Antenna Basic 2

Lecture 7

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Elliptical Polarisation

Most antennas are either:

Linear polarised or circularly polarised

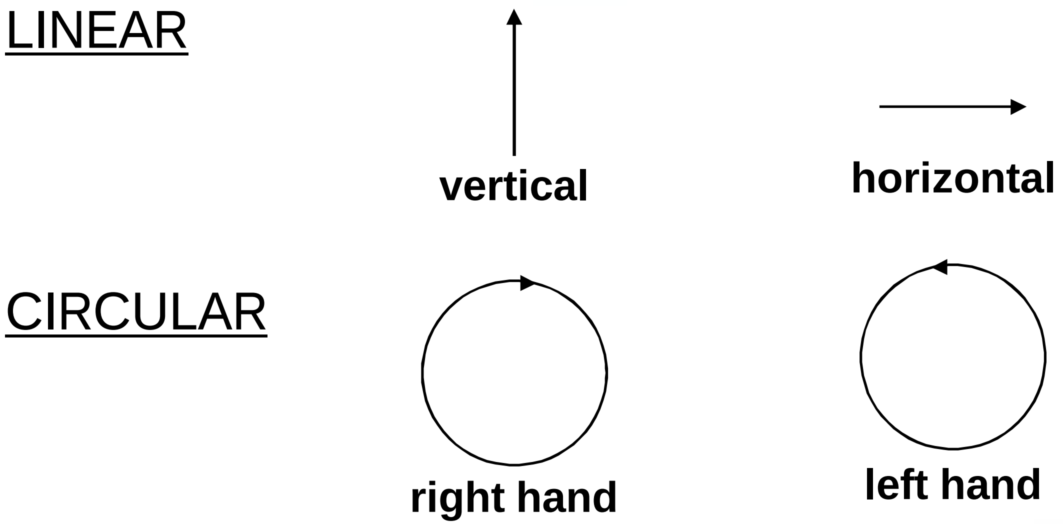
Both are particular cases of elliptical polarisation:

Linear when the Axial ratio is infinite

Circular when the Axial ratio is unity

Note that elliptical polarisation can be expressed as either the combination of two linear polarisations or the combination of two circular polarisation

Polarisation



EUTELSAT

INTELSAT 11/14GHz

INTELSAT 4/6GHz

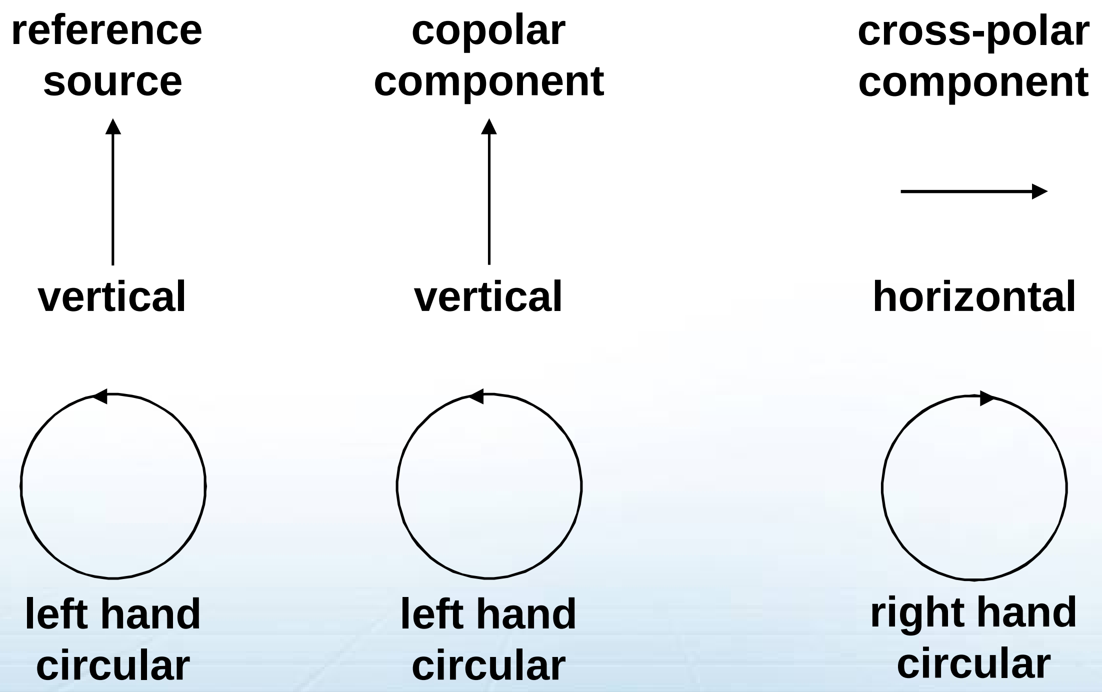
Antennas can be:

1. Single polarised — e.g.vertical linear at all frequencies
2. Orthogonally polarised in receive and transmit band — e.g.vertical linear at receive frequencies horizontal linear at transmit frequencies
3. Dual-Polarised — e.g. vertical and horizontal linear at all frequencies

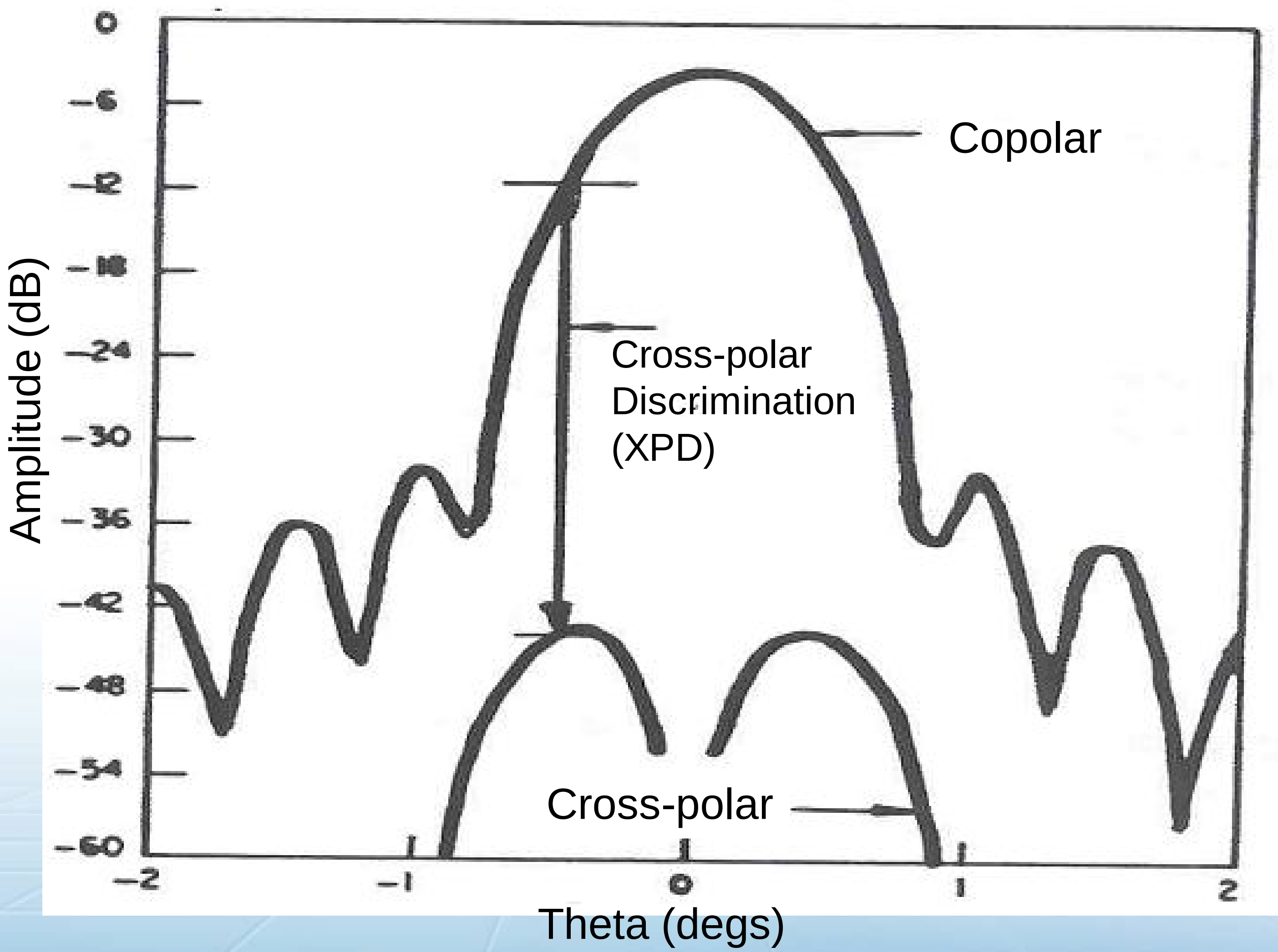
Definitions

CO-POLAR – component of field parallel to the field of the reference source

CROSS-POLAR – component in orthogonal direction

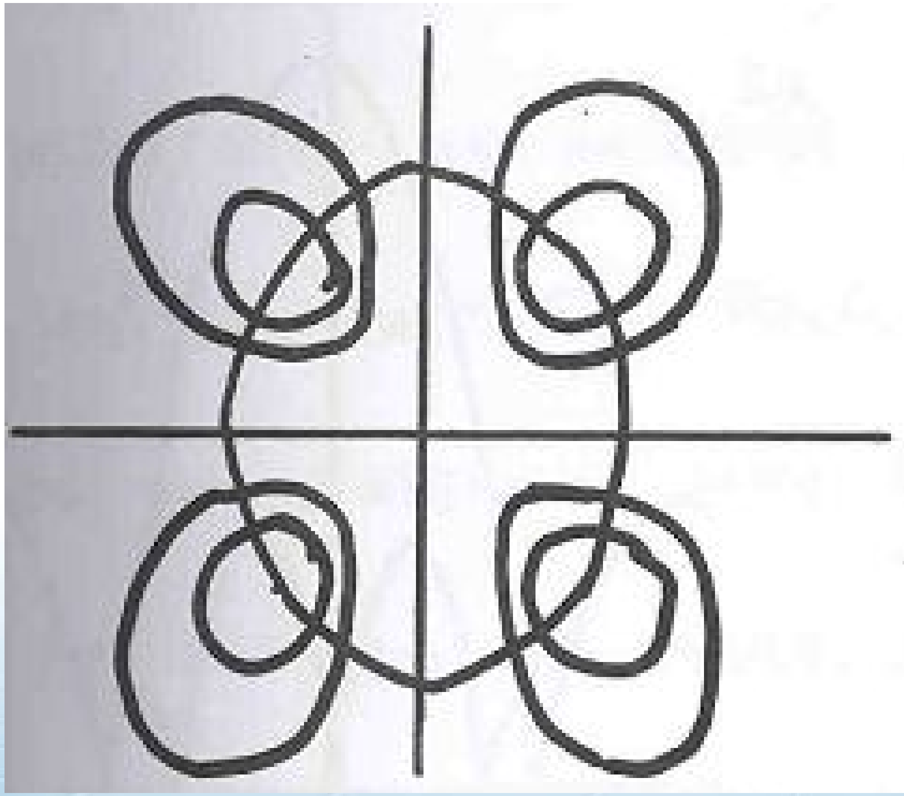


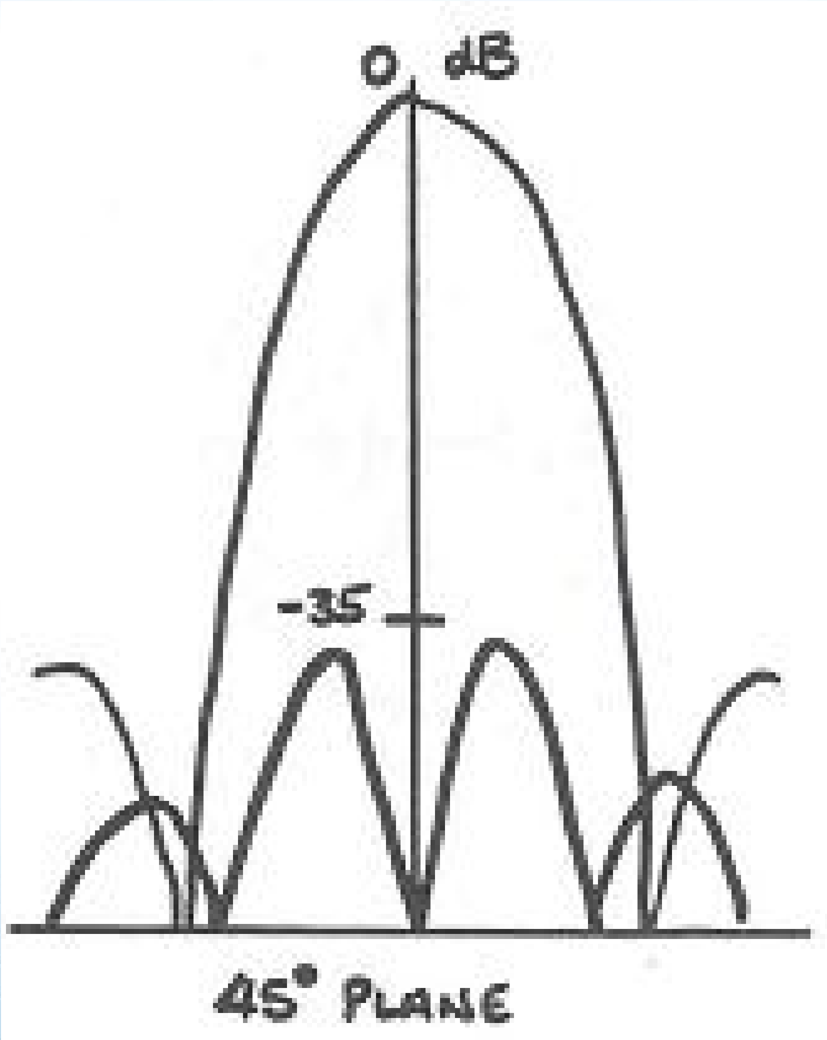
Cross-polar discrimination



Axis - symmetric Systems

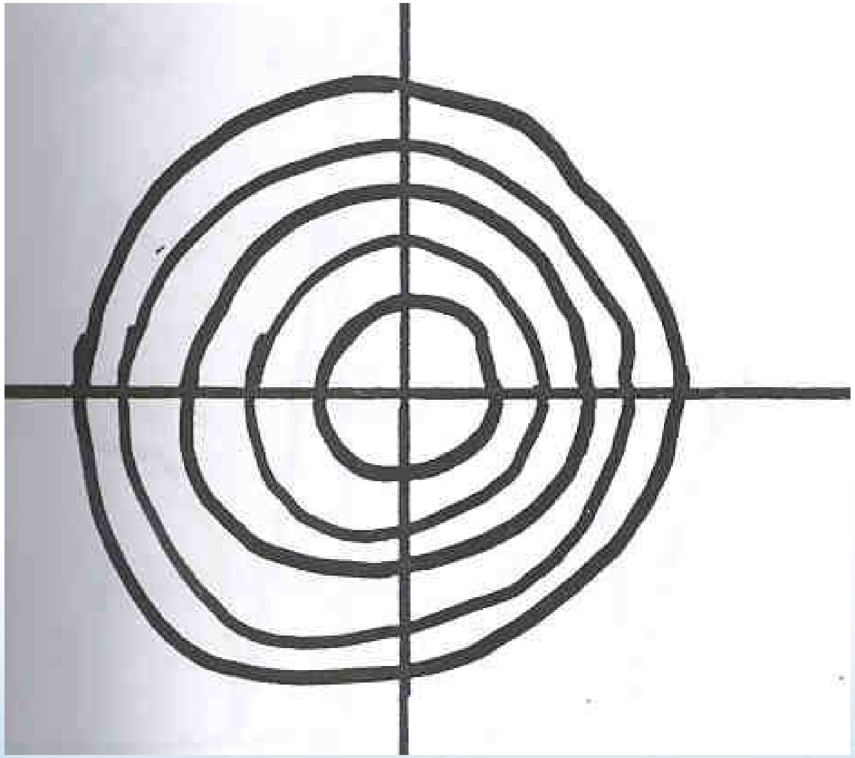
- Linear Polarisation

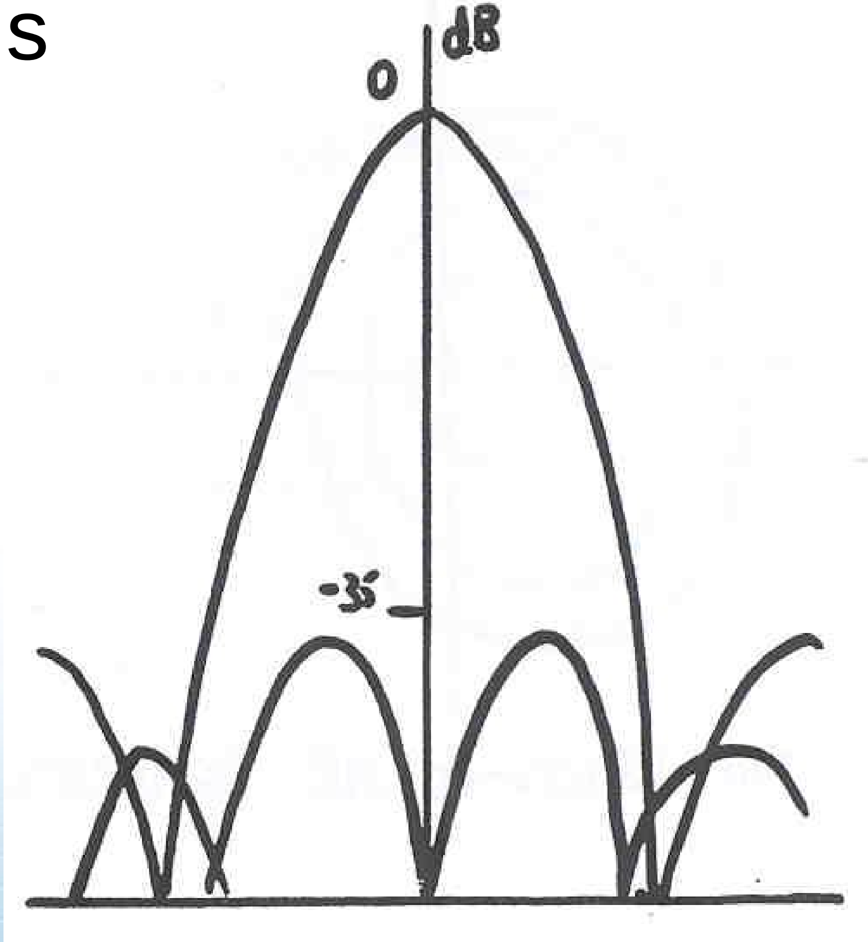




Axis - symmetric Systems (cont.)

- Circular Polarisations



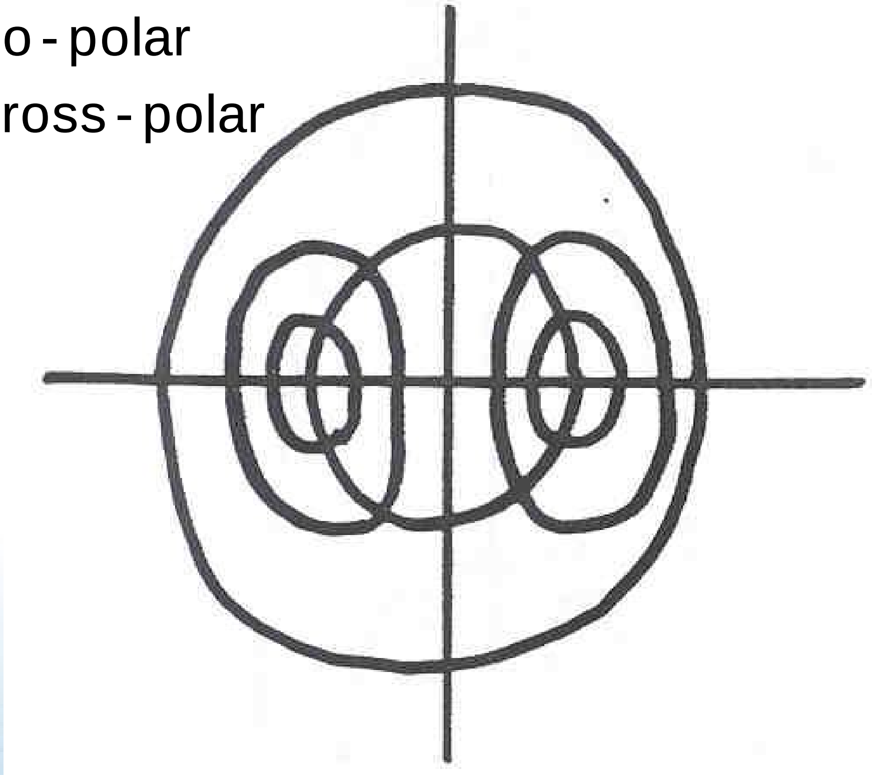


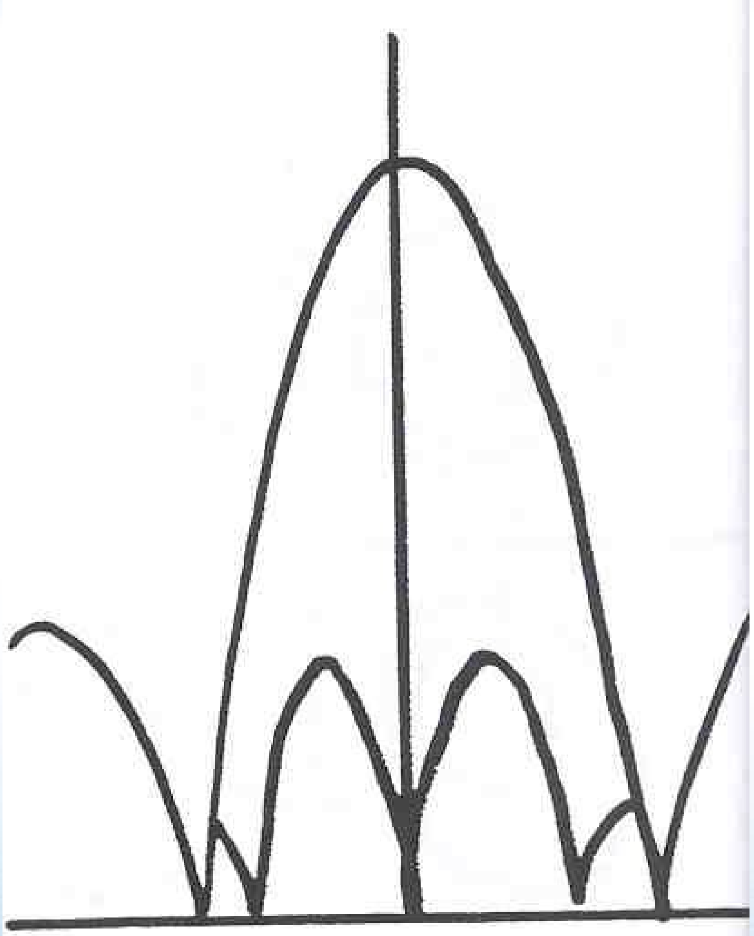
Offset Systems

- Linear Polarisation

Co-polar

Cross-polar



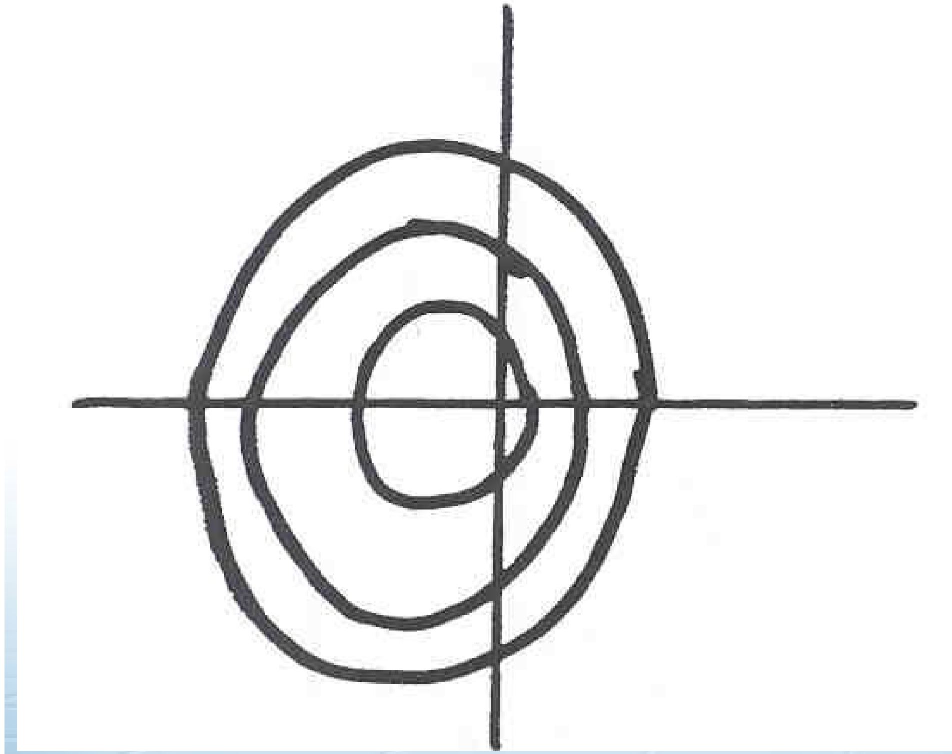


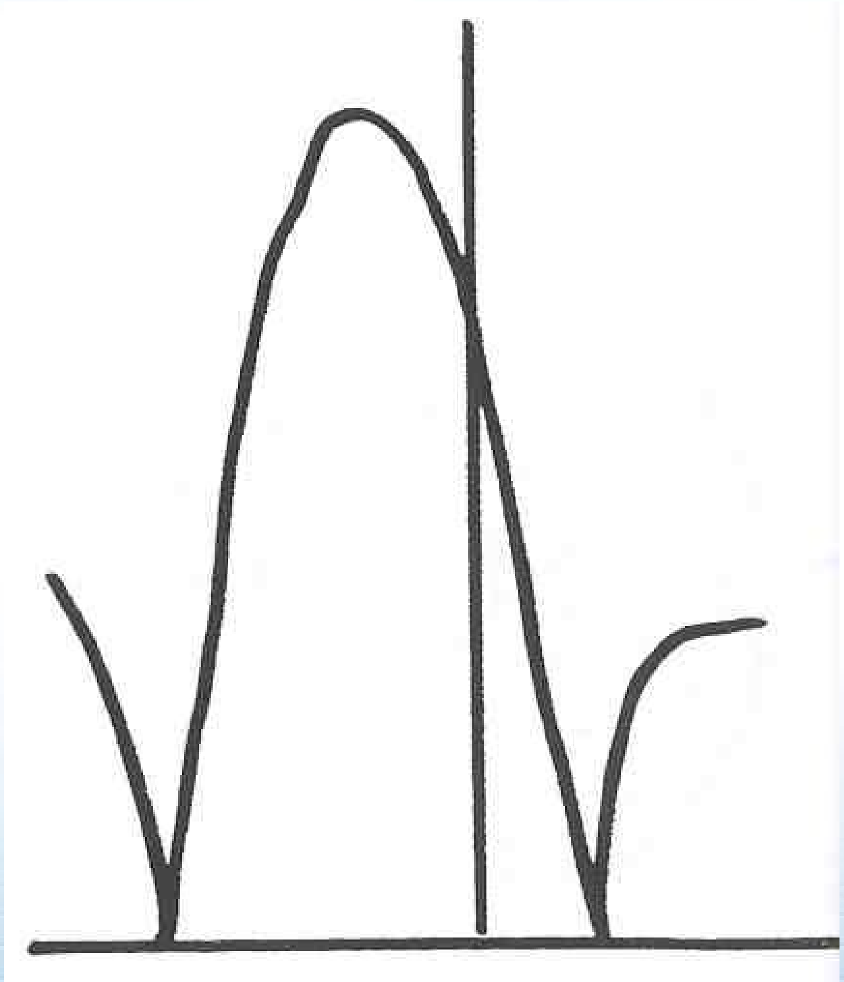
Plane perpendicular to offset

Offset Systems

- Circular Polarisations

No cross-polar generated





Plane perpendicular to offset

Noise Temperature

- Components for total system noise temperature:
  - Antenna noise temperature
  - Noise temperature due to feed system
  - Receiver noise temperature

Antenna noise temperature

- Dependent on:
  - Antenna radiation pattern [$G(\theta,\phi)$]
  - Antenna elevation [θ_0]
  - Brightness temperature which is a function of frequency

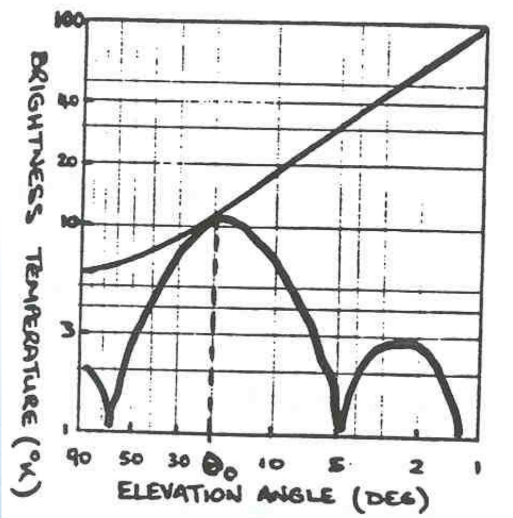
Antenna noise temperature

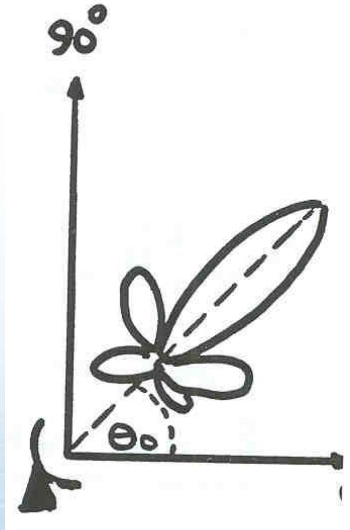
$$T_A(\theta_0) = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi} T'(\theta_0,\theta,\varphi)\,G(\theta,\varphi)\sin\theta\, d\theta\, d\varphi$$

$$T'(\theta_0,\theta,\varphi) = T(\theta^*)$$,brightness temperature function

where, $\cos\theta^* = \cos\theta_0 \cos\theta - \sin\theta_0 \sin\theta \cos\phi$

θ_0 = antenna elevation angle





Typical brightness temperature function at 4GHz

Feed system and Received noise temperature

- Dependent on
  - feed loss
  - ambient noise temperature
- If ambient noise temperature is 290K and feed loss is small (<1dB) then feed system noise temp. is:

$$T_P = 66.7x(\text{loss in dB})\ K$$

i.e. 6.7 K for each 0.1dB loss in feedchain

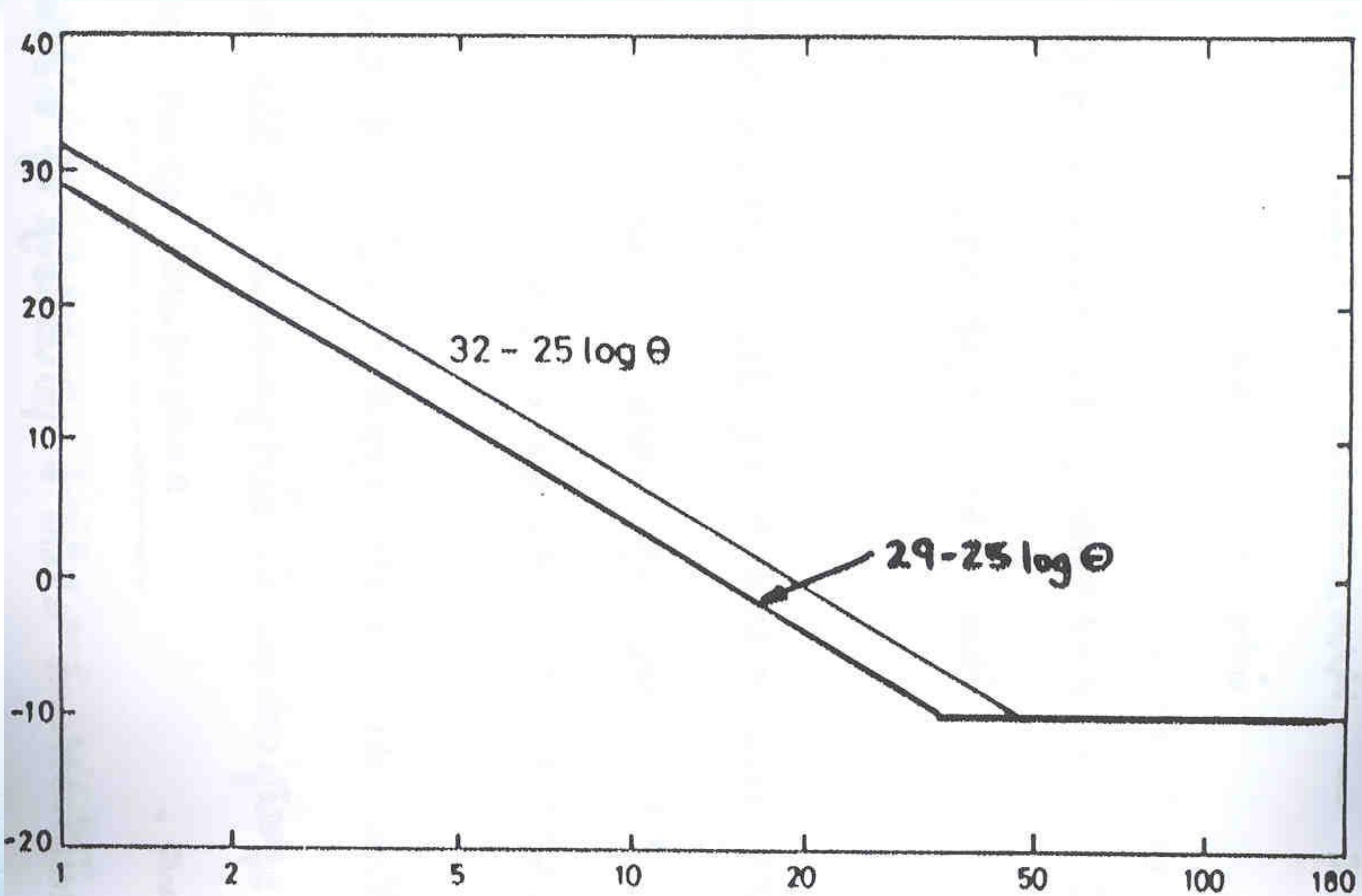
- <u>Received noise temperature</u>

  Dependent on type of LNA and whether cooled or uncooled

Side-lobe Specifications

- Transmit – Mandatory to avoid interference into other systems
- Receive – Advisable to reduce interference from other systems
- For antenna diameters greater than 150λ, the sidelobe specification is independent of the size of antenna.
- Some specifications allow a percentage of sidelobes to be above template.

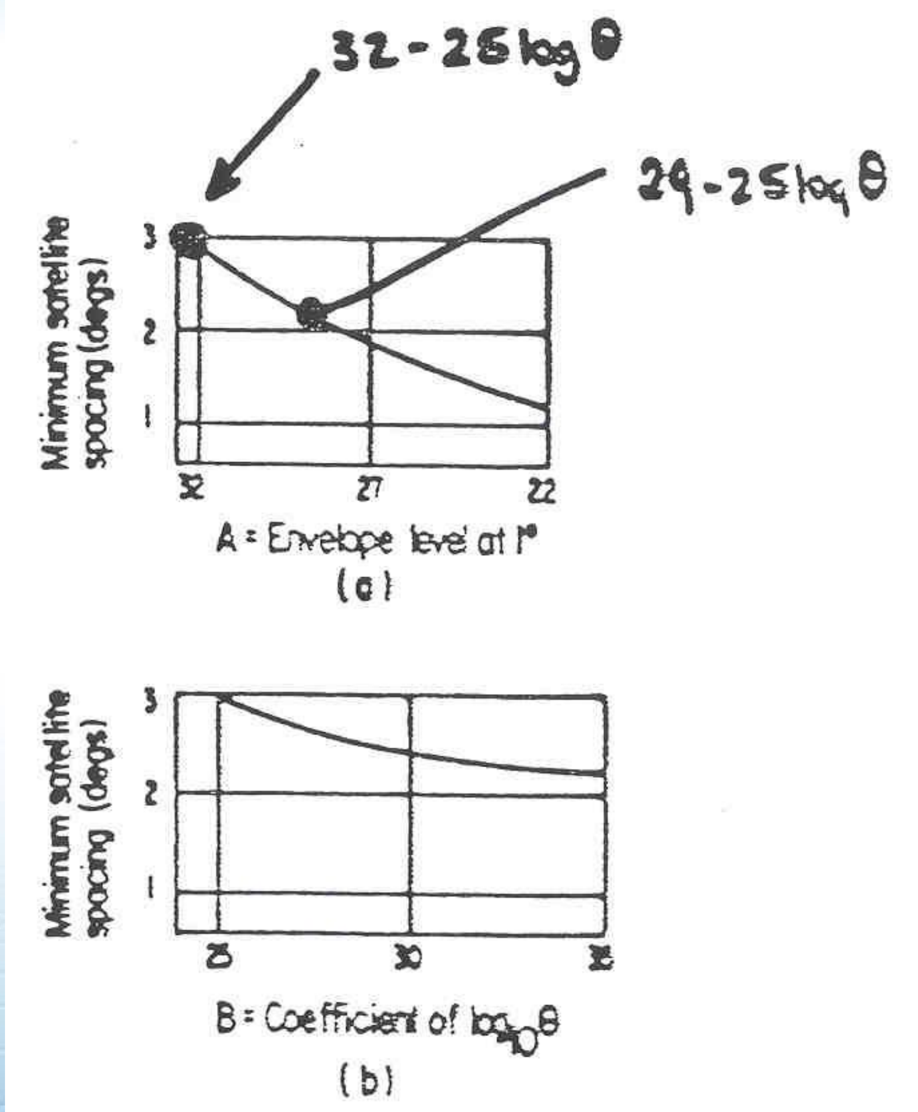
Side-lobe Specifications (cont.)



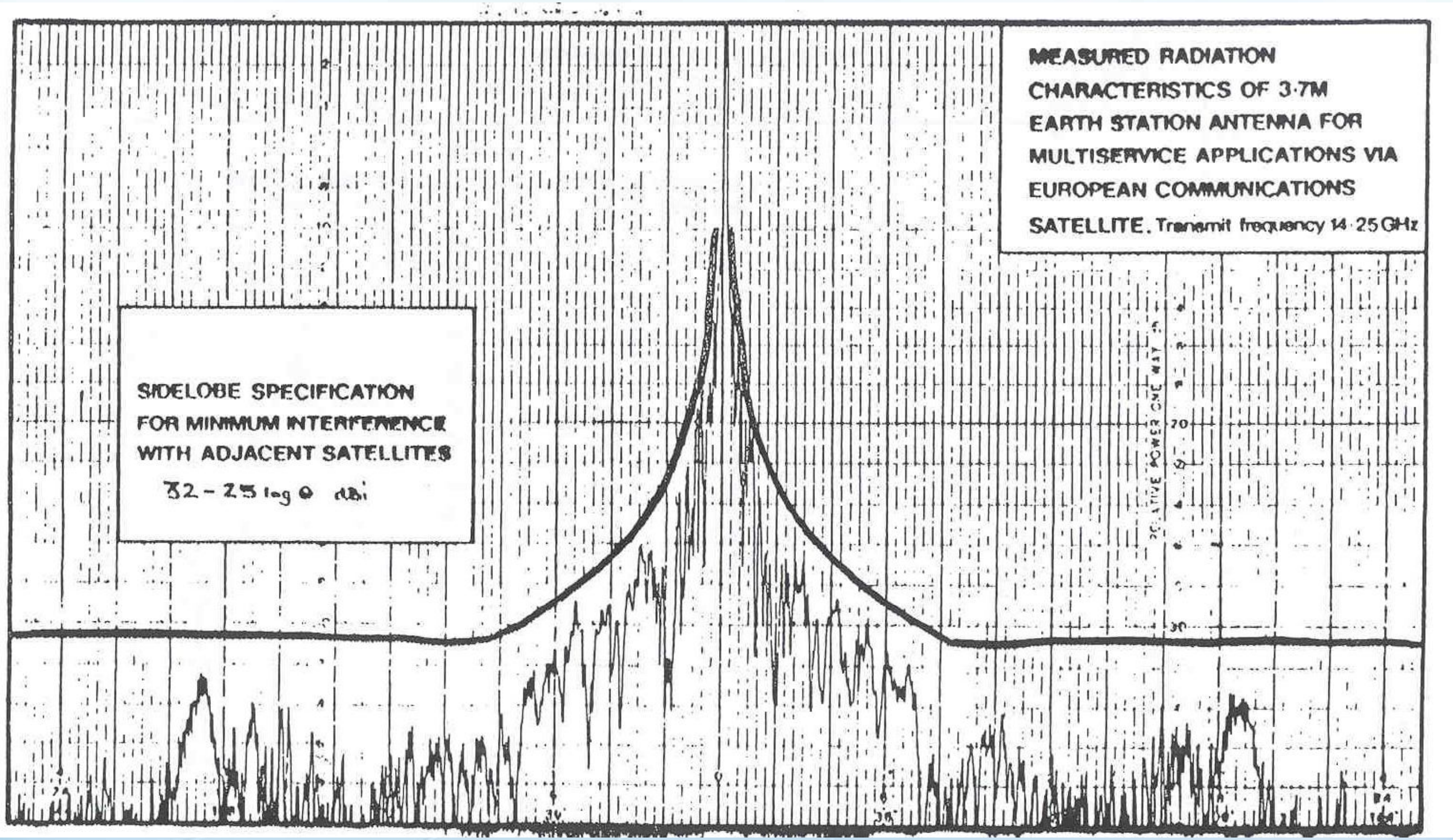
Decibels relative to isotropic

Angle of axis (degrees)

Minimum Satellite Spacings



Side-lobe Specification



Antenna tracking techniques

- Monopulse
  - Static split
  - Higher order modes
- Conical scan
- Step track
- Programmed track

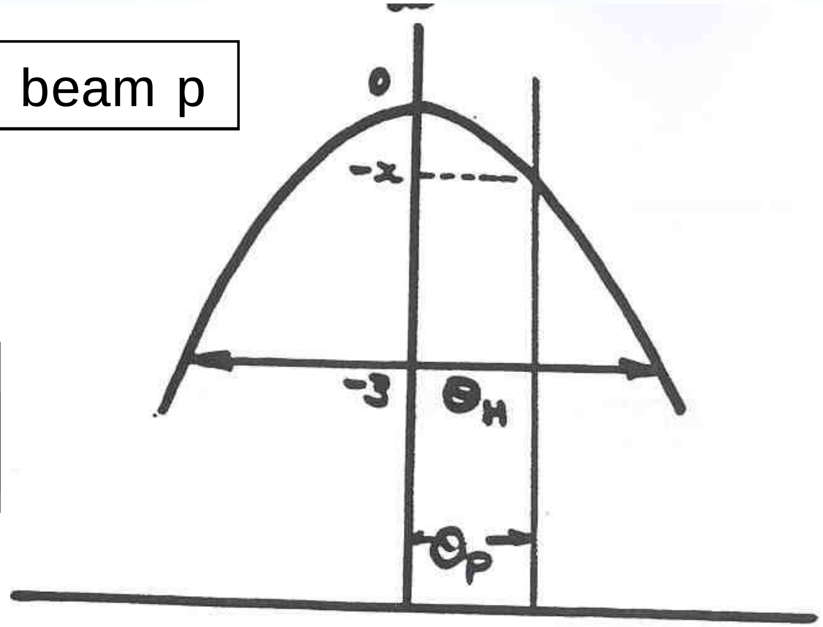
Gain Loss

Simple expression for antenna main beam pattern

$$G(\theta) = 20\log_{10}\left[10^{-0.6\left(\frac{\theta}{\theta_H}\right)^2}\right] dB$$

Pointing loss $(xdB) = 20\log_{10}\left[10^{-0.6\left(\frac{\theta_P}{\theta_H}\right)^2}\right]$

$$Loss = 12\left(\frac{\theta_P}{\theta_H}\right)^2 dB$$



Antenna diameter 25m at 4GHz, $\theta_H \approx 67/D_\lambda$, $D_\lambda \approx 333$

∴if half power beamwidth, θ_H=0.2deg

Pointing error, θ_P=0.05deg

$$GainLoss = 12\left(\frac{0.05}{0.2}\right)^2 dB$$

$$= 0.75 dB$$

Programmed Track

- A predetermined movement for the antenna is programmed into the memory of the controller. This updates the position of the antenna in a particular time interval.

- Precise satellite bearing relative to antenna needs to be known

Step Track

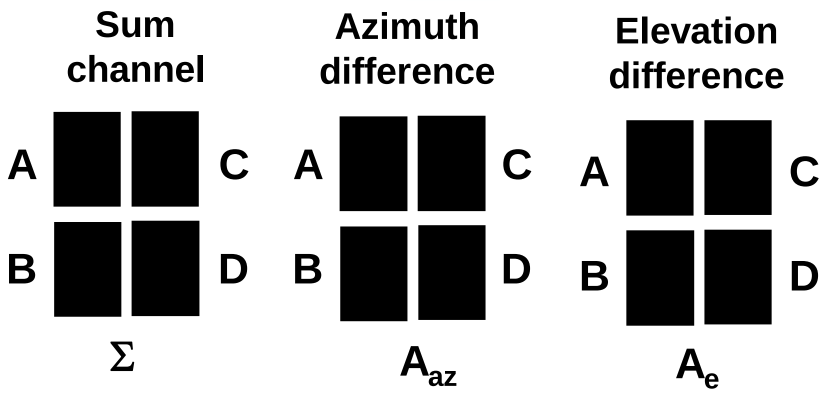
- Sometimes referred to as hill-climbing
- Antenna is moved predetermined distance in one direction.
  - if satellite signal increases, a further similar move is made.
  - if satellite signal decreases, a similar more is made in opposite direction.
- Some level of intelligence can be introduced
- Fairly cheap to include but continuous movement of complete antenna is wearing driving motors.

Conical Scan

- Mechanical steering concept
- Antenna main beam is offset from mechanical boresight by tilt of feed or subreflector
- Feed system is rotated (at high speed) such that antenna main beam performs a conical scan
- Modulates the received satellite system if it is offset from the antenna boresight
- Disadvantage is that it requires moving mechanical parts.

  e.g. Goonhilly2 antenna feed rotates at 1000 rpm.

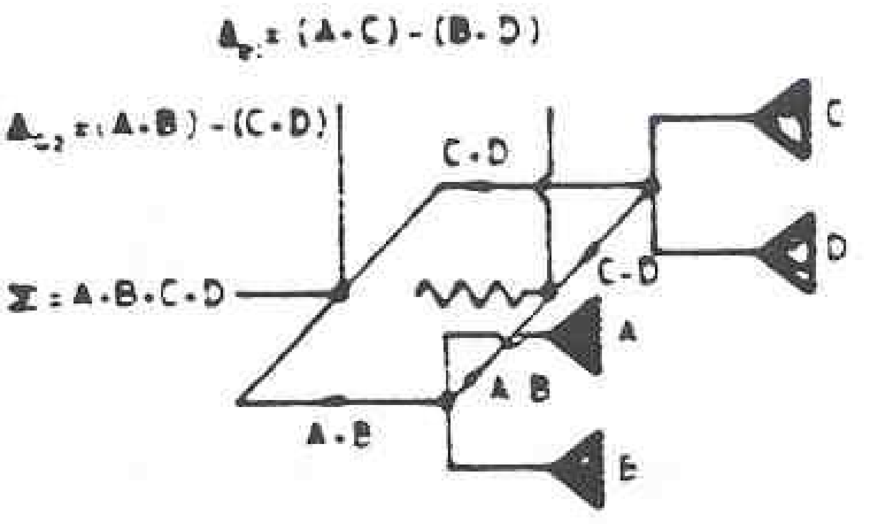
Four-Horn Static split System



Sum = A+B+C+D

Δ_{AZ}=(A+B) - (C+D)

Δ_{EL}=(A+C) - (B+D)

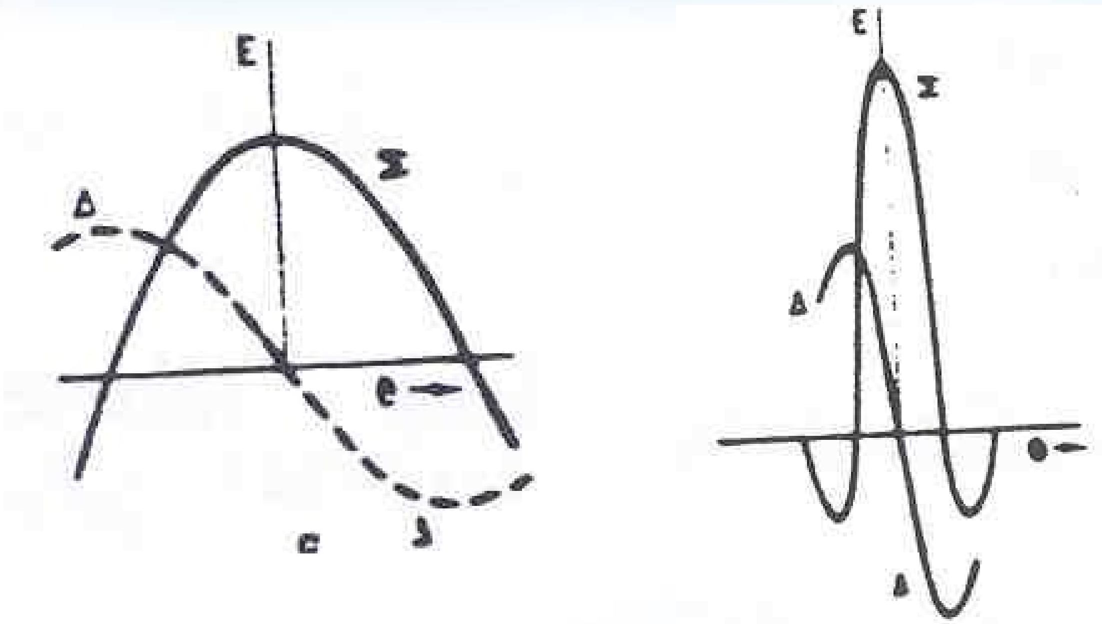


Simple two-channel tracking feed

a   Modes in horn apertures

b   Comparator bridge network

Four-Horn Static split System (cont.)



Sum and difference channel radiation patterns

a Feed illumination patterns

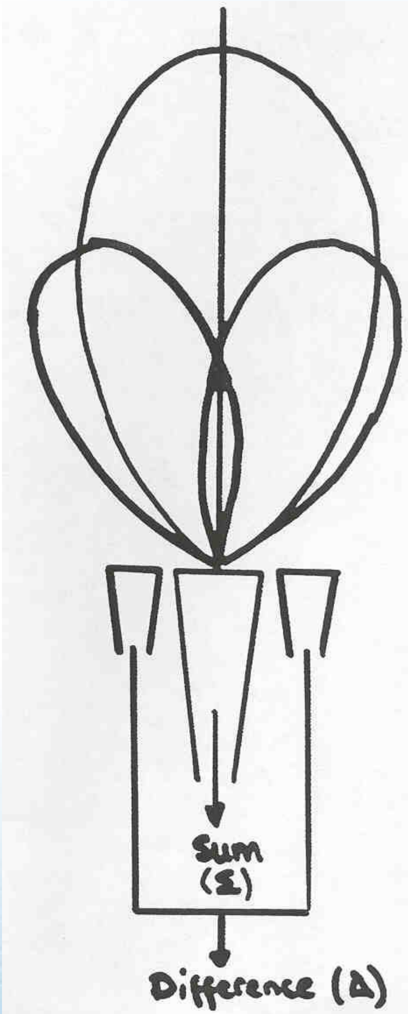
b Reflector for field patterns

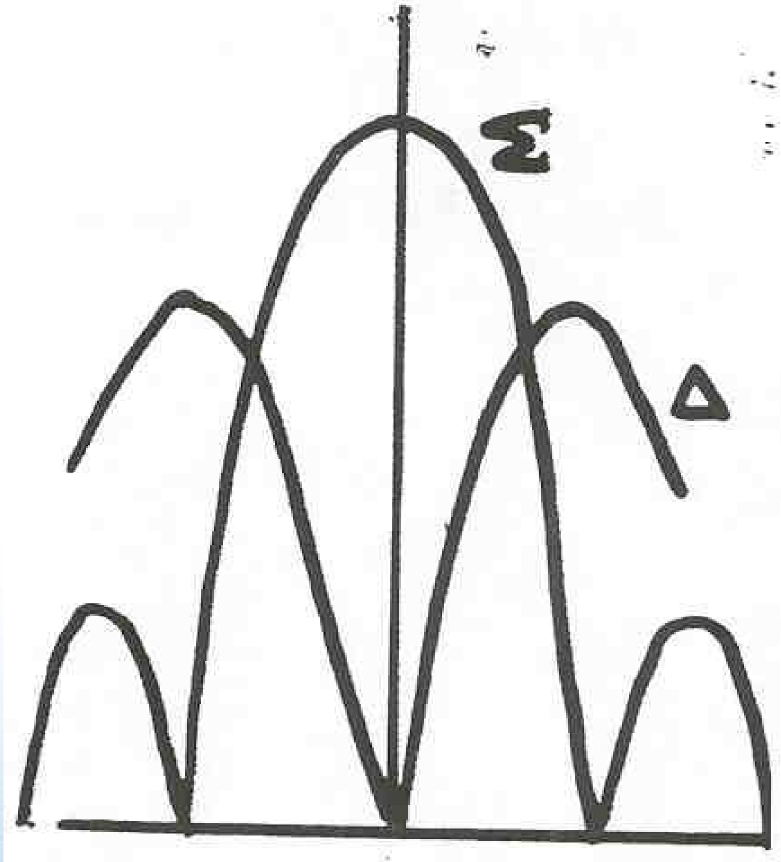
Normal sum type pattern

Difference pattern has null on boresight

Satellite should be steered to be in null

Monopulse Tracking Static – Split System





Multimode Tracking System

- Single feedhorn provides both communication channel and tracking information.
- Higher order modes are employed which have no field component (a null) in the boresight direction.
- As for static split system, the tracking accuracy is dependent on the slope of the null.
- Again error signals in azimuth and elevation are determined.