

Antenna Fundamentals

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Historical Development

Thales 600 B.C.: static electricity with amber (Bernstein),
in Greek: Elektron

Oersted, Ampère 1820: Laws of Electromagnetic Theory

Faraday 1835: Electromagnetic Induction and
Electromagnetic Waves (EMW)

Maxwell 1860: Equations of EMW Propagation

Hertz (Lodge) 1890: Demonstration of their physical existence

Marconi since 1895: Practical Application

20. and 21. century: Enormous influence on our society

Introduction

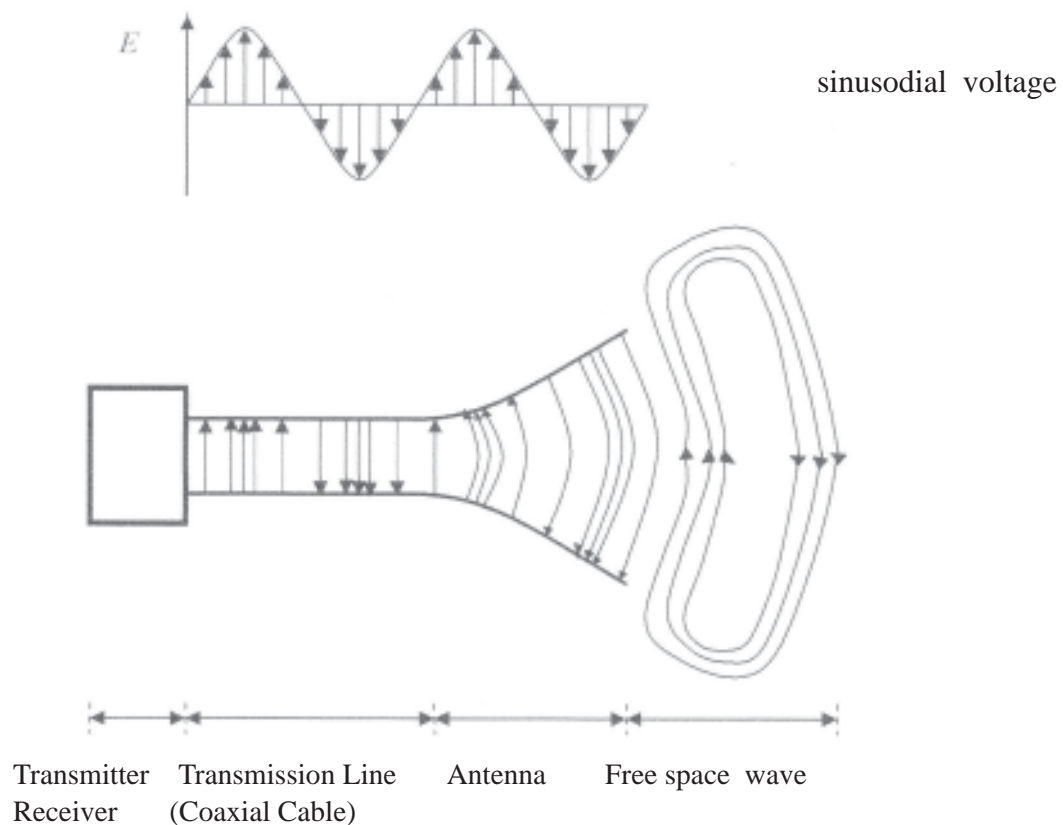
This paper is specific to wipic antennas

What an Antenna does

Metallic structure designed for radiating and receiving electromagnetic waves (EMW)

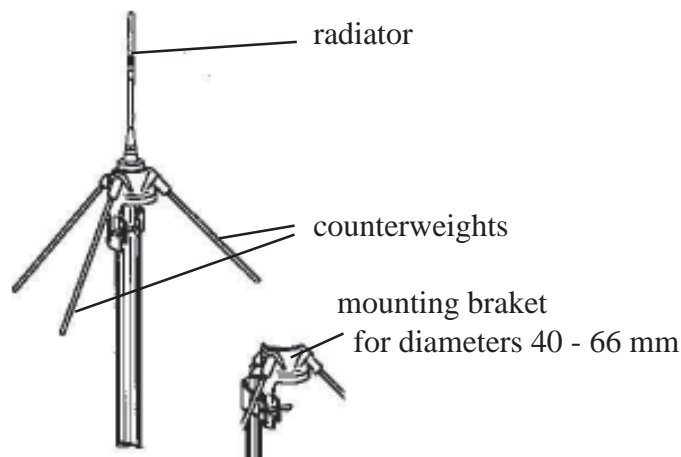
Acts as a transitional structure between the guiding device and the free space

Radiation/Receiving from an antenna

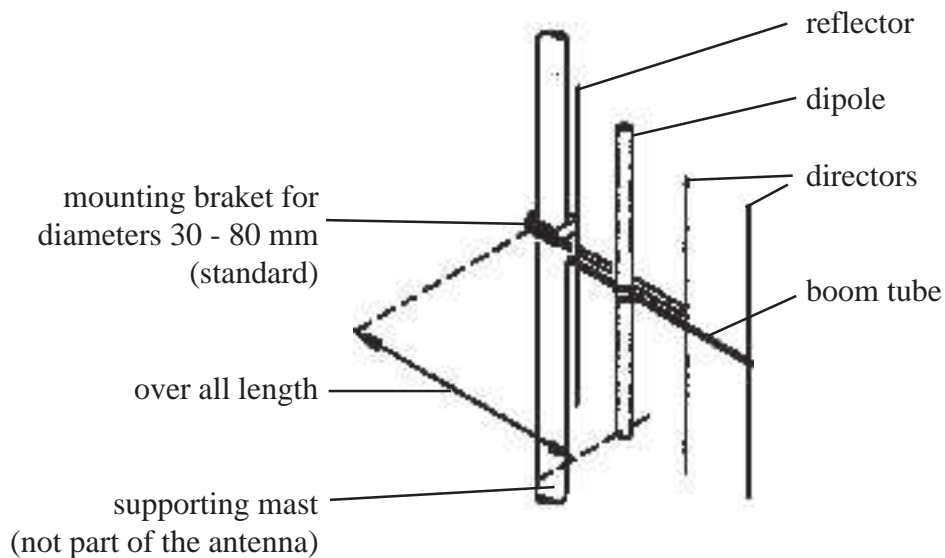


Parts of simple wipic antennas

Omnidirectional (ground plane) antenna vertical polarized

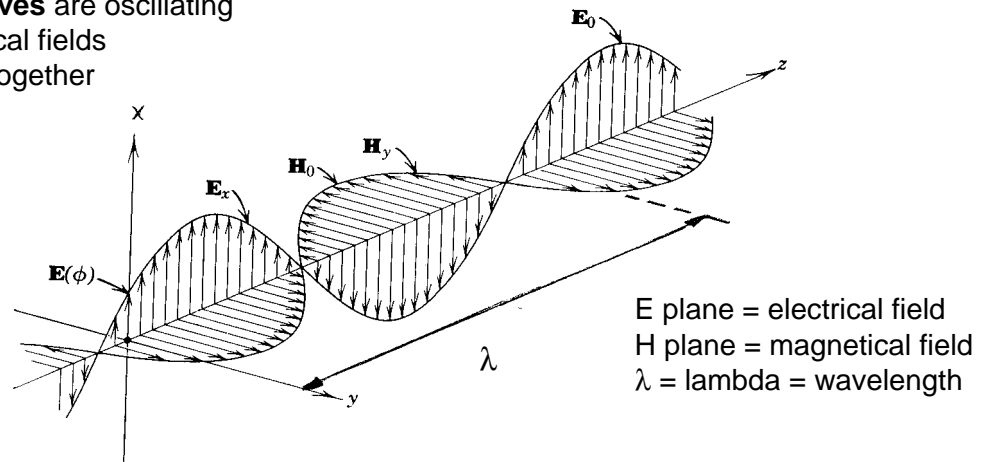


Directional (4 element Yagi) antenna vertical polarized

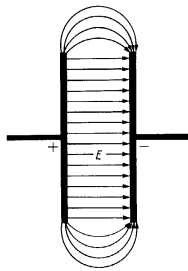


Electromagnetic Waves (EMW)

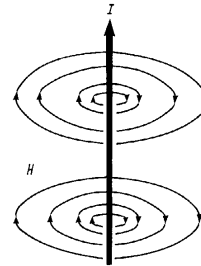
Electromagnetic waves are oscillating electrical and magnetical fields standing orthogonal together



Example of an electrical field: capacitor

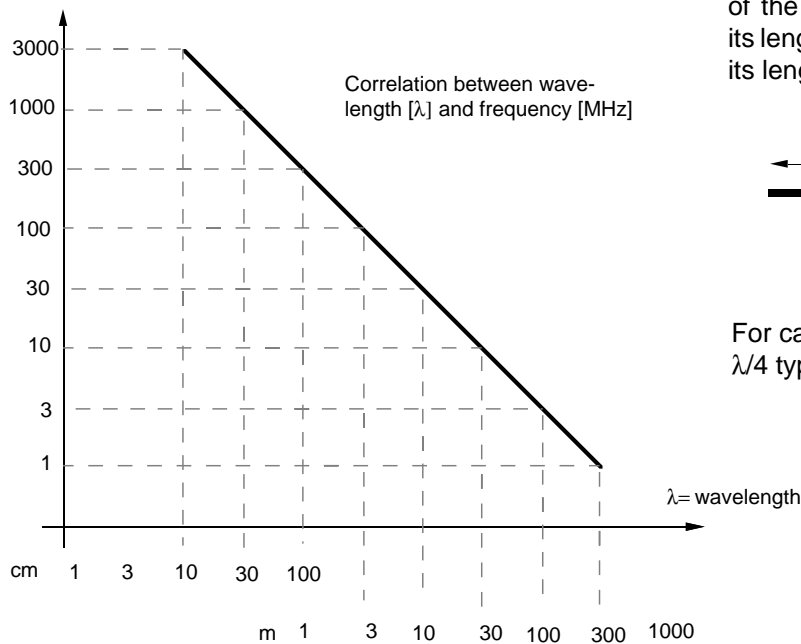


Example of an magnetical field: around a wire with current flow



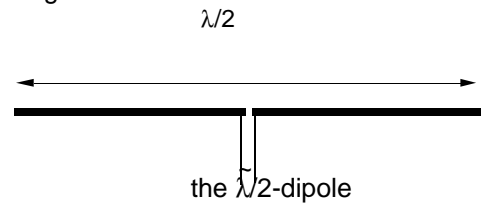
Wavelength and frequency

Frequency in MHz = million oscillations / second [s^{-1}]



Wavelength and antenna dimensions

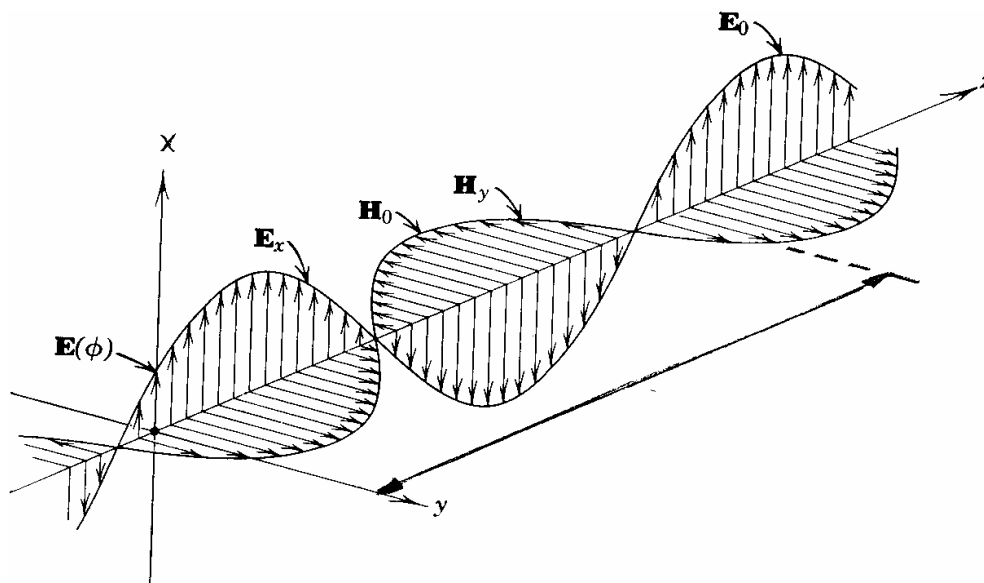
One of the simplest antenna is the $\lambda/2$ -dipole. It consists of two isolated conductors with an overall length of the half length of the working frequency. In the FM band its length is 1.5 m, in the 900 MHz mobile band its length is about 15 cm.



For cars and cellular phones the $\lambda/4$ type antenna is mostly used.

Elektrical und magnetical planes of EMV

- The planes are perpendicular (orthographic) together
- The E plane is established by dipole, reflectors and directors, the place of the electrical conductors
- The H plane stands perpendicular to the E plane



Polarisation of antennas

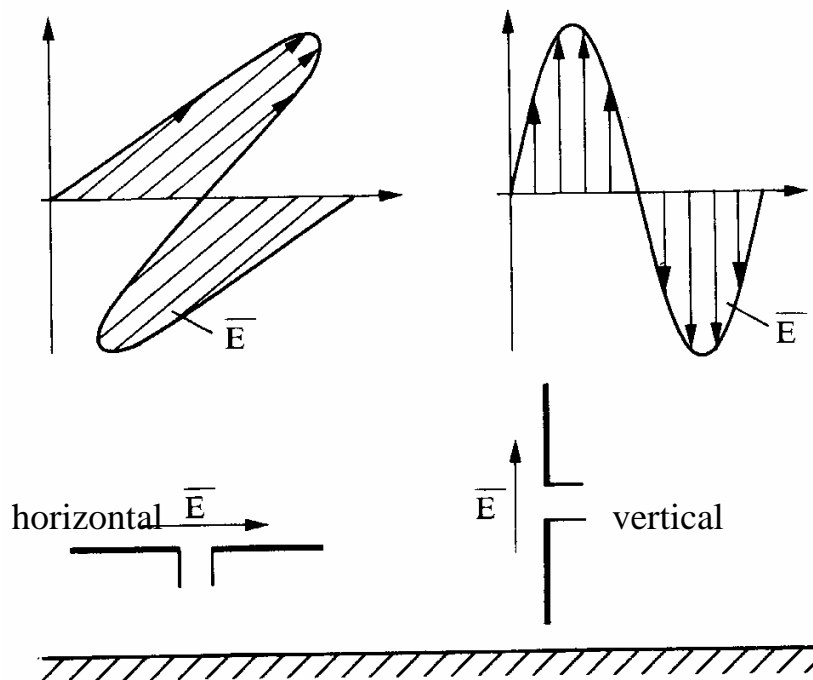
The following polarisations are typical:

Linear -> horizontal
vertical
other angles (eg. +/-45°)

Circular left or right

Elliptic

For linear polarisation the following applies:



Some Antenna Types

Omnidirectional antenna

Directional antenna

Transmitting and Receiving antennas

Lambda/2 dipole, half wave or $\lambda/2$ dipole

Yagi antenna

Corner reflector

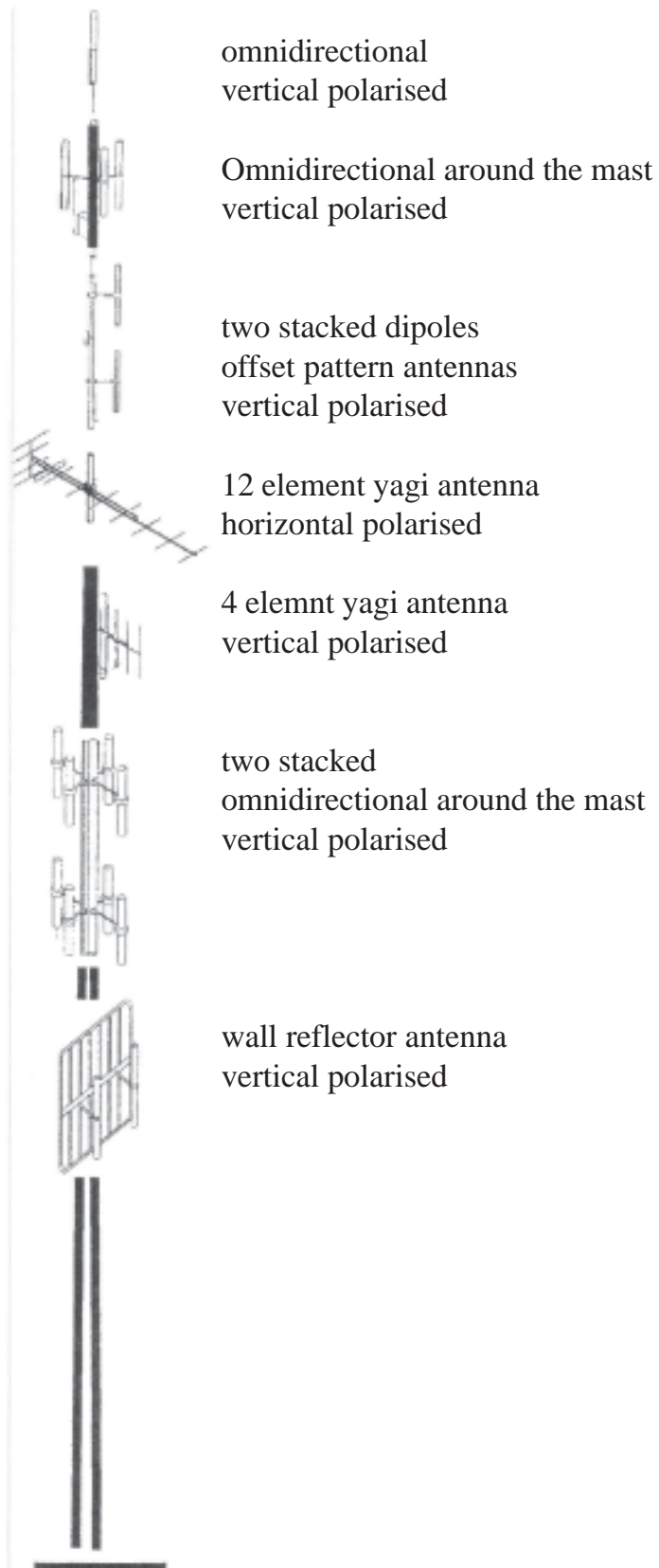
Wall reflector

Logarithmic periodical (logper) antenna

Groundplain antenna

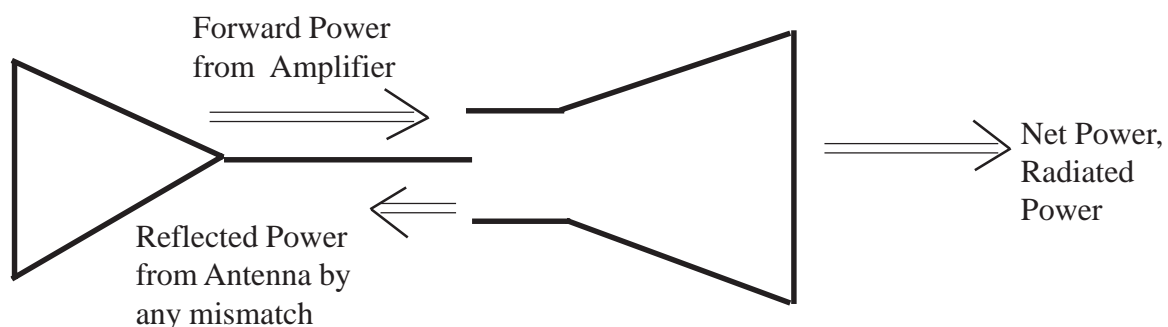
All of these antennas have a linear polarisation and a $\lambda/2$ dipole as beaming element.

Mounting of antennas on a mast



Standing Wave Ratio (SWR) Reflection Coefficient (RC) Return Loss (RL)

- all describe the same physical phenomenon that is the mismatch factor of an antenna
- Standing Wave Ratio SWR
or Voltage Standing Wave Ratio VSWR
- if the match is perfect the following is true:
 $SWR = 1$
 $RC = 0$
 $RL \text{ (in dB)} = \infty$
- the measurement is relative simple and very sensitive to antenna dimensions
- relationship among them:
 $SWR = (1+RC)/(1-RC)$ $RC = (SWR-1)/(SWR+1)$
 $RL = -20 \times \log RC$
Example: $SWR = 1.5$ (measured) $RC = 0.2$ $RL = 14 \text{ dB}$
or: 4% of the power is reflected, 96% is radiated



Gain, Directivity, 3 dB Beamwidth

The above indicate how strong a transmitting antenna can bundle its beam (also applies to receiving antennas)

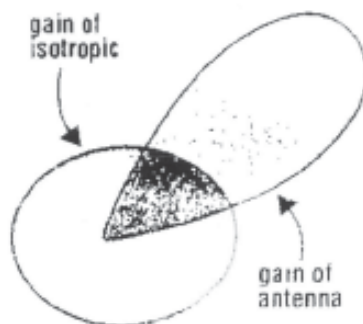
The gain is given in dB with two common references:

- dBi: the reference 0 dB is an isotropic omnidirectional radiator (it does not exist in reality)
 - dBd: the reference 0 dB is the $\lambda/2$ dipole
- note: $\text{dBd} = \text{dBi} + 2$

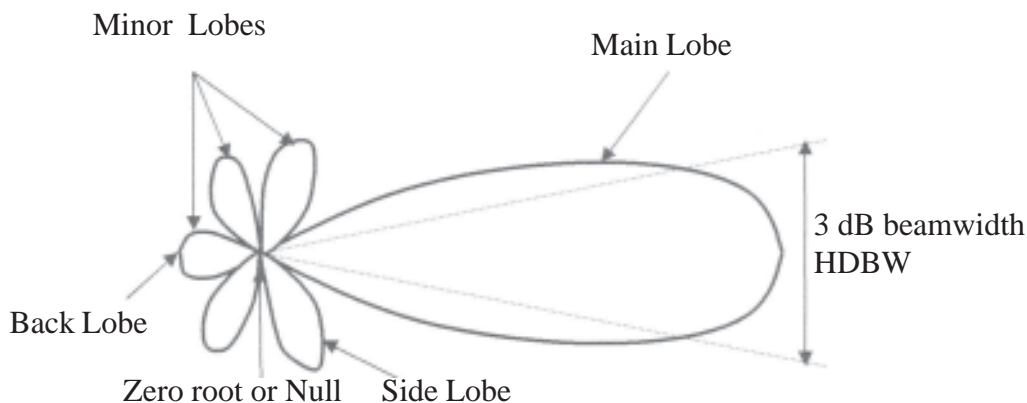
There is a relationship between gain and directivity

3 dB beamwidth or half power beamwidth (HDBW) can be defined as the angle subtended by the half power points of the main lobe

Gain and isotropic radiator

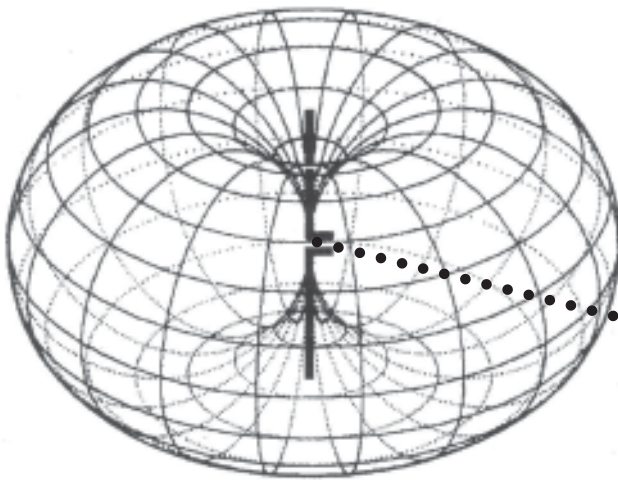


Radiation pattern of a generic directional antenna



Radiation Pattern of a $\lambda/2$ Dipole

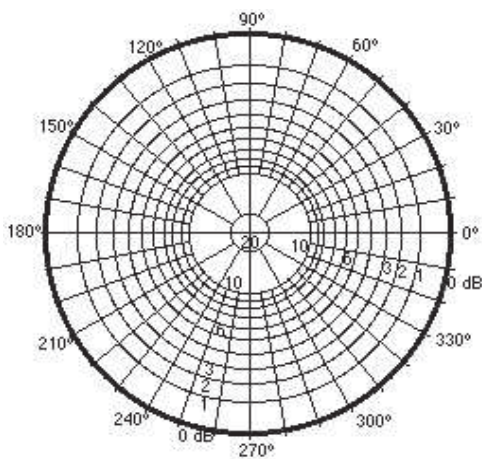
The pattern shows the response of the dipole as the viewing angle is varied



spacious illustration of the pattern

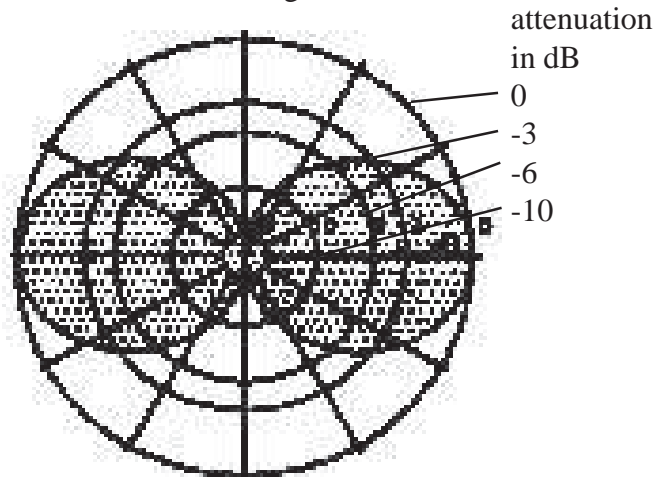
... null, zero root

horizontal cut through null



Horizontal Pattern
H plane
Omnidirectional
3 dB beamwidth 360°
Gain 0 dBd

vertical cut through null



Vertical Pattern
E plane
3 dB beamwidth 78°
Gain 0 dBd

Bandwidth

The bandwidth is the operating frequency range of the antenna and is expressed in MHz. In this band some properties of the antenna are defined, for instance:

SWR < 1.5

3 dB beamwidth 90°

Gain 5 - 6 dB

Preferred transmitting bands are:

68 - 87.5 MHz

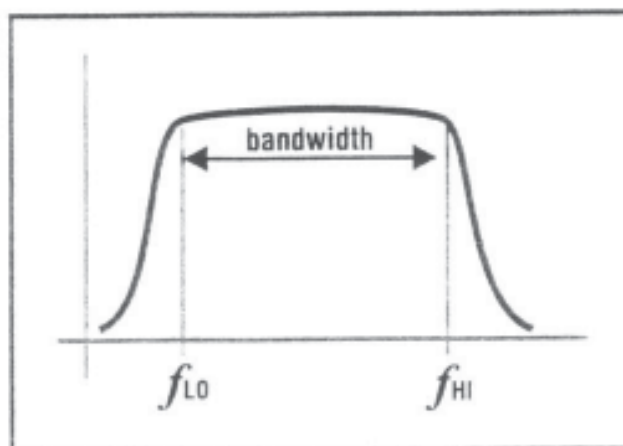
87.5 - 108 MHz (FM-band)

108 - 144 MHz (airband)

380 - 430 MHz (polycom)

GSM and UMTS bands

the broadcast bands: I, II, III IV/V, DAB



Coaxial Cables or Lines

A typical cable (as example 7/8" foamed) consists of:

Inner or center conductor

Dielectric (here SPE)

Outer conductor

Jacket (here PE-LD)
outer \varnothing 27.6 mm

Velocity of signal propagation 88 % of C



Some other types

Type	outer \varnothing in mm	dielectric	velocity % of C
RG 58	5	PE	66
RG 303	4.3	PTFE	69
RG 213	10.3	PE	66
RG 214	10.8	PE	66
1/2" foamed	16	SPE	88



Key:

C: velocity of light = 300 000 km/s

PE: Poly-ethylene

PTFE: Poly-tetrafluoro-ethylene (Teflon)

SPE: foamed Poly-ethylene

