Overview of Antennas

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Outline

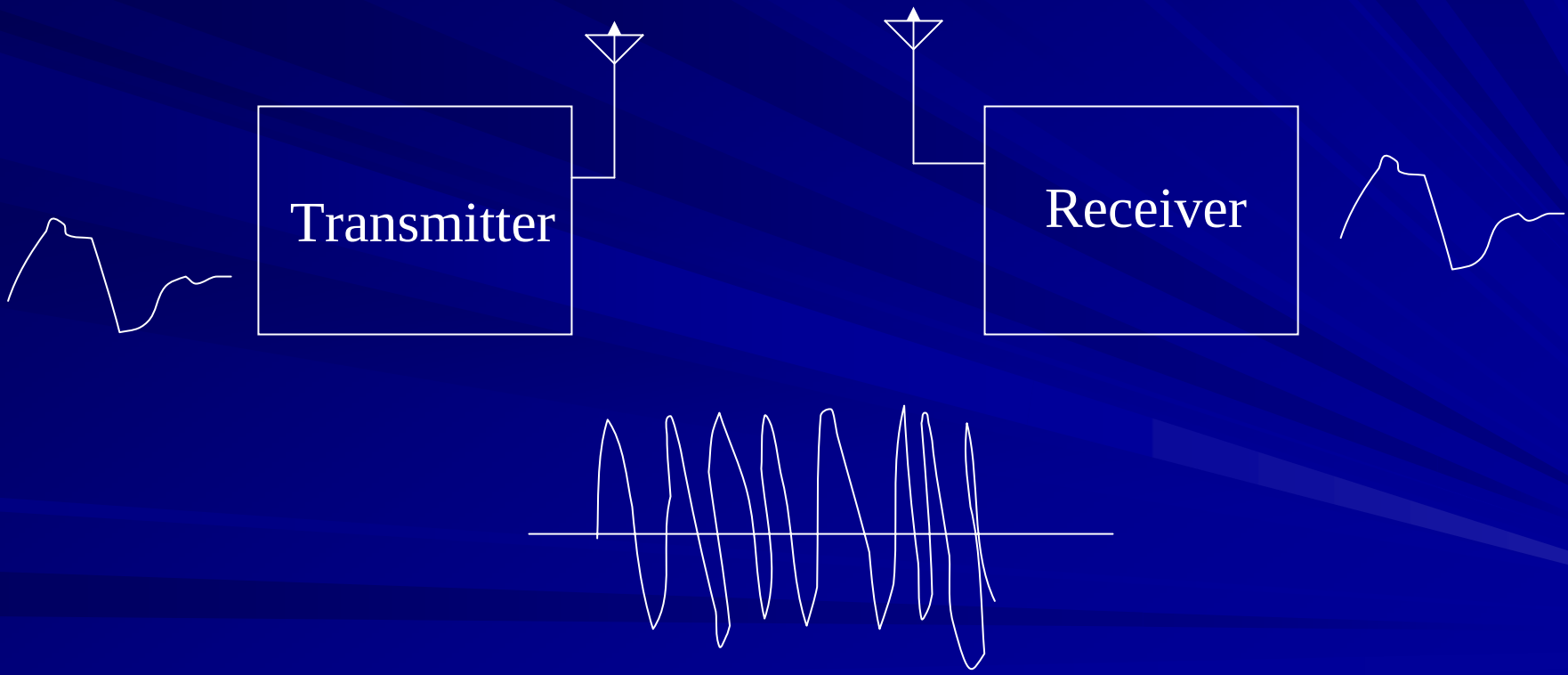
- What is an Antenna?
- Historical Background
- Antenna Radiation Mechanism
- Antenna Performance Parameters
- Overview of different types of Antennas
- Antenna Arrays
- Smart Antennas and digital beamforming
- ???

Antenna Defined

Webster's Dictionary: " a usually metallic device (as a rod or wire) for radiating or receiving radio waves."

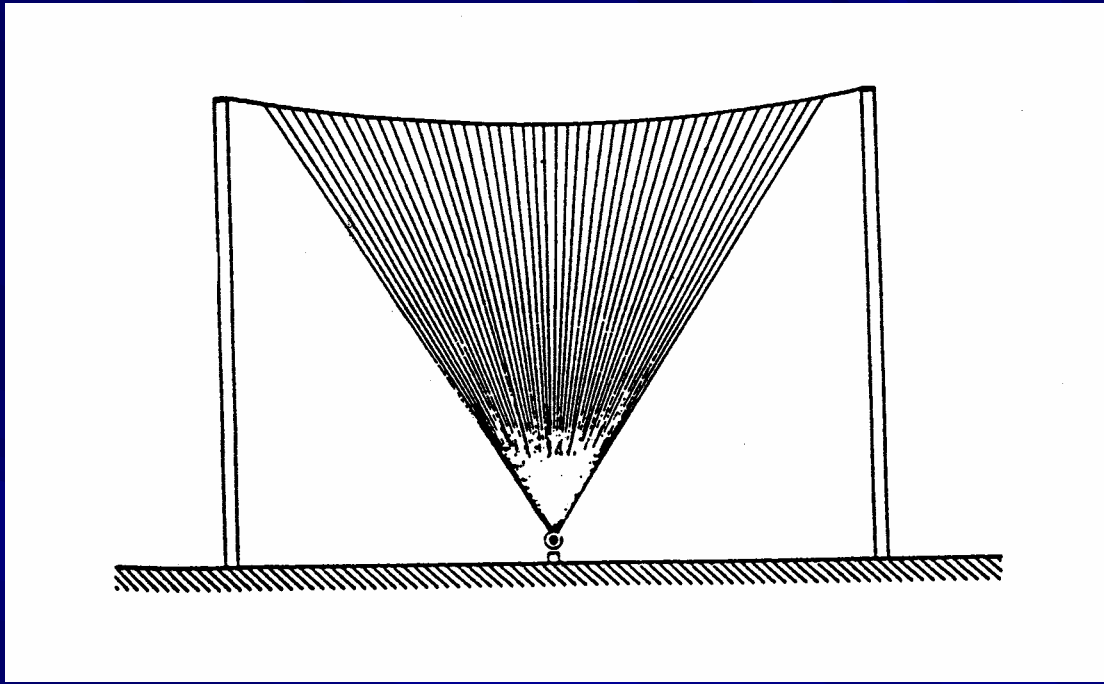
IEEE: " a means for radiating or receiving radio waves."

Typical Wireless System Arrangement



Historical Background

- Joseph Henry, 1842: “telegraph key closures radiate”
- James Clerk Maxwell, 1864: Theoretical foundations- electricity and magnetism – now known as “Maxwell’s Equations.”
- Thomas Edison, 1885: patented a communication system.”
- Heinrich Hertz, 1887; Marconi, 1895, ….

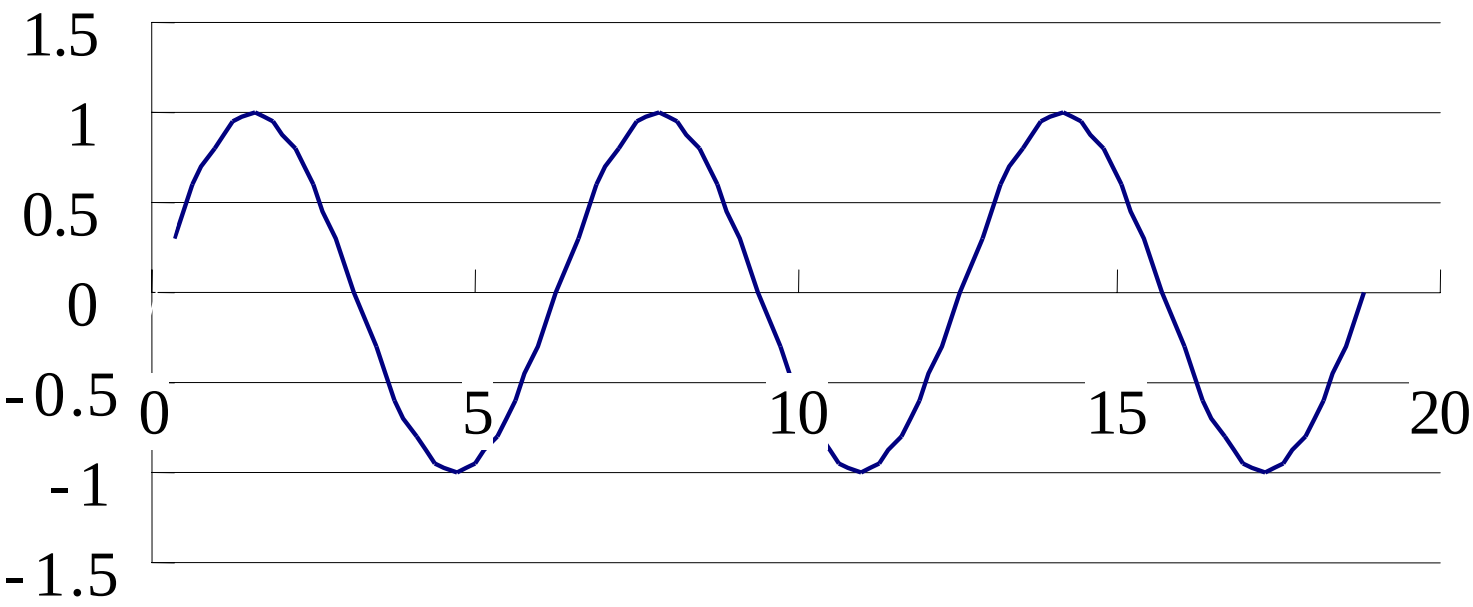


Marconis' first transatlantic transmitting antenna (1901)

Radiation Mechanism

- Waves in a water pond
- Sound waves
- Radiation: “ a disturbance in the electromagnetic fields that propagates away from the source of the disturbance.”
- Disturbance is created by a time-varying current source that has accelerated/decelerated charge distribution associated with it – Time-harmonic signals.

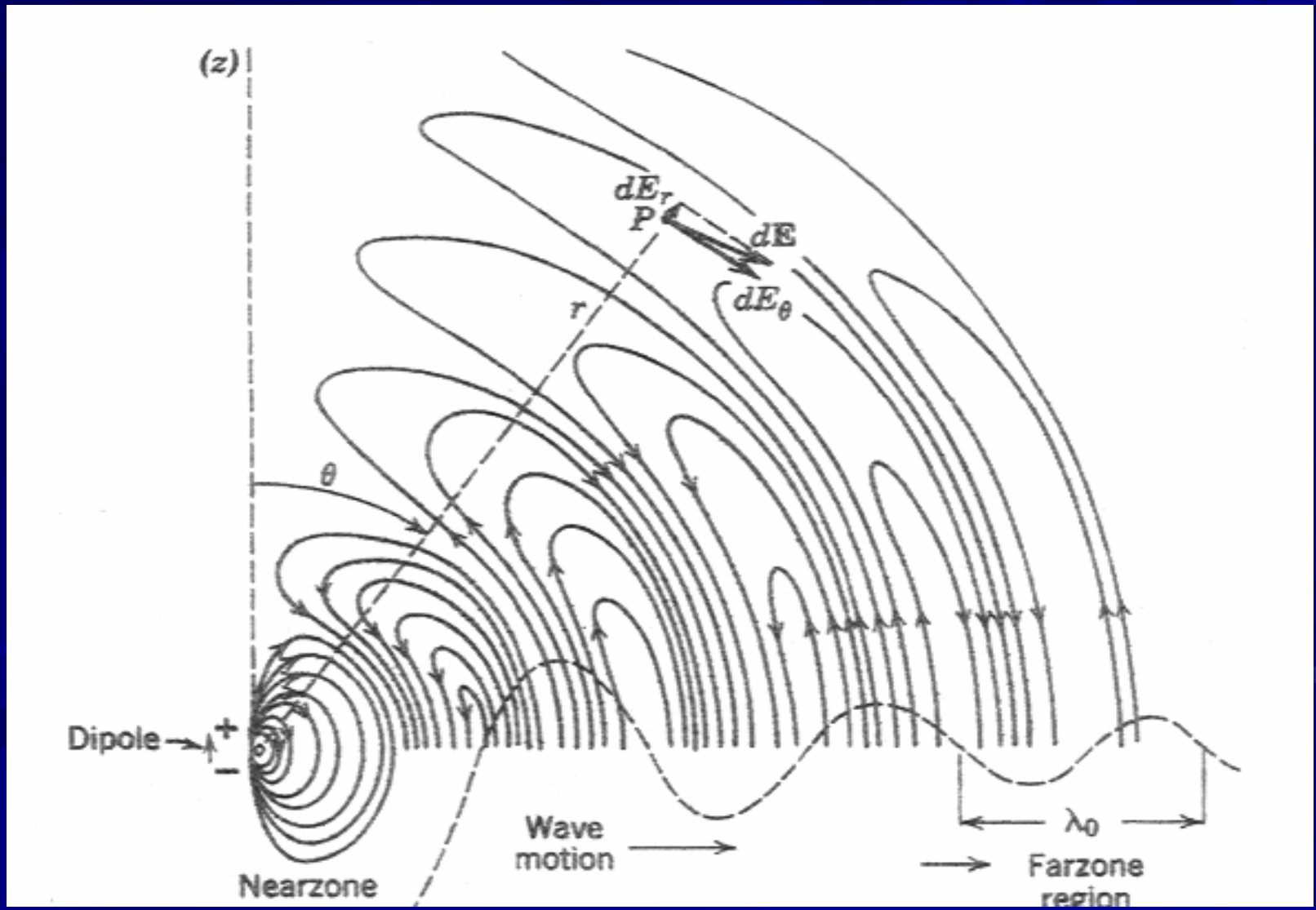
Time-Harmonic Signals



$$y = A\sin(2\pi ft + \phi)$$

$$y = \mathrm{Re}\left\{Ae^{j\phi}e^{j2\pi ft}\right\} = \mathrm{Re}\left\{Ye^{j2\pi ft}\right\}$$

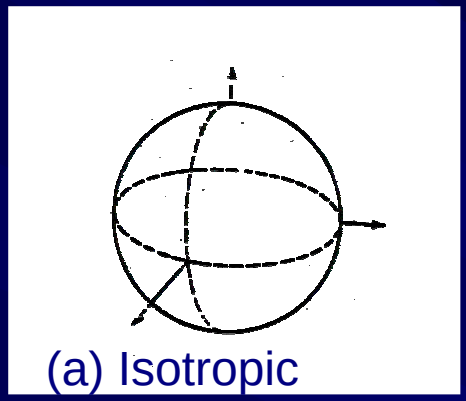
Radiation cont'd



Performance Parameters

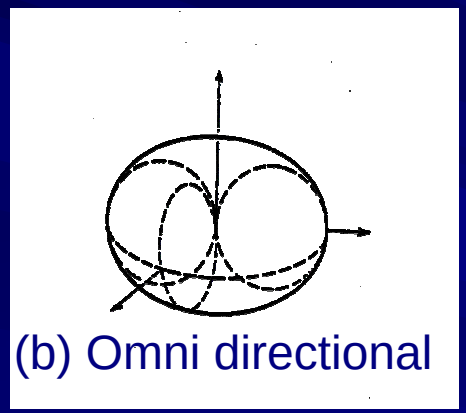
1.Radiation Pattern (or reception pattern) is a plot of the strength of the electric (or magnetic) part of the electromagnetic field in all directions around an antenna.

A **Power Pattern** is a plot of the density of power flowing thru the surface of the sphere and is obviously proportional to the square of the field pattern.



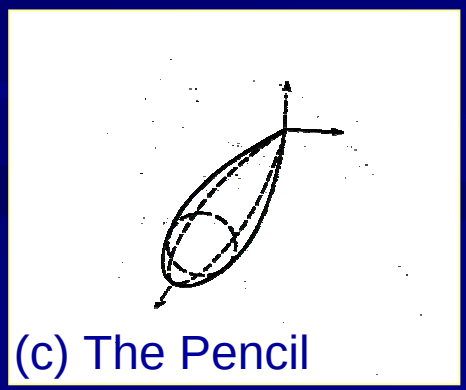
(a) Isotropic

Idealized Point Radiator



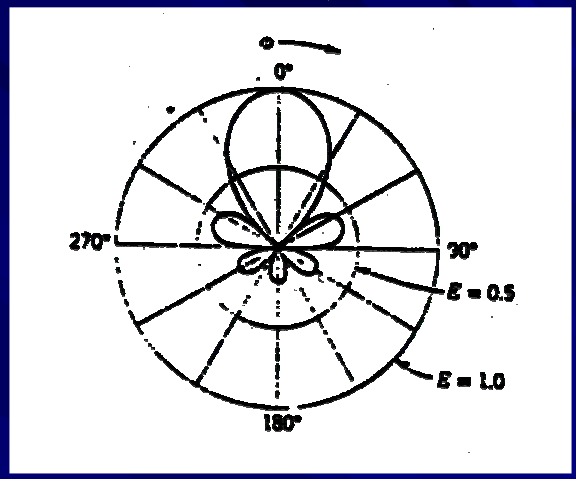
(b) Omni directional

Vertical Dipole

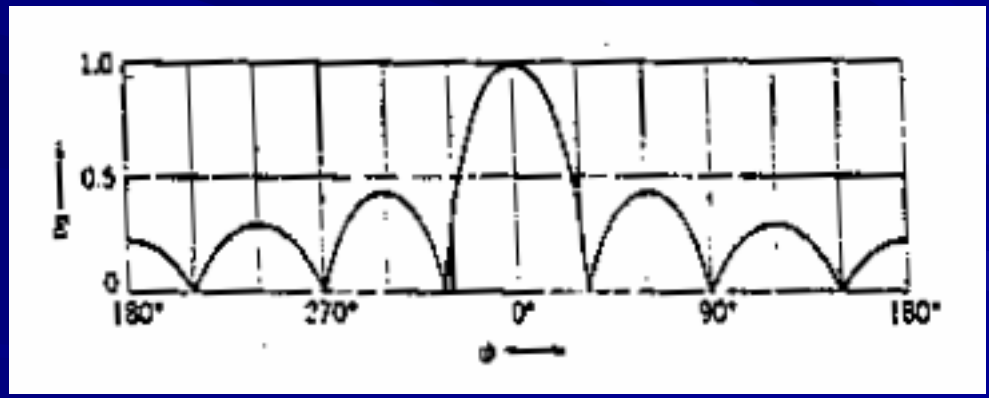


(c) The Pencil

Radar Dish



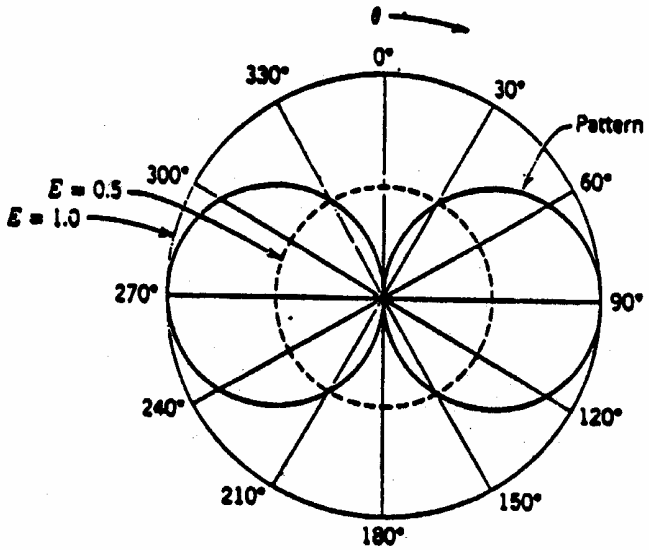
Polar Plot



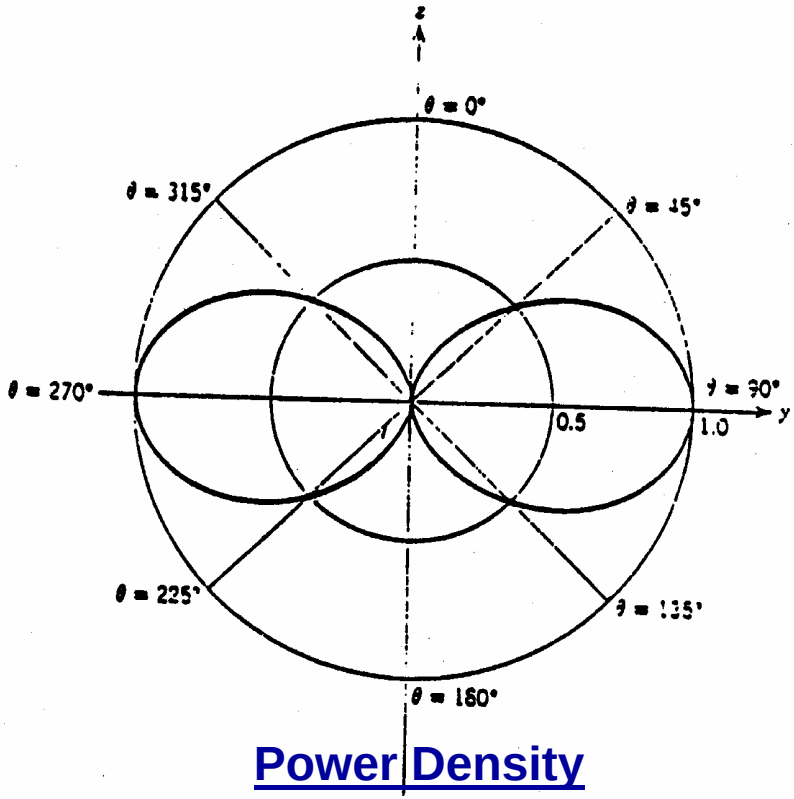
Same Pattern

Rectangular Plot

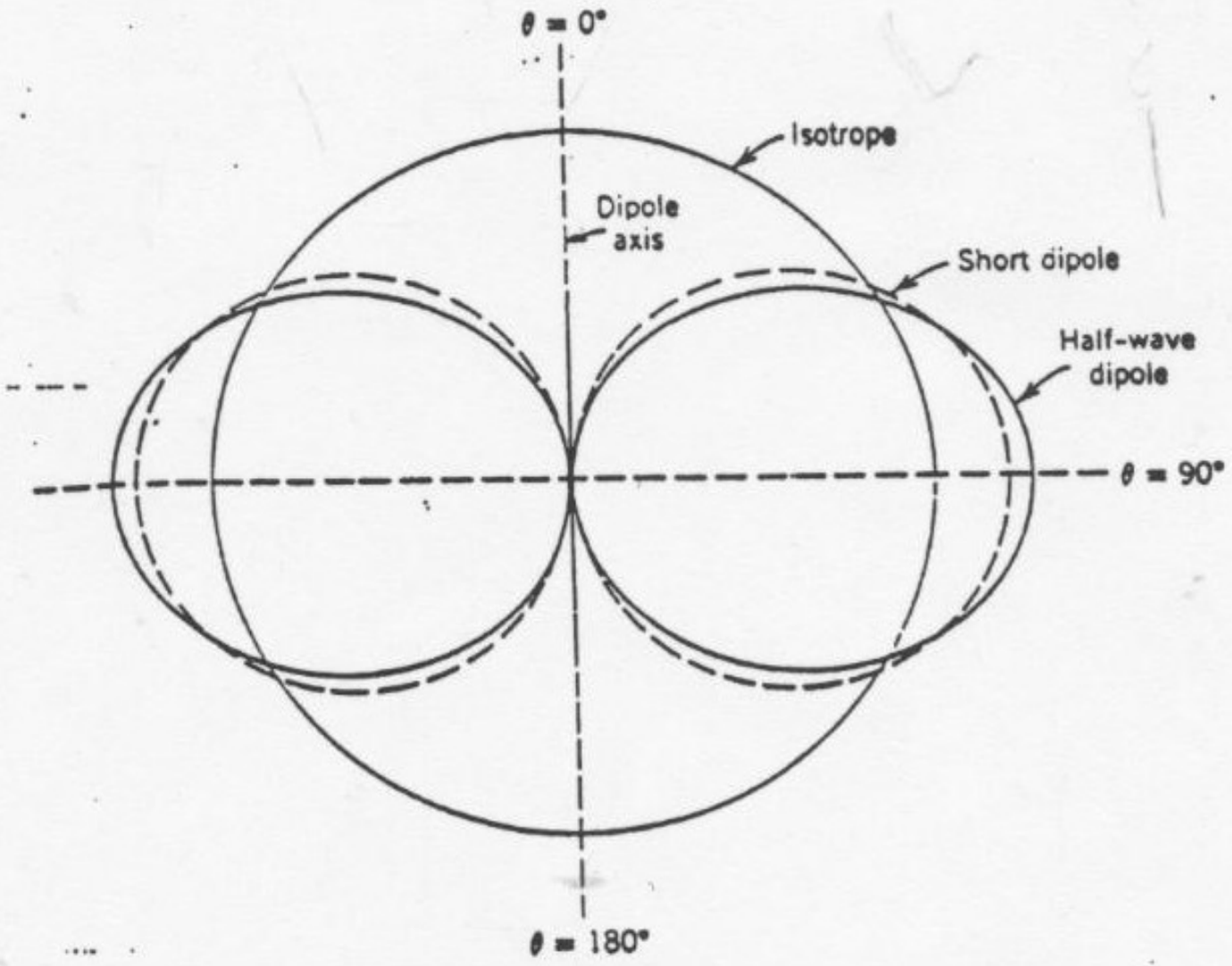
Patterns Showing **Field** & **Power Density**



Field Intensity



Power Density



Half-wave-dipole, short-dipole, and isotrope patterns compared for equal power radiated (electric-intensity patterns), in plane containing dipole axes.

2. Gain is used to compare the ability of different antennas to focus energy in a given direction. Hi gain implies narrow beams & a better efficiency.

3. Impedance represents the kind of load the antenna presents to its transmission line. The part of the impedance associated with power accepted & then radiated is called the Radiation Resistance. Any other resistance an antenna presents usually represents losses.

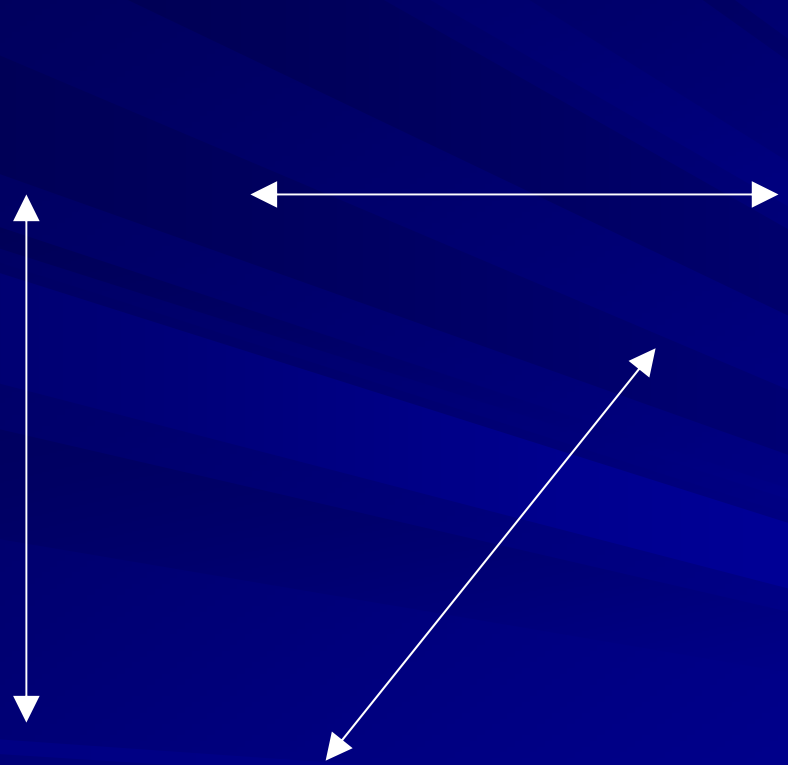
4. Effective Aperture & Effective Length: If an antenna is able to extract a certain amount of power from a passing wave of known power density, an effective area or aperture can be calculated and associated with it. Likewise, if a linear (wire) antenna develops a certain voltage across its terminals when it is excited by a known field intensity from a passing wave, an effective length or height (for vertical wires) can be determines.

5. Coupling between nearby antennas is a measure of the power delivered or received by one when the other transmits a given power. Coupling depends on antenna gain, orientation, relative location & physical surroundings; importance on crowded platforms when considering interference.

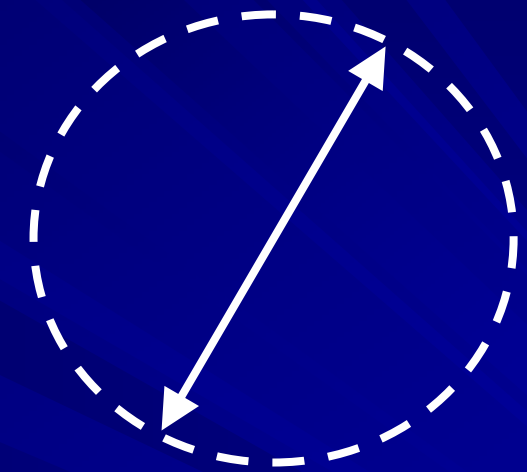
6. Bandwidth: Range of frequencies over which important performance parameters are acceptable.

7. System Considerations: Size, weight, power handling, radar cross section, environmental operating conditions, etc.

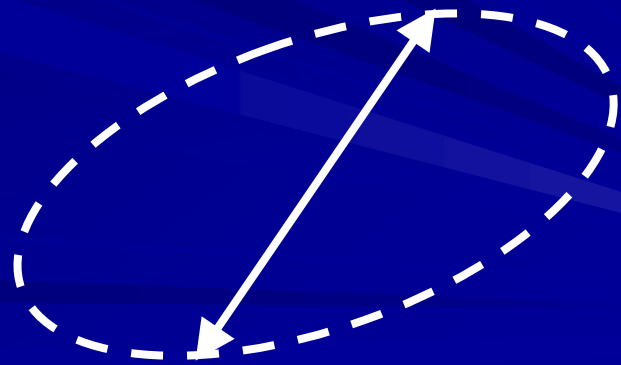
Polarization



Linear

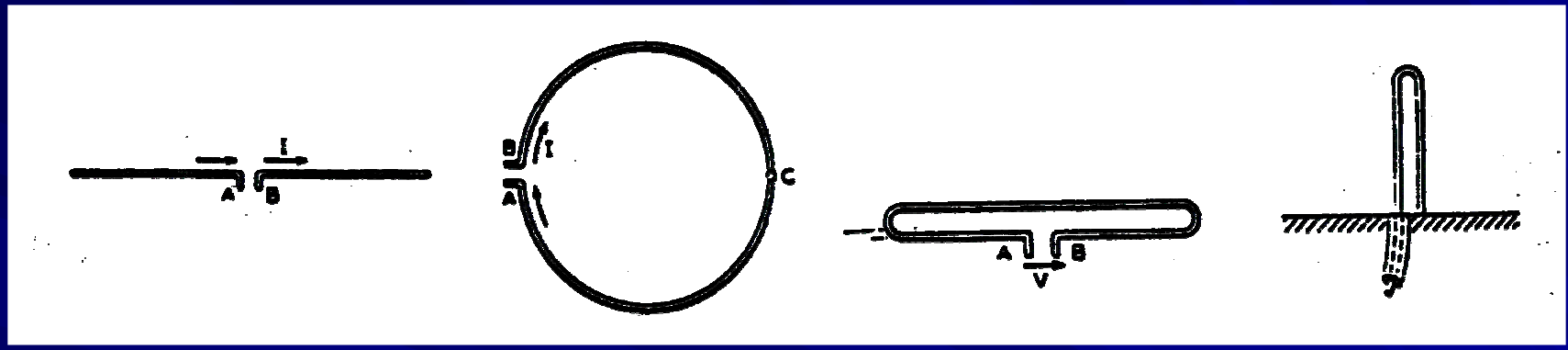


Circular

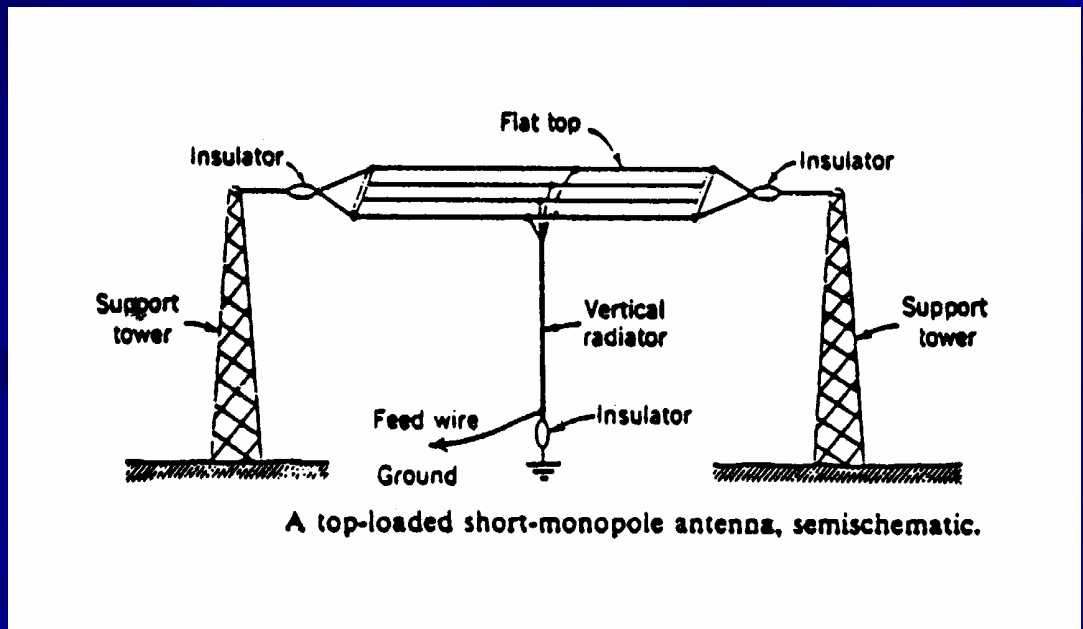


Elliptical

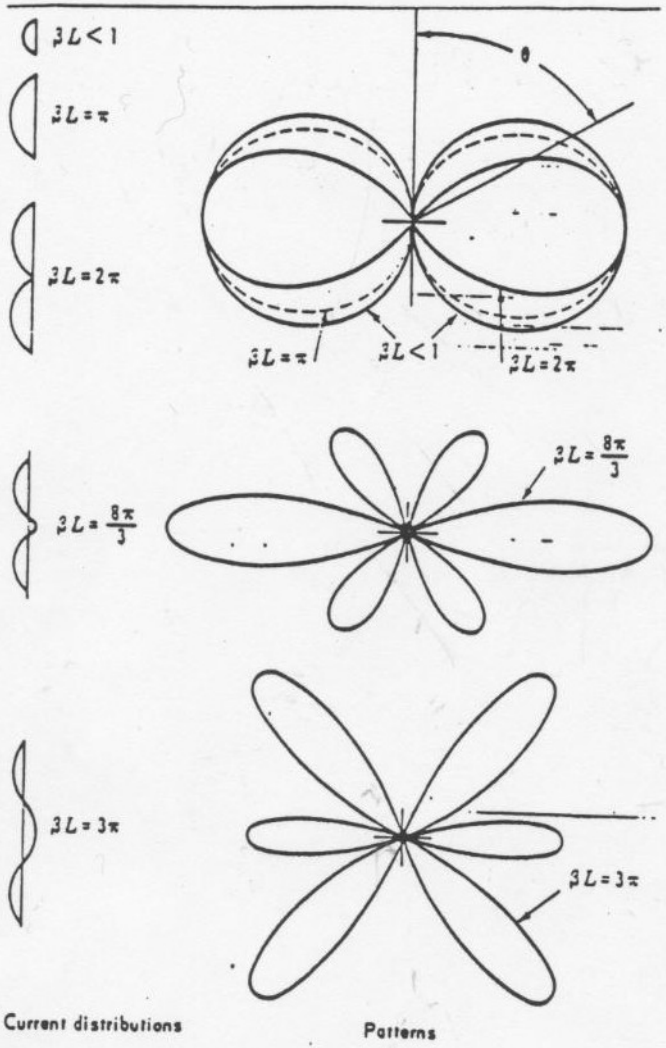
Examples & Pictures Of Some Antennas and Their Patterns



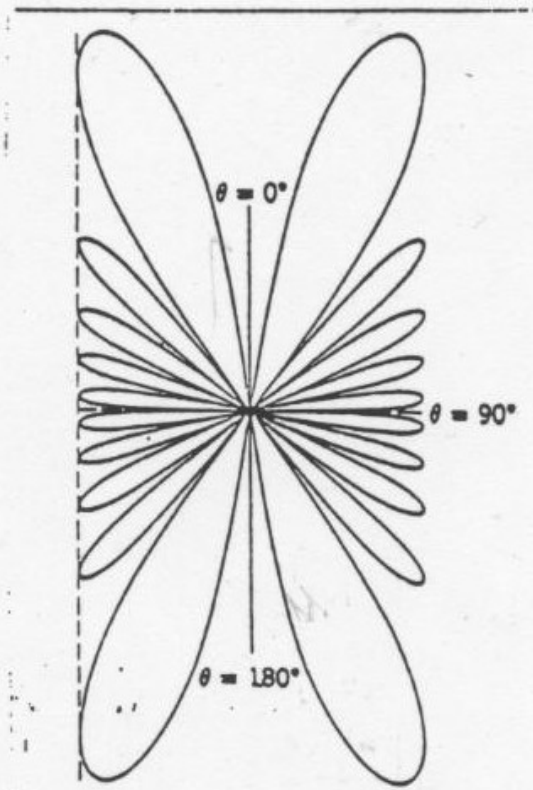
(a) A Dipole antenna and (b) A Loop Antenna (c) A folded dipole (d) A folded unipole



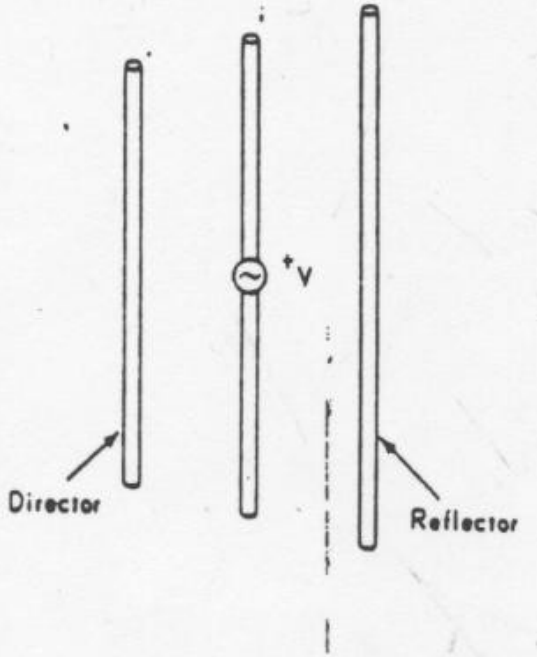
A top-loaded short-monopole antenna, semischematic.



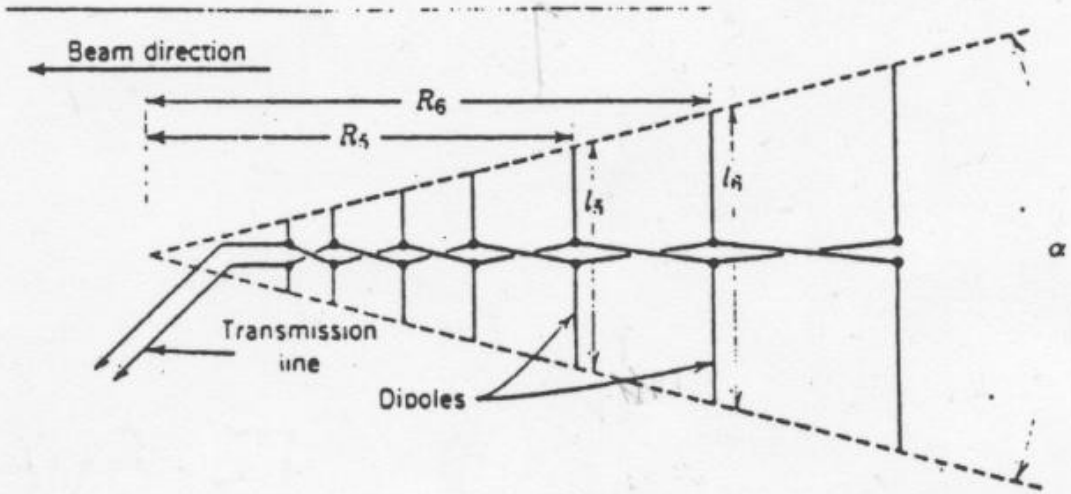
Radiation patterns of straight-wire antennas.



Pattern of five-wavelength resonant antenna ($n = 10$).

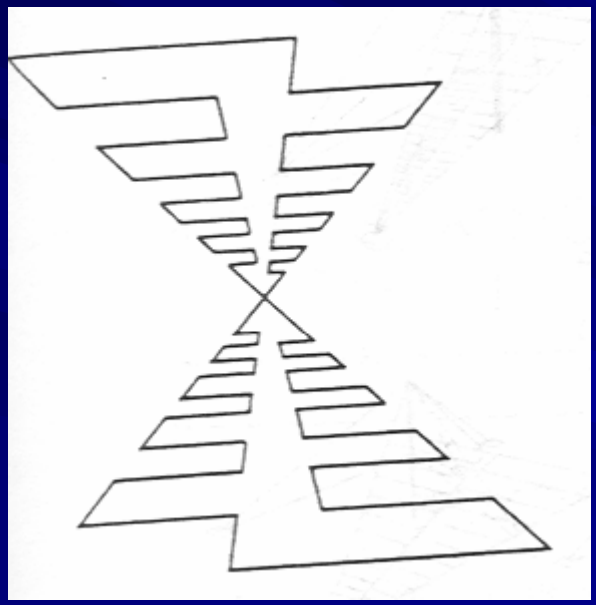


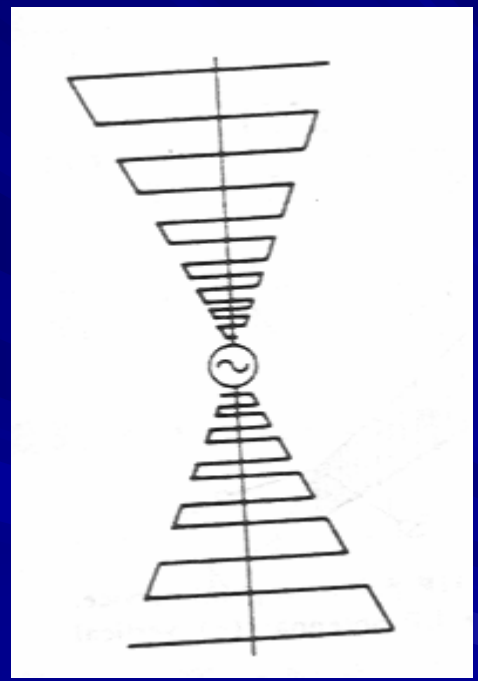
A three-element Yagi array.

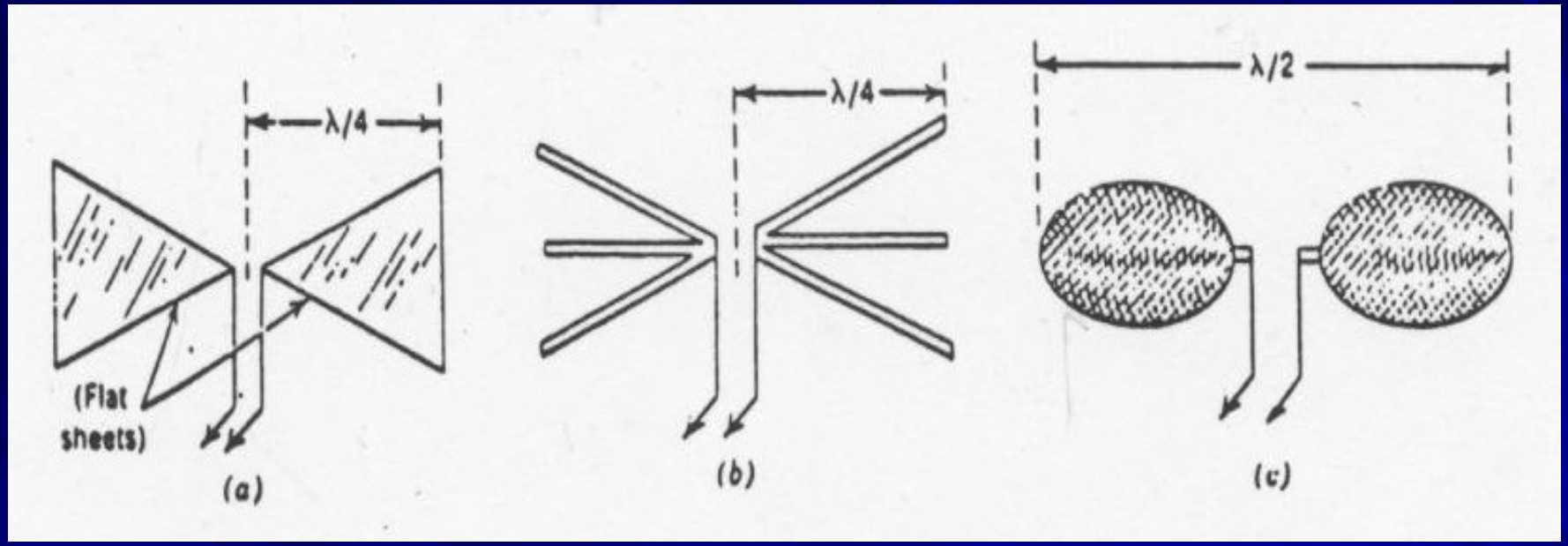


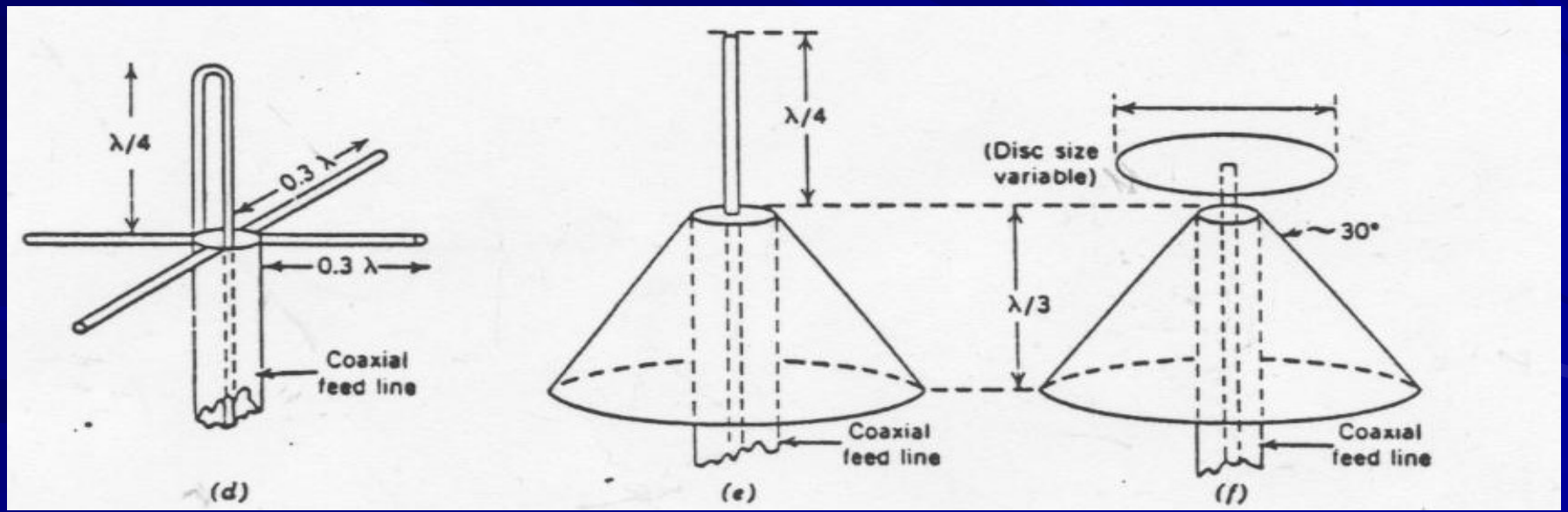
Log-periodic dipole array.

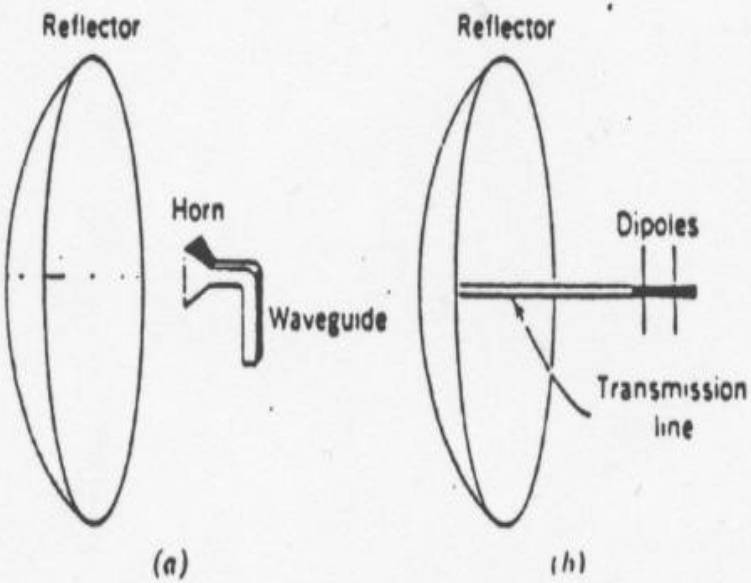
Log Periodic Antennas



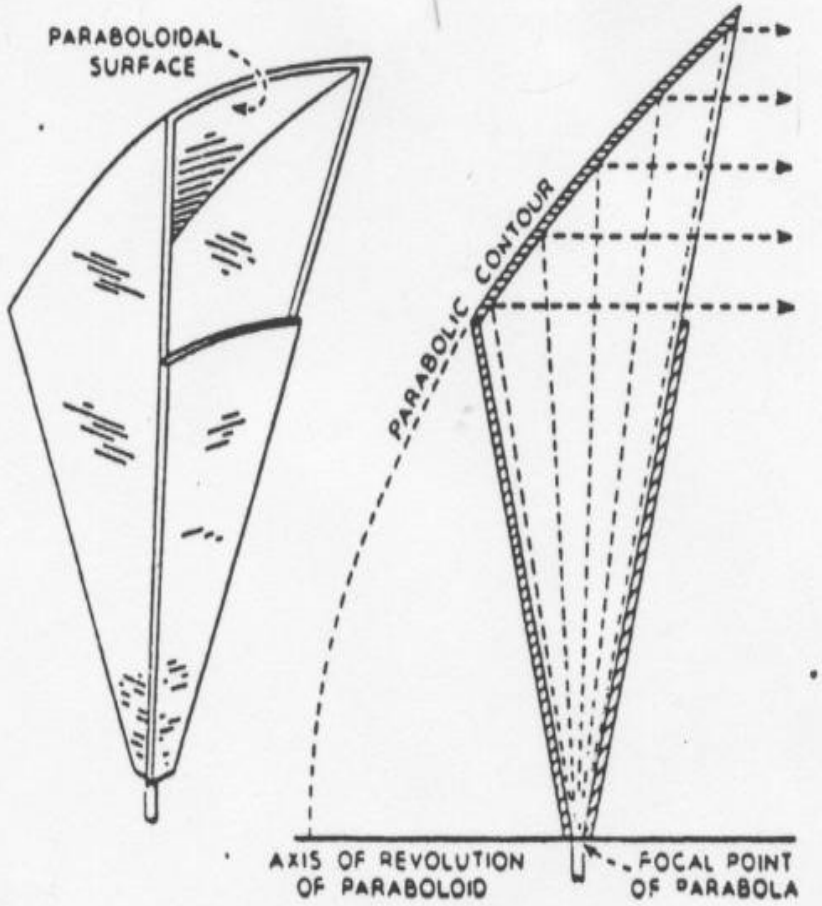



λ/4
(Flat sheets)
(a)
λ/4
(b)
λ/2
(c)


λ/4
0.3 λ
0.3 λ
Coaxial feed line
(d)
λ/4
(Disc size variable)
30°
λ/3
Coaxial feed line
(e)
Coaxial feed line
(f)

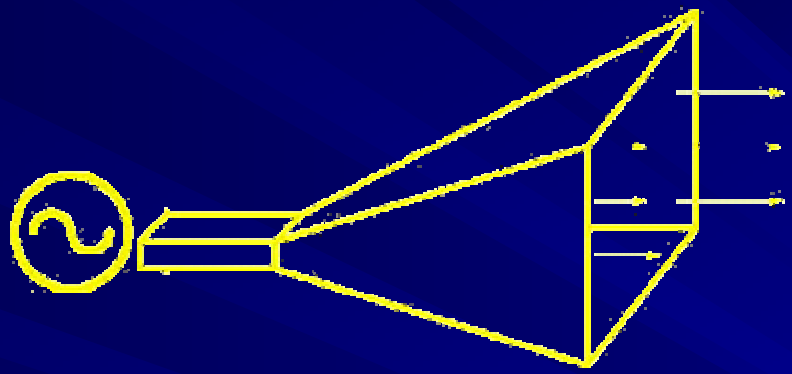


Paraboloidal-reflector antenna fed by (*a*) horn radiator and (*b*) double-dipole endfire array



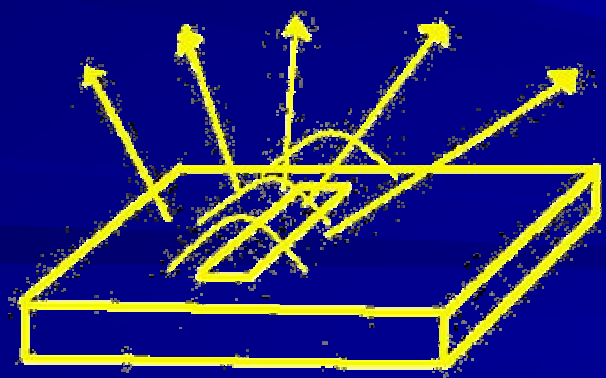
A horn-reflector antenna.

At microwave frequencies, hollow pipes (Waveguides) are used - opening up a waveguide gives a “Horn”.

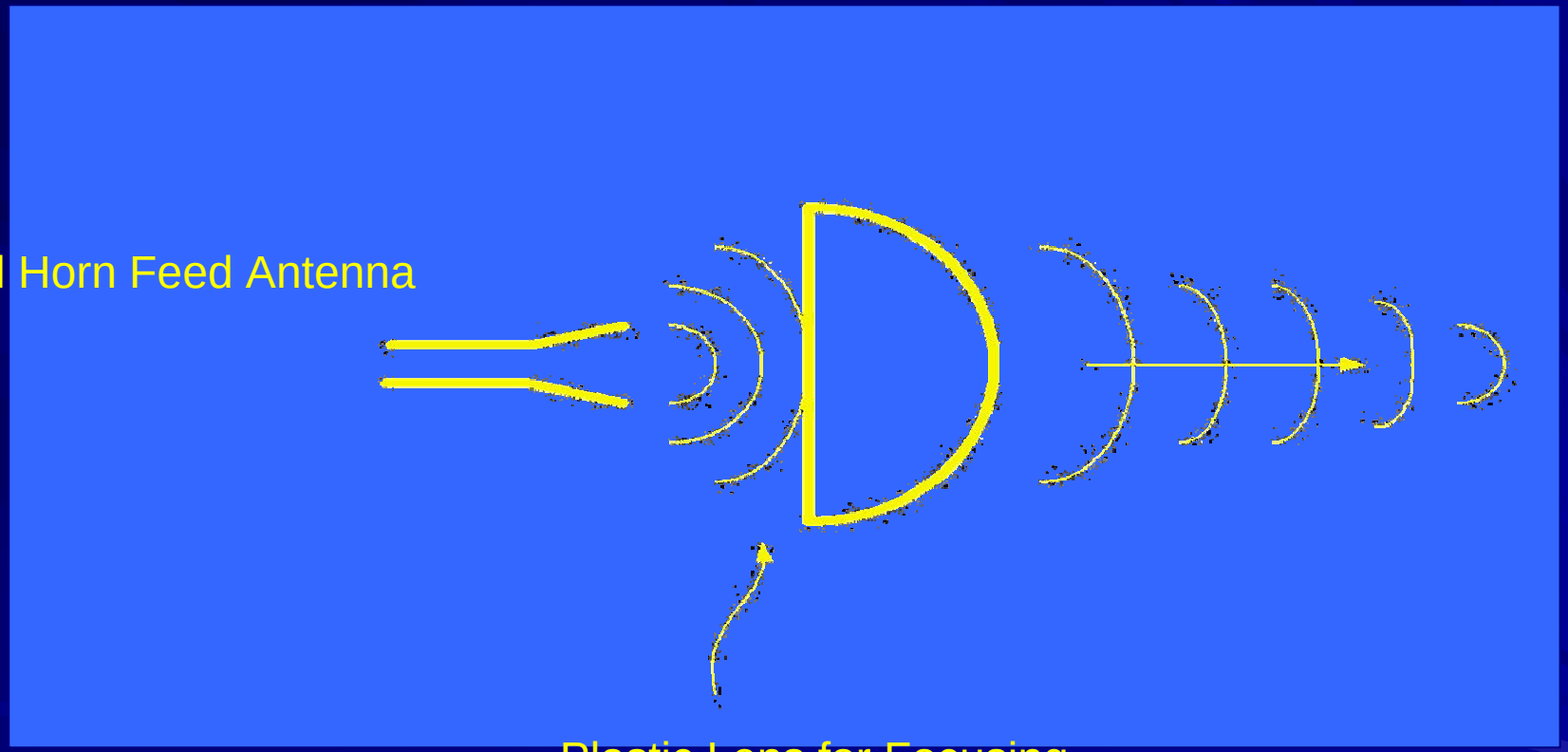


energy flow outward

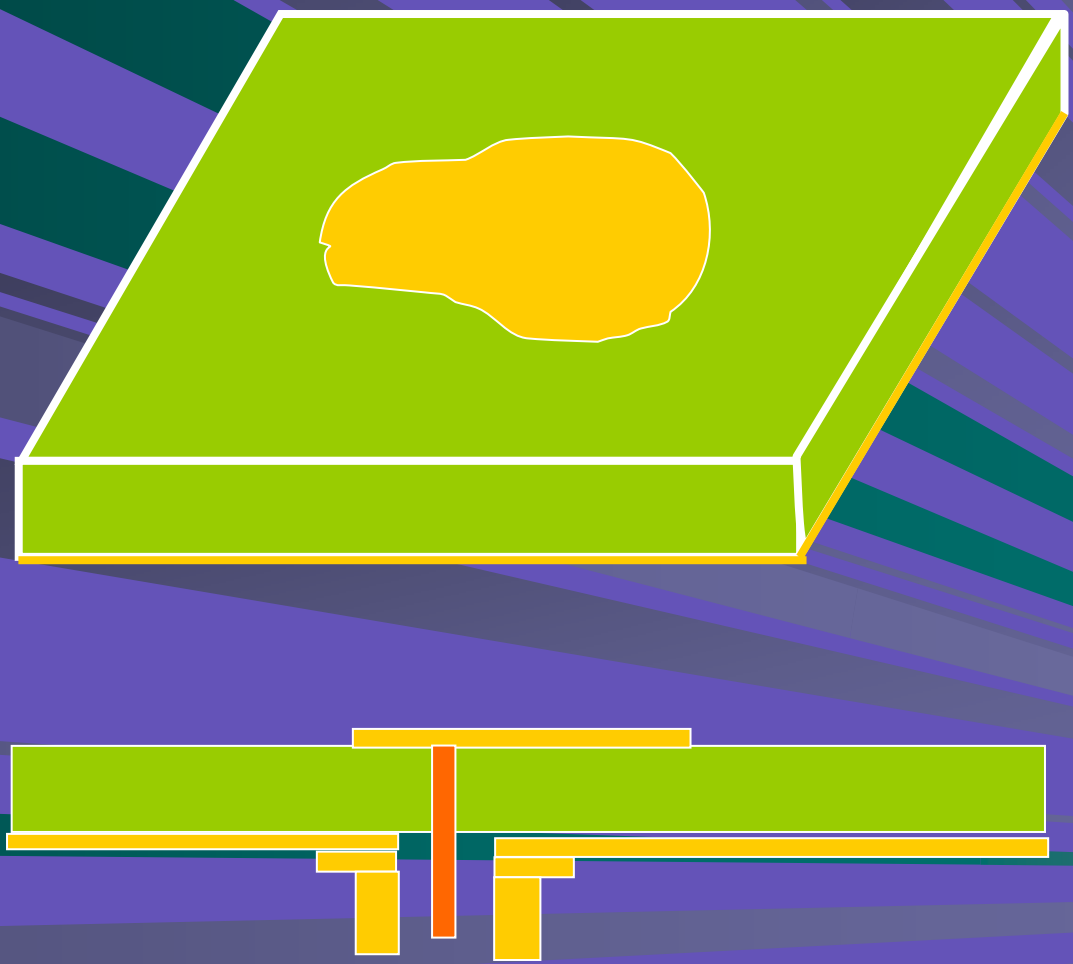
If you cut slots in waveguides, the slots leak energy out -- Slot Antennas!



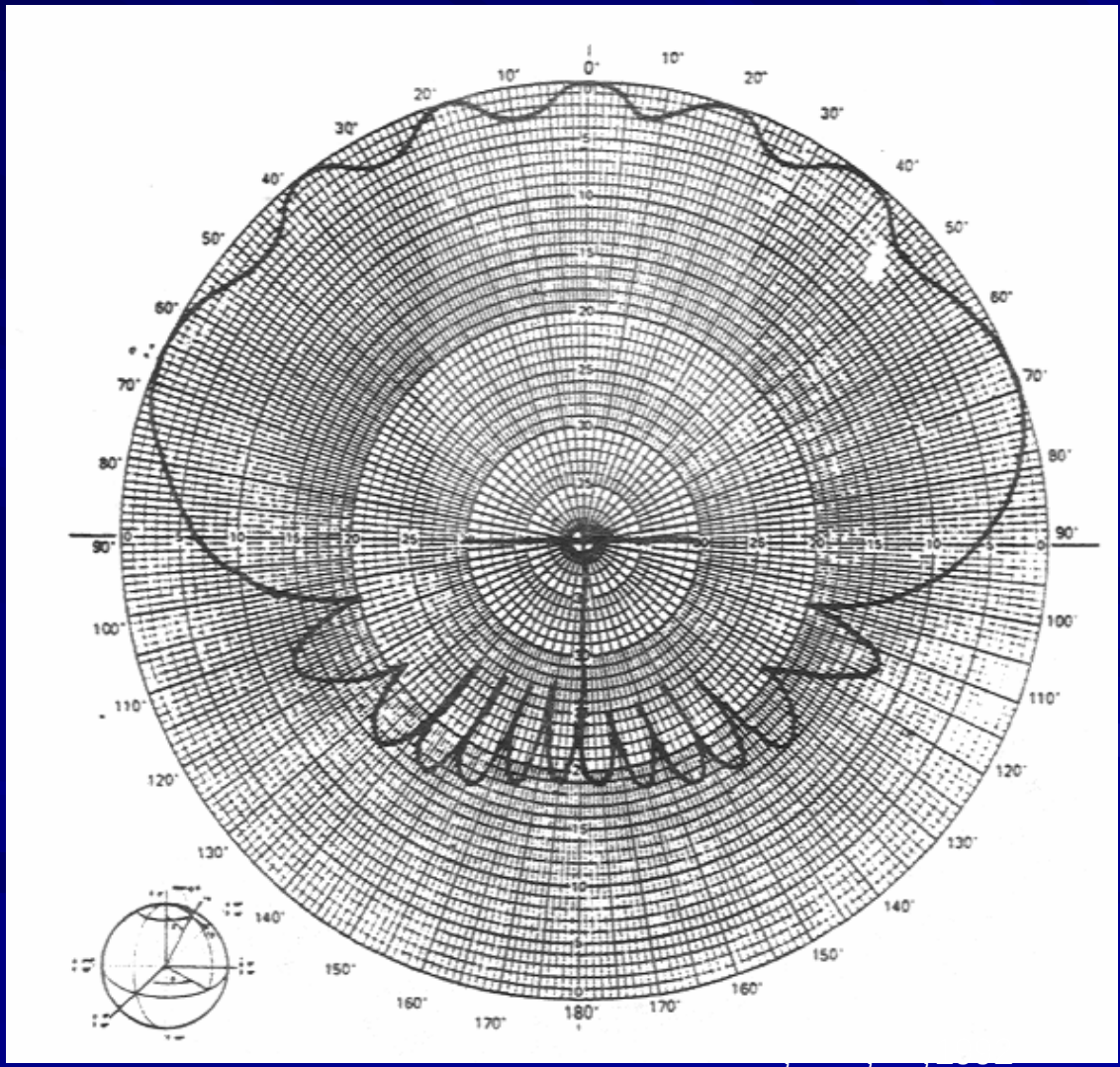
Example: Lens Antenna



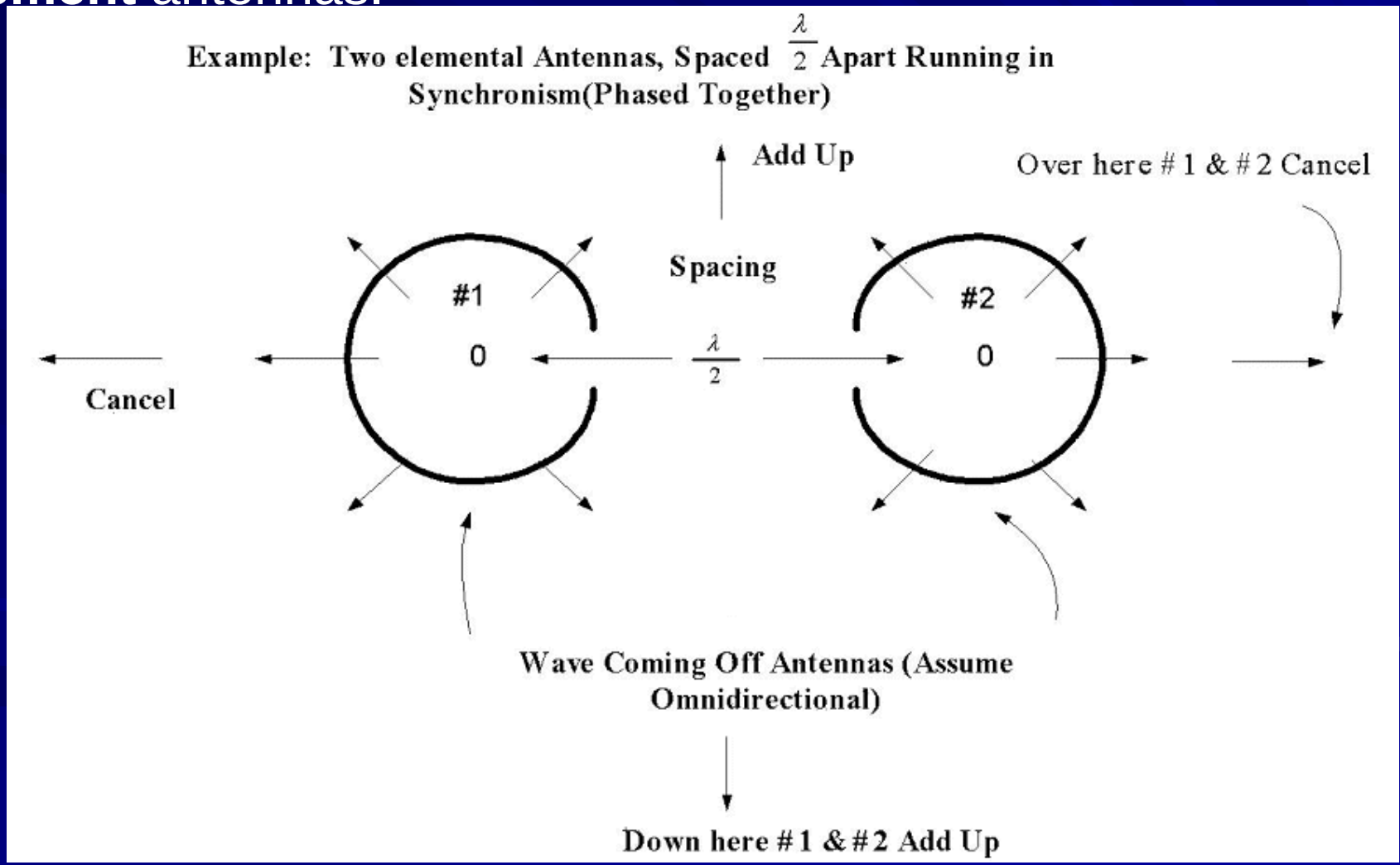
Microstrip Antennas



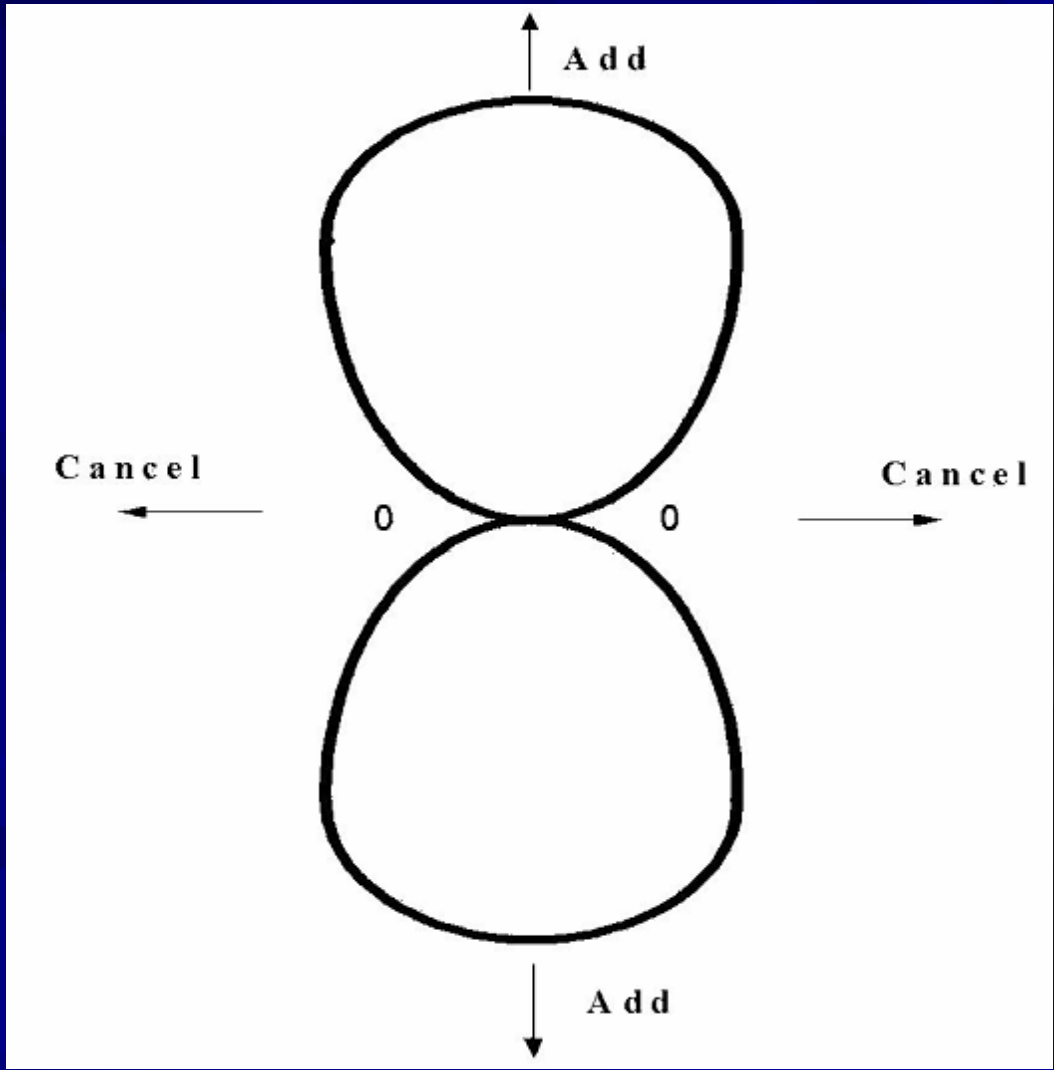
Radiation Pattern



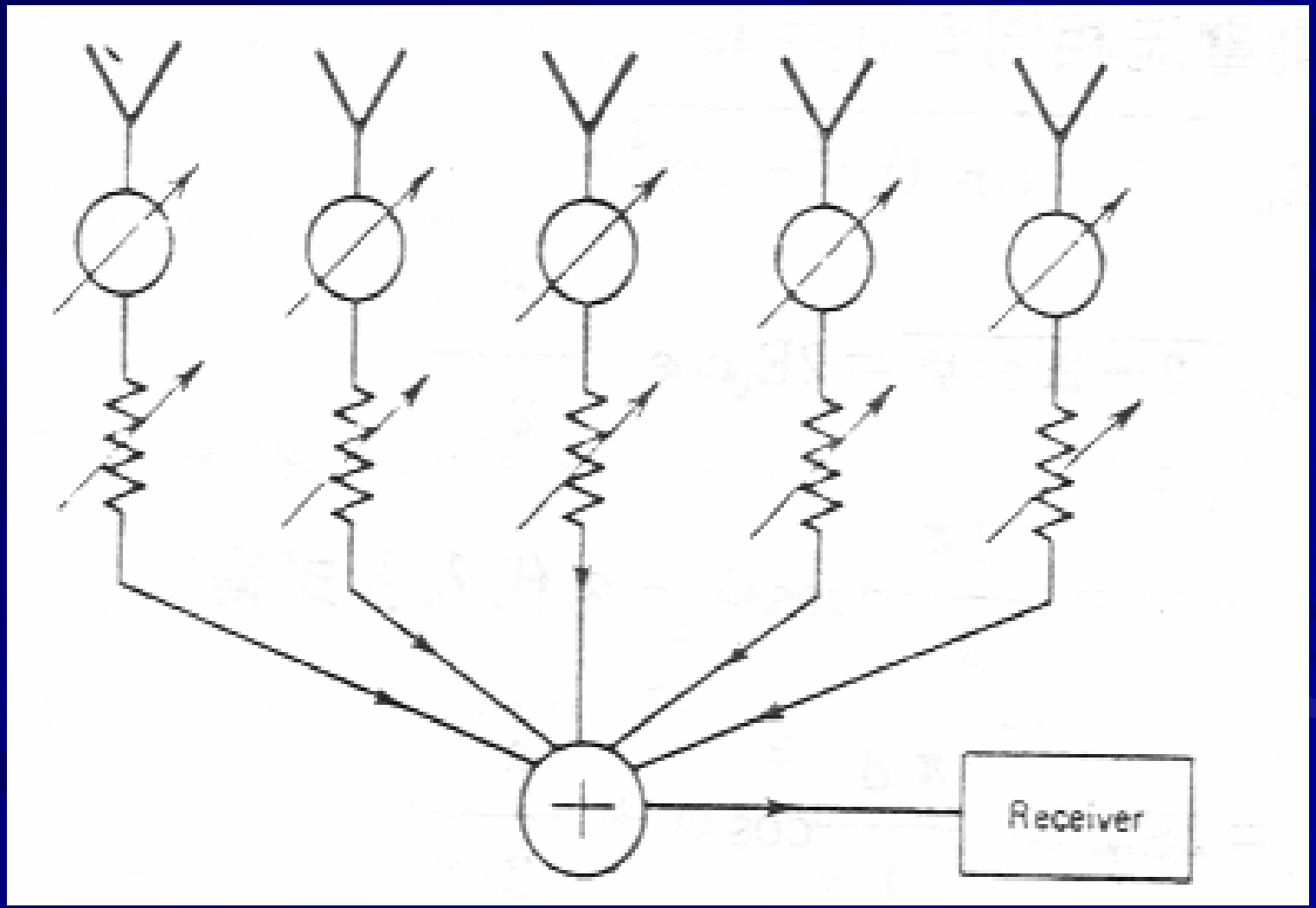
3. Arrays are collections of linear (Wire) antennas or aperture antennas arranged to transmit in a desired direction by causing addition & subtraction of waves from all of the individual **Element** antennas.



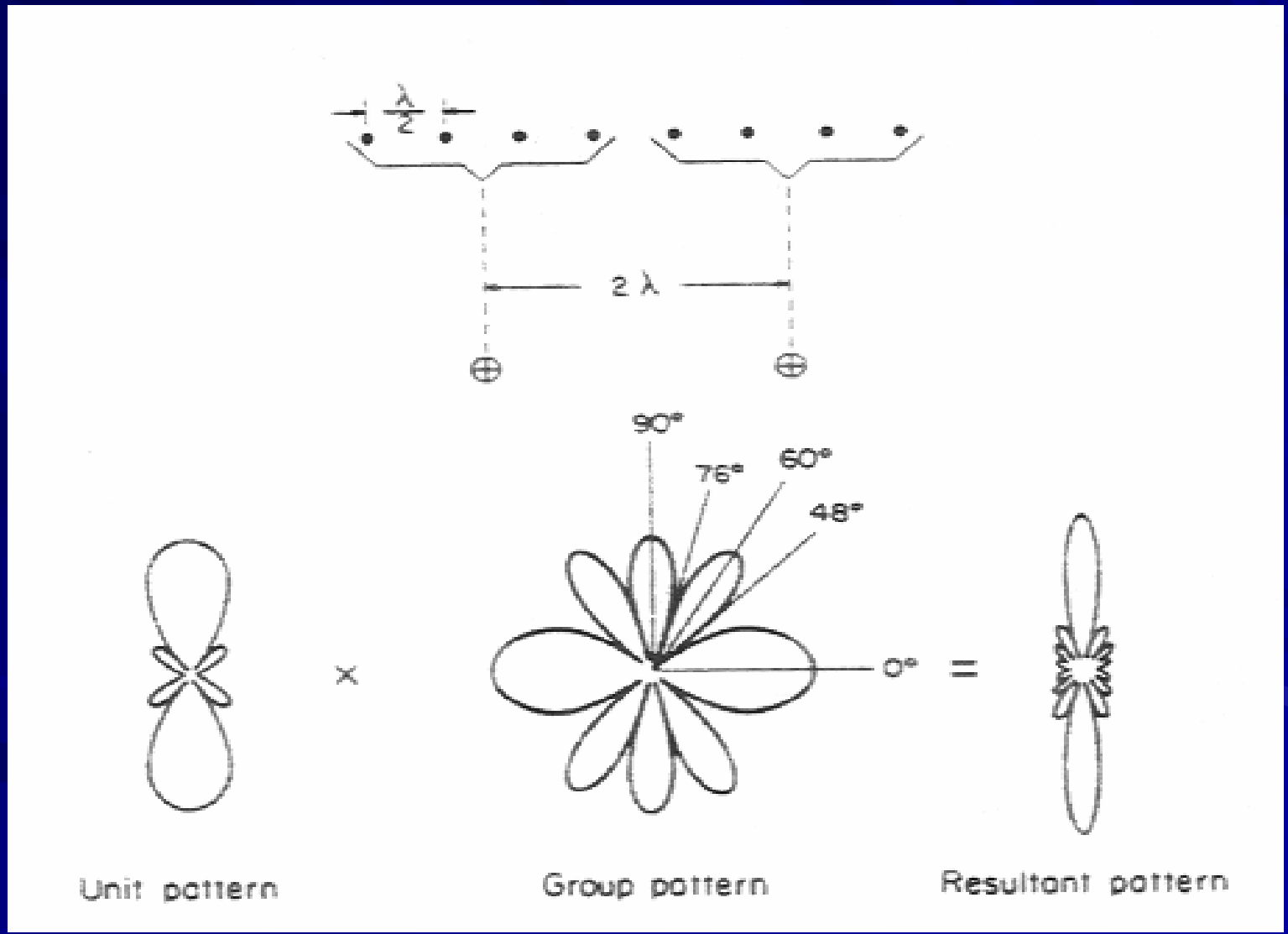
So if both antennas are identical, we expect their individual omni directional waves to add up to a wave that radiates with “directional preference” like this:



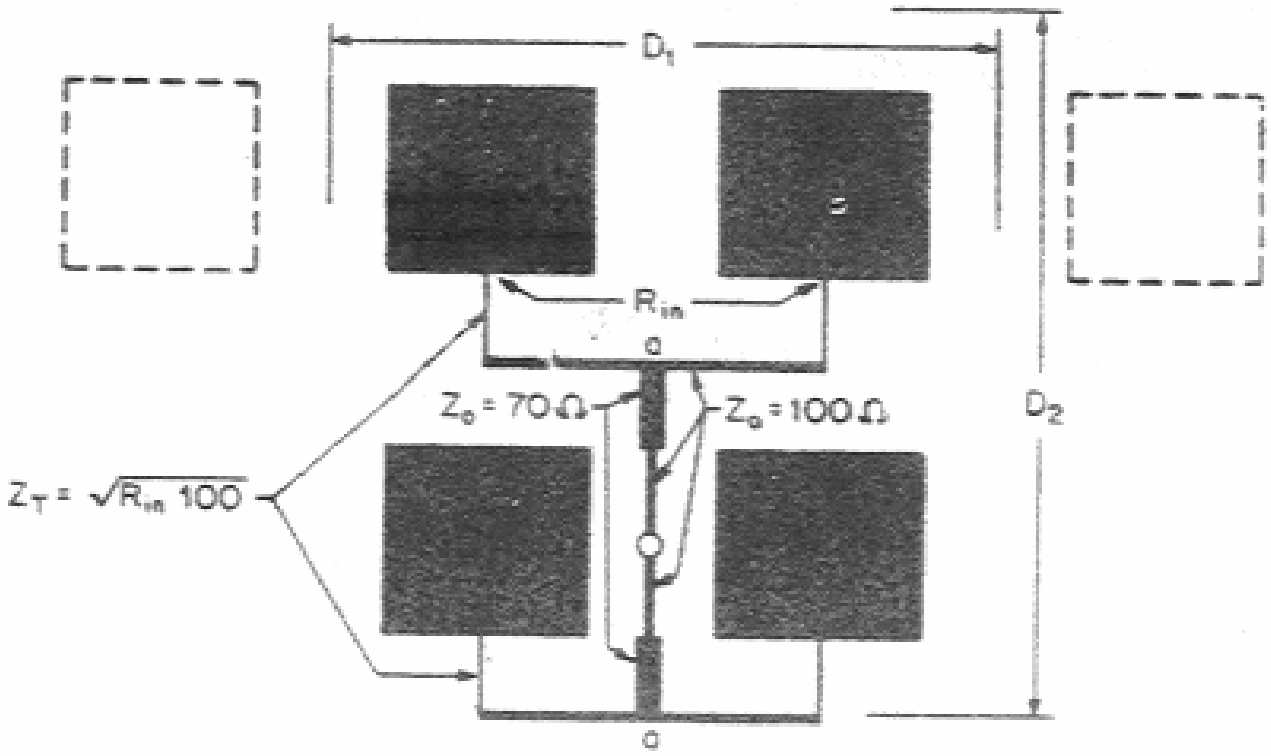
Antenna Array



Antenna Array Patterns



Microstrip Antenna Array Elements



INPUT IMPEDANCE = 50 Ω

Directional fixed-beam microstrip antenna.

- Almost any kind of shape of radiation can be achieved by choosing
  - Spacing
  - Phasing
  - Amplitudes
  - Number of Elements
  - Patterns of individual elements

Smart Antennas

A Smart Antenna consists of several antenna elements, whose signals are processed in an intelligent manner in order to exploit the spatial dimension.

It is not the antenna that is smart, but the antenna system – use some form of digital beamforming.

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