Wireless Transmission

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Wireless transmission: frequencies

- Microwave frequencies: 1 GHZ to 40 GHz – directional beams, suitable for point-to-point transmission, satellite transmissions
- Radio range: 30 MHz to 1 GHz – suitable for omnidirectional applications (cell phones, FM radios, walkie-talkies, wireless computer networks, cordless phones)
- Infrared: $3 * 10^{11}$ to $2 * 10^{14}$Hz – point-to-point and multi-point applications within confined spaces such as a room

Transmission and reception are achieved using antennas

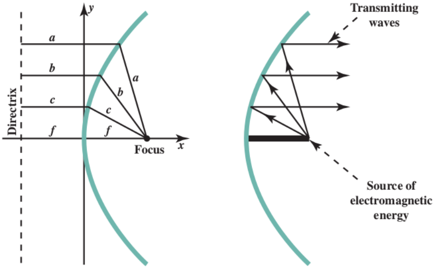
Antennas

- an electrical conductor or system of conductors used either for radiating electromagnetic energy or for collecting electromagnetic energy
- radio-frequency electrical energy from the transmitter is converted to electromagnetic energy by the antenna
- electromagnetic energy is radiated into the environment (atmosphere, space, water)
- Reception occurs when the electromagnetic signal intersects the antenna
- electromagnetic energy is converted into radio-frequency electrical energy and fed into the receiver

Antennas

- Same antenna for transmission and reception
- Any antenna transfers energy from the surrounding environment to its input receiver terminals with the same efficiency that it transfers energy from the output transmitter terminals into the surrounding environment
- Radiates power in all directions, but not equally well
- Isotropic antenna or an omnidirectional antenna - a point in space that radiates power in all directions equally
- – its radiation pattern is a sphere

Parabolic reflective antennas



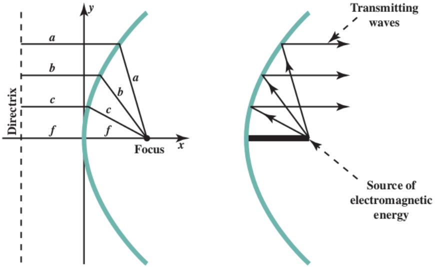
(a) Parabola

(b) Cross section of parabolic antenna showing reflective property

- A parabola is the locus of all points equidistant from a fixed line and a fixed point not on the line
- Focus: the fixed point , Directrix: the fixed line
- If a parabola is revolved about its axis, the surface generated is called a paraboloid

Parabolic reflective antennas

Parabolic reflective antennas

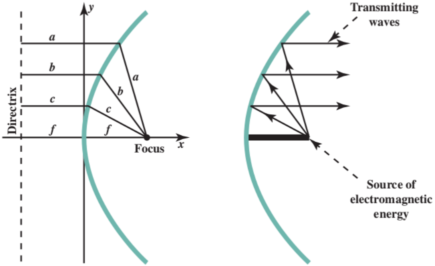


(a) Parabola

(b) Cross section of parabolic antenna showing reflective property

- If a source of electromagnetic energy (or sound) is placed at the focus of the paraboloid, and if the paraboloid is a reflecting surface, then the wave bounces back in lines parallel to the axis of the paraboloid
- Parallel beams without dispersion
- In practice, there is some dispersion, because the source of energy must occupy more than one point

Parabolic reflective antennas



(a) Parabola

(b) Cross section of parabolic antenna showing reflective property

- The larger the diameter of the antenna, the more tightly directional is the beam
- On reception, if incoming waves are parallel to the axis of the reflecting paraboloid, the resulting signal is concentrated at the focus

Antenna Gain

- Antenna gain is defined as the power output, in a particular direction, compared to that produced in any direction by a perfect omnidirectional antenna (isotropic antenna)
- $$G_{dB} = 10 \log(P_2/P_1)$$

  G: Antenna Gain, P_1: radiated power of the directional antenna, P_2:radiated power from the reference antenna (how much power must the reference antenna radiate to provide the same signal power in the preferred direction)
- Increased power is radiated in one direction by reducing the power radiated in other directions
- Antenna gain does not refer to obtaining more output power than input power but rather to directionality

Question

if an antenna has a gain of 3 dB, that antenna improves upon the isotropic antenna in that direction by

(A) 3 dB, 2

(B) 6 dB, 10

(C) 3 dB, 1

(D) 6 dB, 2

Question

Consider a directional antenna that has a gain of 6 dB over a reference antenna and that radiates 700 W. How much power must the reference antenna radiate to provide the same signal power in the preferred direction?

Effective Area

$$G = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi f^2 A_e}{c^2}$$

G = antenna gain
A_e = effective area in m^2
f = carrier frequency (Hz)
c = speed of light (3 * 10^8 m/s)
l = carrier wavelength (m)
In decibels, $G_{dB} = 10 \log G$

Isotropic Antenna

For an isotropic antenna, $G = 1 = \frac{4\pi A_e}{\lambda^2}$
Therefore, $A_e = \frac{\lambda^2}{4\pi}$

Effective Area

$$G = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi f^2 A_e}{c^2}$$

Parabolic Antenna

A = Face Area ($= \pi r^2$ if the mouth of the reflector is a circle)
$A_e = 0.56A$
For a parabolic antenna,

$$G = \frac{4\pi * 0.56A}{\lambda^2} = \frac{7A}{\lambda^2}$$

Question

For a parabolic reflective antenna with a diameter of 2 m, operating at 12 GHz, what are the effective area and the antenna gain?

Wireless Transmission

- Terrestrial Microwave
- Satellite Microwave
- Broadcast Radio
- Infrared

Terrestrial Microwave

- The most common type of microwave antenna: the parabolic dish (3 m in diameter)
- Line of sight transmission (a direct path from the transmitter to the receiver)
- Located at substantial heights above ground.
- Series of microwave relay towers are used for long-distance transmission

Terrestrial Microwave

- Long-haul telecommunications service
- Requires far fewer amplifiers or repeaters than coaxial cable over the same distance, but requires line-of-sight transmission
- short point-to-point links between buildings, CCTV, data link between LANs
- Short-haul microwave - bypass application
- Cellular applications
- Microwave links are used to provide TV signals to local cable TV installations; the signals are then distributed to individual subscribers via coaxial cable

Terrestrial microwave

- Common frequencies: 1 to 40 GHz
- The higher the frequency, the higher the data rate
- For microwave and radio frequencies, loss due to attenuation is

$$L = 10\log(\frac{4\pi d}{\lambda})^2 dB$$

  where d is the distance and λ the wavelength
- Attenuation is increased with rainfall

Question

For microwave, loss varies as the ______ of the distance. For twisted pair and coaxial cables, loss varies ______ with distance.

(A) square, exponentially

(B) square, linearly

(C) first power, linearly

(D) first power, exponentially