INTEGRATED TECHNICAL EDUCATION CLUSTER
AT ALAMEERIA

E-716-A
Mobile Communications Systems

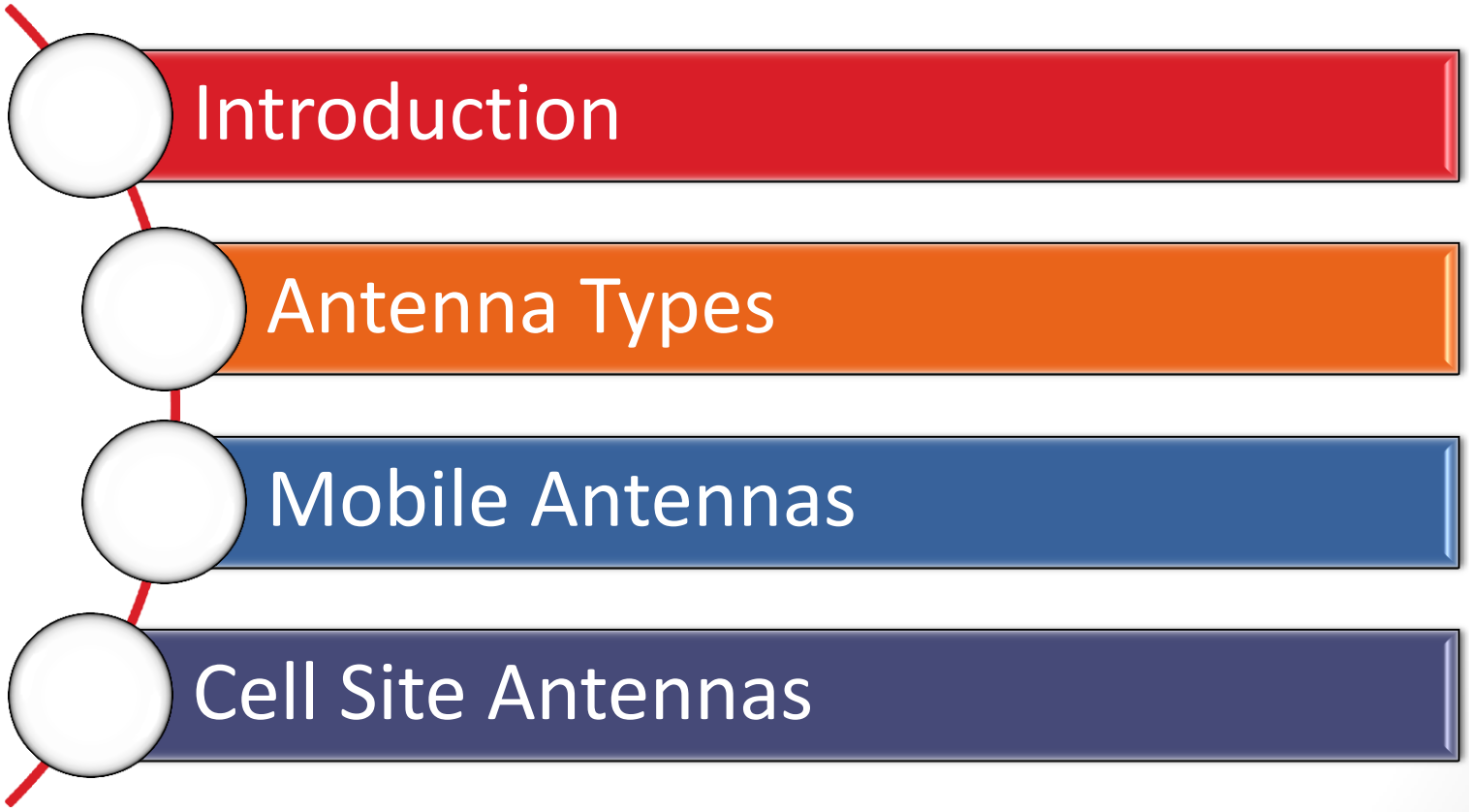
Lecture #12
Cell Site and Mobile Antennas

Instructor:

Dr. Ahmad El-Banna

JANUARY 2015

Agenda

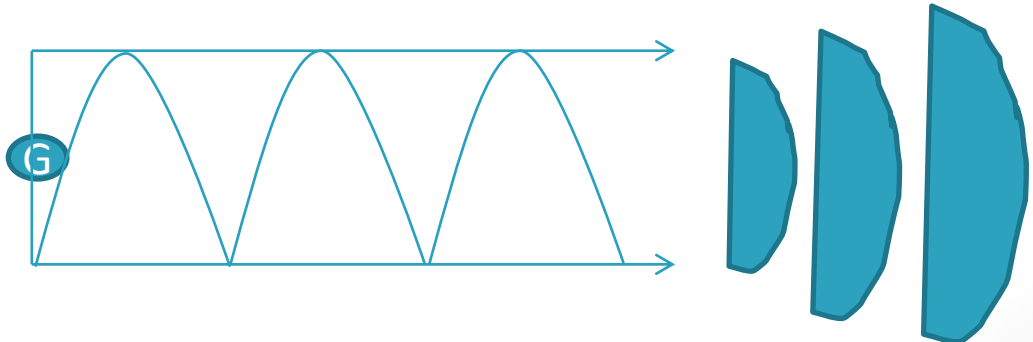

Introduction
Antenna Types
Mobile Antennas
Cell Site Antennas

Introduction

- An antenna is a device used to transform an RF signal, traveling on a conductor, into an electromagnetic wave in free space.
- The first antennas were built in 1888 by German physicist Heinrich Hertz in his pioneering experiments to prove the existence of electromagnetic waves predicted by the theory of James Clerk Maxwell.
- Typically an antenna consists of an arrangement of metallic conductors (“elements"), electrically connected (often through a transmission line) to the receiver or transmitter.
- Antennas are reciprocal, i.e. the same design works for receiving systems as for transmitting systems.

Radiation Mechanism

- Ideally all incident energy must be reflected back when open circuit.
- But practically a small portion of electromagnetic energy escapes from the system that is it gets radiated.
- The amount of escaped energy is very small due to mismatch between transmission line and surrounding space.
- Also because two wires are too close to each other, radiation from one tip will cancel radiation from other tip.(as they are of opposite polarities and distance between them is too small as compared to wavelength)

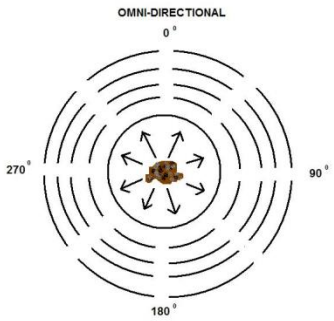


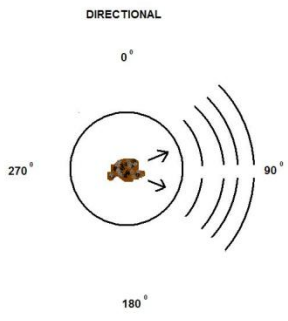
Radiation Mechanism..

- To increase amount of radiated power open circuit must be enlarged , by spreading the two wires.
- Due to this arrangement, coupling between transmission line and free space is improved.
- Also amount of cancellation has reduced.
- The radiation efficiency will increase further if two conductors of transmission line are bent so as to bring them in same line.

Antenna Types

- According to their applications and technology available, antennas generally fall in one of two categories:
- 1.**Omnidirectional** or only weakly directional antennas which receive or radiate more or less in all directions.
  - These are employed when the relative position of the other station is unknown or arbitrary.
  - They are also used at lower frequencies where a directional antenna would be too large, or simply to cut costs in applications where a directional antenna isn't required.
- 2. **Directional or beam antennas** which are intended to preferentially radiate or receive in a particular direction or directional pattern.





Antenna Types..

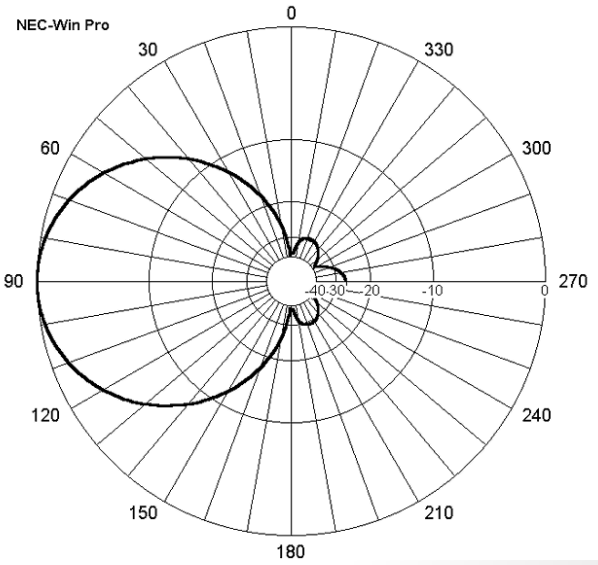
- According to length of transmission lines available, antennas generally fall in one of two categories:
- **1. Resonant Antennas** – is a transmission line, the length of which is exactly equal to multiples of half wavelength and it is open at both ends.
- **2. Non-resonant Antennas** – the length of these antennas is not equal to exact multiples of half wavelength.
  - In these antennas standing waves are not present as antennas are terminated in correct impedance which avoid reflections.
  - The waves travel only in forward direction.
  - Non-resonant antenna is a unidirectional antenna.

Antenna Principals

- **Radiation Resistance**

$$R_{rad} = \frac{P_{rad}}{I^2}$$

  - This relates the power supplied to the antenna and the current flowing into the antenna.
  - The greater the radiation resistance, the more energy is radiated or received by the antenna.
  - To optimize an antenna system, this resistance should match the resistance of the transmitter or receiver system.
- **Antenna Pattern**
  - This shows a distribution of radiated power as a function of direction in space.
  - Typically displayed in a polar plot.
  - This example shows an antenna that radiates a lot of power in one direction but very little in other directions.



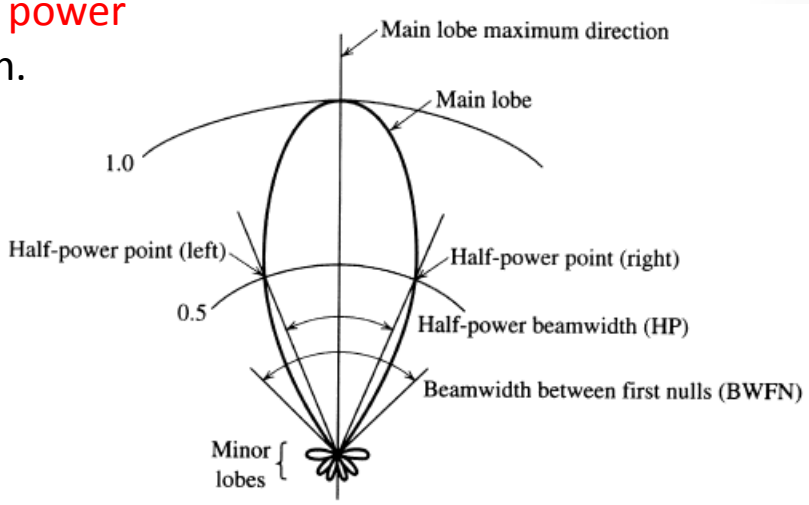
Antenna Principals..

- **Directivity and Gain**
  - The directivity and gain are related parameters; the directivity measures the antenna's ability to concentrate its power in a given direction and the gain is the ratio of power radiated to input power.
- **Bandwidth**
  - The bandwidth of an antenna refers to the frequencies available outside the center frequency.
  - For example, a 10MHz transmitter with 10% bandwidth could send information on frequencies from 9 MHz to 11Mhz.
- **Beam-width**
  - Beam-width of an antenna is defined as

angular separation between the two half power points on power density radiation pattern.

OR

  - Angular separation between two 3dB down points on the field strength of radiation pattern.
  - It is expressed in degrees.

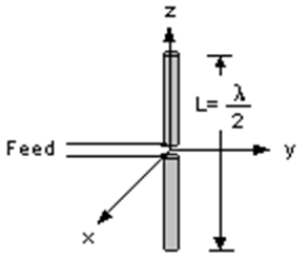


Common Antenna Types

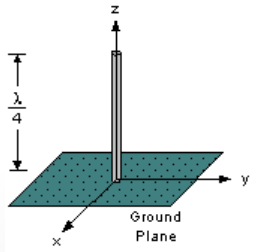
- **Isotropic** (Reference)
  - The Isotropic Radiator would radiate all the power delivered to it and equally in all directions
  - The isotropic radiator would also be a point source.

- **The Half-Wave Dipole**
  - The total length of the antenna is equal to half of the wavelength of the signal you're trying to transmit or receive.
  - The dipole is fed by a two wire line where the

  two currents are equal in amplitude but opposite in direction.
  - The ends are essentially an open circuit, so most of the energy is radiated out the center of the antenna.
  - The electric field radiates in a donut shaped pattern around the dipole axis, and the magnetic field radiates in a circle outward from the antenna.

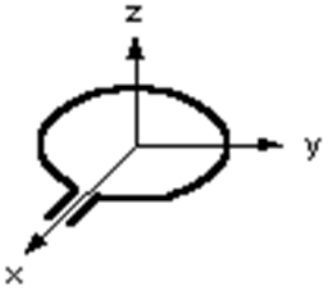


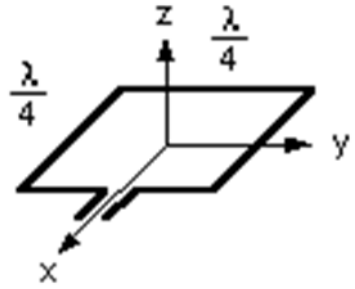
- **The quarter-wave Monopole**
  - It is very similar to the above type.
  - It basically consists of one-half a dipole plus a perfectly conducting plane.

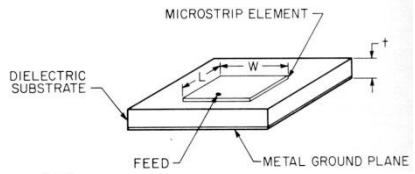


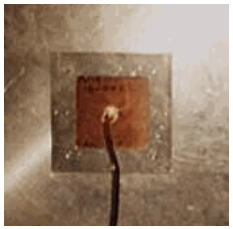
Common Antenna Types..

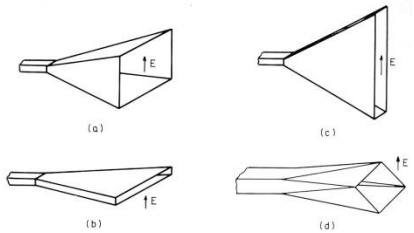
- **Loop Antennas**
- **Microstrip Antennas**
- **Horn Antennas**
- **Helical Antennas**
- **Dish Antennas**
- **....**

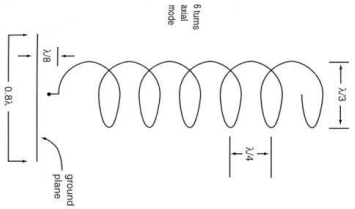


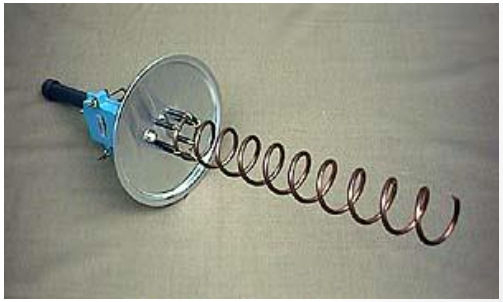












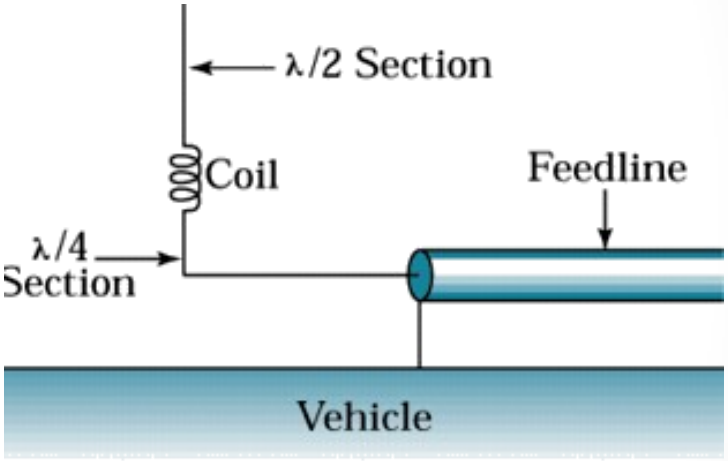
Antenna Arrays

- Simple antenna elements can be combined to form **arrays** resulting in reinforcement in some directions and cancellations in others to give better gain and directional characteristics
- Arrays can be classified as *broadside* or *end-fire*
- Examples of arrays are:
  - The Yagi Array
  - The Log-Periodic Dipole Array
  - The Turnstile Array
  - The Monopole Phased Array
  - Other Phased Arrays

Yagi-Uda antenna array

Mobile and Portable Antenna

- Mobile and portable antennas used with cellular and PCS systems have to be omnidirectional and small.
- The simplest antenna is the quarter-wavelength monopole are these are usually the ones supplied with portable phones.
- For mobile phones, and common configuration is the quarter-wave antenna with a half-wave antenna mounted above it.

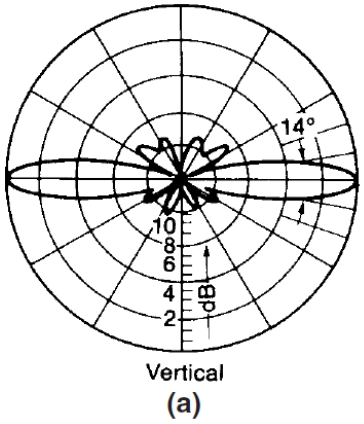


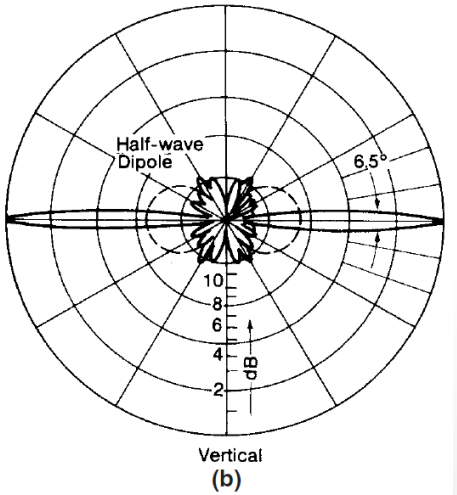
Cell Site Antennas

- *Cell site* is used to refer to the physical location of radio equipment that provides coverage within a cell.
- For cellular radio systems, there is a need for omnidirectional antennas and for antennas with beamwidths of 120º, and less for sectorized cells.
- Cellular and PCS base-station receiving antennas are usually mounted in such a way as to obtain space diversity.
- For an omnidirectional pattern, typically three antennas are mounted on a tower with a triangular cross section and the antennas are mounted at 120º intervals.

Omni-directional Antennas

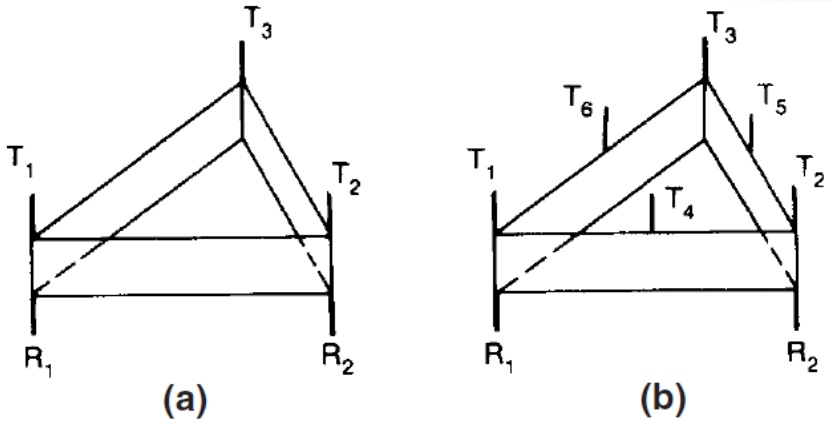
- **For Coverage**
  - **Use Omni-directional Antennas**
    - *High-Gain Antennas*
- There are standard 6-dB and 9-dB gain omni-directional antennas.
- High-gain omnidirectional antennas
  Gain with reference to dipole:
  - *(a) 6 dB;*
  - *(b) 9 dB*



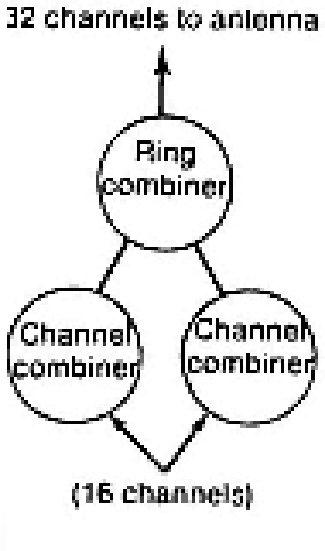


..Ring combiner..

- Cell-site antennas for omnicells
  - (*a) for 3N channels*
  - *(b) for 6N channels.*

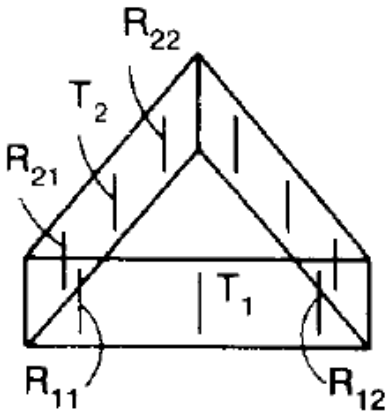


- **Ring combiner**
  - A ring combiner is used to combine two groups of channels into a single output.
  - The function of a ring combiner is to combine two 16-channel combiners into one 32-channel output.
  - Therefore, all 32 channels can be used by a single transmitting antenna.
  - The ring combiner has a limitation of handling power up to 600 W with a loss of 3 dB.

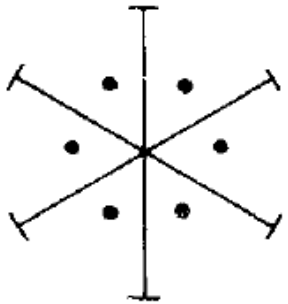


Directional/Sector Antenna for interference reduction

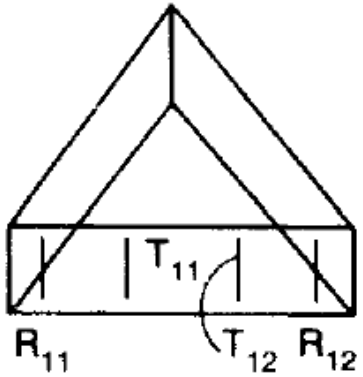
- Directional antenna arrangement
  - (***a) 120◦ sector (45 radios);***
  - (***b) 60◦ sector;***
  - ***(c) 120◦ sector (90 radios).***



(a)

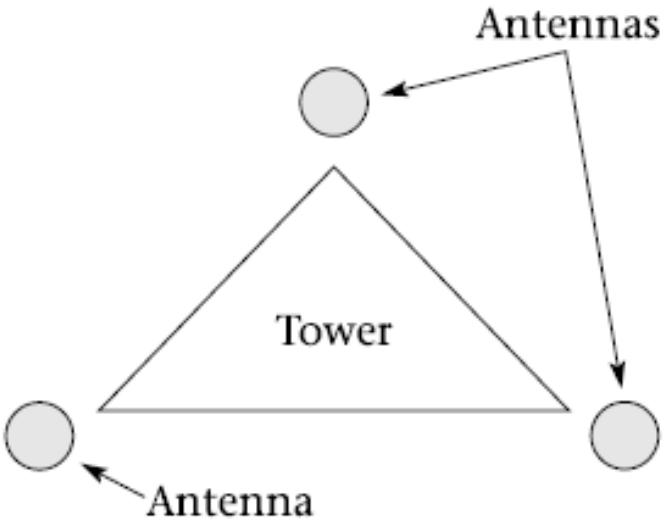


(b)

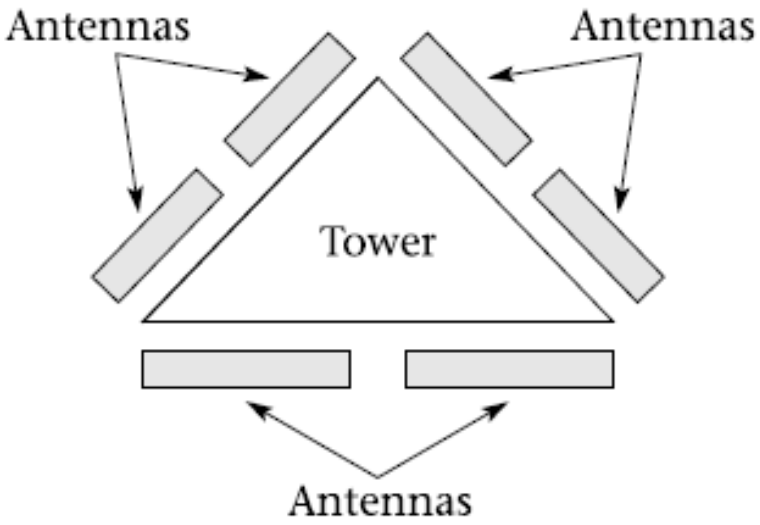


(c)

Cell-Site Antenna Mounting



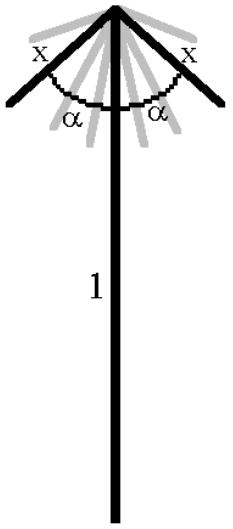
(a) Using omnidirectional antennas



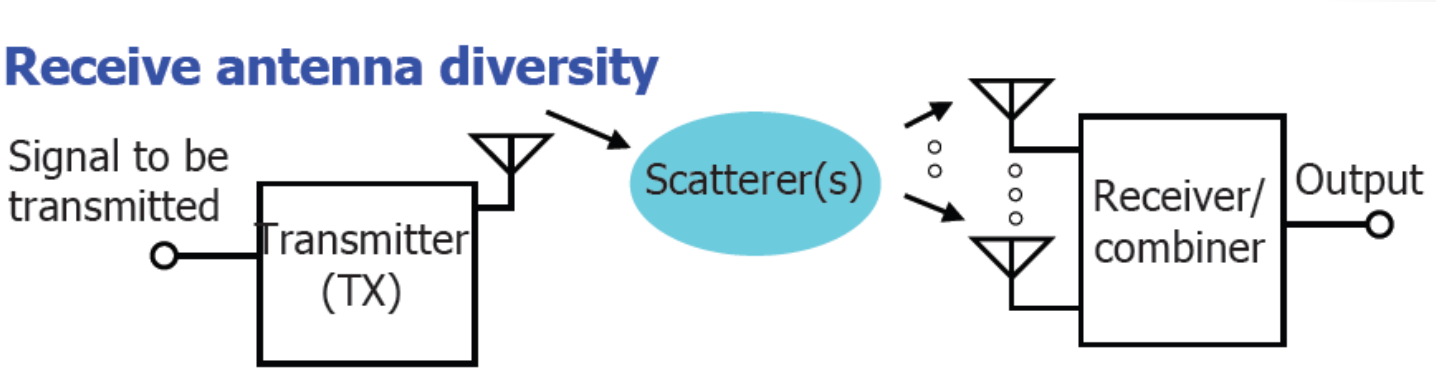
(b) Using directional antennas

Umbrella-Pattern Antennas

- They are useful in increasing coverage for wireless communications and reduce interference.
- An "umbrella antenna" is basically a vertical monopole antenna that is top-loaded with a large "end-hat". The hat consists of a number of radial wires that slope away from the top of the antenna.
- There are many types of umbrella pattern antennas:
  - Normal Umbrella-Pattern Antenna.
  - Broadband Umbrella-Pattern Antenna
  - High-Gain Broadband Umbrella-Pattern Antenna

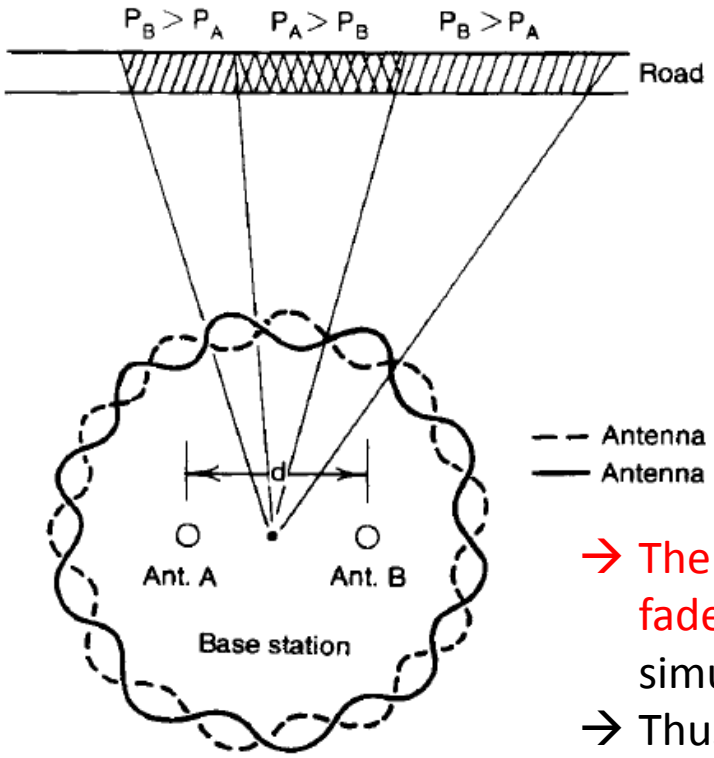


Space Diversity Antennas



- Combining Techniques:
  - Equal-gain combining
    - All the received signals are summed coherently.
  - Maximal-ratio combining
    - The received signals are weighted with respect to their SNR and then summed.
  - Switched combining
    - The receiver switches to another signal when the currently selected signal drops below a predefined threshold.
  - Selection combining
    - Of the N received signals, the strongest signal is selected.

Separation of cell site antennas



Antenna pattern ripple effect

→ The greater the antenna separation, the less likely the fades of the two received signals will occur simultaneously.

→ Thus the diversity gain for reducing the effect of the fades increases as the separation increases.

→ Two types of separation:
- Horizontal (shown in figure).
- Vertical.

→ Separation distance depends on the antenna height.

By experiments, optimum $\eta = \frac{h}{D} = 11$

Fall 2014 Course Feedback

Select your course *

- Mobile Communication Systems
- Electronic Circuits (A)
- Electronic Principals
- Engineering Legislations
- Active Circuits
- CAD of Electronics

The course lies in your area of interest *

- Yes
- No

The course contents had been successfully covered *

- totally agree
- agree
- disagree
- totally disagree

Your evaluation for the instructor *

- excellent
- good
- not bad

Feedback link:
http://goo.gl/forms/ghjNGxQpaj

- For more details, refer to:
  - Chapter 3 & 5, V. Arokiamary , cellular and mobile communications, 2009.
- The lecture is available online at:
  - https://speakerdeck.com/ahmad_elbanna
- For inquires, send to:
  - ahmad.elbanna@feng.bu.edu.eg