Gemini Communication Ltd.

Innovation & Leadership

Basics of RF Technology

Ref. 1020004100

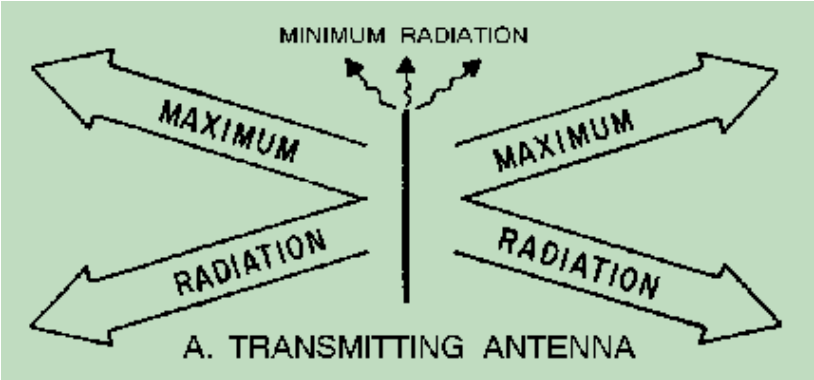
RF Antennas

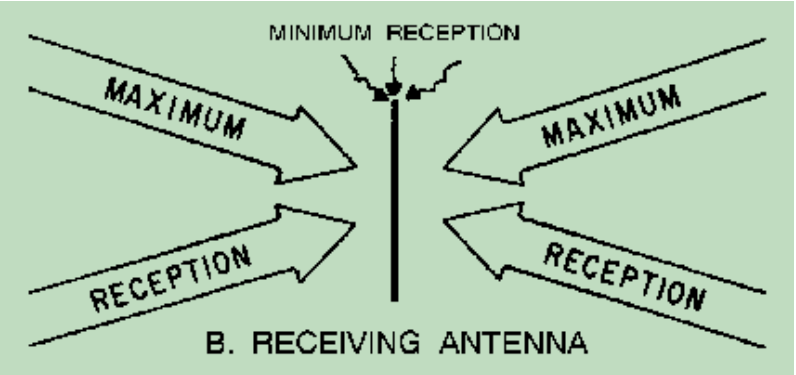
Antenna

- An antenna is an arrangement of conductors to radiate **(transmit)** an electromagnetic field
- This is done in response to an applied alternating current
- Alternatively, if an antenna is placed into an electromagnetic field, that field will induce an alternating current upon the antenna **(receive)**

Antenna

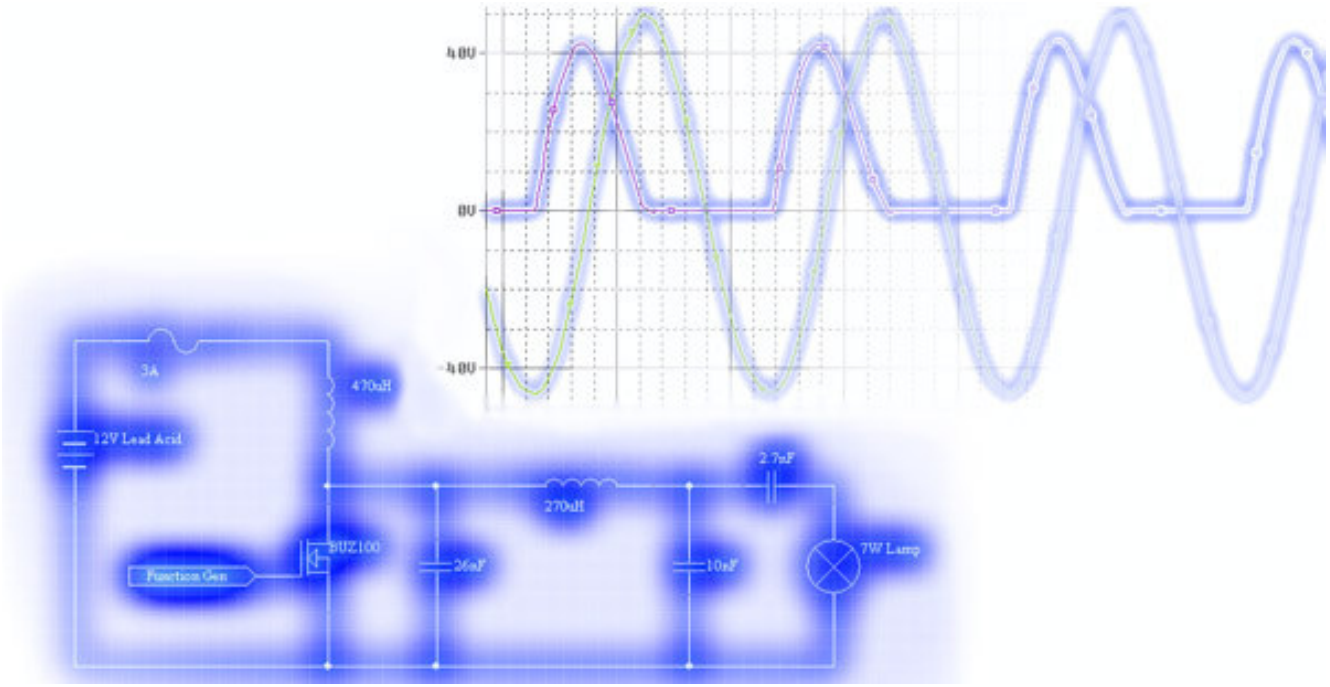
- There are two fundamental types of antennas
  - **Omni directional – radiate equally in all directions**
  - **Directional – radiates more in one direction**
- By adding additional conductors (elements) and varying their length, spacing, and orientation, an antenna with specific desired properties can be created
- An antenna can receive and transmit equally well
- This property is called reciprocity





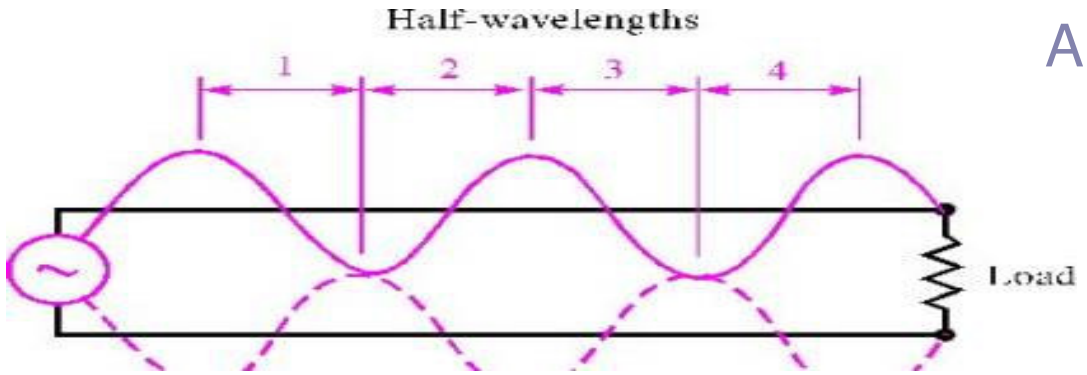
Resonant Frequency

- This is related to the electrical length of the antenna
- This is the physical length of the wire multiplied by the ratio of the speed of wave propagation in the wire to speed of light
- An antenna is tuned for this resonant frequency



Impedance

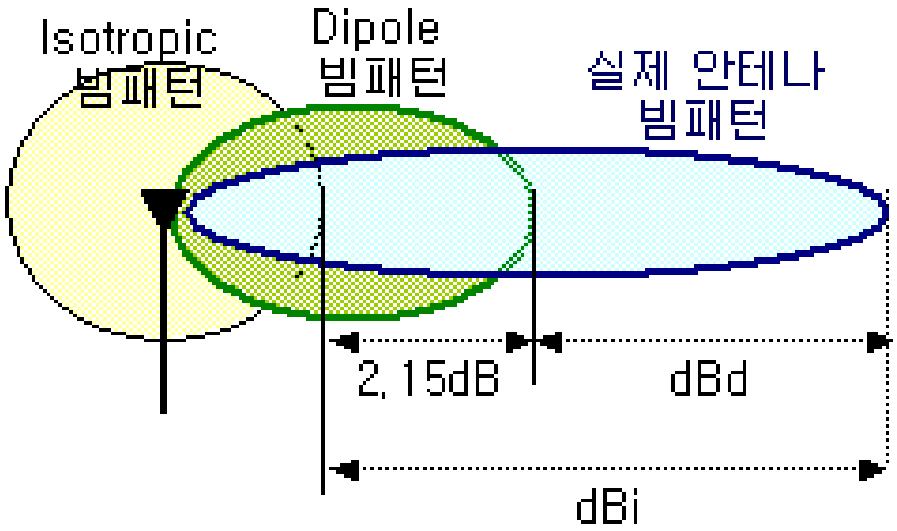
- As the wave travels through the different parts of the antenna system, it encounters different impedances
- At each interface, some fraction of the energy will reflect back to the source, forming a standing wave
- The ratio of maximum to minimum power in the wave is called the standing wave ratio (**SWR**)
- Minimizing impedance differences at each interface will reduce SWR and maximize power transfer
- The impedance is adjusted with an antenna tuner, a balun, a matching transformer, etc.



A SWR of 1:1 is ideal

Gain

- An antenna has **gain** if it radiates more strongly in one direction than in another
- Gain is measured by comparing an antenna to an isotropic antenna
- Gain is essentially directional; the gain of an antenna is measured in the direction which it radiates best
- The gain is expressed in dBi (decibels over isotropic)
- For example, a dipole antenna has a gain of 2.14 dBi
- If the dipole antenna is used as the reference, the gain is measured in dBd (decibels over dipole)



Gain

Gain of Common Antennas

Directional

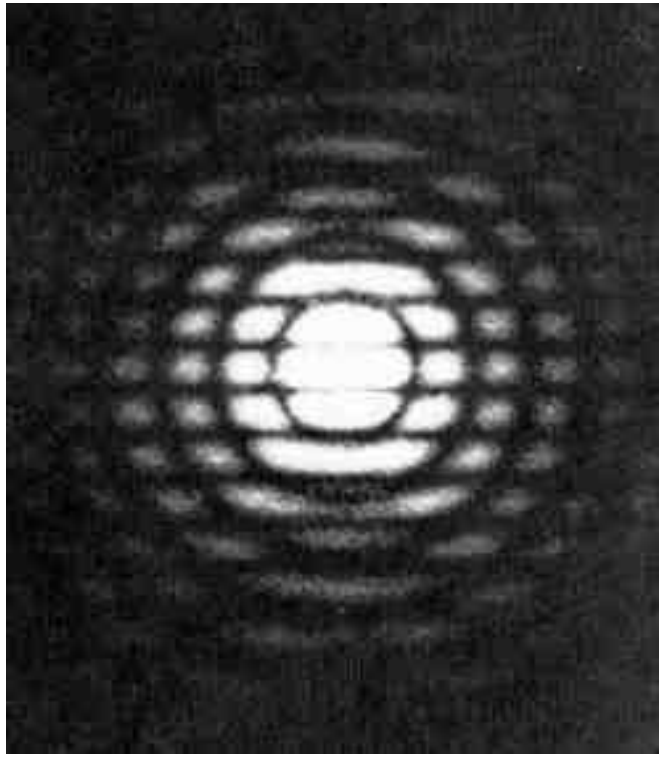
Dipole	0 dBd
Yagi (Beam)	6-12 dBd
Parabolic dish	20+ dBd

Omnidirectional

Rubber ducky	-1 to -3 dBd
Quarter wave vertical	1-2 dBd
Half wave vertical	3 dBd

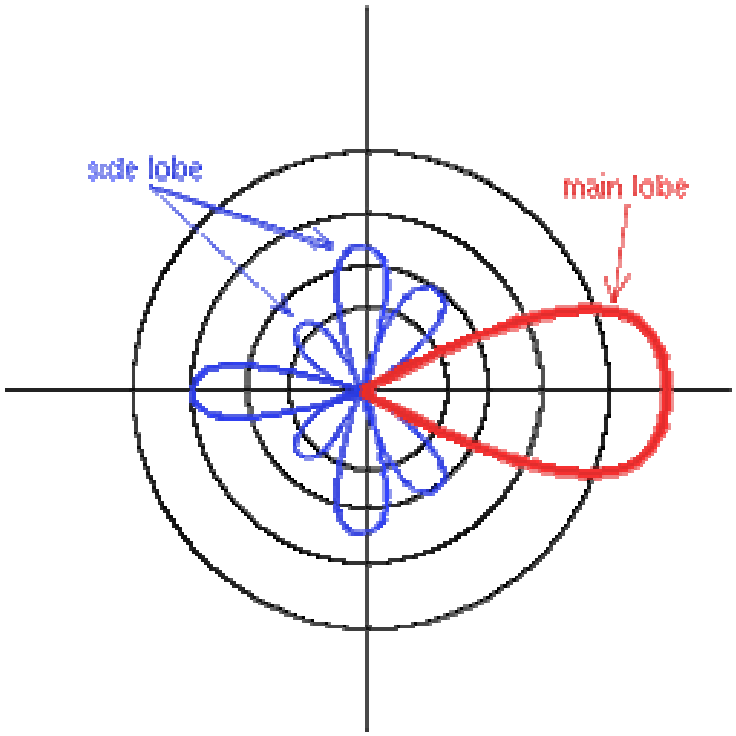
Aperture

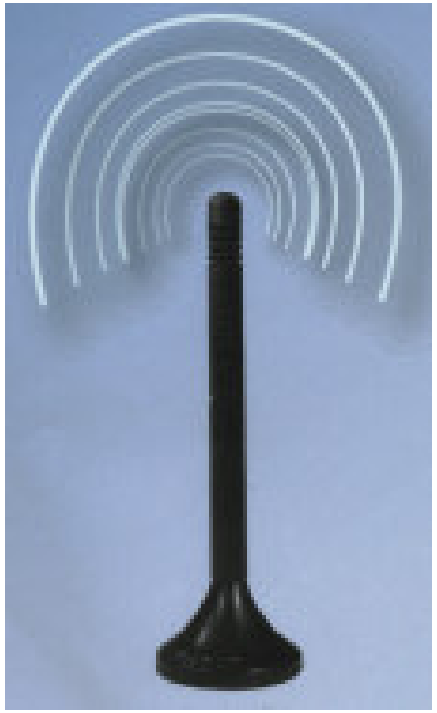
- The diameter of the cross-section of an antenna's radiation pattern in the direction of highest gain



Radiation Pattern

- The three dimensional plot of the gain
- Antennas with high gain show **side lobes** in the radiation pattern
- Side lobes are peaks in gain other than the main lobe

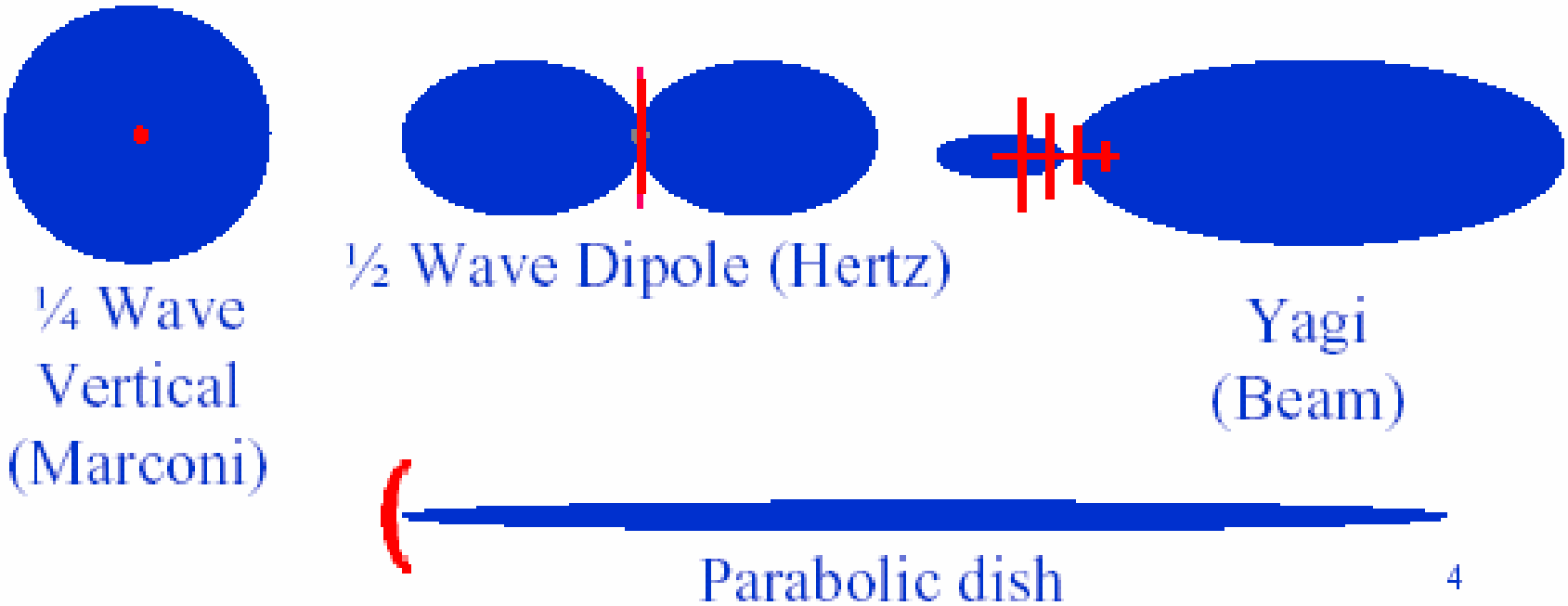




Radiation Pattern

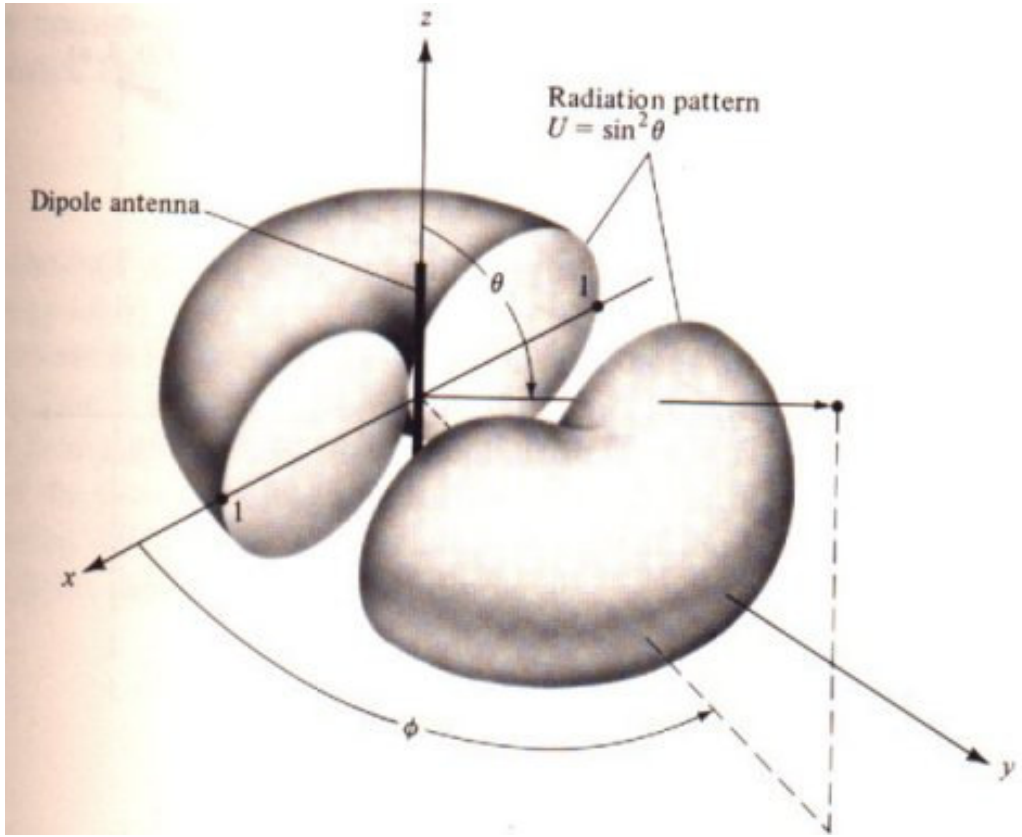
Antenna Patterns & Gain

- Antenna does not "amplify" the signal, only concentrates it in a particular direction or pattern.
- Strength of the radiated field in a particular direction measured relative to a reference antenna, usually a dipole.



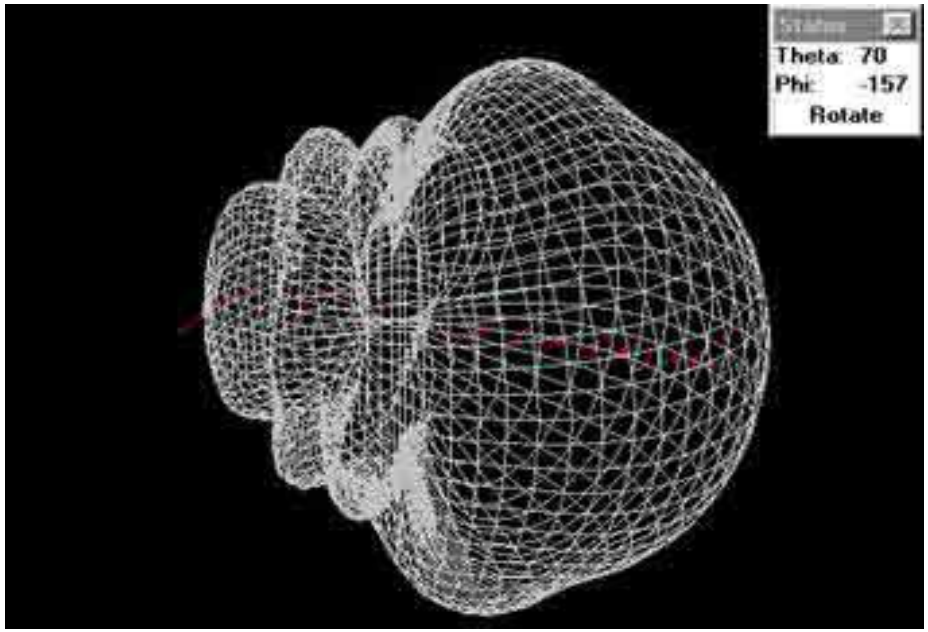
Radiation Resistance

- It is that part of an antenna's feed point resistance that is caused by the radiation of EM waves
- It is determined by the geometry of the antenna



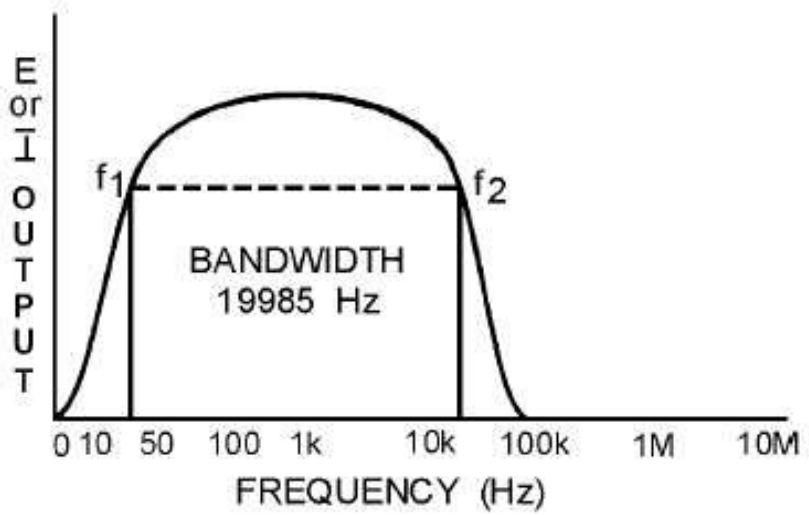
Efficiency

- The ratio of power actually radiated to the power put into the antenna terminals



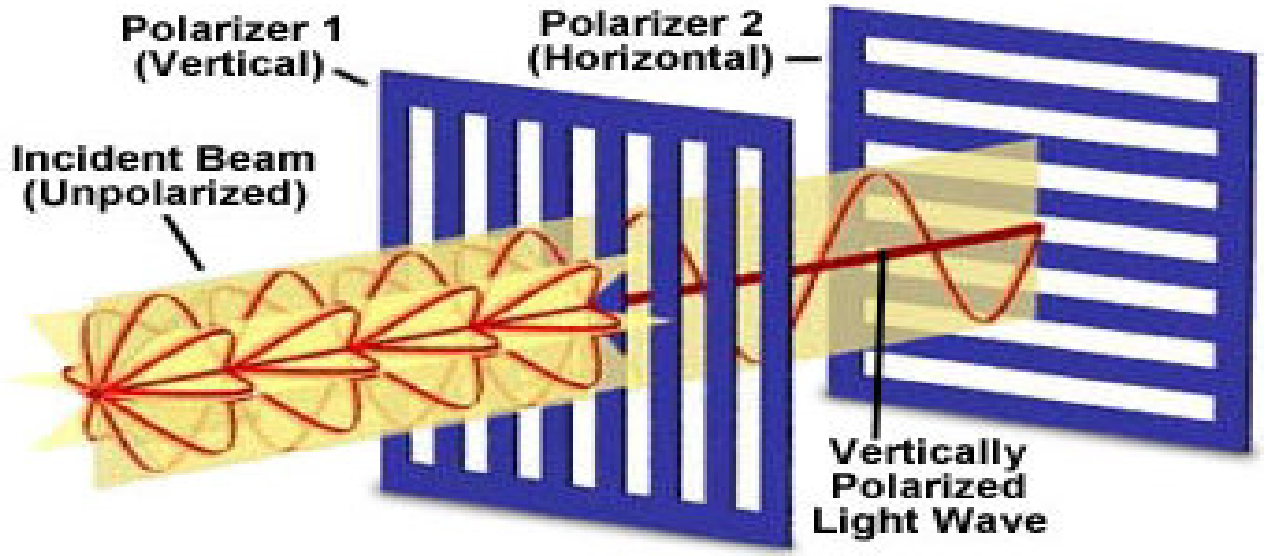
Bandwidth

- The range of frequencies over which it is effective
- The bandwidth of an antenna may be increased by several techniques
  - using thicker wires
  - replacing wires with cages to simulate a thicker wire
  - tapering antenna components
  - combining multiple antennas into a single assembly



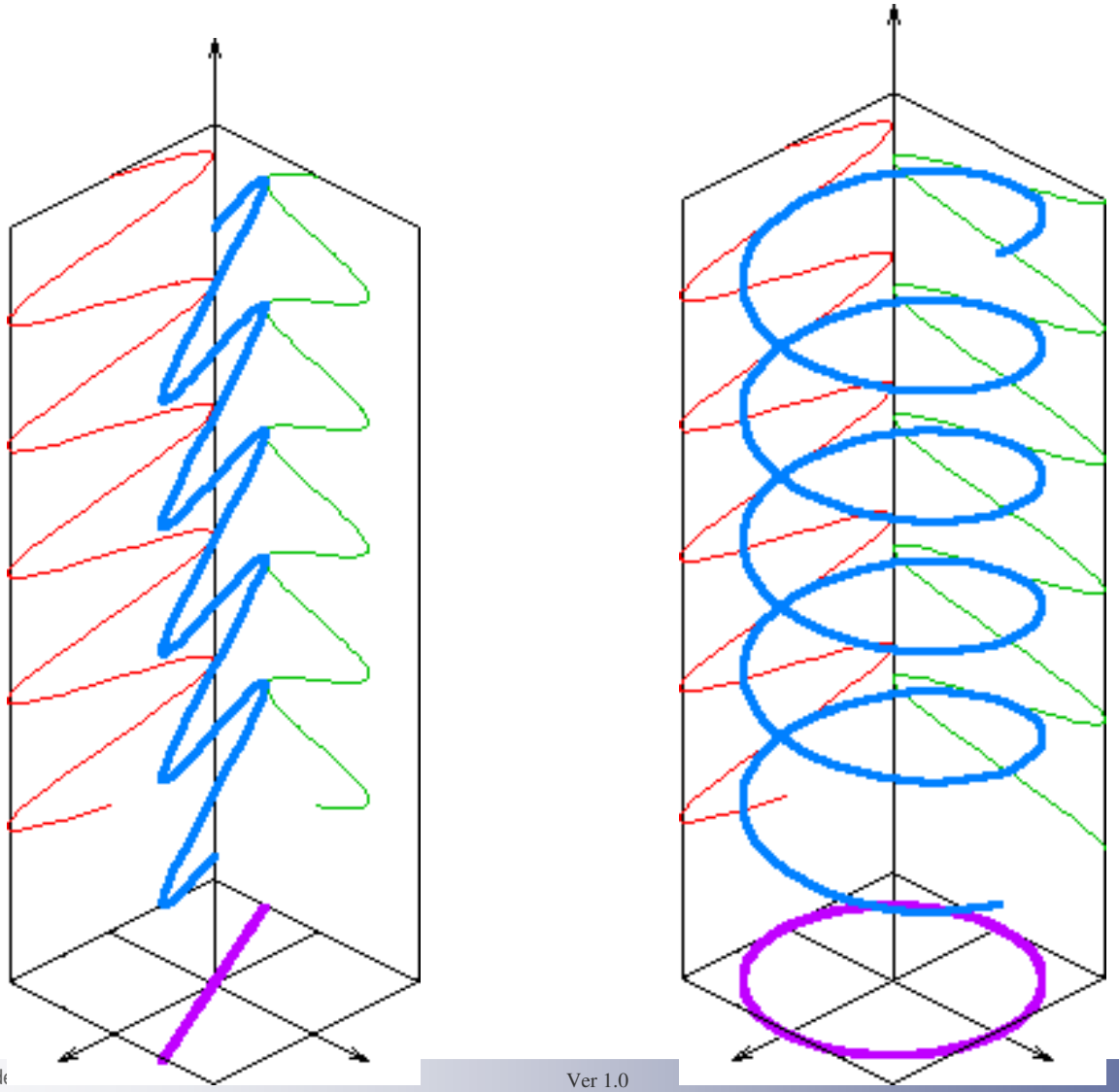
Polarization

- The **polarization** of an antenna is determined by the electric field or E plane
- For LoS communications, it can make a tremendous difference in signal quality to have the transmitter and receiver using the same polarization



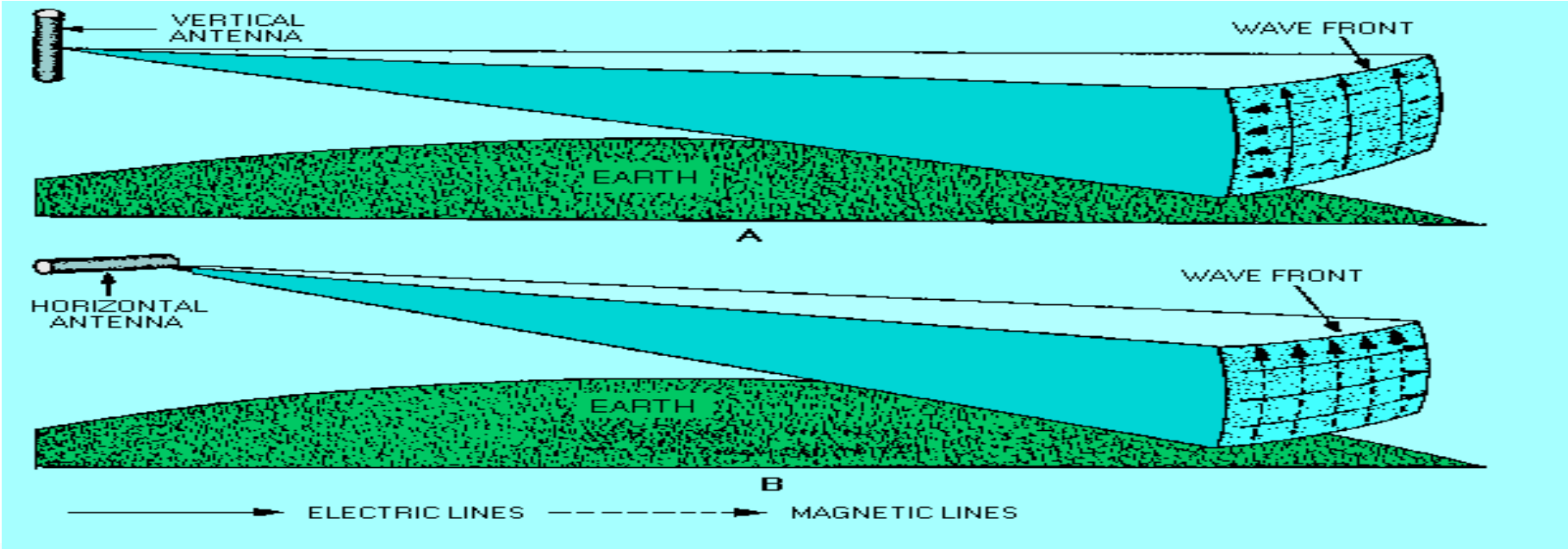
Polarization

- Polarizations are linear, such as vertical and horizontal, and circular, which is divided into right hand and left hand circular.



Polarization

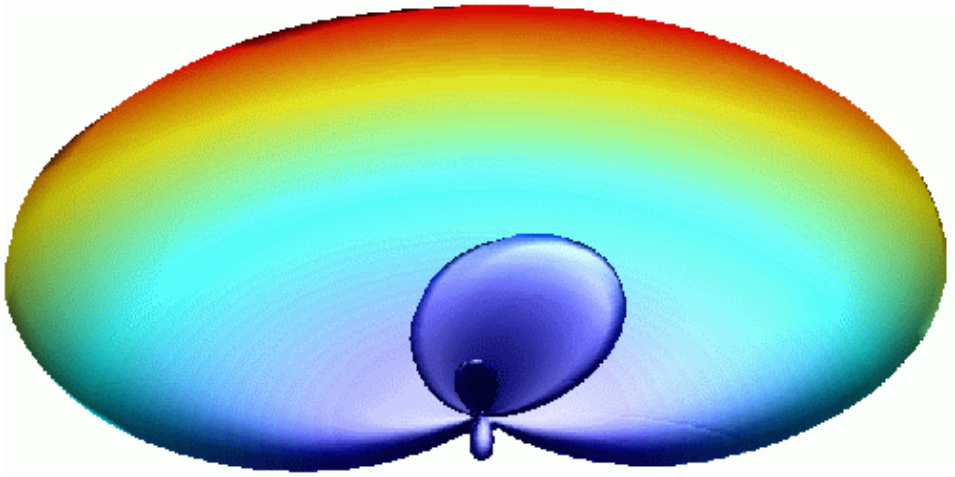
- All antennas are essentially polarized
- For a vertically polarized antenna, the E plane usually coincides with the vertical / elevation plane
- For a horizontally polarized antenna, the E Plane usually coincides with the horizontal / azimuth plane.
- Vertical polarization is most often used when it is desired to radiate a radio signal in all directions



Effective Isotropically Radiated Power

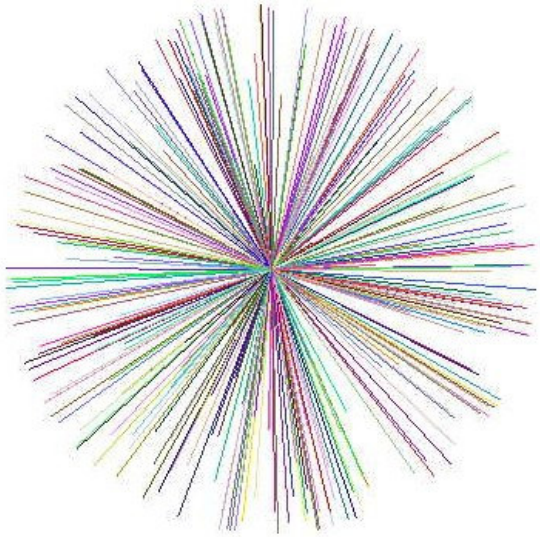
- **EIRP** is the amount of power that would have to be emitted by an isotropic antenna to produce the same signal strength in the direction of maximum gain

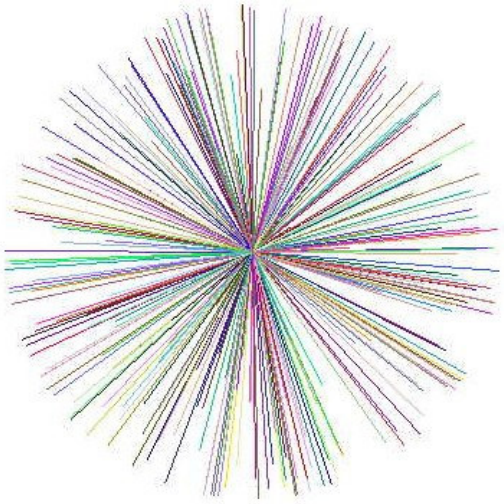
- The EIRP is used to estimate the coverage of a transmitter



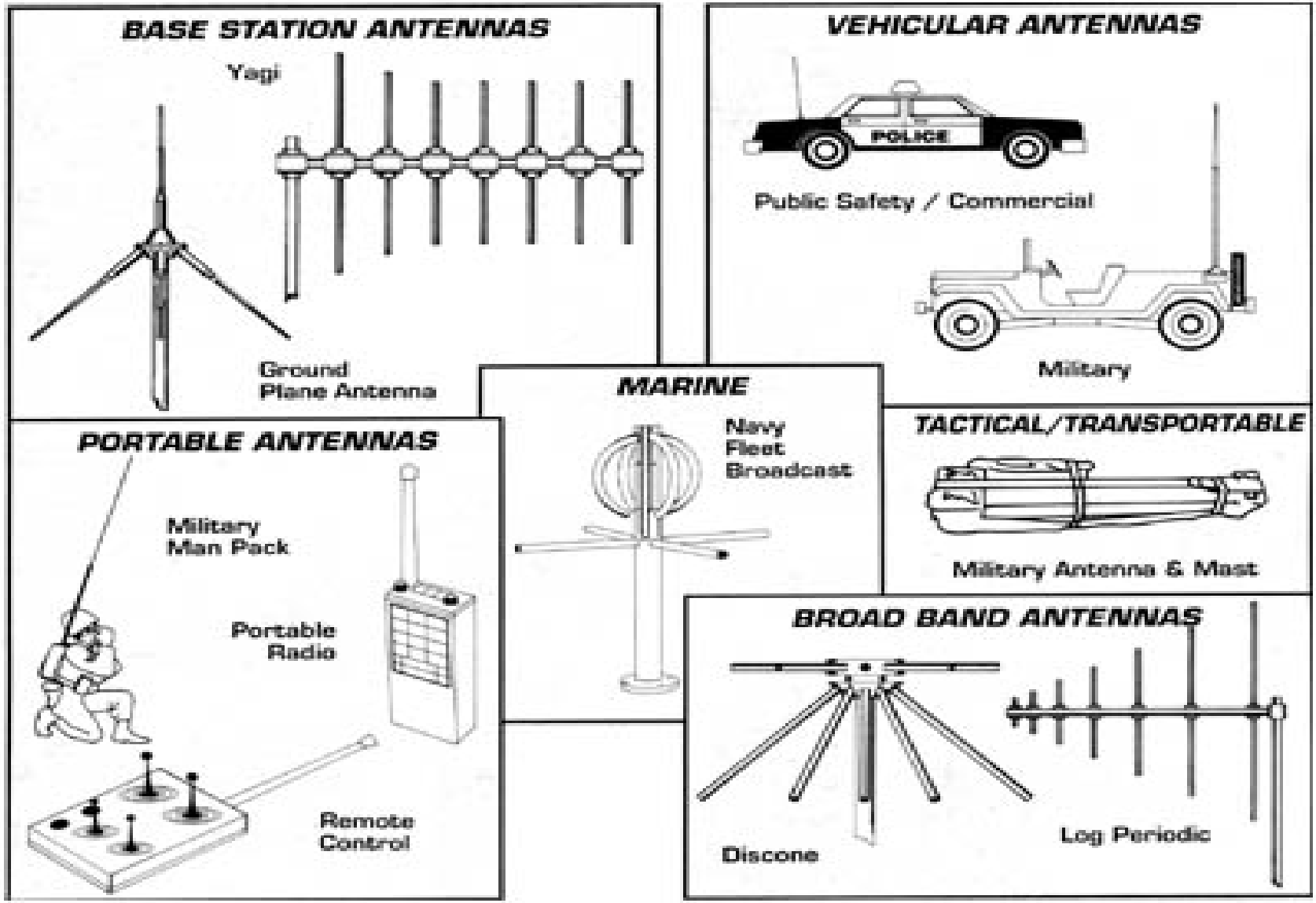
Theoretical Antenna Types

- Isotropic radiator
  - Radiates equally in all directions
  - Considered to be a point in space with no dimensions
  - Purely theoretical and is not achievable in real life





Practical Antenna Models

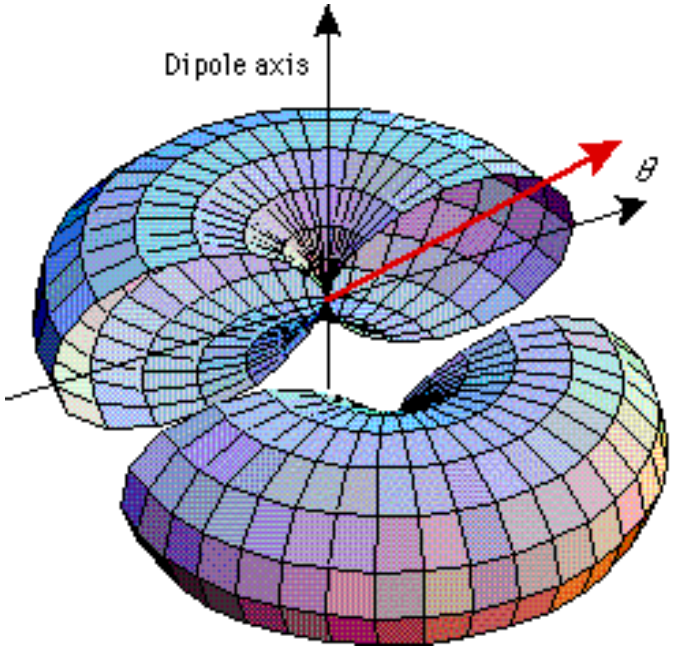


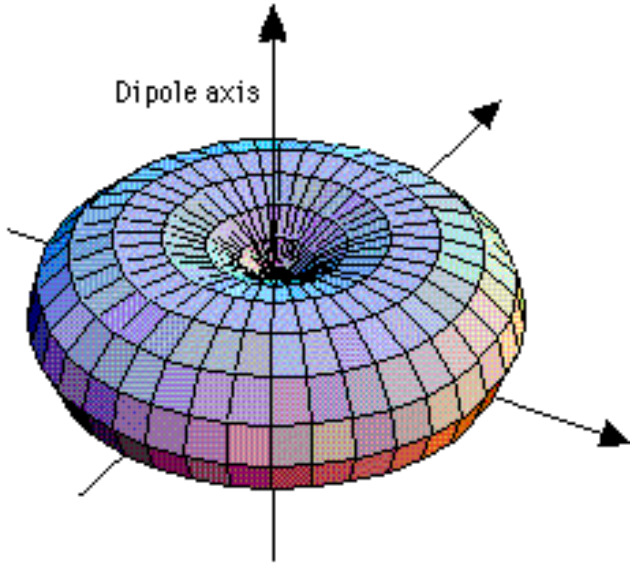
Dipole Antenna

- Simply two wires pointed in opposite directions
- Arranged either horizontally or vertically
- One end of each wire fed and the other end hanging free in space
- The two elements are fed the same signal 180 degrees out of phase
- A multiple of a half wavelength long
- Also referred to as the half-wave antenna

Dipole Antenna

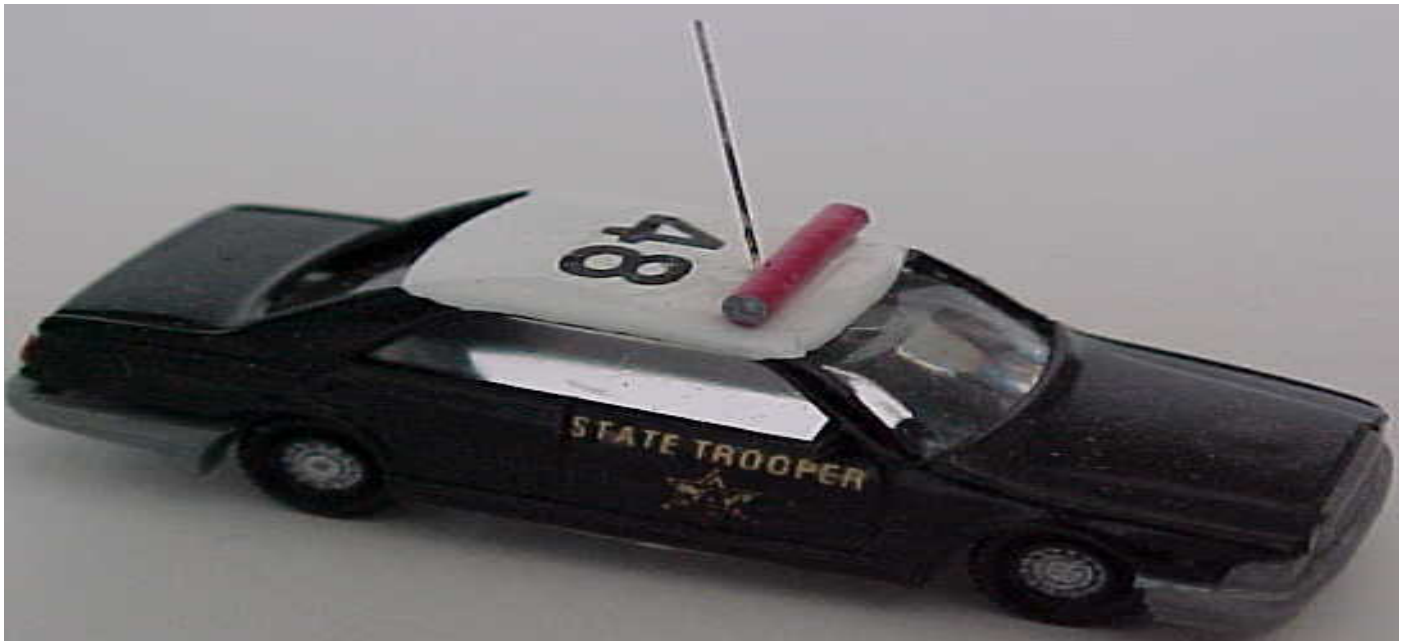
- The most common dipole antenna is used with televisions called "rabbit ears“
- Considered to be omni directional in the plane perpendicular to the axis of the antenna
- But it has deep nulls in the directions of the axis
- Dipoles have a toroidal (doughnut shaped) radiation pattern





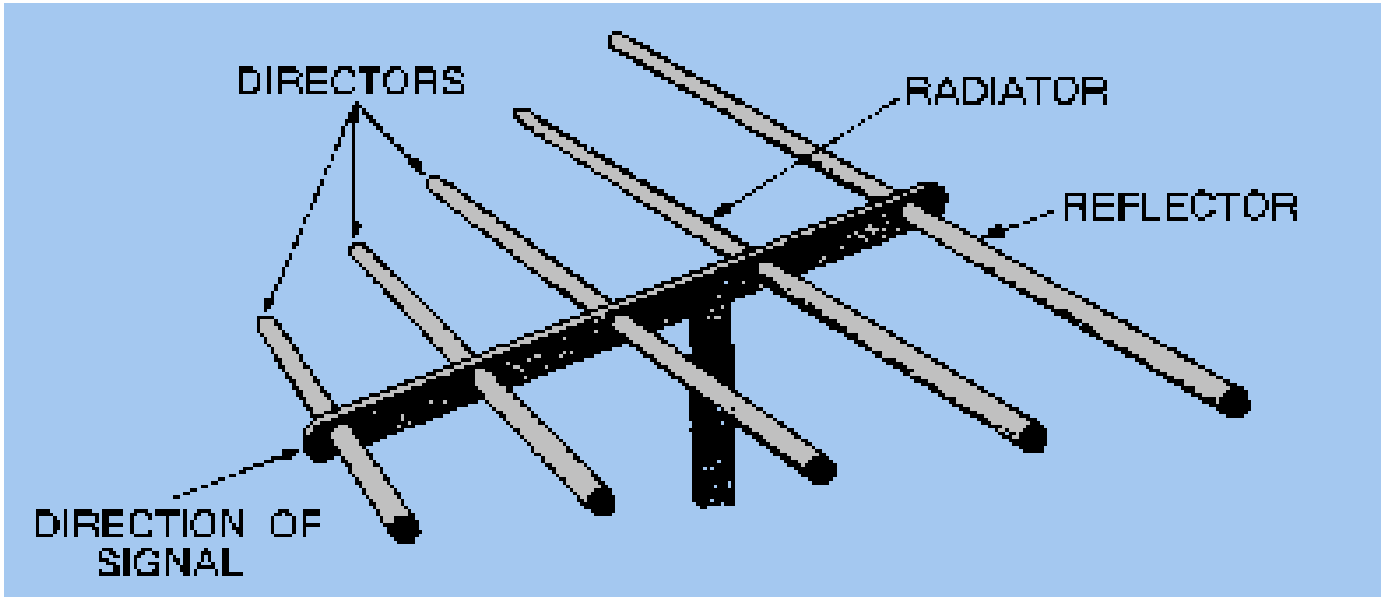
Whip Antenna

- A stiff, yet flexible, wire mounted vertically
- Attached at one end to a ground plane
- Also called a half dipole antenna
- The length of the whip determines its wavelength
- Attached to a vehicle and designed to be flexible
- Name is derived from the whip like motion they exhibit



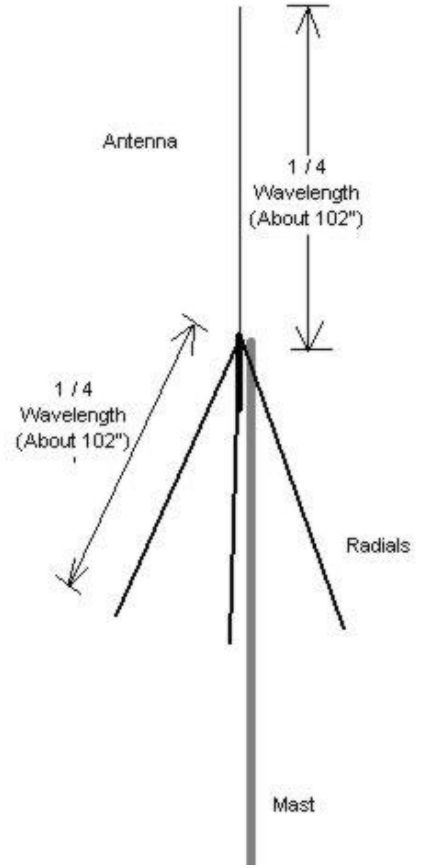
Yagi Uda Antenna

- Consisting of an array of a dipole and additional parasitic elements
- The dipole is fed
- Another element, slightly longer, operates as a reflector
- Other shorter parasitic elements can be added in front of the dipole as directors
- This arrangement gives the antenna directionality that a single dipole lacks



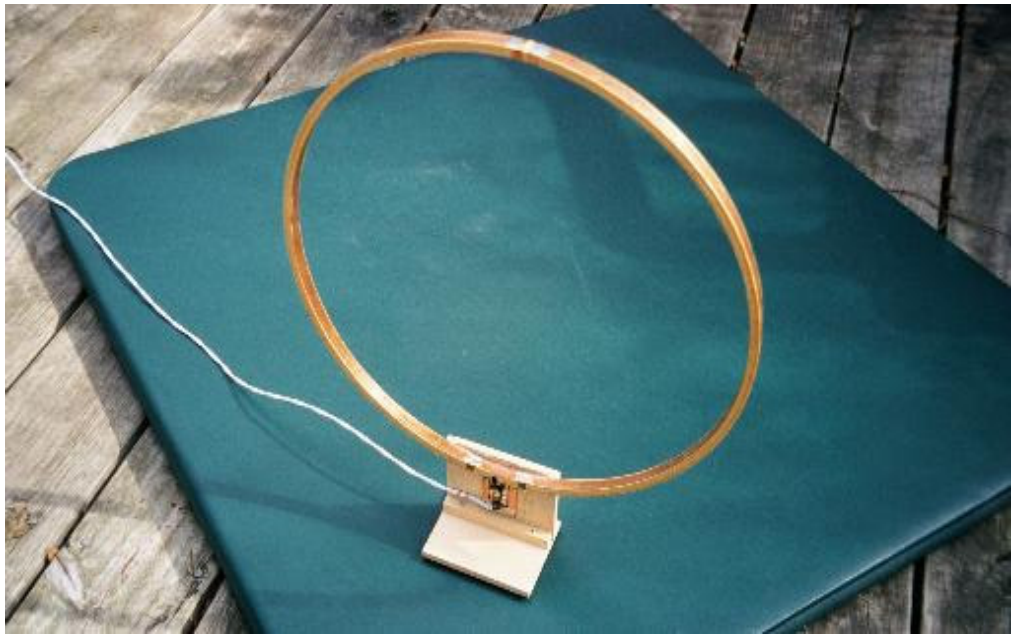
Ground Plane Antenna

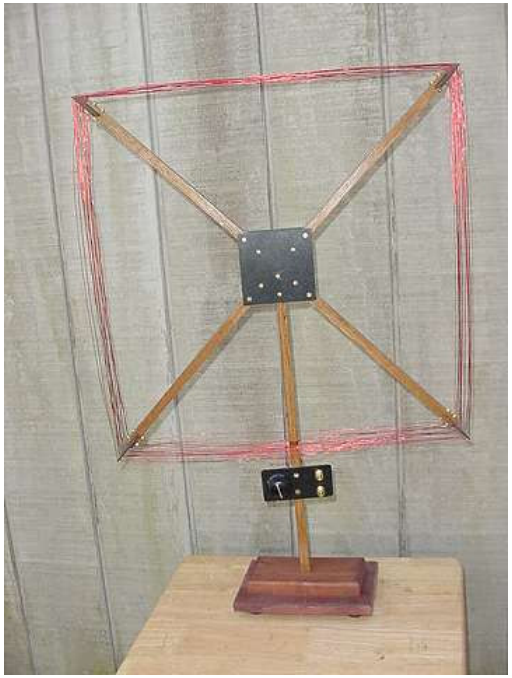
- It is a driven vertical element 1/4 wave long, 1/2 wave in diameter
- The end of the vertical element nearest the ground plane is fed
- The far end is in hanging in free space



Loop Antennas

- They have a continuous conducting path from one conductor of a two-wire feed line to the other conductor
- They are connected to form a circle, triangle or square
- Typically a loop is a multiple of a half or full wavelength in circumference





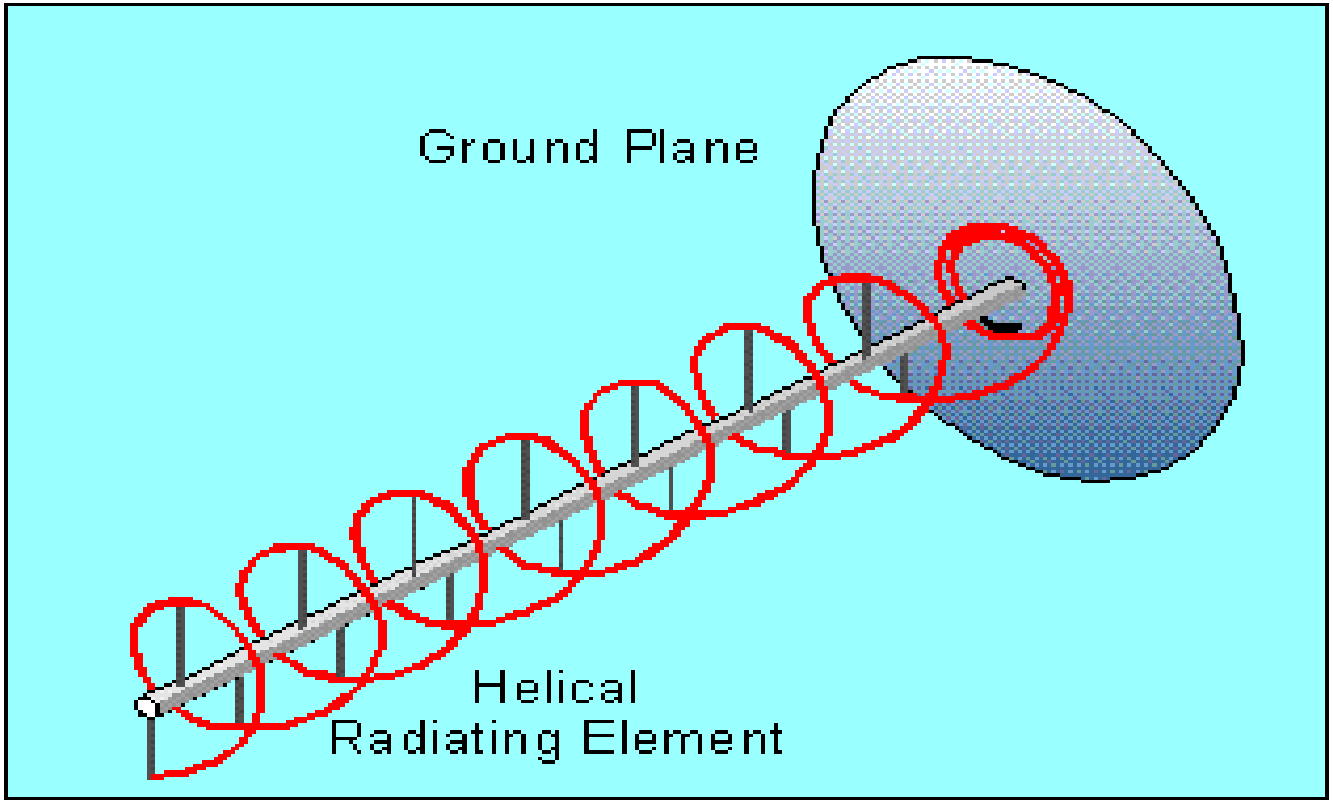
Micro Strip Antenna

- Consists of a patch of metallization
- Low profile, light weight antennas
- Suitable for aerospace and mobile applications
- Low power handling capability
- Used in low power applications
  - Mobile communications
  - Satellite links
  - Wireless LAN

- Circuit functions can be directly integrated to the micro-strip antenna to form compact transceivers

Helical Antenna

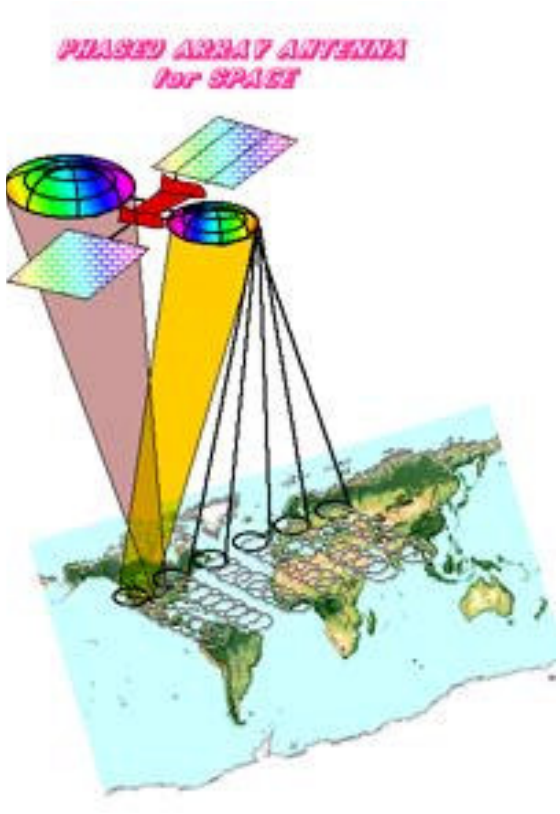
- A directional antenna suited for receiving signals that are circular polarized
- Used with satellites, and used for the driven element on a dish



helical antenna

Phased Array Antenna

- A group of independently fed active elements
- The phases of the signals feeding the elements are varied
- The effective radiation pattern of the array is
  - reinforced in a desired direction
  - suppressed in undesired directions



Parabolic Antenna

- A high gain, reflector antenna
- Used for radio, television and data communications, RADAR, on the UHF and SHF frequencies

Satellite Dish

- A type of parabolic antenna for transmitting signals to and receiving from satellites

Thank You

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