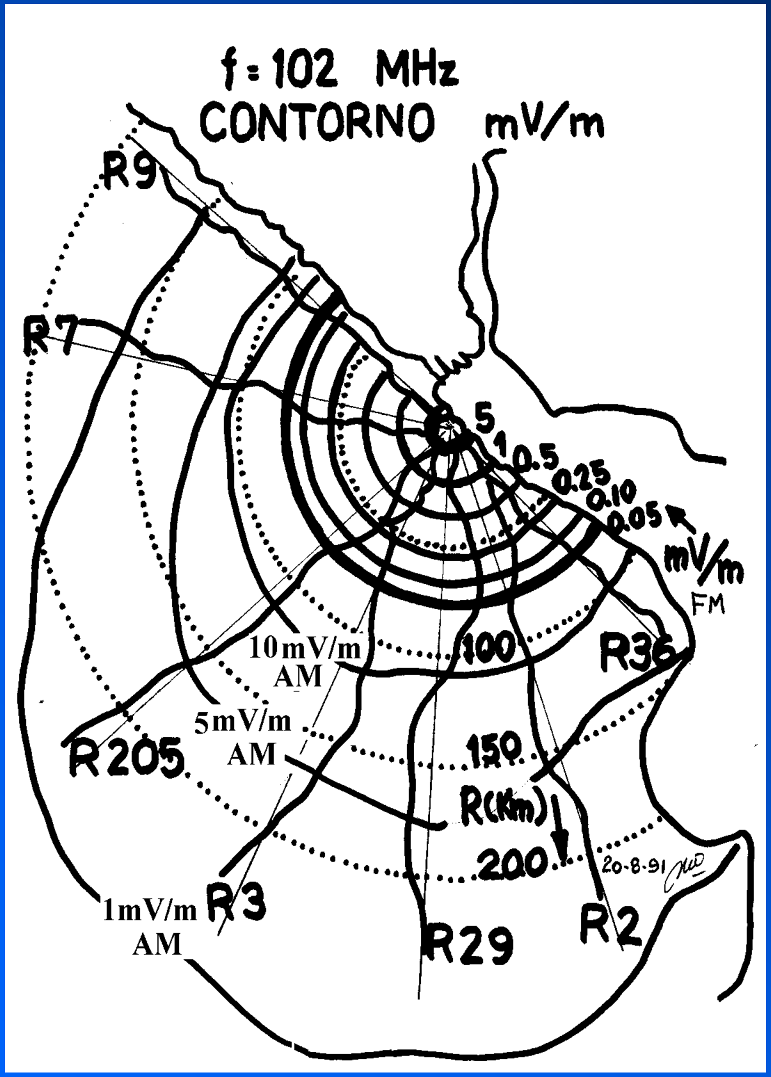
VHF AND UHF BROADCAST ANTENNAS

8 VERTICAL DIPOLE ARRAY



N=8

d=0.7λ

W_T=20kW

f=102MHz

h_t=150m

h_r=6m

AM/FM SERVICE AREA COMPARISON IN BUENOS AIRES

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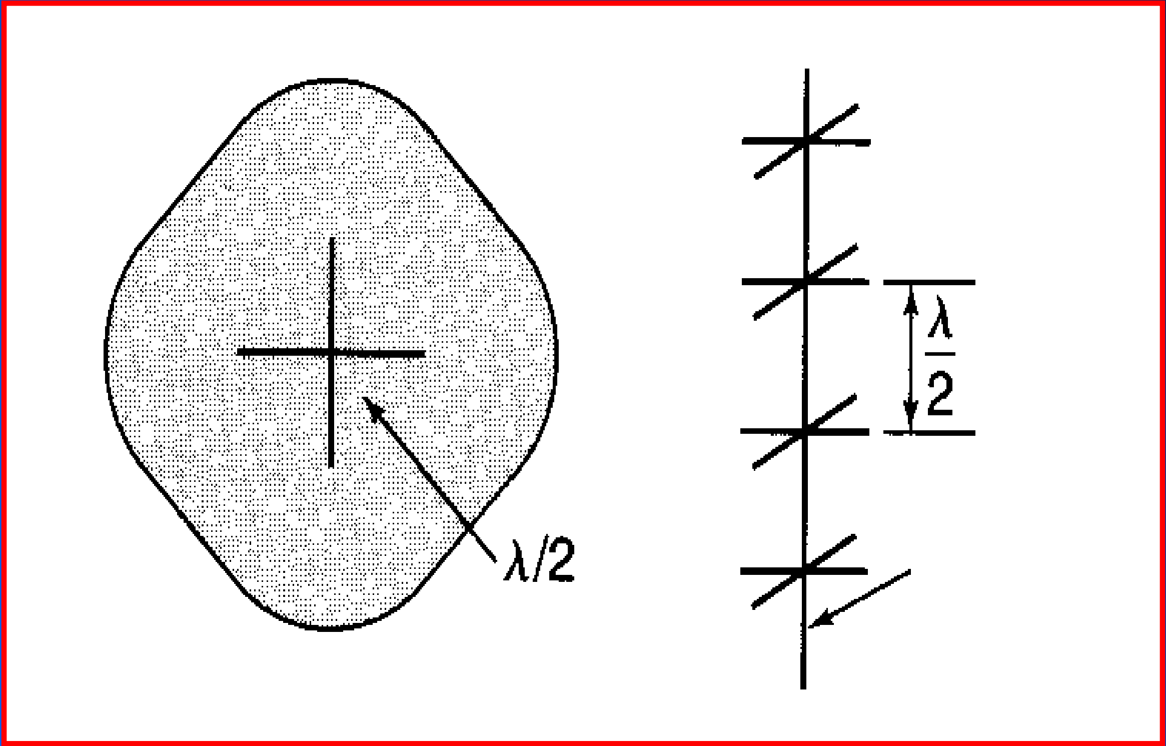
VHF BROADCAST ANTENNAS
DIRECTIONAL ARRAYS

TURNSTILE ANTENNA (Dr. G. H. BROWN 1936)



HORIZONTAL PLANE OMNIDIRECTIONAL
HORIZONTAL POLARIZATION

VHF BROADCAST ANTENNAS

FM RADIATORS (VHF= 88-108MHz)

FM ARRAY

FM ARRAY WITH REFLECTOR

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VHF BROADCAST ANTENNAS

DIRECTIONAL ARRAY

ARRAY OF TWO VERTICAL DIPOLES

VERTICAL POLARIZATION

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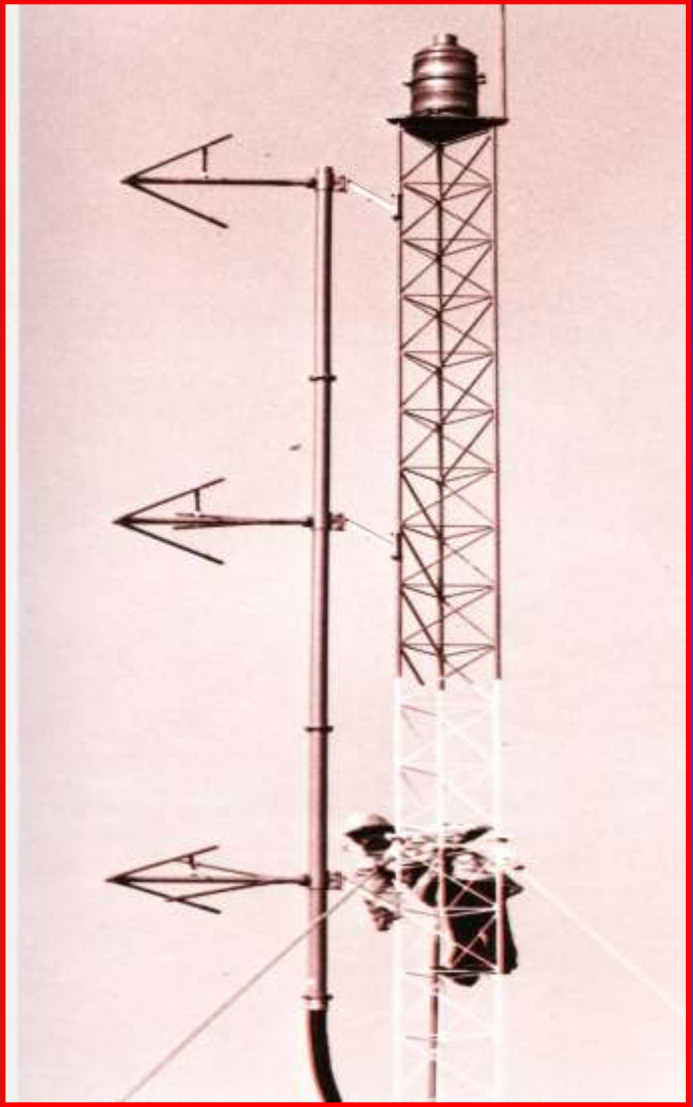
VHF BROADCAST ANTENNAS



DIRECTIONAL ARRAY

ARRAY OF THREE BAYS OF TWO SHUNT SLANTED DIPOLES 90º IN SPACE

(PENETRATOR)

CIRCULAR POLARIZACION

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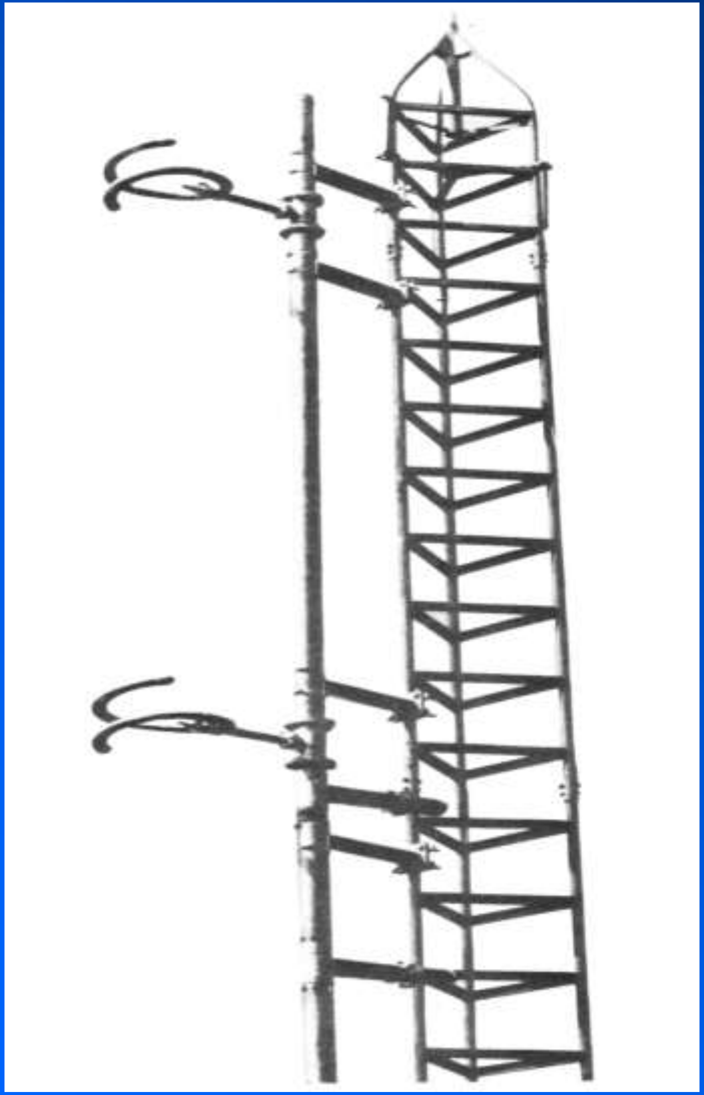
VHF BROADCAST ANTENNAS



DIRECTIONAL ARRAYS

TWO TWIST
RING ARRAY

ELLIPTICAL
POLARIZATION

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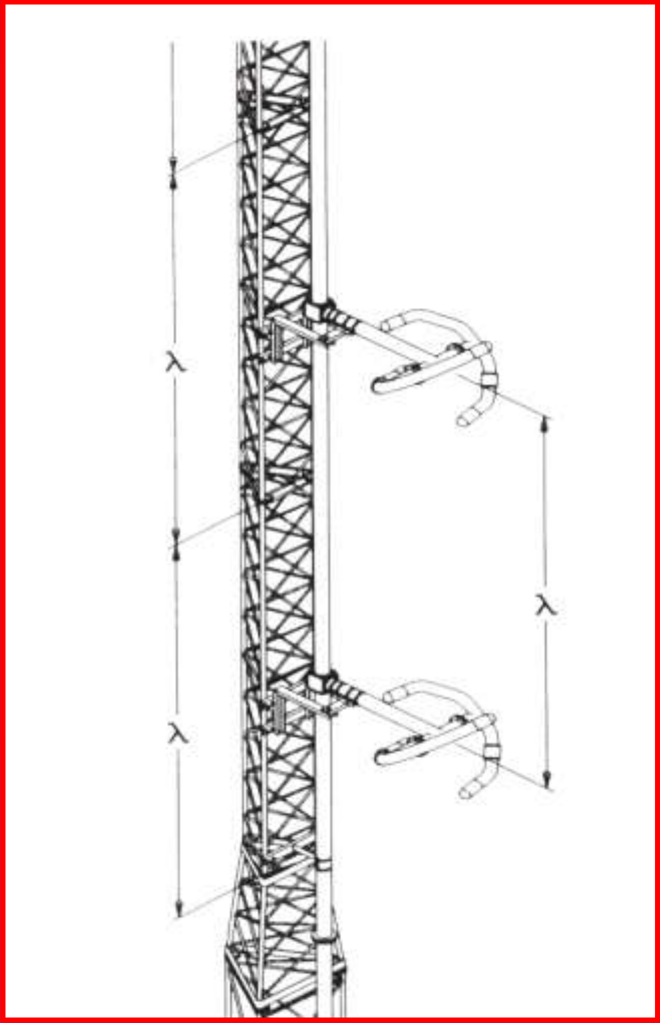
VHF BROADCAST ANTENNAS

DIRECTIONAL ARRAYS



ELEMENT OF TWO SERIES FED SLANTED DIPOLES OF 90º IN SPACE

CIRCULAR POLARIZATION

VHF BROADCAST ANTENNAS

DIRECCIONAL ARRAYS

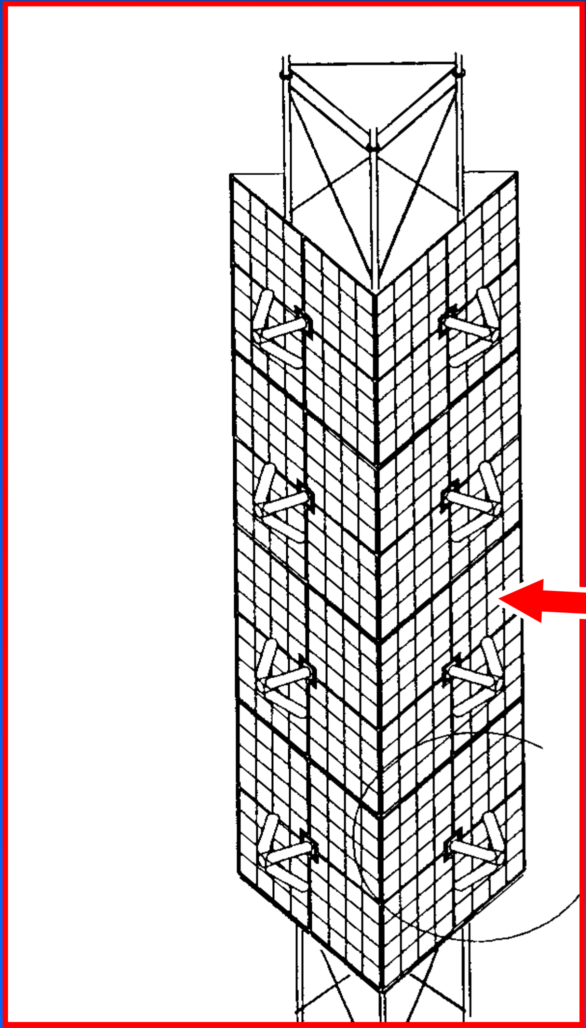
TWO CROSSED
HALF WAVE DIPOLES
WITH REFLECTOR

REFLECTOR

CIRCULAR POLARIZATION

VHF BROADCAST ANTENNAS

DIRECTIONAL ARRAYS



ARRAY OF FOUR BAYS HALF WAVE CROSSED DIPOLES WITH REFLECTOR

REFLECTOR

CIRCULAR POLARIZATION

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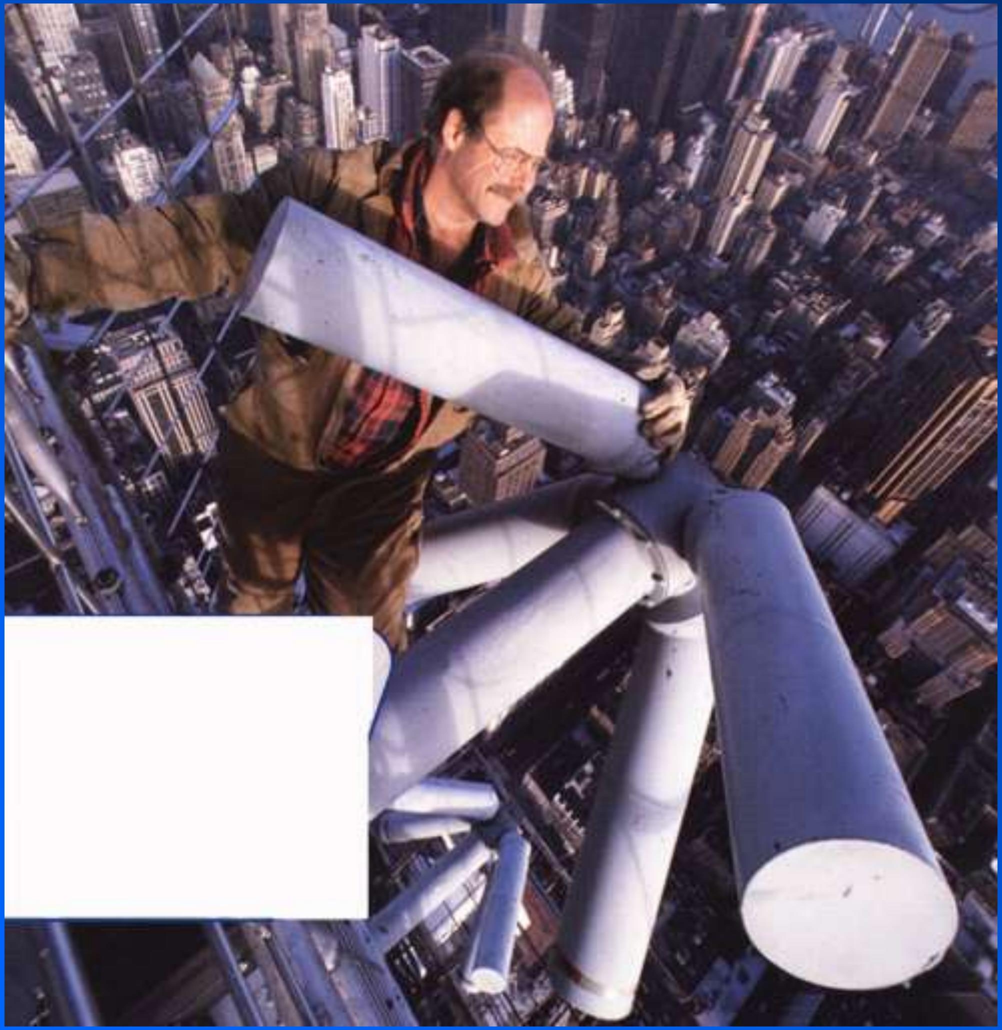
VHF BROADCAST ANTENNAS

DIRECTIONAL ARRAYS



ARRAY OF HIGH POWER CROSSED HALF WAVE DIPOLES ON THE EMPIRE STATE BUILDING NEW YORK

(RF OFF)

CIRCULAR POLARIZATION

VHF BROADCAST ANTENNAS

- **FM IBOC Antenna Operation (Digital Trans.)**
- **Three methods are possible:**

a) Single Transmitter with A and D combined and feed them to a commom Antenna.

b) Separated A and D Transmitter Signals combined in the Transmitter Building and fed to a common Antenna.

c) Separated A and D Transmitters each feeding signals through separated Transmission Lines and Antennas

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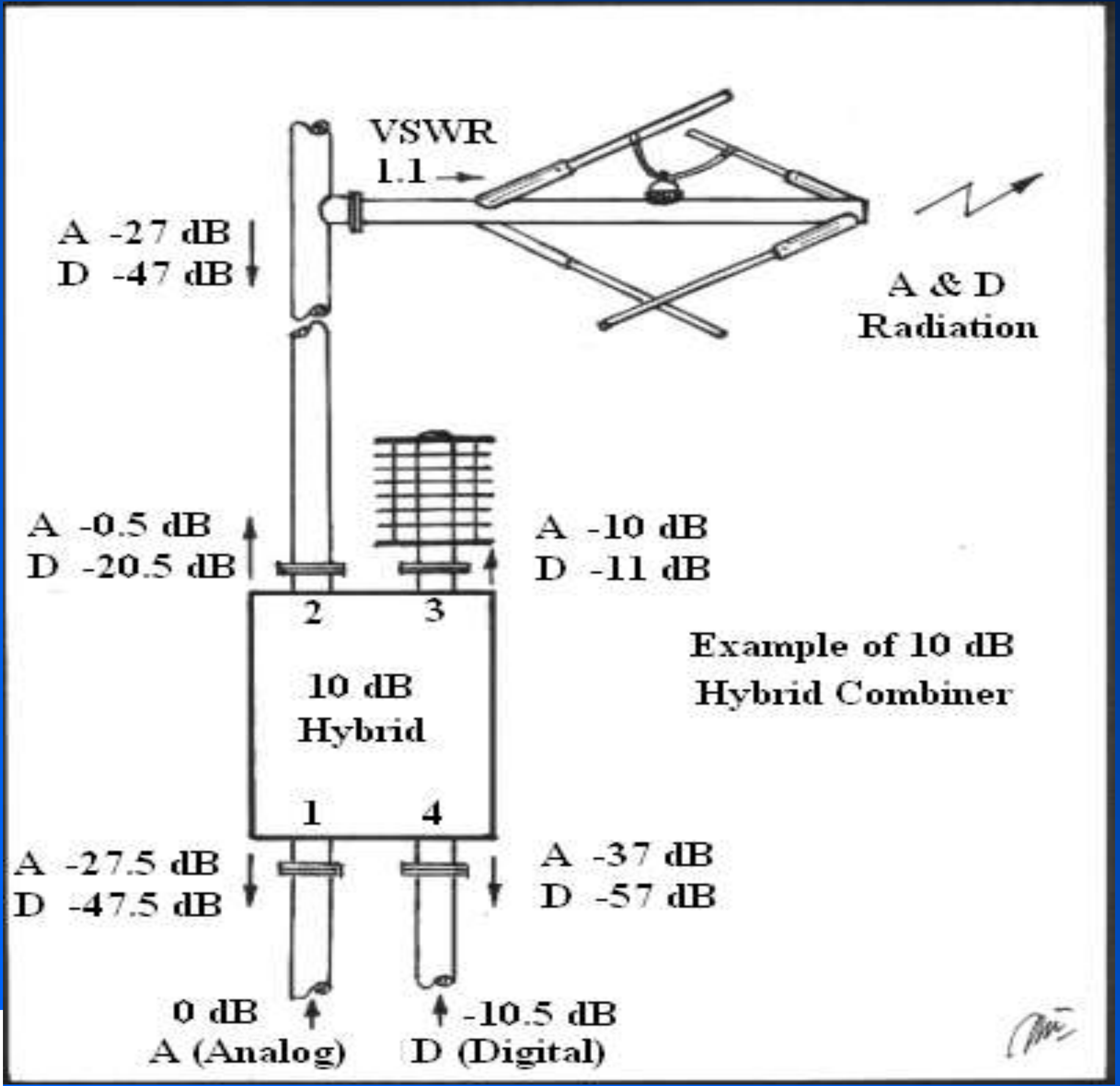
VHF BROADCAST ANTENNAS

FM IBOC ANALOG/DIGITAL TRANS.



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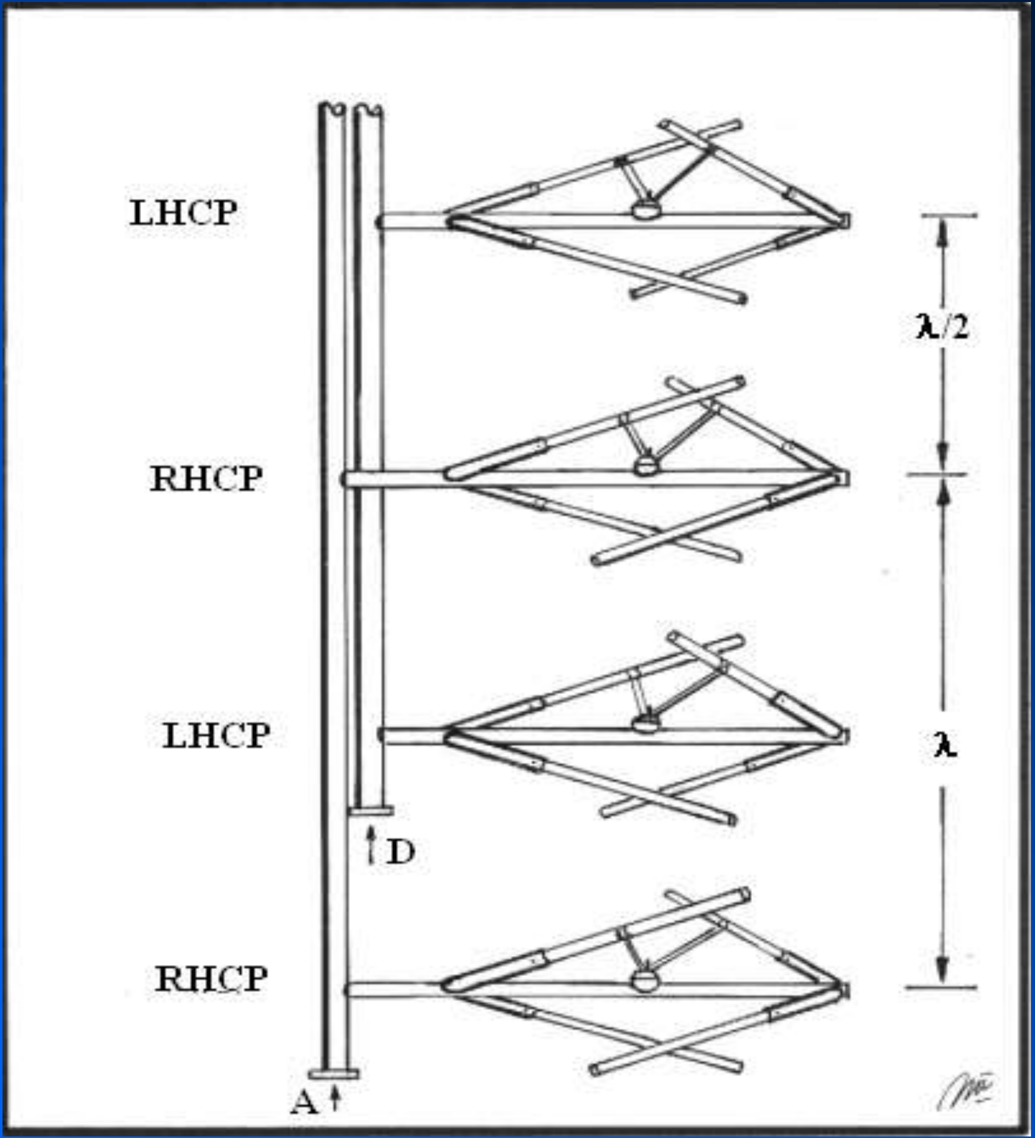
VHF BROADCAST ANTENNAS

FM IBOC ANALOG/DIGITAL TRANSMISSION

Two Interleaved FM Antennas



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VHF BROADCAST ANTENNAS

- FM Multistation Operation
- Two systems are possible:
- a) Branched Combiner (Tee or Star)
- b) Balanced Combiner (Quadrature Hybrid)

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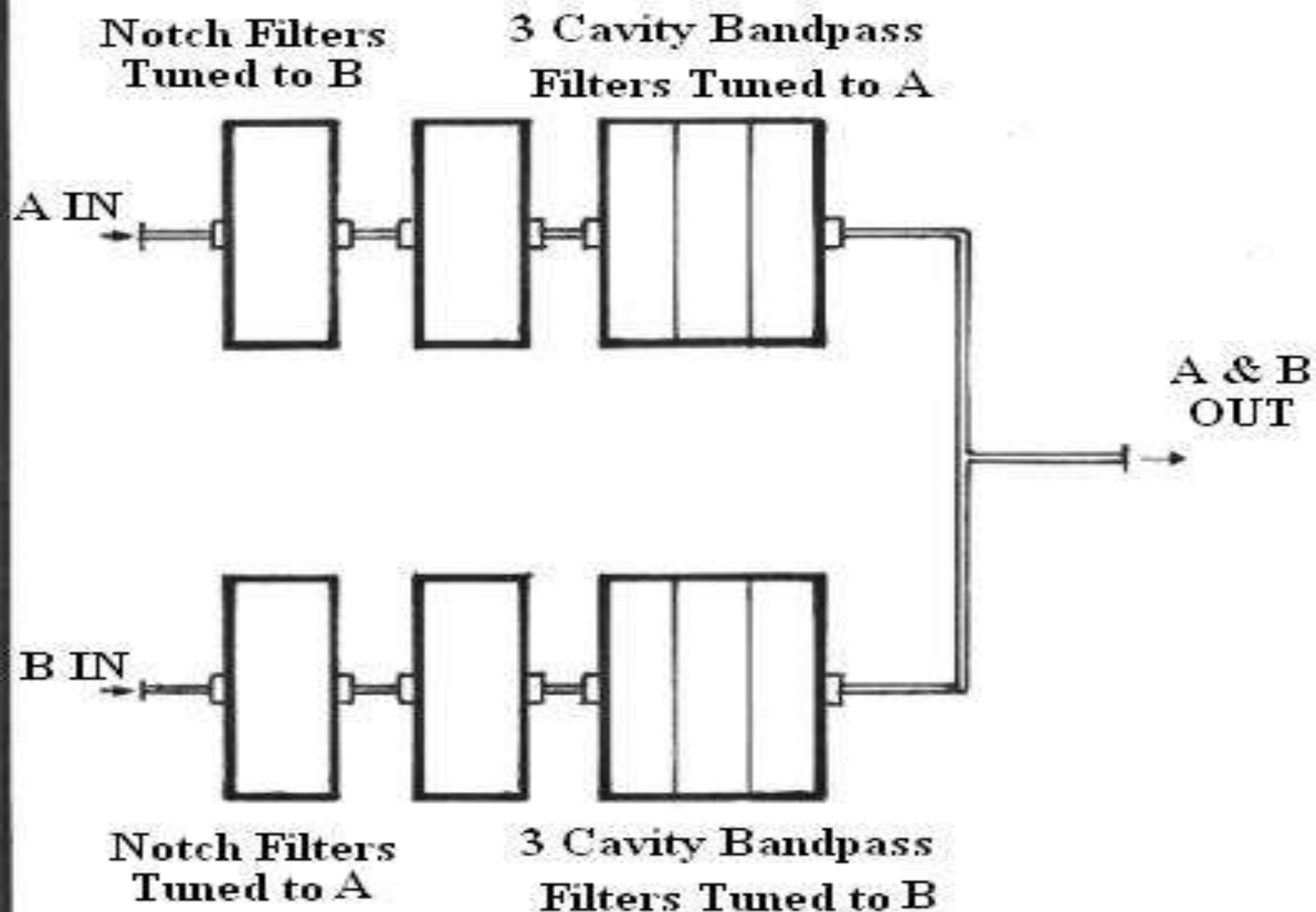
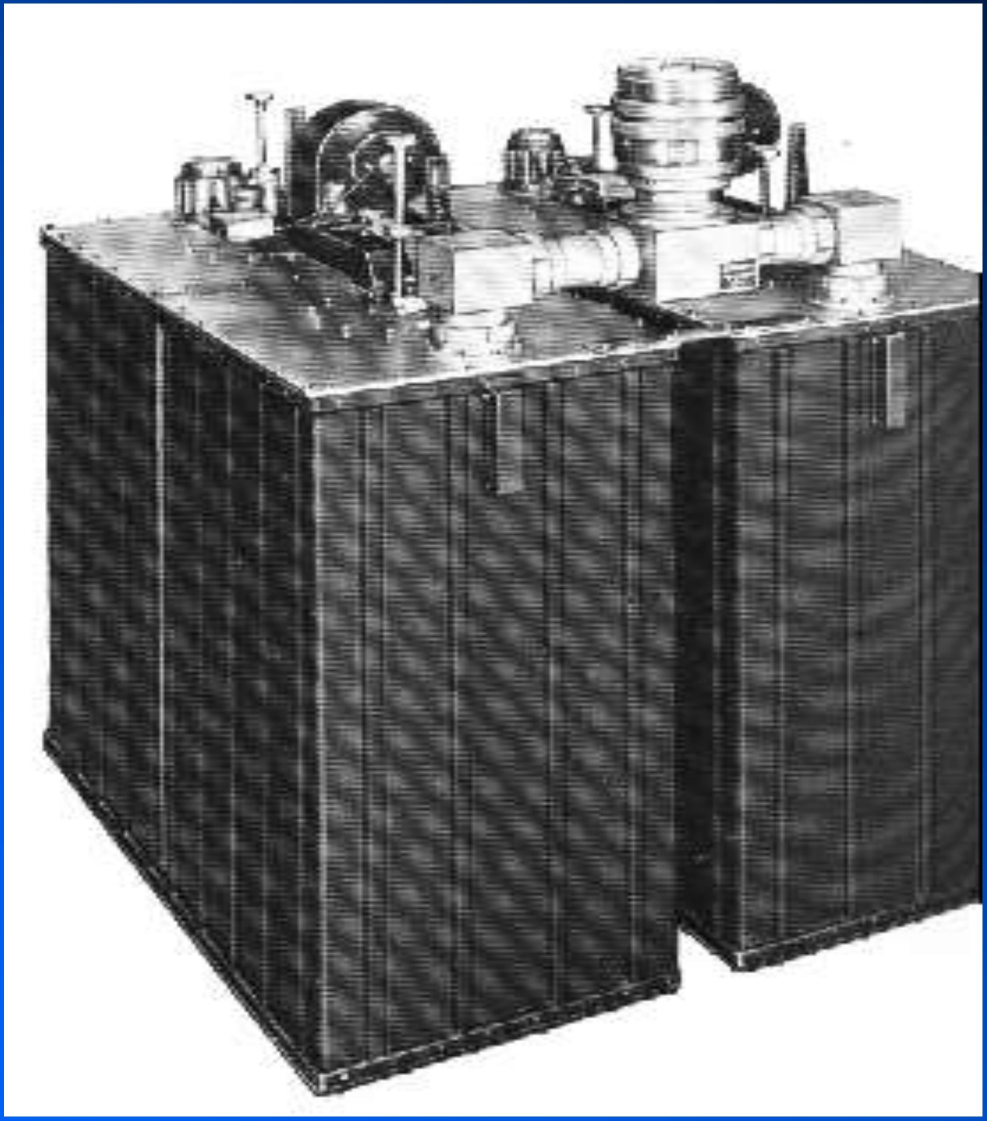
VHF BROADCAST ANTENNAS



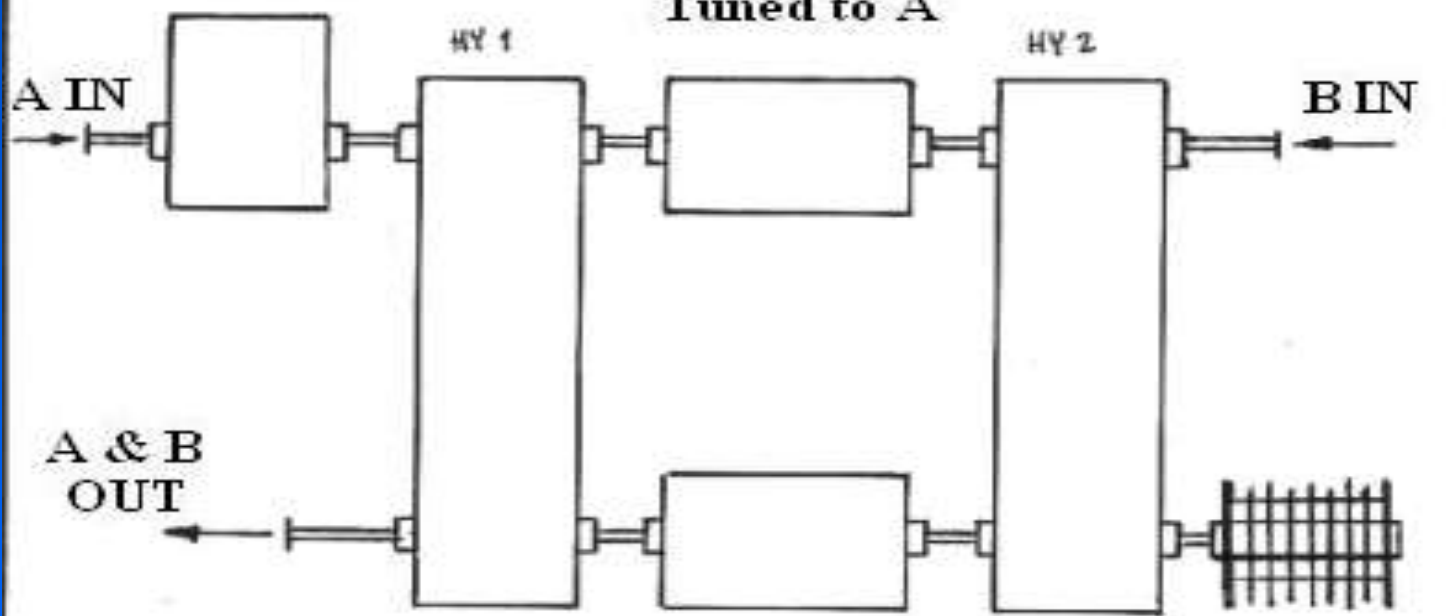
2 Station Branched Combiner

VHF BROADCAST ANTENNAS

FM Branched Combiner



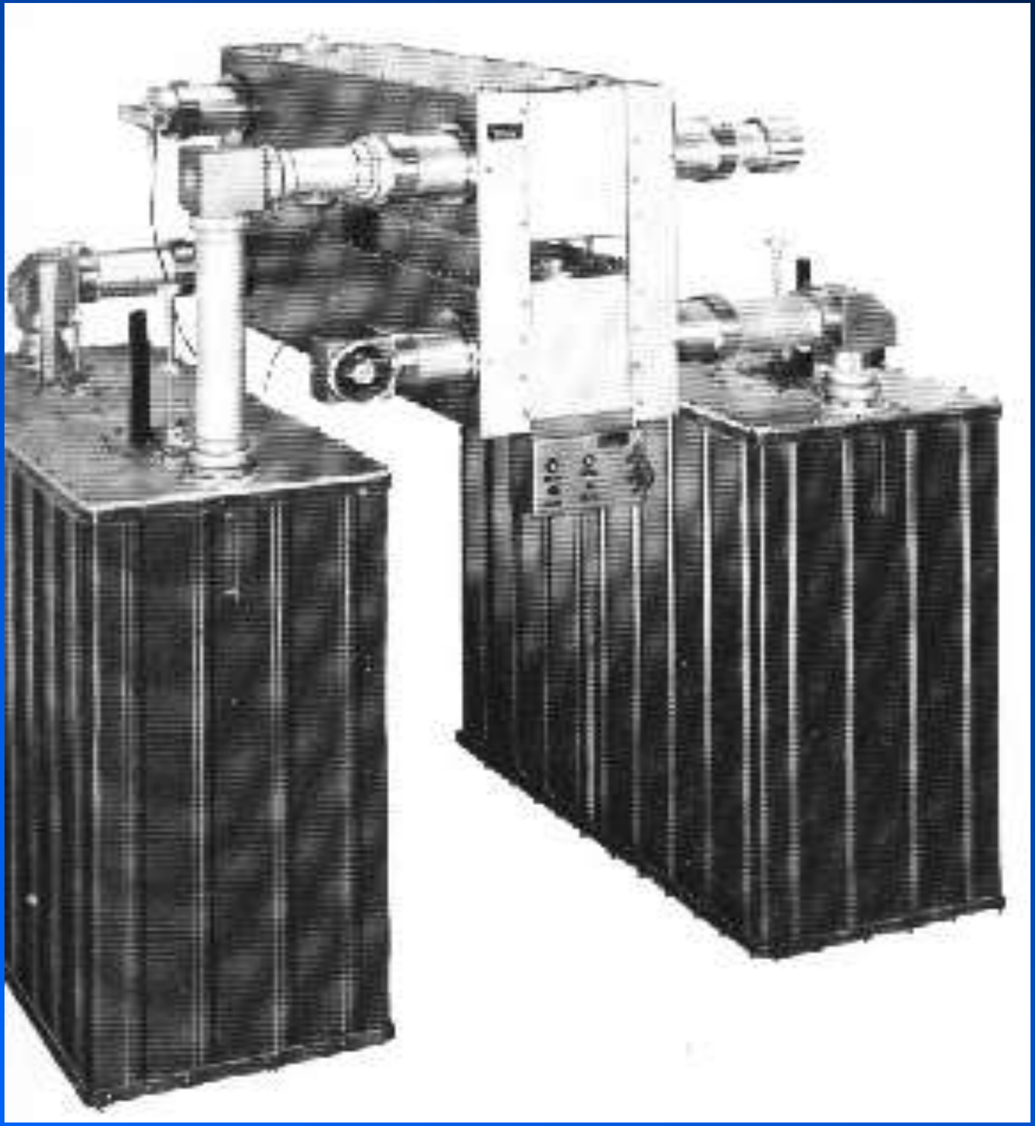
VHF BROADCAST ANTENNAS



2 FM Transmitter Balanced Combiner

VHF BROADCAST ANTENNAS

FM Balanced Combiner



VHF and UHF BROADCAST ANTENNAS

- TV Antenna Element
- Panel Dipole (HP) Directional
- Panel Crossed Dipole (CP) Directional
- Batwing (Superturnstile) HP Omni
- Batterfly (HP) Directional
- Travelling Wave Slot :
    - Resonant (HP)
    - Non Resonant (HP)

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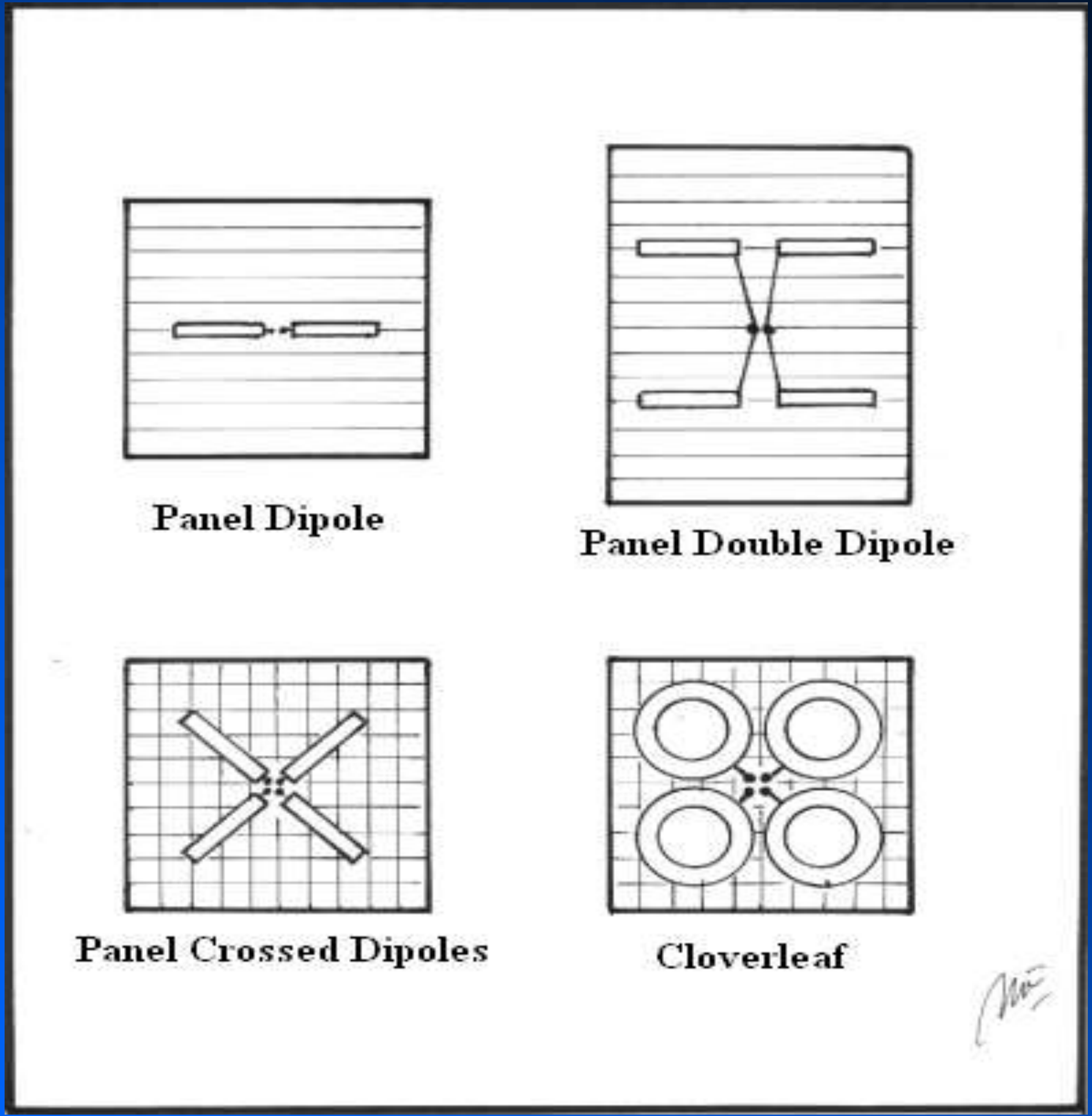
VHF TV BROADCAST ANTENNAS

TV Directional Antenna Elements



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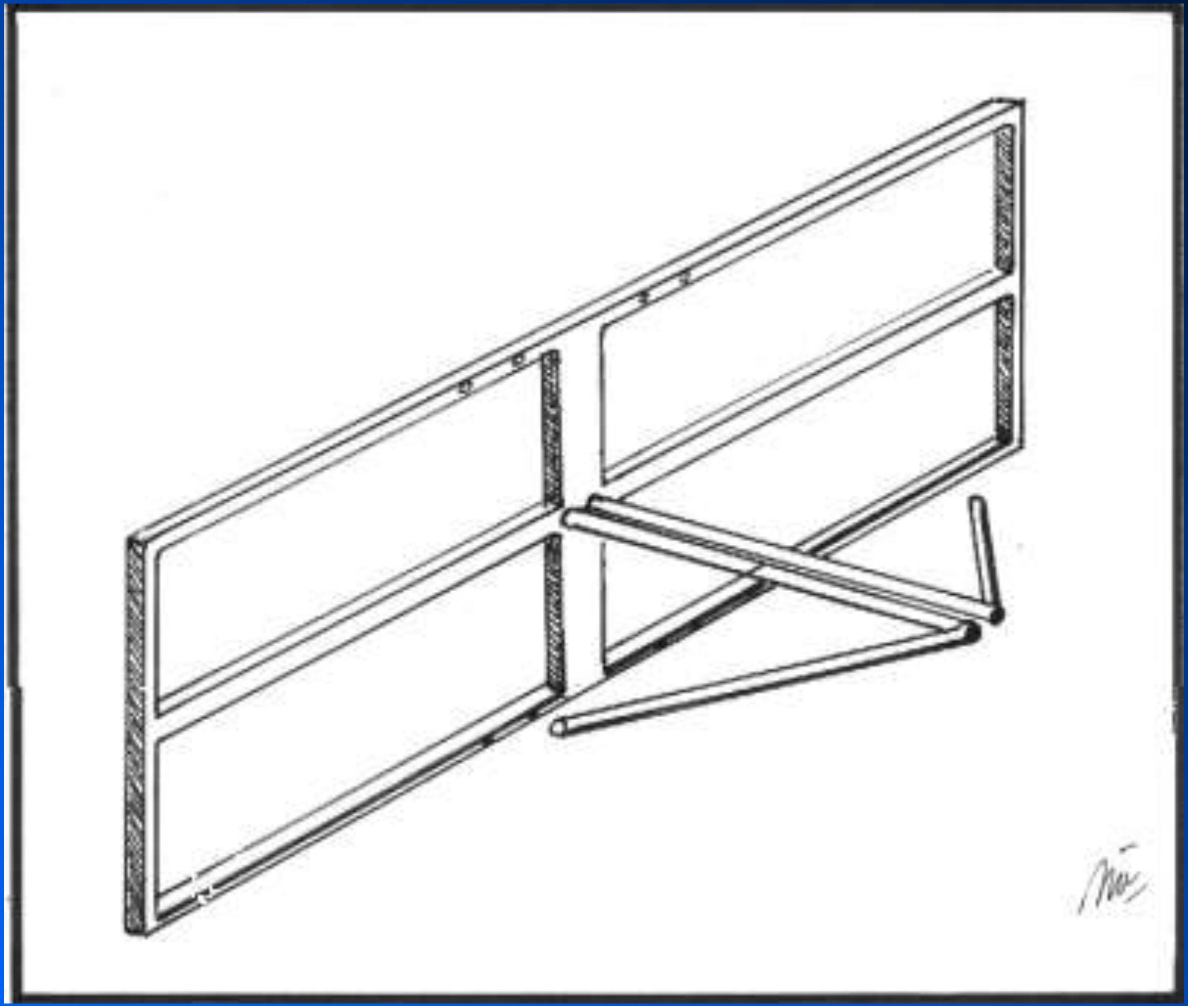
VHF TV BROADCAST ANTENNAS
TV DIRECCIONAL ELEMENT

Low VHF TV Antenna



Flat Panel Dipole

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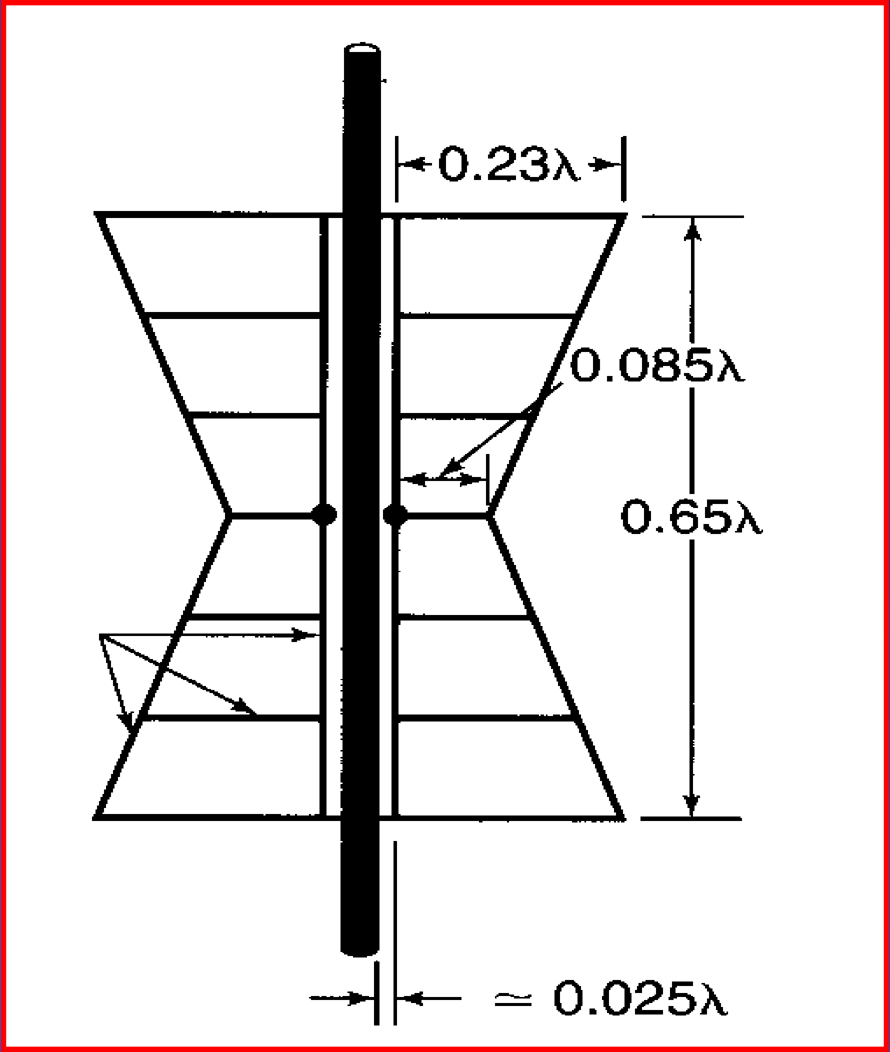
VHF TV BROADCAST ANTENNAS

TV DIRECCIONAL ELEMENT



SUPER TURNSTILE ANTENNA ELEMENT (BATWINGS)

MASTERS 1946

POLARIZACION HORIZONTAL

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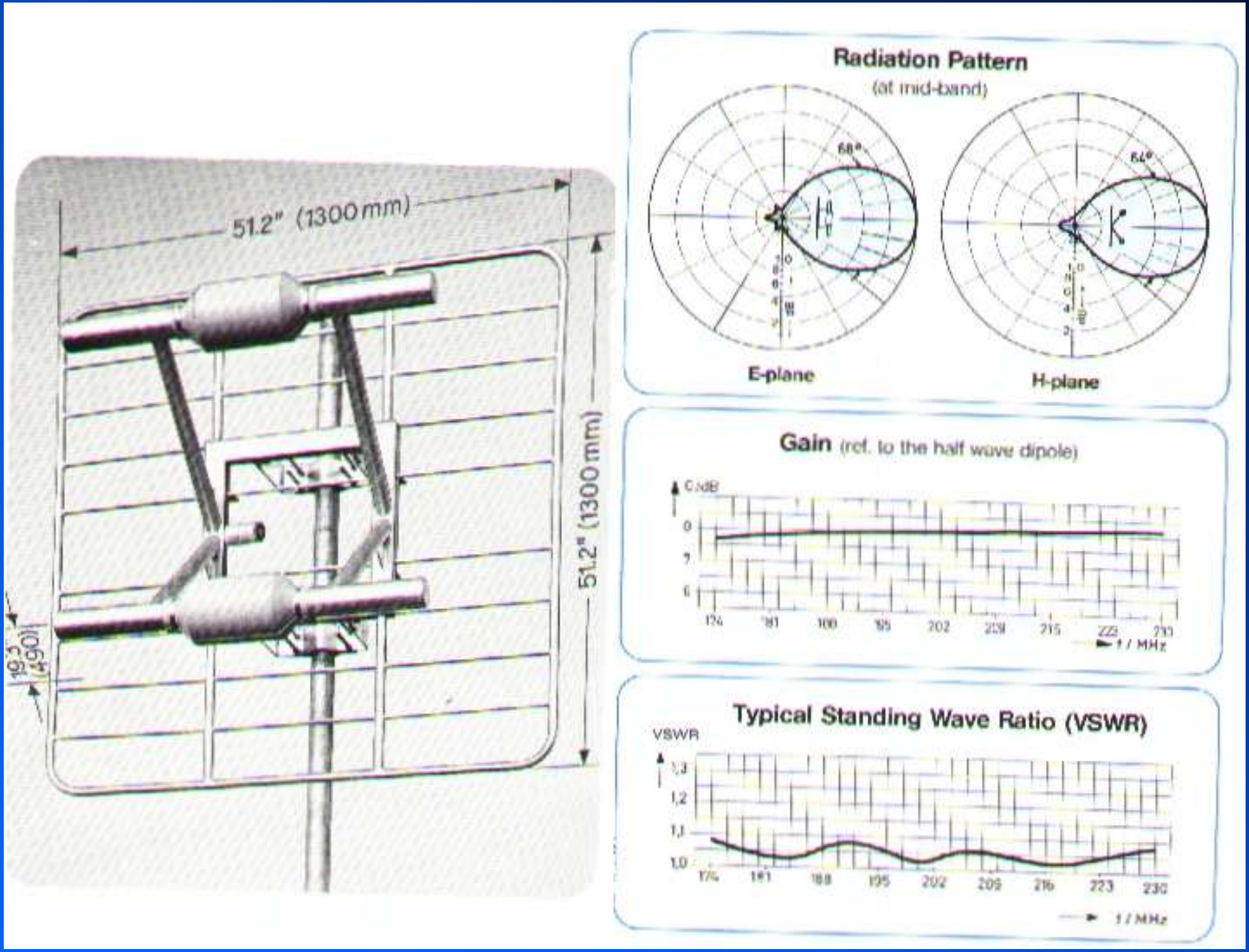
VHF TV BROADCAST ANTENNAS



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VHF TV BROADCAST ANTENNAS

TV DIRECTIONAL ARRAYS

SUPER TURNSTILE ANTENNA

HORIZONTAL POLARIZATION

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VHF TV BROADCAST ANTENNAS

LOW BAND 54-88 MHZ (# 2 A 6)

HIGH BAND 174-216 MHZ (# 7 A 13)

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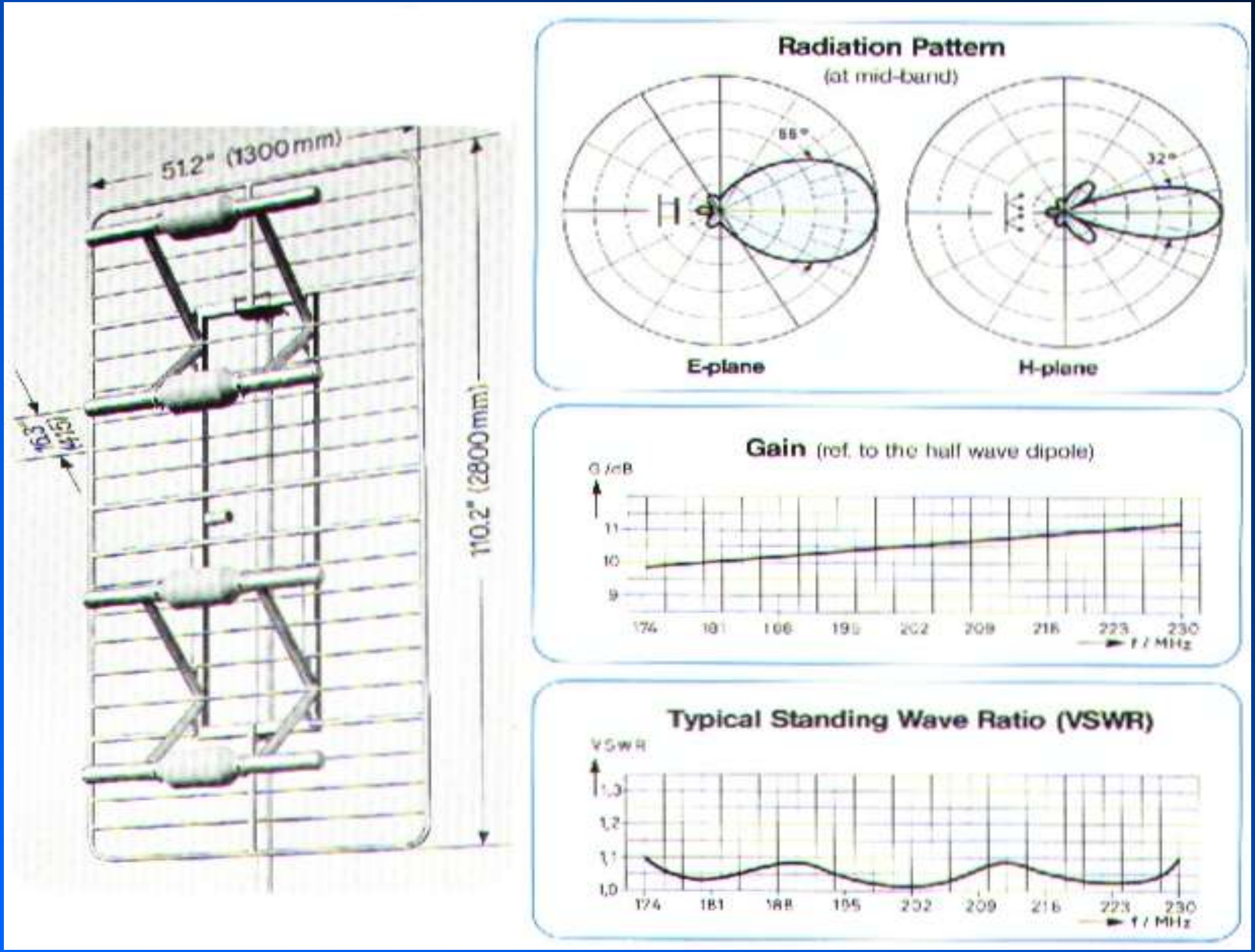
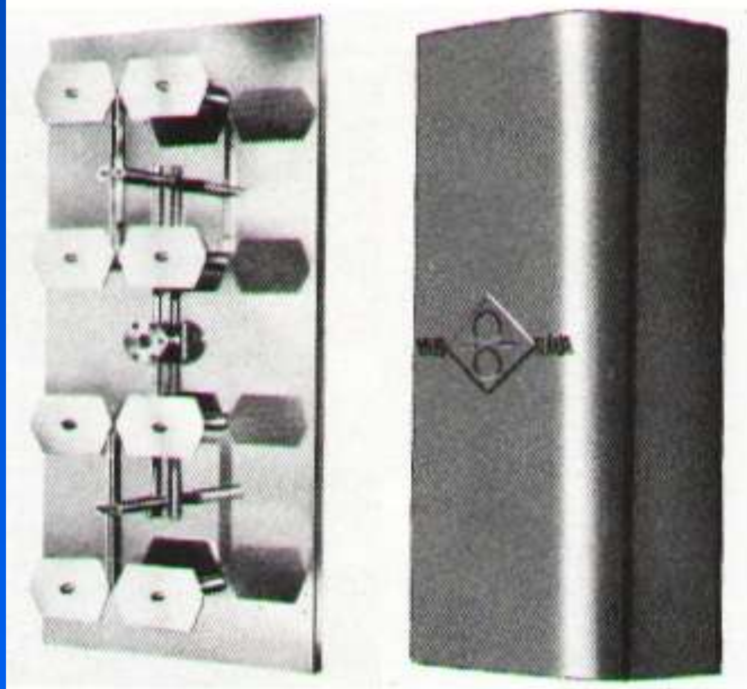
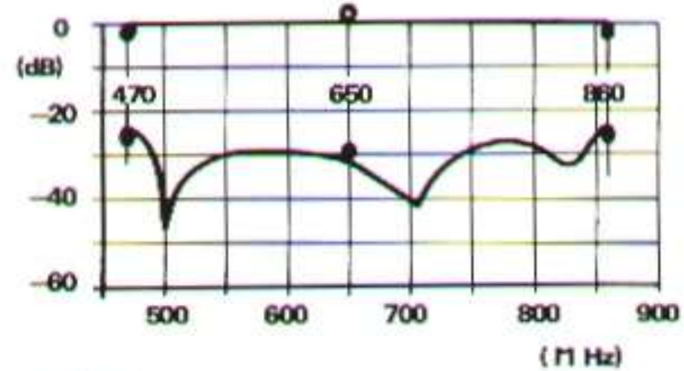
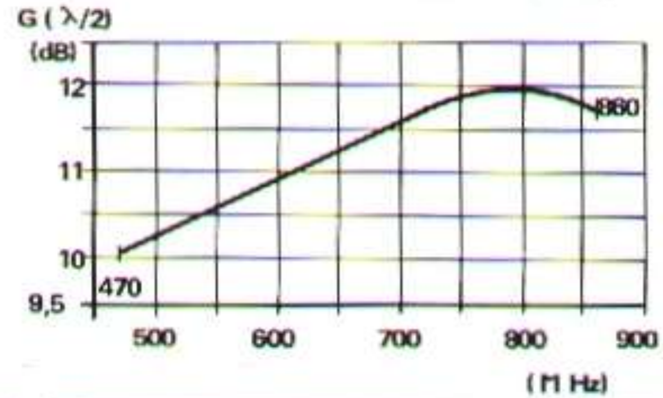
VHF TV BROADCAST ANTENNAS

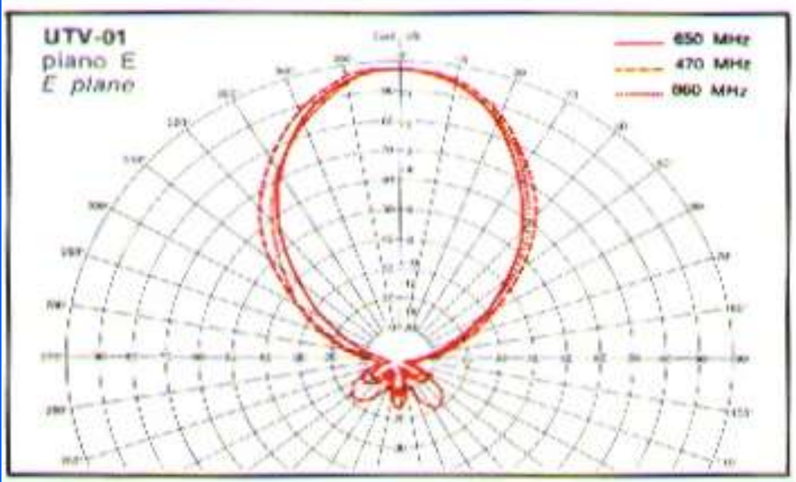


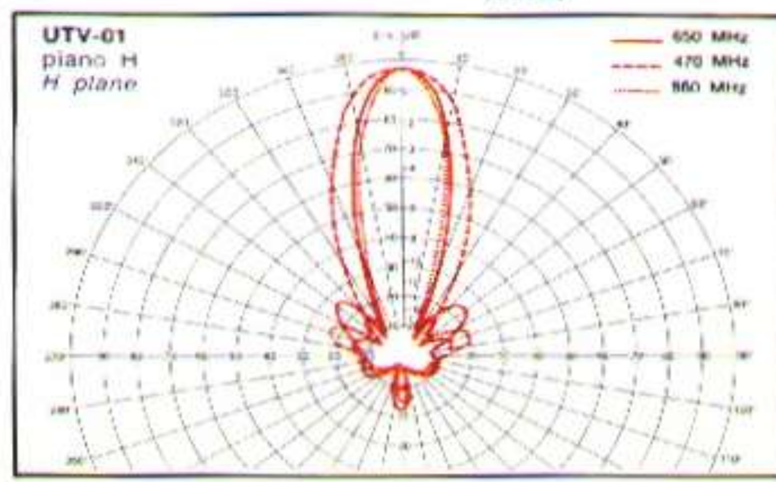
UHF TV BROADCAST ANTENNAS





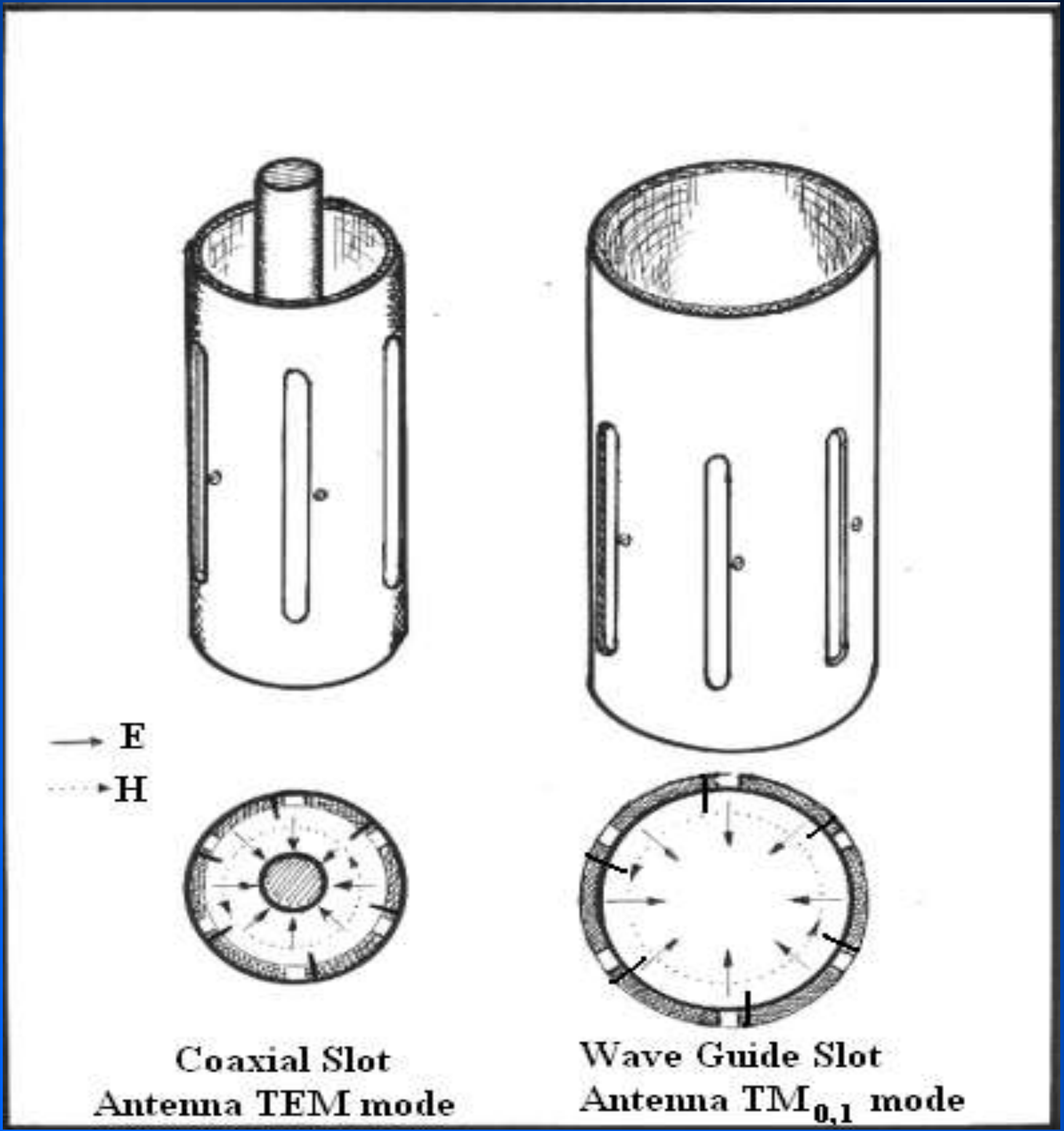






VHF TV BROADCAST ANTENNAS

TV Slotted Antenna Elements



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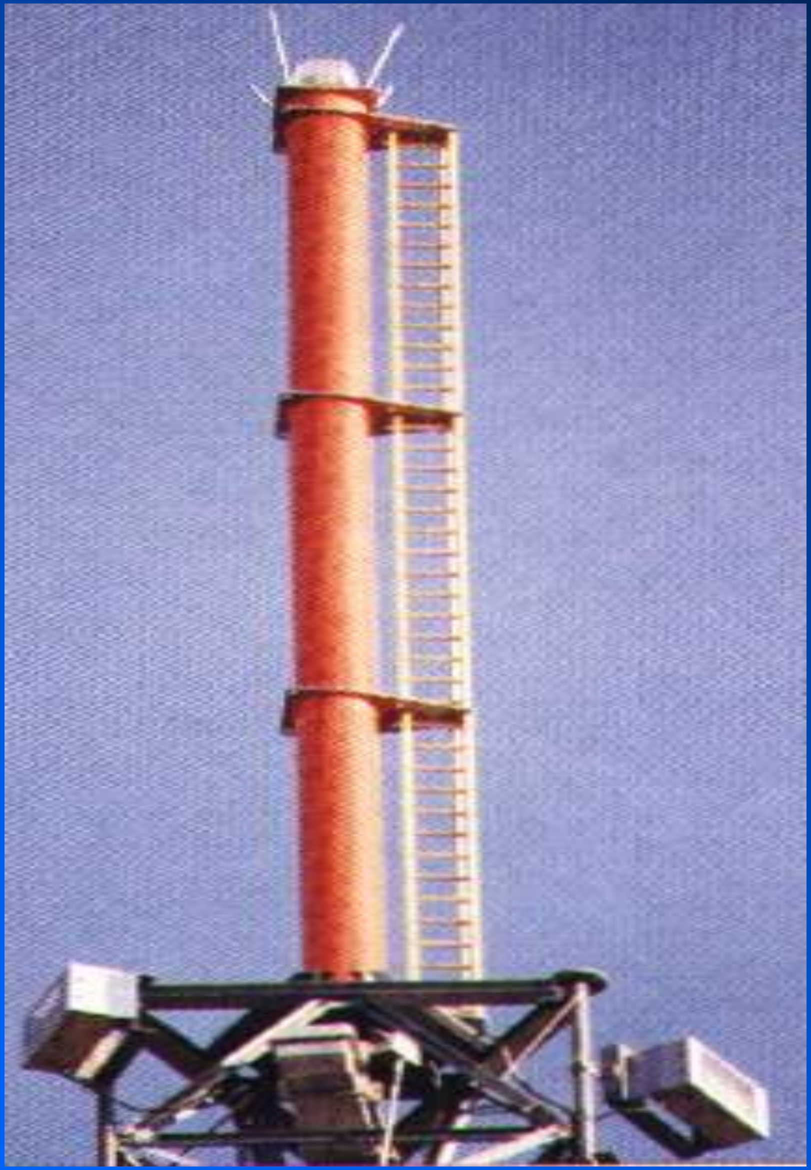
UHF TV BROADCAST ANTENNAS



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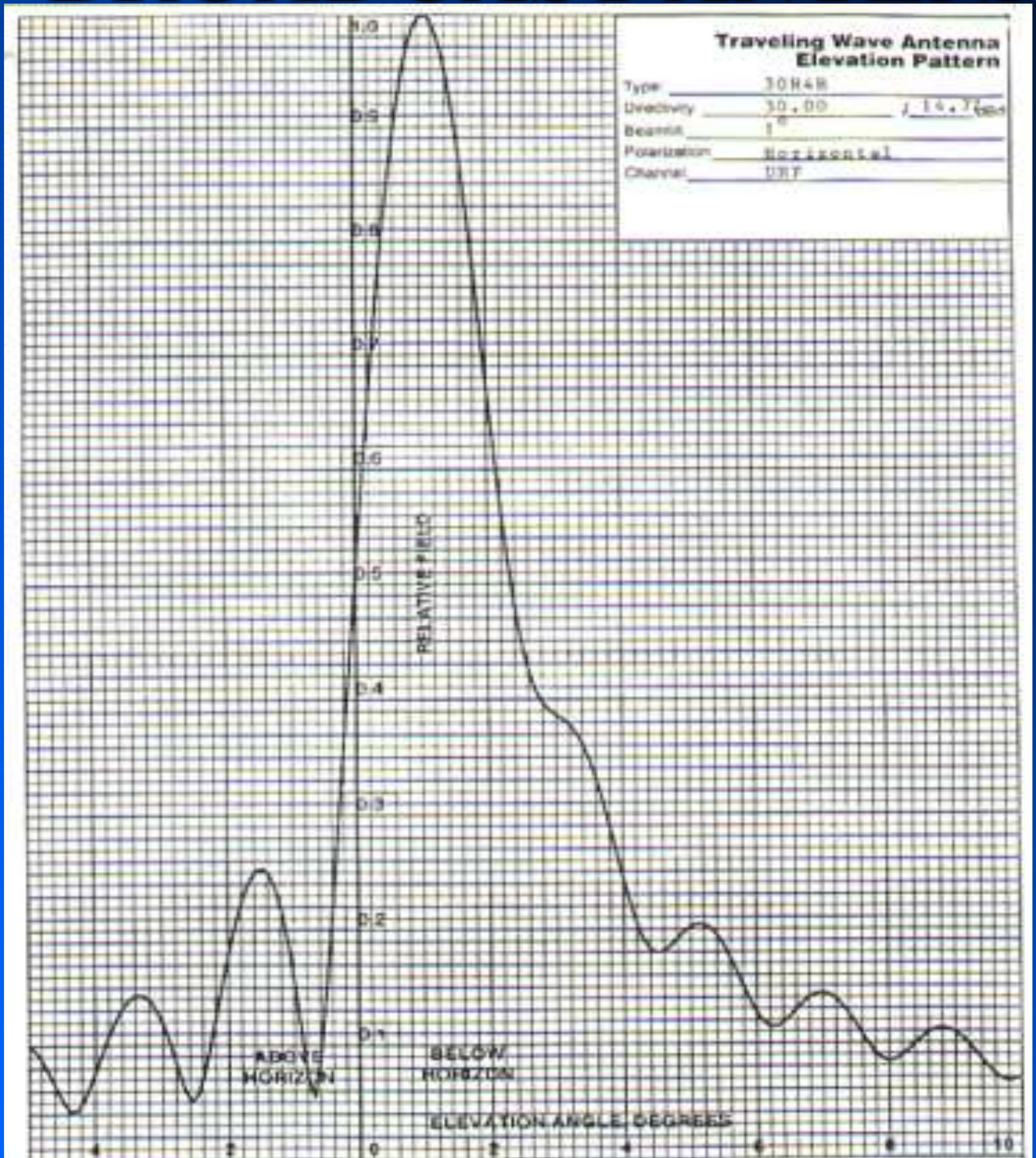
UHF TV BROADCAST ANTENNAS



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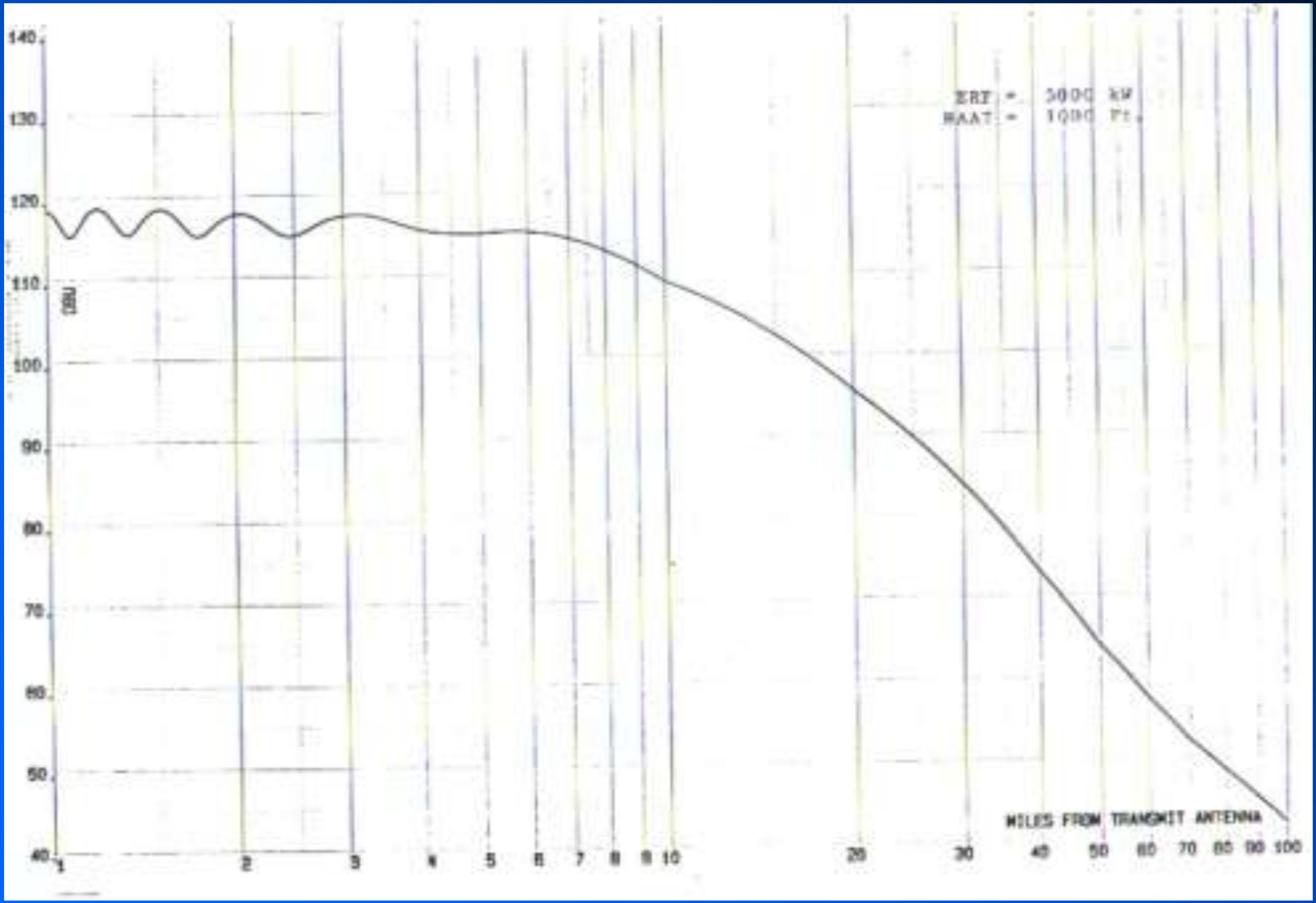
UHF TV BROADCAST ANTENNAS



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FM and TV Transmission Lines

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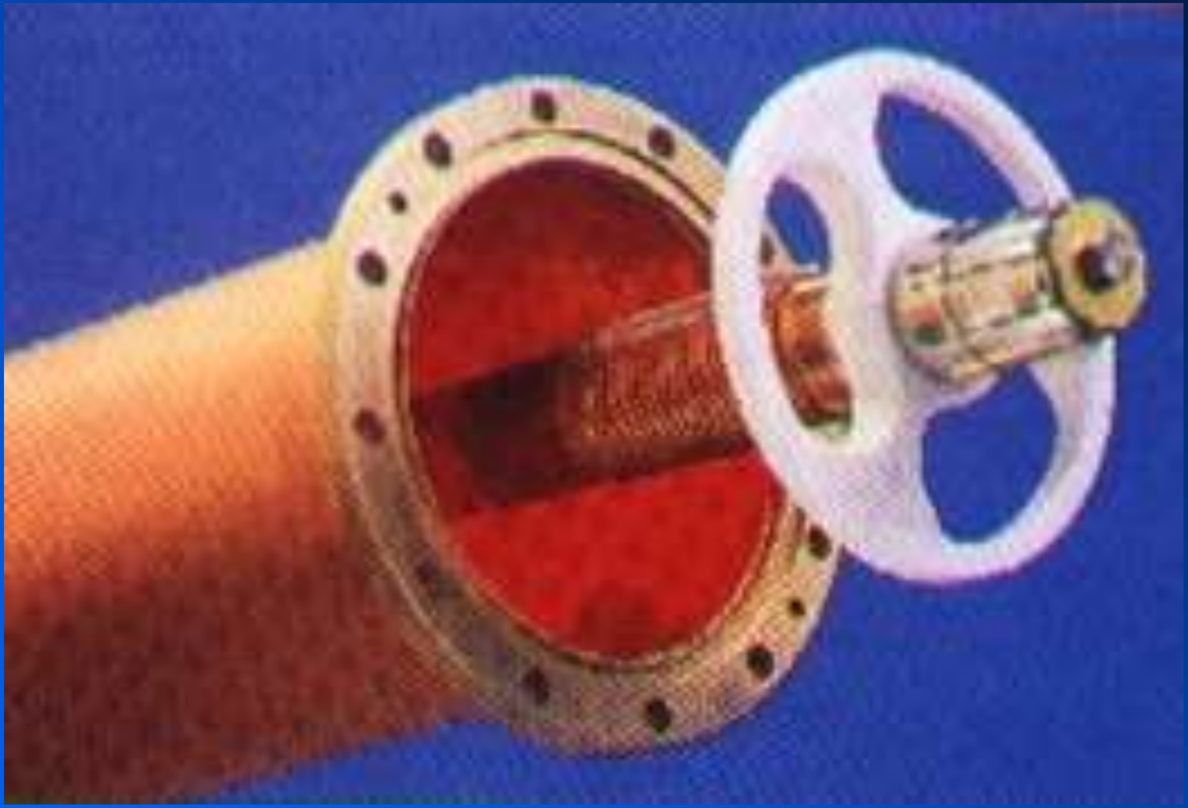
COAXIAL TRANSMISSION LINE

FM and TV Transmission Lines



RIGID COAXIAL TRANSMISSION LINE

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FM and TV Transmission Lines

SIZE	Maximum Frequency	VP / c	ATT / W_T 50 MHz	ATT / W_T 200 MHz	ATT / W_T 500 MHz
1 5/8	2.7	0.92	0.44/27	0.90/13	1.45/8
3	1.64	0.93	0.29/58	0.60/28	1.0/17
6 1/8	0.86	0.97	0.13/244	0.27/120	0.45/75
9	0.65	0.97	0.11/878	0.23/422	0.41/252

Air Coaxial Line

FM and TV Transmission Lines

SIZE	Maximum Frequency	VP / c	ATT / W_T 50 MHz	ATT / W_T 200 MHz	ATT / W_T 500 MHz
7/8	5.0	0.89	0.79/12	1.62/6	2.61/4
6 ¼	3.3	0.89	0.57/19	1.19/9	1.94/6
1 5/8	2.5	0.89	0.45/25	0.93/12	1.53/7
2 1/4	2.2	0.89	0.39/30	0.83/14	1.39/8

Foam Coaxial Line

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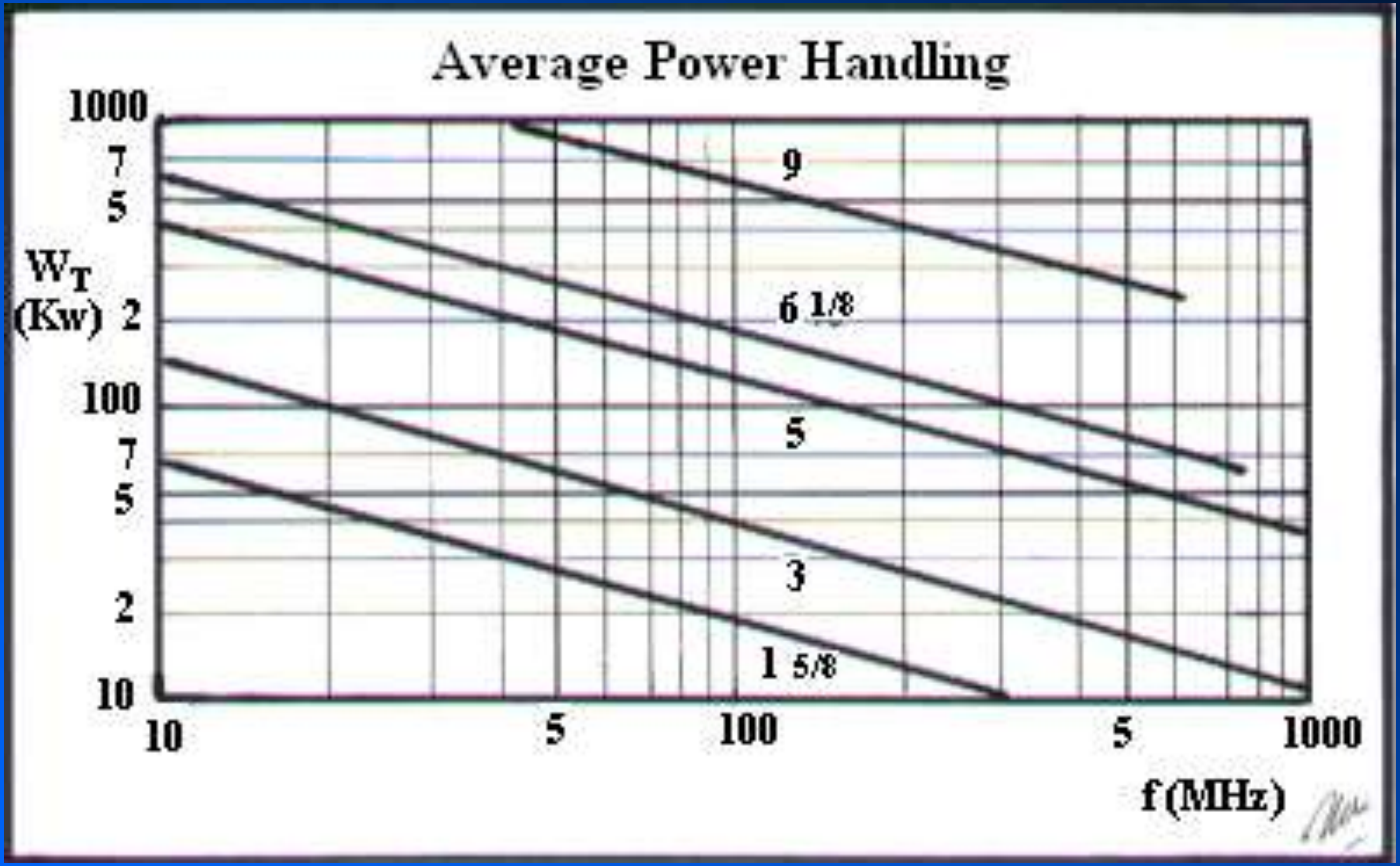
FM and TV Transmission Lines



Braodcast Semifexible Air Coaxial Lines

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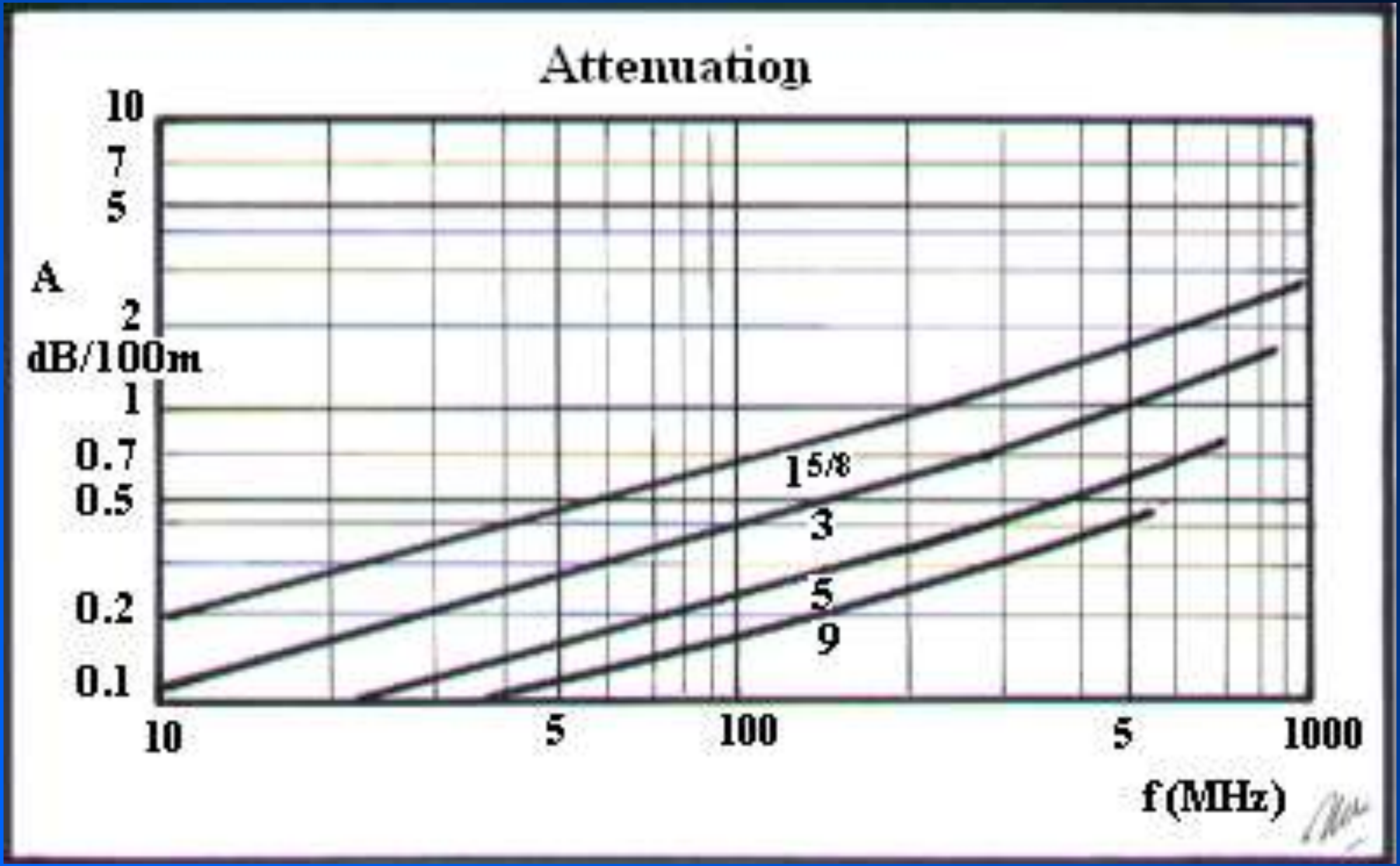
BROADCAST ANTENNAS



Braodcast Semifexible Air Coaxial Lines

VHF BROADCAST ANTENNAS

MAXIMUM ELECTROMAGNETIC RADIATION

IEEE/ANSI STANDARD C95-1

CONTROLLED

BAND	Emax		Hmax		Pmax	
MHz	V/m	dBµV/m	A/m	dBµA/m	mW/cm^2	$dBpW/m^2$
50-300	61.4	155.8	0.163	104.2	1.0	130.0

NON CONTROLLED

BAND	Emax		Hmax		Pmax	
MHz	V/m	dBµV/m	A/m	dBµA/m	mW/cm^2	$dBpW/m^2$
50-300	27.5	148.8	0.073	97.2	0.2	123.0

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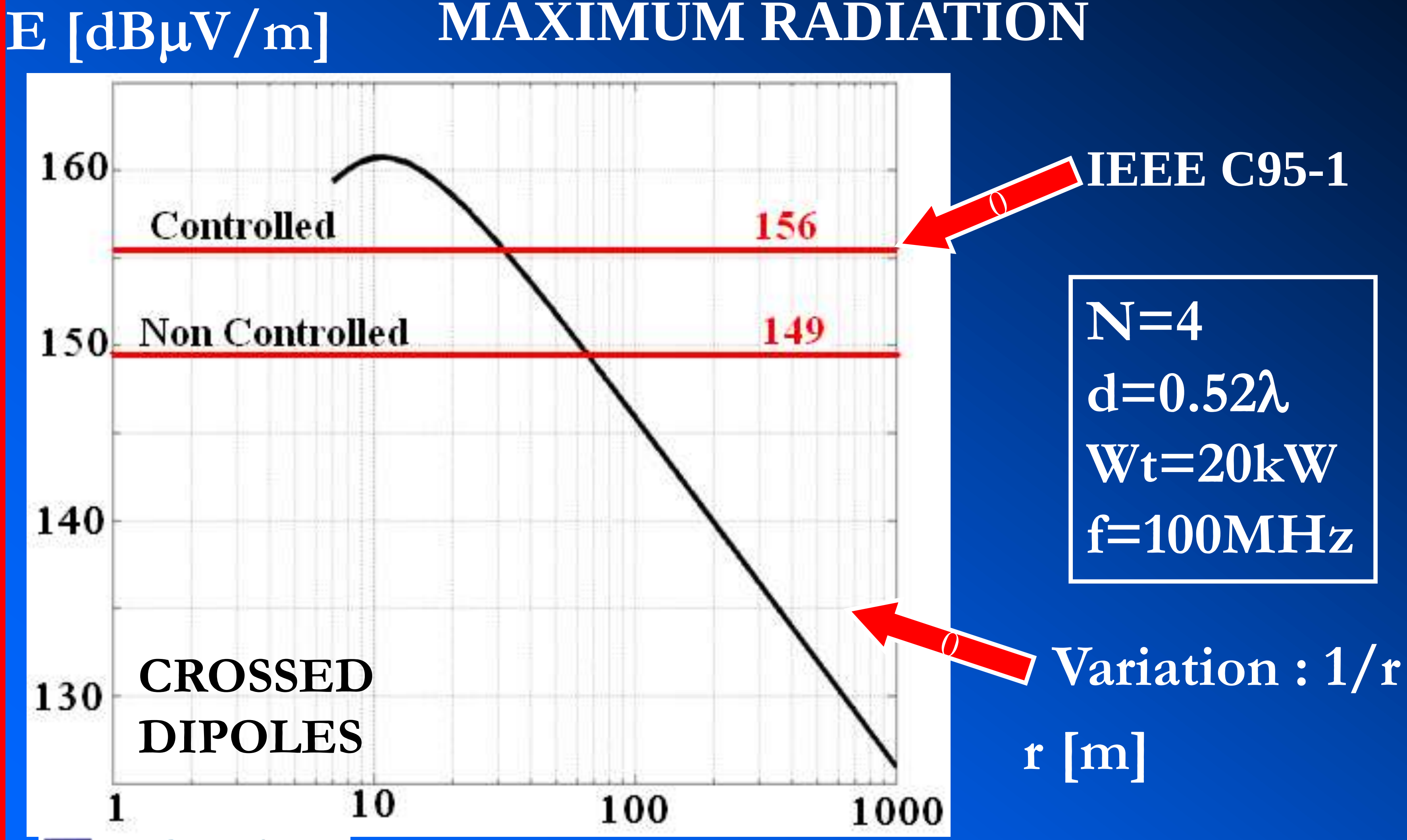
VHF BROADCAST ANTENNAS

4 VERTICAL DIPOLE ARRAY

MAXIMUM RADIATION



N=4

d=0.52λ

Wt=20kW

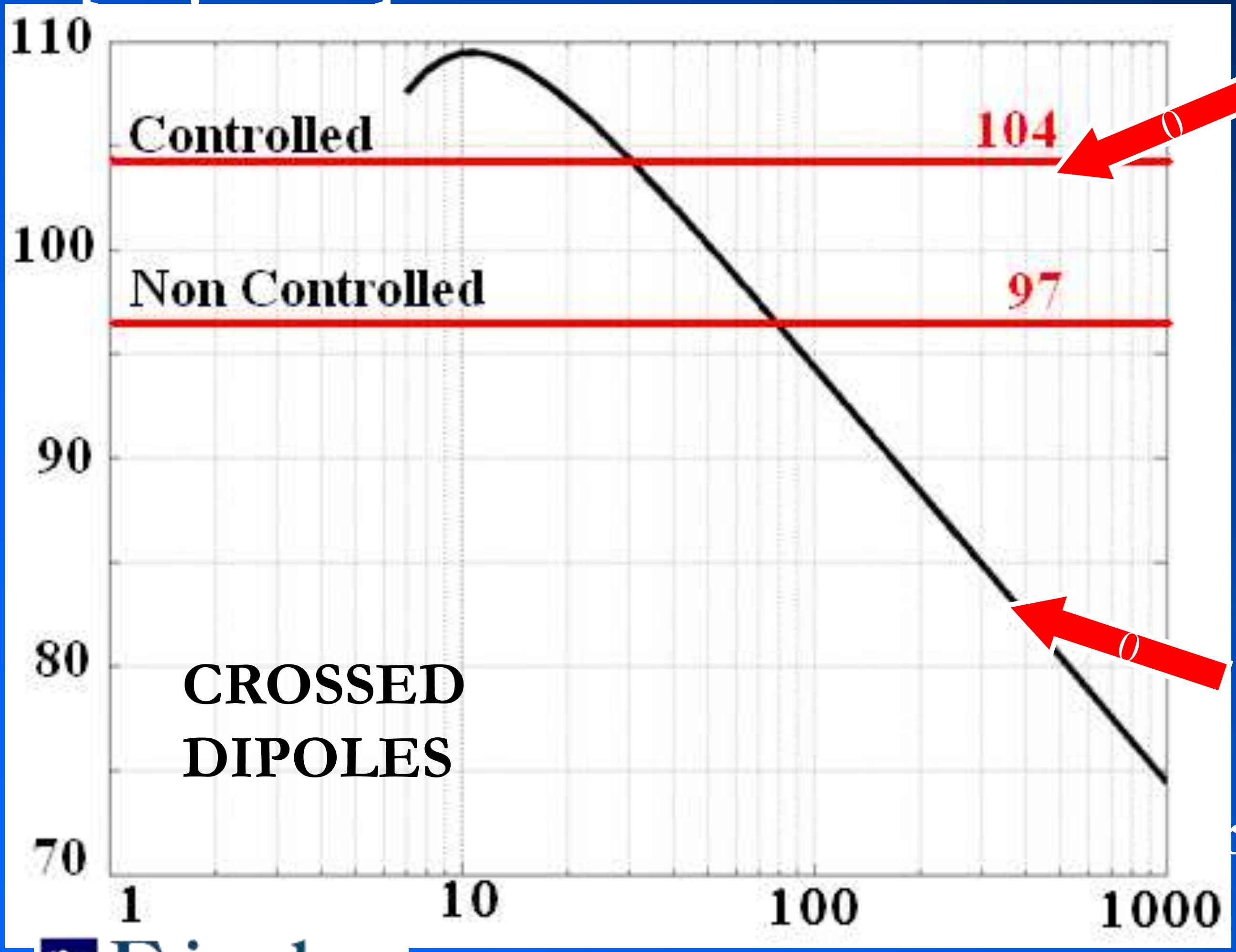
f=100MHz

VHF BROADCAST ANTENNAS

4 VERTICAL DIPOLE ARRAY

MAXIMUM RADIATION

H [dBµA/m]



IEEE C95-1

N=4
d=0.52λ
Wt=20kW
f=100MHz

Variation : 1/r

r [m]

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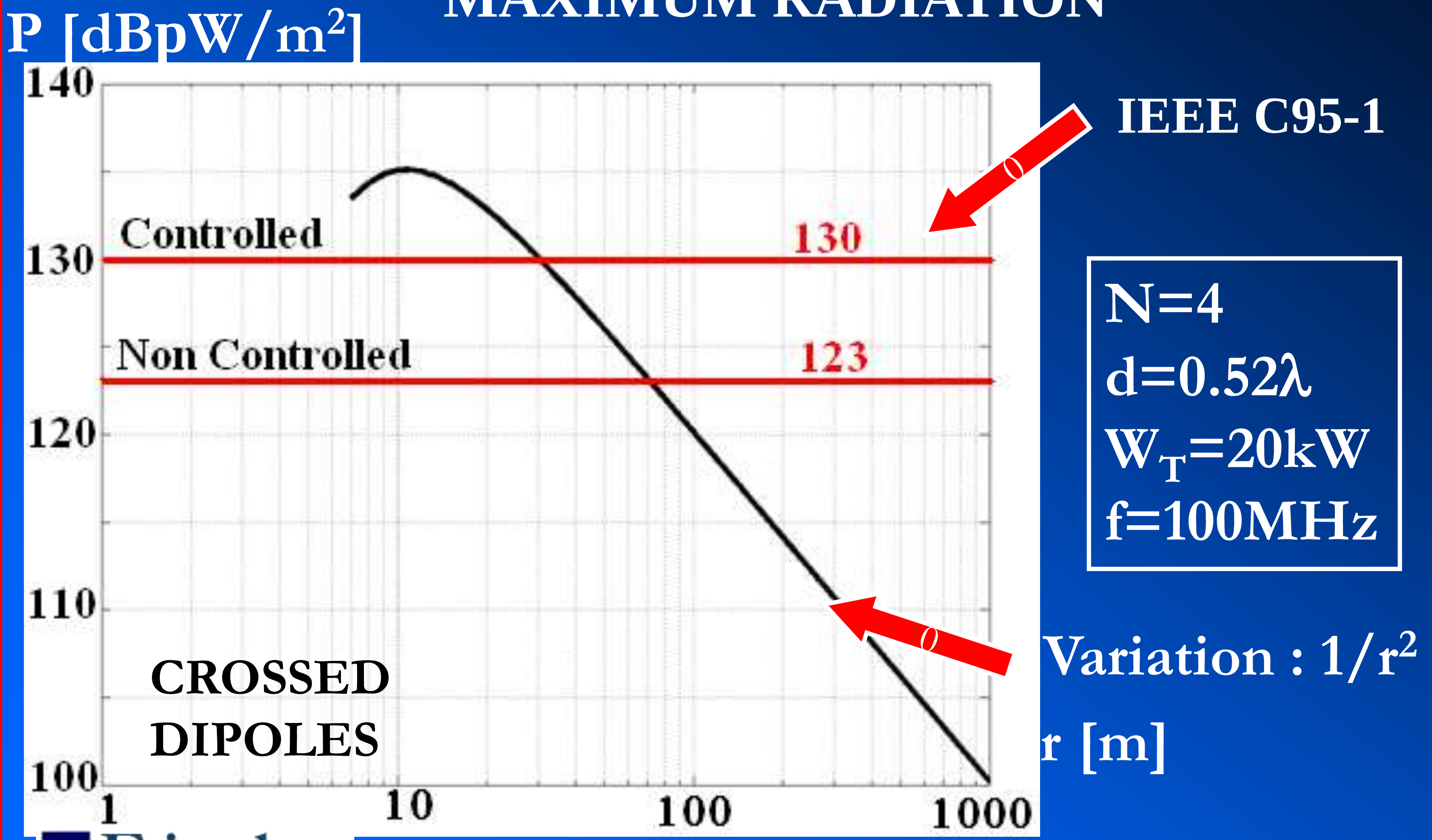
VHF BROADCAST ANTENNAS

4 VERTICAL DIPOLE ARRAY
MAXIMUM RADIATION



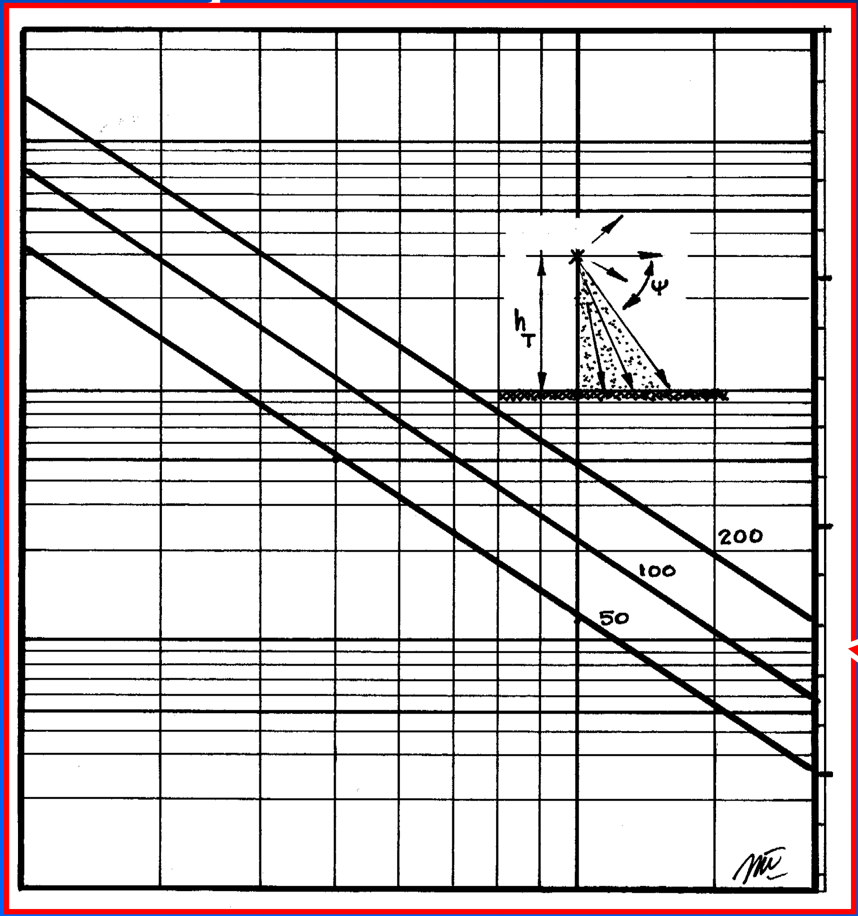
N=4
$d=0.52\lambda$
$W_T=20kW$
f=100MHz

VHF BROADCAST ANTENNAS

8 VERTICAL DIPOLE ARRAY

P[mW/cm^2]

E [dBµV/m]



10^{-2}

10^{-3}

10^{-4}

10^{-5}

130

120

110

20 30 50 70 100 200 h_t [m]

RADIATION

IEEE C95-1

P = 0.2 mW/cm^2

EIRP

N=8
d=0.7λ
f=100MHz

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BROADCAST ANTENNAS

END OF PRESENTATION

THANK YOU !!