

## DDPP 2163 Propagation Systems

# Microwave Devices and Antenna

## Microwave Antennas



# Microwave Antennas

- Parabolic dish is used to gain the microwave signals but actually, parabolic dish is not really an antenna.
- It is a reflector and it needs an antenna to provide a signal.
- The most common feed antenna for parabolic dish is the **horn antenna**.

# Parabolic Reflectors Antenna

- Parabolic antenna – consist two (2) main parts;
  - i. A parabolic reflector – the passive device
  - ii. The feed mechanism - the active element

# Parabolic Reflectors Antenna (cont.)

- The *feed* mechanism
  - usually a dipole or a dipole array
  - radiates electromagnetic waves toward the reflector.
- The *parabolic reflector*
  - the most basic component of a parabolic antenna
  - sometimes called *parabolic dish* antennas or *dish* antennas.
  - reflects the energy radiated by the feed mechanism

# Parabolic Reflector Antenna

Feed

A parabolic satellite communications antenna at Erdfunkstelle Raisting, Bavaria, Germany is the biggest facility for satellite communication in the world. It uses a Cassegrain type feed



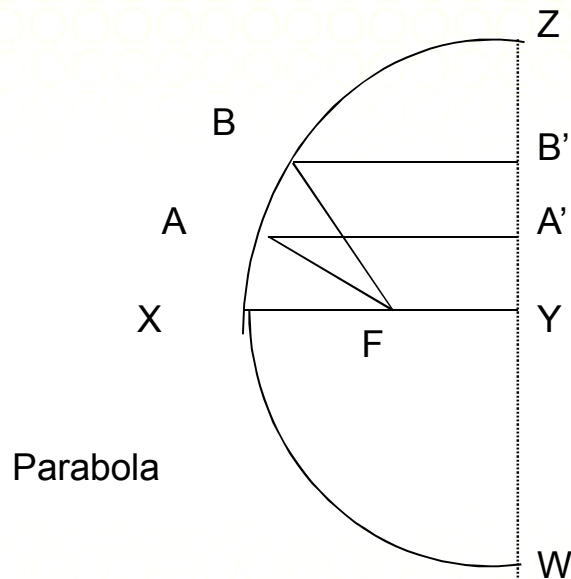
Parabolic reflector





# How a Parabolic Reflectors works?

- Figure shows the geometry of a parabola whose focus is at point **F** and whose axis is line **XY**.



The following relationship exist;

$$FA + AA' = FB + BB' = k \text{ (constant length)}$$

where

FX = focal length of the parabola (m)

k = a constant for a given parabola (m)

WZ = directrix length (m)

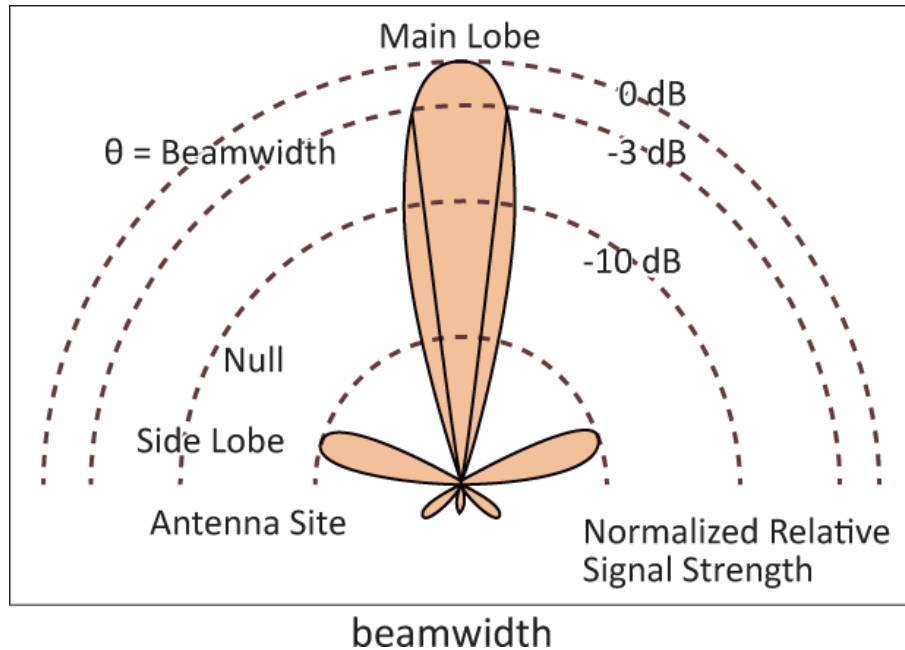
- As a locus of a point that moves –so that its distance from point (focus) added to its distance from the a straight line (directrix) is of constant length.



# Parabolic Reflectors

- The curved surface dish is called the paraboloid (XY axis).
- If electromagnetic energy is radiating towards the parabolic reflector from the **focus**, all radiated waves **travel the same distance** by the time they reach the directrix (line WZ).
- Parabolic reflector that used to receive electromagnetic energy also exhibits exactly the same behavior.
- *Principle of reciprocity* – works equally as a receive antenna for waves arriving from the XY directions

# Parabolic Antenna Beamwidth



- The three-dimensional radiation from a parabolic reflector has a main lobe in direction XY.
- The approximate  $-3\text{dB}$  beamwidth for a parabolic antenna;

$$\theta = (70\lambda) / D$$

$$\theta = (70c) / fD$$

where  $\theta$  = beamwidth between half-power point (degrees)  
 $\lambda$  = wavelength (meters)  
 $D$  = diameter of the dish (meters)  
 $c = 3 \times 10^8$  meter per second  
 $f$  = frequency (hertz)



# Parabolic Antenna Power Gain, G

- For a transmit parabola antenna, the power gain is approximate as

$$G = ((\pi D) / \lambda)^2 = (\pi^2 D^2) / \lambda^2$$

$$\theta = (70c) / fD$$

where  $G$  = gain as a power ratio (not in decibels)

$\lambda$  = wavelength (meters)

$D$  = diameter of the dish (meters)

- This gain is reduced by imperfection factors – uneven illumination, losses, any radiation spilling off at the edges.
- It is necessary to include a constant ‘ $\eta$ ’ = efficiency (typical value 0.4 to 0.7).
- So, the gain;

$$G = \eta ((\pi D) / \lambda)^2$$



# Feed Mechanisms

- The feed mechanism in a parabolic antenna radiates the electromagnetic energy and often called the *primary antenna*.
- There are three primary types;
  1. Center feed / Gregorian feed
  2. Horn feed
  3. Cassegrain feed

# Center Feed/Prime Focus

- The primary antenna is placed at the focus.
- It has an additional spherical reflector.
- Additional spherical reflector helps to concentrate more energy in the desired direction and also has a tendency to block some of the initial reflections.
- The spherical reflector redirects such emissions back toward the parabolic reflector where they are re-reflected in the proper direction.
- Its overall performance is **marginally better** than without the additional spherical reflector.

# Horn Feed

- The primary antenna is a small horn antenna.
- The horn antenna provide a simple and efficient method to feed power to antenna.
- The horn is a flared piece of waveguide material that placed at the focus and radiates a somewhat directional pattern toward the parabolic reflector.

# Horn Antenna

- Horn antenna can be viewed as impedance transformers that match waveguide impedances to that of free space.
- It has an open-ended sections of waveguides that can be used as radiators of electromagnetic energy.
- There are several common types of horn antenna:
  - Conical @ circular horn
  - Pyramidal horn flares
  - E- and H-plane sectoral horns



## Horn Antenna (cont)

- The horn structure has several different shapes
  - sectoral
  - Pyramidal
  - conical
- All these types provide a gradual flare to the waveguide to allow maximum radiation and this minimise the reflection back into the guide.
- The gain and directivity of horn antennas depend on the type of horn and its dimensions.

# Cassegrain Feed

- The primary radiating source (horn) is located in or just behind a small opening at the vertex of the paraboloid.
- A small secondary reflector (hyperboloid) located at between the vertex and the focus.
- The primary antenna is aimed at a small secondary reflector.
- The rays emitted from the primary antenna are reflected from the hyperboloid and, then illuminate the main parabolic reflector as if they had originated at the focus.
- It is used for receiving extremely weak signals or when extremely long transmission line



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