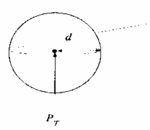
Antenna directivity and gain

Isotropic antenna

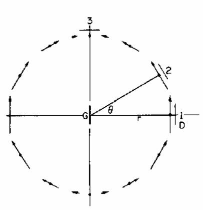
- Before we can describe the gain of a practical antenna we must first introduce a completely theoretical antenna, the ***isotropic radiator***.
- Envision an infinitely small antenna, located in outer space.
- The uniquely useful property of this theoretical point antenna is that it ***radiates equally well in all directions***, i.e., it has absolutely no directivity.
- All practical antennas exhibit some degree of directivity.



$$S_r = \frac{P_t}{4\pi r^2}$$

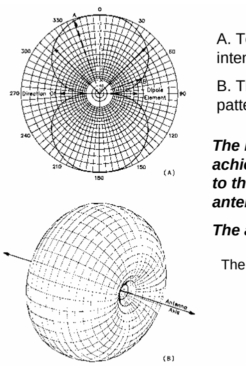
Antenna directivity and gain

The electric field formula said that the field should be the acceleration of the charge projected perpendicular to the line of sight.



1. Strong field
2. Medium field
3. Zero field

Antenna directivity and gain



A. Top view (horizontal view) radiation intensity pattern for a half-wave dipole.

B. Three dimensional radiation intensity pattern for a half-wave dipole.

The increase in radiation intensity that is achieved in a certain direction, with respect to the isometric radiating antenna, is called antenna gain.

The antenna has directivity.

The antenna gain is given by:

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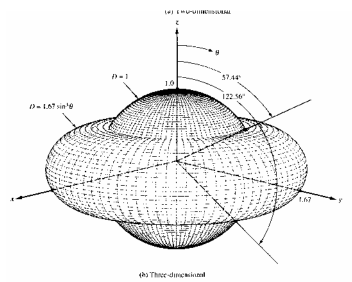
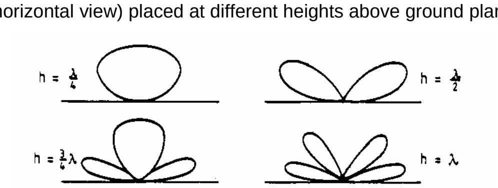


Half-wave dipole radiation intensity pattern compared with the isometric antenna radiation intensity pattern. The half wave dipole has a gain of approx. 2 dBi.

Antenna directivity and gain

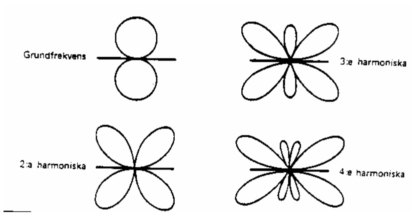
So far we have only looked at the half wave dipole in free space.

Considering the fact that most antennas are in close neighborhood with earth (ground plane) gives approx. the following characteristics for a horizontal half-wave dipole (horizontal view) placed at different heights above ground plane.



Antenna directivity and gain

Horizontal radiation diagram for a half-wave dipole operating at resonance harmonics

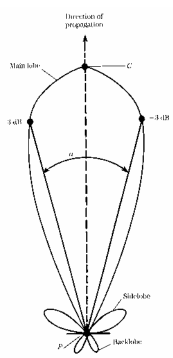


Directional beam antenna

This radiation pattern is typical for a beam antenna

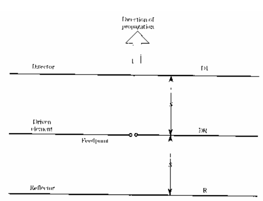
The beam width of the antenna is the angle between the points on the main lobe that -3dB down from the center point C.

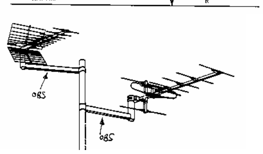
A perfect beam antenna will have only the main lobe, but that never occurs.



Directional beam antenna

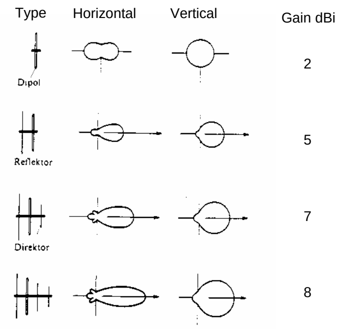
- The most common directional beam antenna is the Yagi/Uda antenna. This antenna consists of a number of linear dipole elements.
- One which is energized directly by a feed transmission line.
- While the other elements act as ***parasitic radiators*** whose currents are induced by mutual coupling (near field) between the elements.
- This radiator is designed to act as a end fire array, this is accomplished by having parasitic elements in forward beam acting as ***directors*** while those in the rear acting as ***reflectors***.
- The Yagi/Uda array is widely used as a home TV antenna.
- Common in HF, VHF, and UHF frequency range (300MHz-3GHz).





Directional beam antenna

The Yagi antenna gain ranges from 5 dBi for a small 2 element design to about 20 dBi for a 31 element.



Directional beam antenna

The gain and directional pattern of a Yagi/Uda array is determined by the relative amplitudes and phase of the currents induced into all parasitic elements.

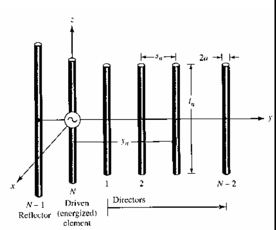
To achieve the end-fire beam formation, the parasitic elements in the direction the beam are somewhat smaller in length than the feed element.

The driven element is resonant with its length slightly less than ●/2 (usually 0.45-0.49 ●).

The directors length is about 0.4 to 0.45 ●.

The separation between directors is typically 0.3 to 0.4 ●.

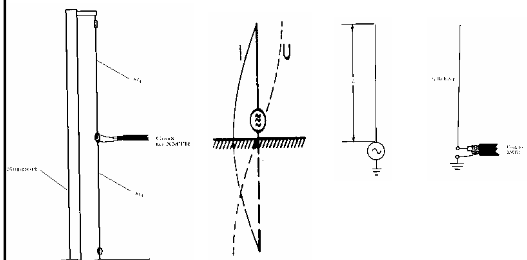
The reflector length is greater than the feed, 0.55-0.60 ●. The reflector element is also smaller in spacing, 0.25 ●.



Directional beam antenna

- Since the length of each director is smaller than its corresponding resonant length, the impedance of each is capacitive, –*X* ,and its ***current leads*** the induced EMF.
- Similarly the impedance of the reflectors is inductive, *X* ,and the phase of the ***current lags*** those of the induced emf.
- The ***total phase*** of the currents in the ***directors and reflectors*** is not determined solely by their lengths but also by ***their spacing*** to the adjacent elements.
- Properly spaced elements with lengths slightly less than their corresponding resonant length acts as directors. Because they form an array with currents approximately equal in magnitude and with equal progressive phase shifts which will ***reinforce the field***.
- Similarly, a properly spaced element with a length of ●/2 or slightly greater will act as a reflector.
- The Yagi/Uda antenna can be summarized by saying that its performance can be considered in three parts: the reflector-feeder arrangement, the feeder, and the row of directors

Vertical antennas



The ***quarter wavelength vertical antenna*** (ground mounted) is basically half the half-wave dipole placed vertically with the other half of the dipole being the ground.

The direction of the electrical field, which sets the polarity of the antenna, is a function of the geometry of the radiator element.

Vertical antennas

A vertical quarter length antenna mounted above the ground level need a virtual ground plane.

Ground plane antennas