Lecture (04)
Transmission Media (II)

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Agenda

- Un-Guided media transmission
- Microwave communication
  - Terrestrial microwave
  - Satellite
- Radiowave communication
  - Groud wave
  - Sky wave
  - Line of sight (micro) waves (Terrestrial microwave)

Un-Guided media transmission

Applications

- Unguided transmission techniques commonly used for information
  - communications include broadcast radio,
  - terrestrial microwave, and
  - satellite.
  - Infrared transmission is used in some LAN applications.

Un-Guided media transmission (cont,..)

Bands

- 1 to 40 GHz are referred to as **microwave frequencies.**
  - **highly directional beams**
  - microwave is quite suitable for point-to-point transmission.
  - Microwave is also used for satellite communications.
- 30 MHz to 1 GHz referred as **radio range.**
  - are suitable for omnidirectional applications.
- 3×10^{11} to 2×10^{14} Hz.
  - Infrared
  - useful to local pointto-point and multipoint applications within confined areas, such as a single room.

Un-Guided media transmission (cont,..)

Antenna

- An antenna can be defined as an electrical conductor or system of conductors used either for radiating electromagnetic energy or for collecting electromagnetic energy.
- In two-way communication, the same antenna can be and often is used for both transmission and reception.
- This is possible because antenna characteristics are essentially the same whether an antenna is sending or receiving electromagnetic energy.

Un-Guided media transmission (cont,..)

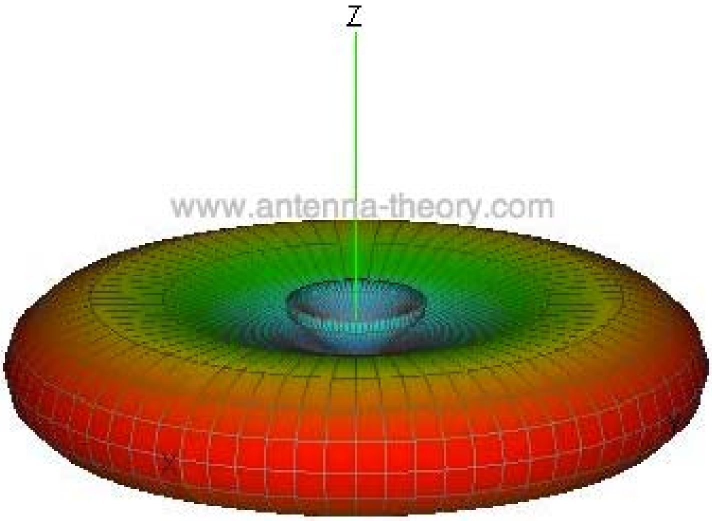
Radiation pattern

- is a graphical representation of the radiation properties of an antenna as a function of space coordinates.
- The simplest pattern is produced by an idealized antenna known asthe isotropic antenna.
- An **isotropic antenna** is a point in space that radiates power in all directions equally.
- The actual radiation pattern for the isotropic antenna is a sphere with the antenna at the center. (ideal antenna no a practical one)

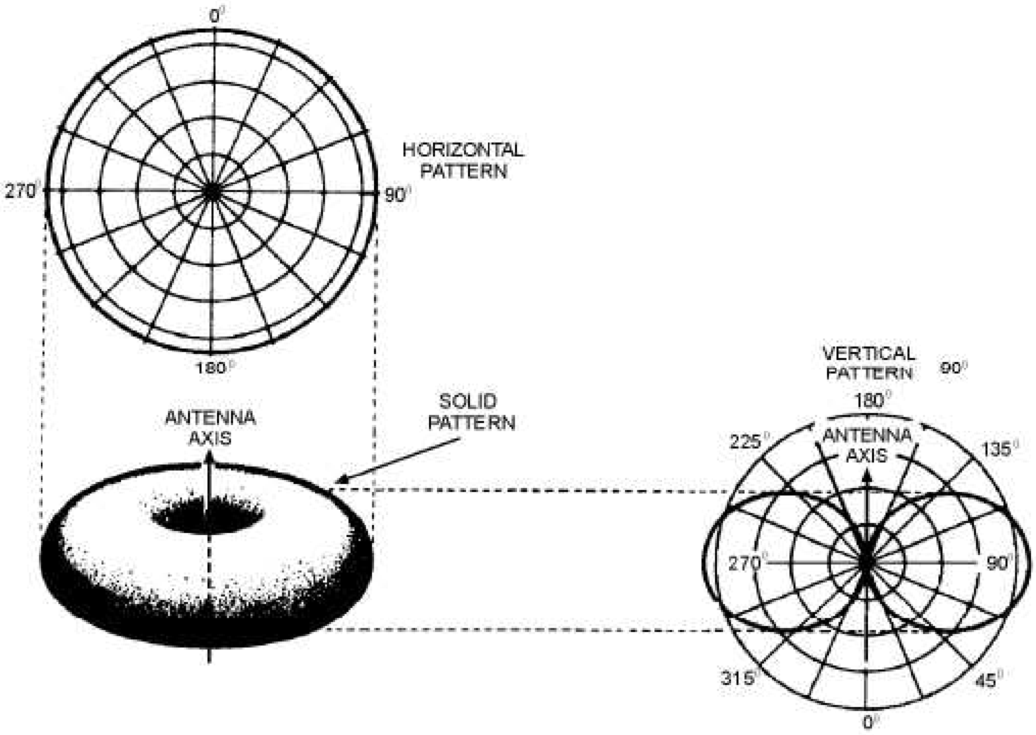
Un-Guided media transmission (cont,..)

Linear Antenna

- The common practical antenna is the linear antenna.
- Linear antenna has a donat radiation pattern.



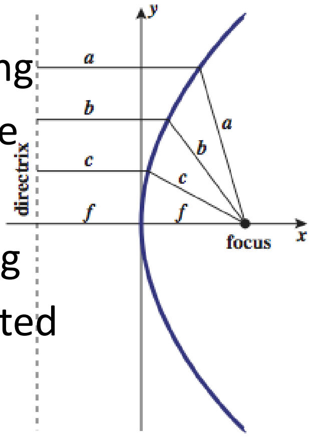
Un-Guided media transmission (cont,..)



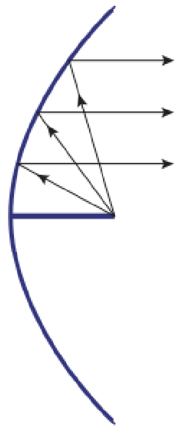
Un-Guided media transmission (cont,..)

Parabolic reflective antenna (Dish antenna)

- If a source of electromagnetic energy is placed at the focus of the paraboloid, and if the paraboloid is a reflecting surface, then the wave will bounce back in lines parallel to the axis of the paraboloid;
- On reception, if incoming waves are parallel to the axis of the reflecting paraboloid, the resulting signal will be concentrated at the focus.

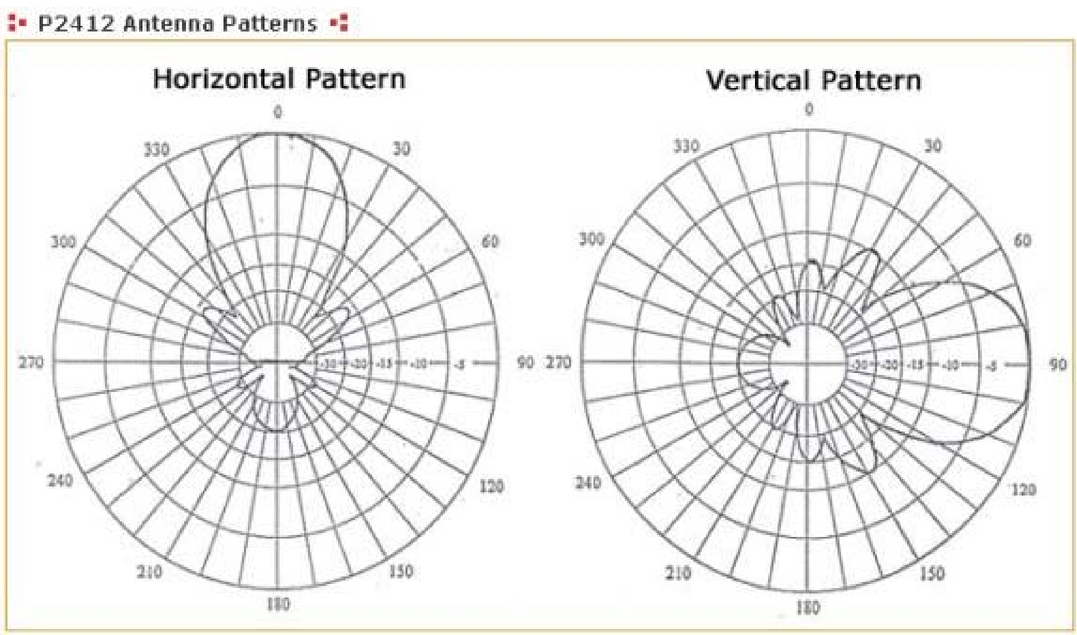


(a) Parabola



(b) Cross-section of parabolic antenna showing reflective property

Un-Guided media transmission (cont,..)



Un-Guided media transmission (cont,..)

Antenna gain

- Antenna gain is defined as the power output, in a particular direction, compared to that produced in any direction by a ideal antenna (isotropic antenna).
- For example, if an antenna has a gain of 3 dB, that antenna improves upon the isotropic antenna in that direction by 3 dB, or a factor of 2.
- The increased power radiated in a given direction is at the expense of other directions.
- It is important to note that antenna gain does not refer to obtaining more output power than input power but rather to directionality.

Microwave communication

1. Terrestrial microwave

- is in long haul telecommunications service, as an alternative to coaxial cable or optical fiber.
- The microwave facility requires far fewer amplifiers or repeaters than coaxial cable over the same distance, (typically every 10-100 km) but requires line-of sight transmission.

Applications

- used for both voice and television transmission.
- short point-to-point links between buildings,
- closed-circuit TV
- data link between local area networks.

Microwave communication (cont,..)

Deployment

- The most common type of microwave antenna is the parabolic "dish”,
- typical size is about 3 m in diameter
- Microwave antennas are usually located at substantial
- heights above ground level to extend the range between antennas and to be able to transmit over intervening obstacles
- To achieve long-distance transmission, a series of microwave relay towers is used, and point-to-point microwave links are strung together over the desired distance.

Microwave transmission (cont,..)

Spectrum

- In 1 to 40 GHz spectrum
- Commonly used spectrum is 4-6GHz and
- now 8, 11, 25, and 38 GHz bands the most common.

impairment

- a main source of loss is attenuation, related to the square of distance.
- rainfall become especially noticeable above 10 GHz

Microwave communication (cont,..)

2. Satellite communication

- satellite is, in effect, a microwave relay station.
- It is used to link two or more ground-based microwave transmitter/receivers, known as earth stations, or ground stations.
- The satellite receives transmissions on one frequency band (uplink), amplifies or repeats the signal, and transmits it on another frequency (downlink).
- A single orbiting satellite will operate on a number of frequency bands (channels), called **transponder channels, or simply transponders**

Microwave communication (cont,..)

Spectrum

- range 5.925 to 6.425 GHz for transmission from earth to satellite (uplink)
- and a bandwidth in the range 3.7 to 4.2 GHz for transmission from satellite to earth (downlink).
- This combination is referred to as the 4/6-GHz band, but has become saturated.
- So the 12/14-GHz band has been developed (uplink: 14 - 14.5 GHz; downlink: 11.7 - 12.2 GHz).

Microwave communication (cont,..)

Theory of operation

- it is required that it remain stationary with respect to its position over the earth to be within the line of sight of its earth stations at all times.
- To remain stationary, the satellite must have a period of rotation equal to the earth's period of rotation, which occurs at a height of 35,863 km at the equator.
- Two satellites using the same frequency band, if close enough together, will interfere with each other.
- To avoid this, current standards require a 4° spacing in the 4/6-GHz band and a 3° spacing at 12/14 GHz.
- Thus the number of possible satellites is quite limited.

Microwave communication (cont,..)

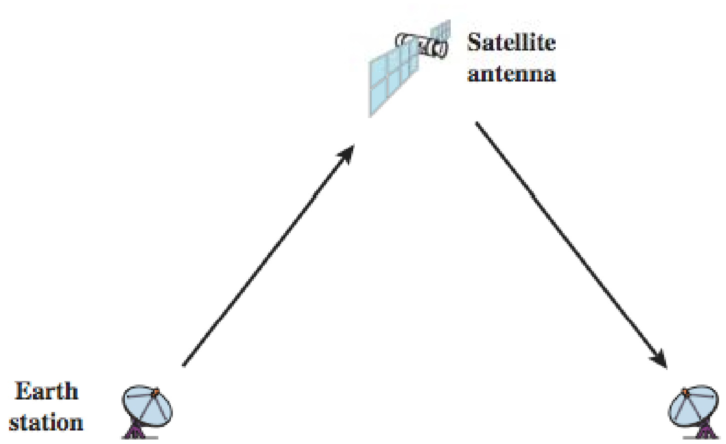
Application

- Television distribution,
- Long-distance telephone transmission,
- Private business networks,
- Global positioning.

Deployment

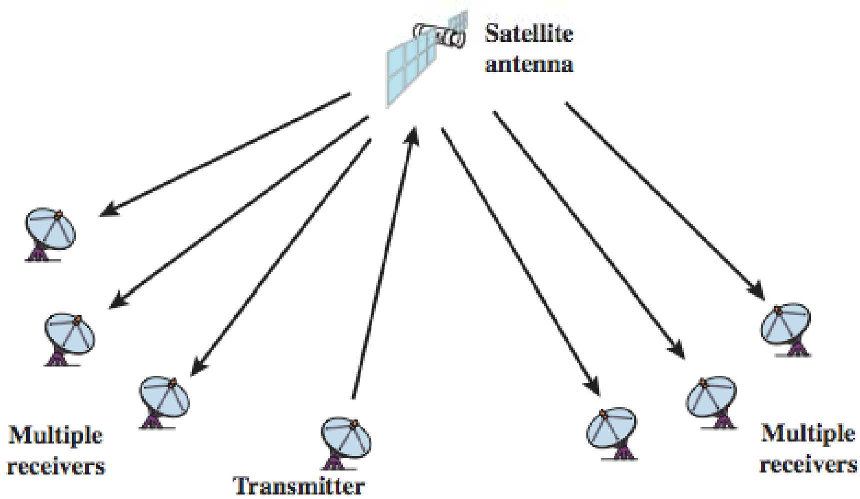
- point-to-point link between two distant ground-based antennas.
- provides communications between one ground-based transmitter and a number of ground-based receivers.

Microwave communication (cont,..)



(a) Point-to-point link

Microwave communication (cont,..)



(b) Broadcast link

Radiowave communication

- use broadcast radio, 3MHz - 1GHz, for:
  - FM radio
  - UHF and VHF television
- broadcast radio is omni-directional and microwave is directional.
- Thus broadcast radio does not require dish-shaped antennas, and the antennas don't need alignment.
- From propagation point of view, broadcasting radio can be classified to
  - Ground waves
  - Sky waves
  - Line of sight waves

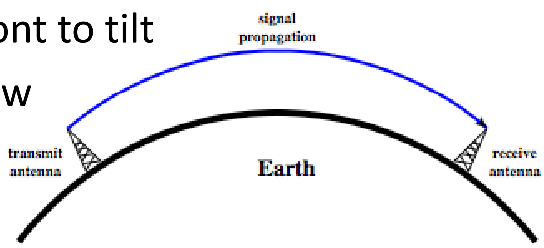
Radiowave communication (cont,..)

1.Ground waves

- follows the contour of the earth and can propagate considerable distances, well over the visual horizon.
- This effect is found in frequencies up to about 2 MHz.

Theory of operation:

1. electromagnetic wave induces a current in the earth's surface, the result of which is to slow the wave front near the earth, causing the wave front to tilt downward and hence follow the earth's curvature.

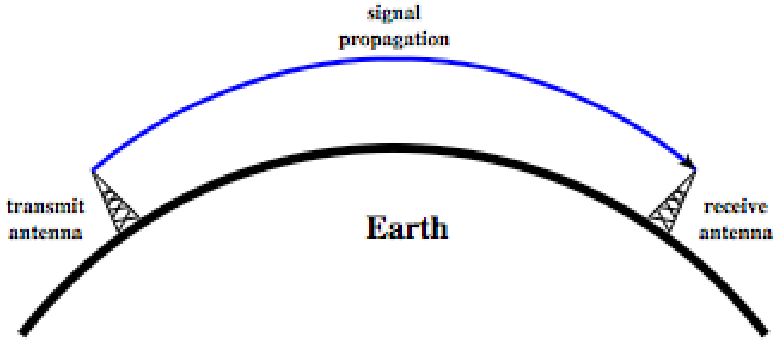


(a) Ground wave propagation (below 2 MHz)

Radiowave communication (cont,..)

2. Electromagnetic waves in this frequency range are scattered by the atmosphere in such a way that they do not penetrate the upper atmosphere.

   The best-known example of ground wave communication is AM radio.

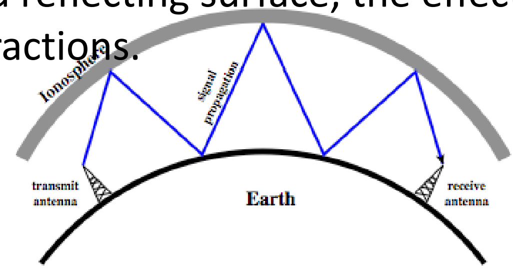


(a) Ground-wave propagation (below 2 MHz)

Radiowave communication (cont,..)

2. Sky waves

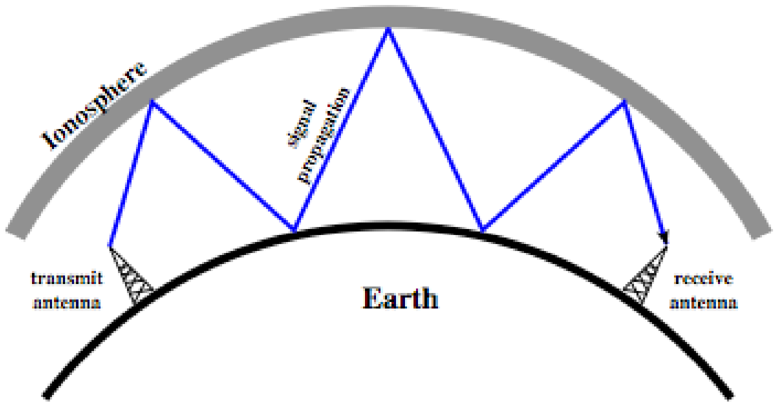
- amateur radio, CB radio, and international broadcasts such as BBC and Voice of America
- With sky wave propagation, a signal from an earth-based antenna is reflected from the ionized layer of the upper atmosphere (ionosphere) back down to earth.
- Although it appears the wave is reflected from the ionosphere as if the ionosphere were a hard reflecting surface, the effect is in fact caused by multiple refractions.



(b) Sky-wave propagation (2 to 30 MHz)

Radiowave communication (cont,..)

- A sky wave signal can travel through a number of hops, bouncing back and forth between the ionosphere and the earth's surface, a signal can be picked up thousands of kilometers from the transmitter.



(b) Sky-wave propagation (2 to 30 MHz)

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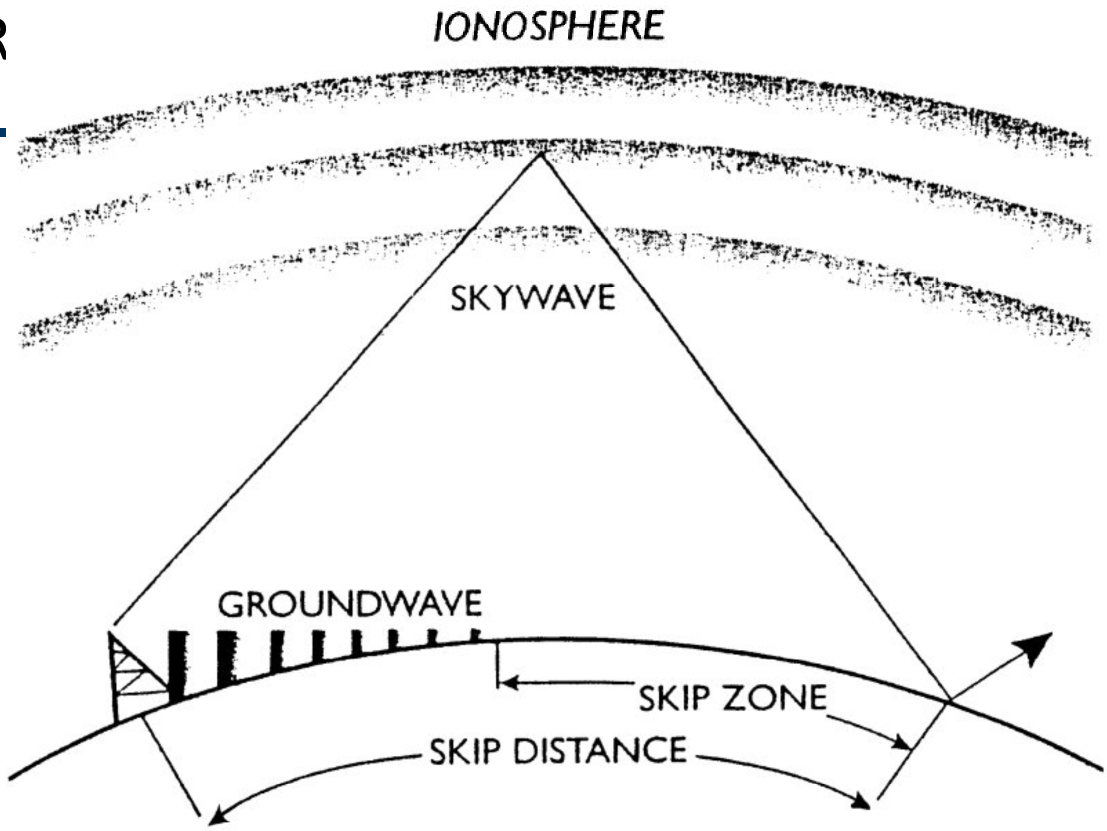
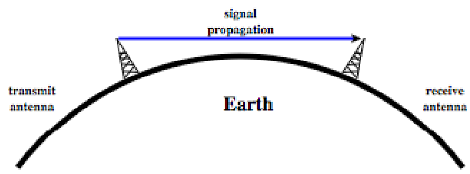


Radiowave communication (cont,..)

3. Line of sight (micro) waves

Above 30 MHz, communication must be by line of sight.

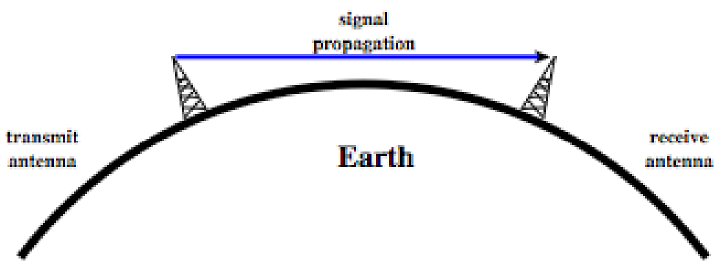
1. In case of satellite communication, a signal above 30 MHz is not reflected by the ionosphere and therefore a signal can be transmitted between an earth station and a satellite overhead that is not beyond the horizon.
2. For ground-based communication, the transmitting and receiving antennas must be within an *effective line of sight of each other.*



(c) Line-of-sight (LOS) propagation (above 30 MHz)

Radiowave communication (cont,..)

- Why *effective? because* microwaves are bent or refracted by the atmosphere.
- The amount and even the direction of the bend depends on conditions,
- generally microwaves are bent with the curvature of the earth and will therefore propagate farther than the optical line of sight.



(c) Line-of-sight (LOS) propagation (above 30 MHz)

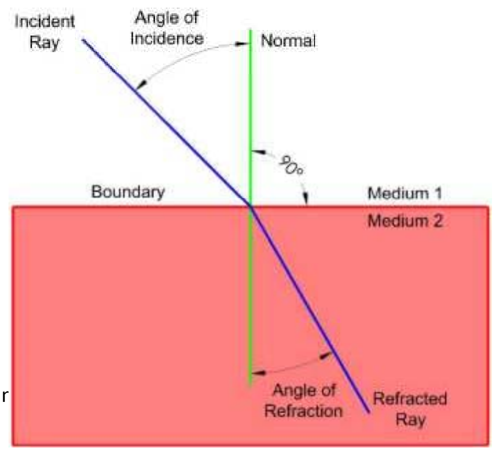
Radiowave communication (cont,..)

Why microwaves bent with the atmosphere? Because of refraction,..

- Refraction occurs because the velocity of an electromagnetic wave is a function of the density of the medium through which it travels.
- In a vacuum, an electromagnetic wave (such as light or a radio wave) travels at approximately 3×10^8 m/s, the constant c.
- In air, water, glass, and other transparent or partially transparent media, electromagnetic waves travel at speeds less than c.

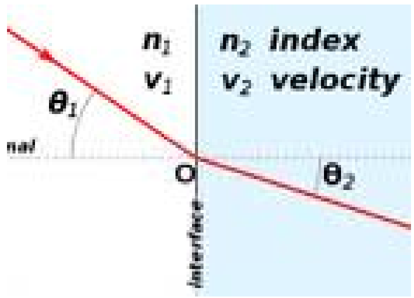
Radiowave communication (cont,..)

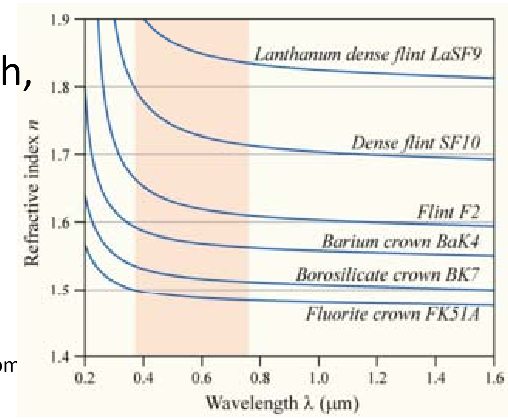
- When an electromagnetic wave moves from a medium of one density to a medium of another density, its speed changes.
- The effect is to cause a one-time bending of the direction of the wave at the boundary between the two media.
- The **index of refraction, or refractive index, of one medium** relative to another is the sine of the angle of incidence divided by the sine of the angle of refraction.



Radiowave communication (cont,..)

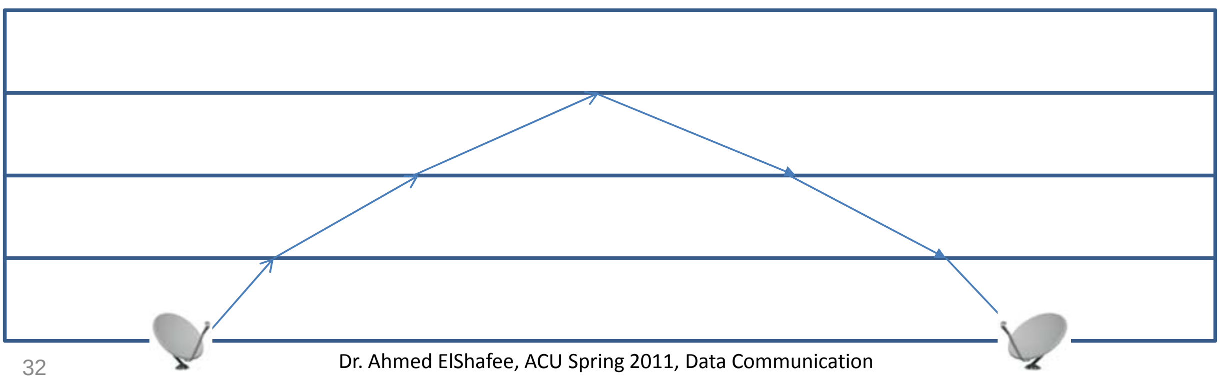
- The index of refraction is also equal to the ratio of the respective velocities in the two media.
- The absolute index of refraction of a medium is calculated in comparison with that of a vacuum.
- Refractive index varies with wavelength, so that refractive effects differ for signals with different wavelengths.





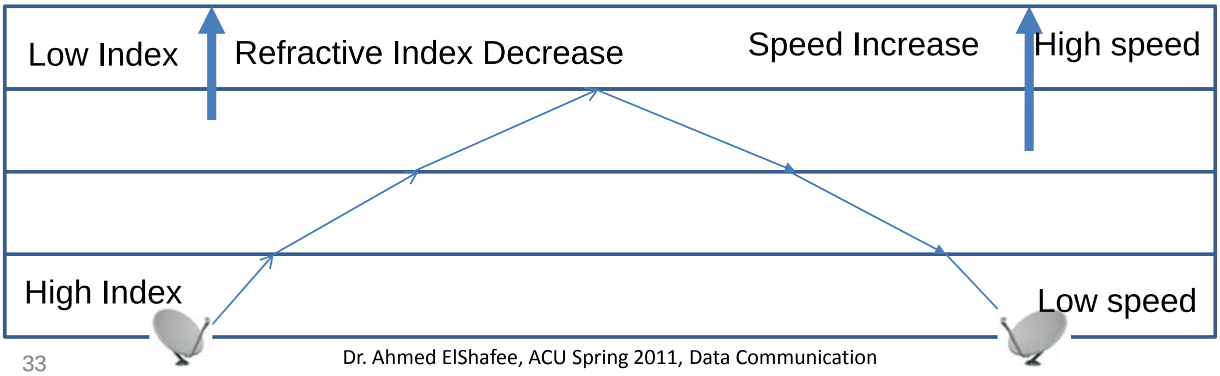
Radiowave communication (cont,..)

- Although an abrupt, one-time change in direction occurs as a signal moves from one medium to another, a continuous, gradual bending of a signal will occur if it is moving through a medium in which the index of refraction gradually changes.



Radiowave communication (cont,..)

- Under normal propagation conditions, the refractive index of the atmosphere decreases with height so that radio waves travel more slowly near the ground than at higher altitudes.
- The result is a slight bending of the radio waves toward the earth, which causes a difference between the optical and radio horizons for LOS transmissions.

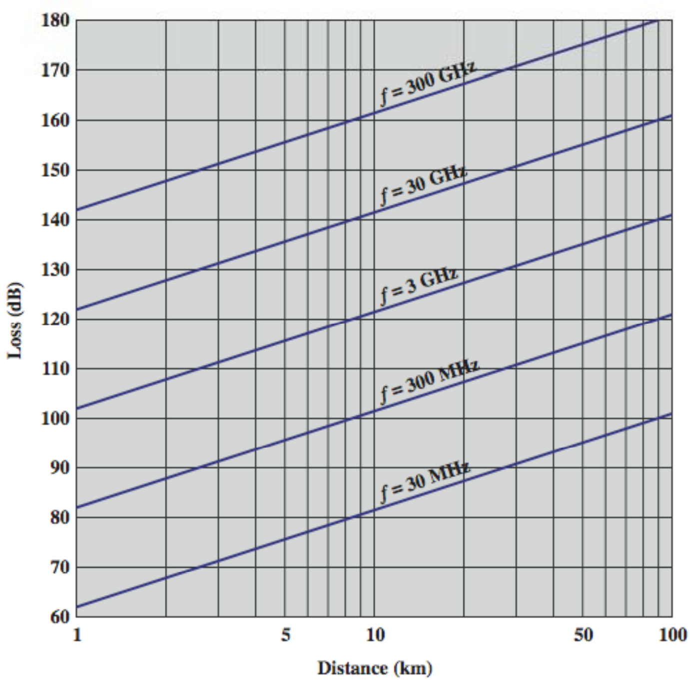


Radiowave communication (cont,..)

Impairments

1. Free space loss

- Even if no other sources of attenuation or impairment are assumed, a transmitted signal attenuates over distance because the signal is being spread over a larger and larger area.



Radiowave communication (cont,..)

- as the frequency increases, the free space loss also increases, which would suggest that at higher frequencies, losses become more burdensome.

Radiowave communication (cont,..)

2. atmospheric absorption

Water vapor and oxygen contribute most to attenuation.

water vapor absorption:

- A peak attenuation occurs in the vicinity of 22 GHz .
- At frequencies below 15 GHz, the attenuation is less.

oxygen absorption

- oxygen results in an absorption peak in the vicinity of 60 GHz but contributes less at frequencies below 30 GHz.

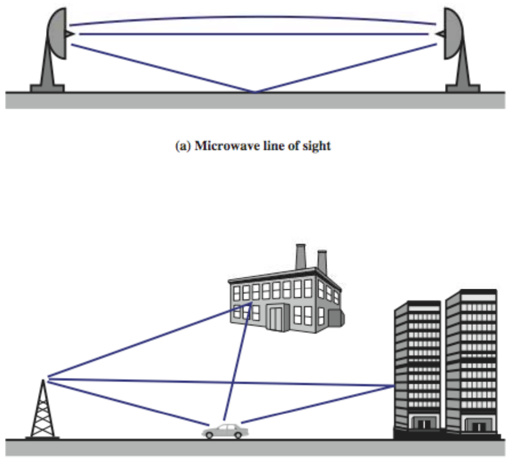
Rain and fog (suspended water droplets)

- Cause scattering of radio waves that results in attenuation.

Radiowave communication (cont,..)

3. Multi Path fading

- signal can be reflected by such obstacles (exists in atmosphere) so that multiple copies of the signal with varying delays can be received, resulting in multipath interference.
- Depending on the differences in the path lengths of the direct and reflected waves, the composite signal can be either larger or smaller than the direct signal.



(a) Microwave line of sight

(b) Mobile radio

Radiowave communication (cont,..)

- For fixed microwave, in addition to the direct line of sight, the signal may follow a curved path through the atmosphere due to refraction and the signal may also reflect from the ground.
- For mobile communications, structures and topographic features provide reflection surfaces.

Thanks,…