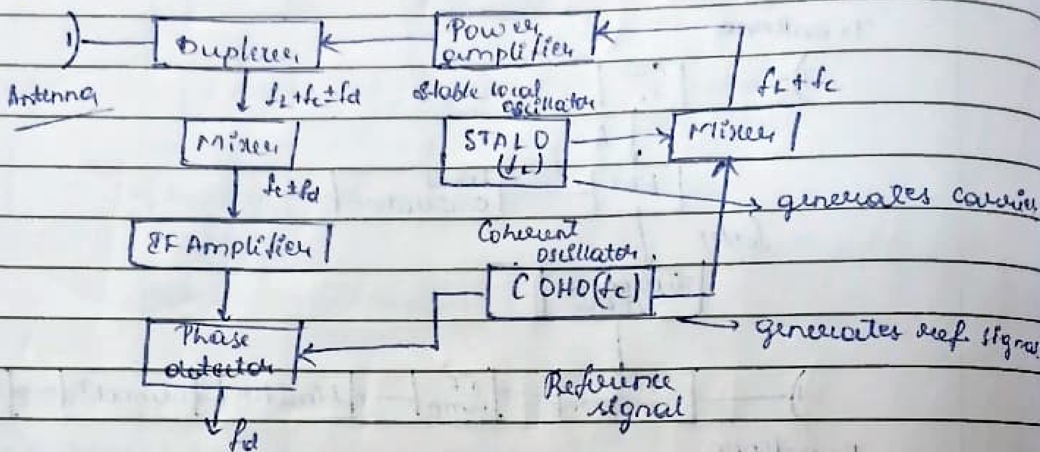
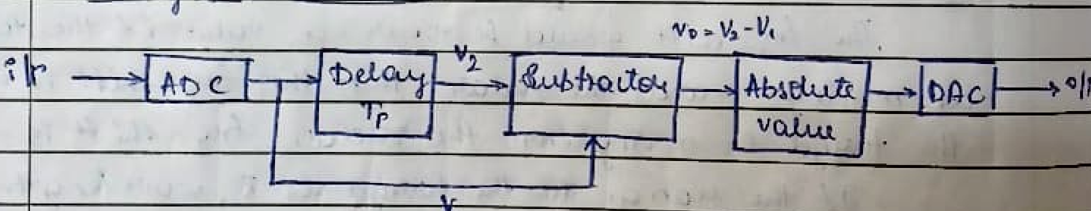
$$f_d = \frac{2V_r}{\lambda}$$

$$\boxed{f_d = \frac{2f V_r}{c}}$$

~~MTI~~ MTI Radar:



Delay line canceller:-



6/10/23

$$V_1 = K \sin[2\pi f_d t - \phi]$$
$$V_2 = K \sin[2\pi f_d (t - T_p) - \phi]$$

$$V = V_2 - V_1$$

$$= K \sin[2\pi f_d(t - T_p) - \phi] - K\sin[2\pi f_d t - \phi]$$

$$\sin A - \sin B = 2\sin\left(\frac{A-B}{2}\right).\cos\left(\frac{A+B}{2}\right)$$

$$= K\left[2\sin\left(\frac{2\pi f_d(t-T_p) - \phi - 2\pi f_d t + \phi}{2}\right).\cos\left(\frac{2\pi f_d(t-T_p) - \phi + 2\pi f_d t - \phi}{2}\right)\right]$$

$$= 2K\left[\sin\left(\frac{-2\pi f_d T_p}{2}\right).\cos\left(\frac{4\pi f_d t - 2\pi f_d T_p - 2\phi}{2}\right)\right]$$

$$= 2K\left[\sin(-\pi f_d T_p).\cos(2\pi f_d t - \pi f_d T_p - \phi)\right]$$

$$f_d = n f_p \rightarrow (1)$$

DATE

$$f_d = \frac{2f_t V_r}{c} \rightarrow (2)$$

Equating (1) & (2)

$$n f_p = \frac{2 f_t V_r}{c}$$

$$V_r = \frac{c n f_p}{2 f_t}$$

$$V_r = \frac{n\lambda}{2T_p} \qquad \boxed{f_p = 1/T_p}$$

Ex: $n = 2 \quad \lambda = 100 \quad f_p = 50.$

$$V_r = \frac{2 \times 100 \times 50}{2} = 5000$$

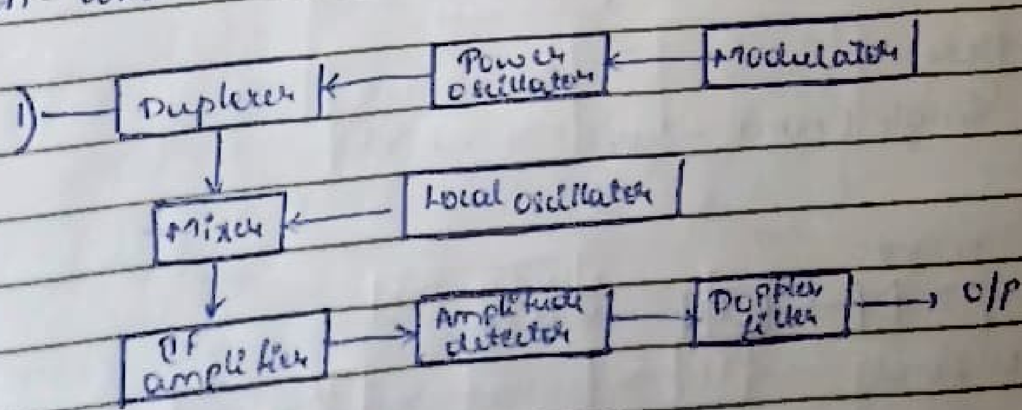
$\lambda = 200$

$$V_r = \frac{2 \times 200 \times 50}{2} = 10000$$

Eliminate blindspeeds

- Increase λ repetitive
- use high freq. i.e., f_p
- Repetitive pair of freq.
-

Non-coherent MTI radar (or) External coherent MTI radar



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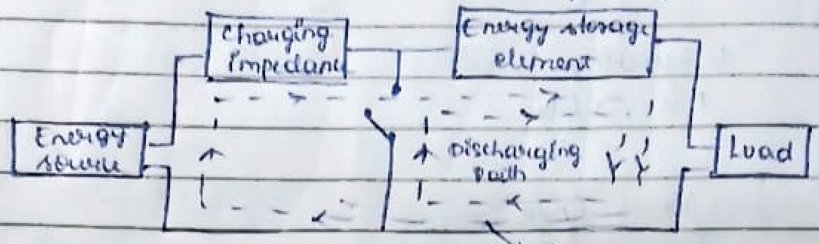
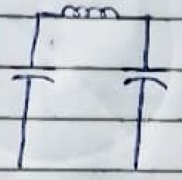
Radar modulator:-

uses a bank of capacitors



Line type modulator:

Active switch modulator



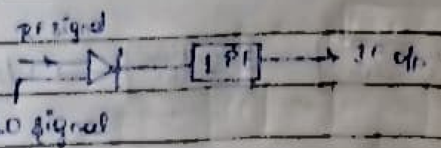
- Radar receiver
- Receiver noise figure

Radar Display:-

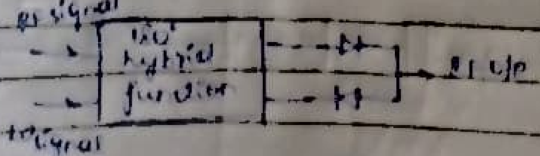
- A scope → Manual tracking operation
- B scope
- C scope
- E scope → intensity kind of display
- PPI → Plan position Indicator

Mixers:-

1. Single ended mixer:

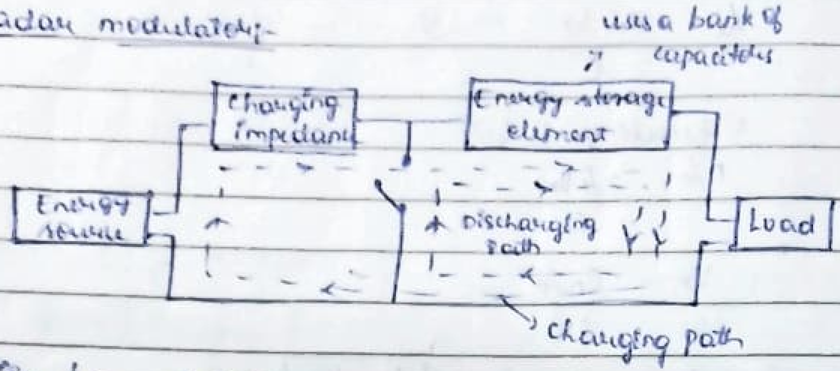


2. Balanced mixer:

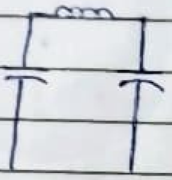


7/10/22 DATE

Radar modulator:-



Line type modulator:



Active switch modulator

- Radar receiver
- Receiver noise figure

Radar Display:-

- A scope → Manual tracking operation
- B scope
- C scope
- E scope → intensity kind of display
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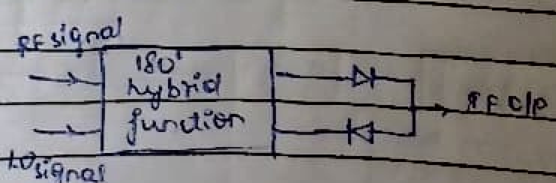
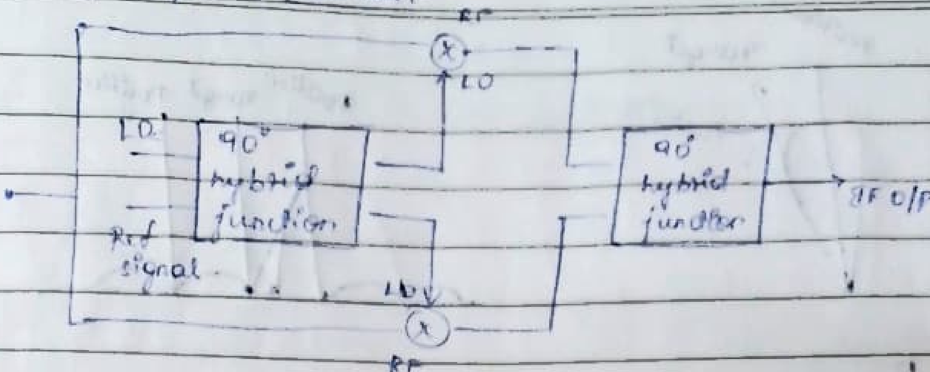
Mixer:-

1. Single Ended mixer:

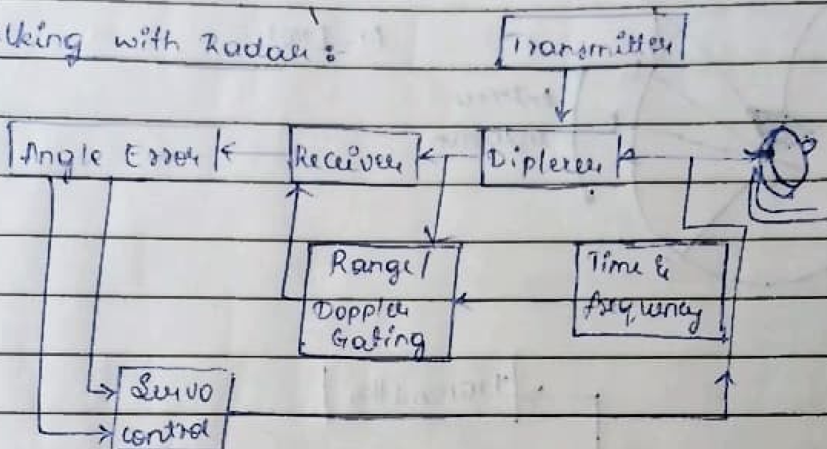
2. Balanced mixer:



c. Image rejection mixer:-



Tracking with Radar:



STT → Single Target Tracking Radar.

ADT → Automatic detection tracking radar.

TWS → Track while Scan

Phased array tracking radar

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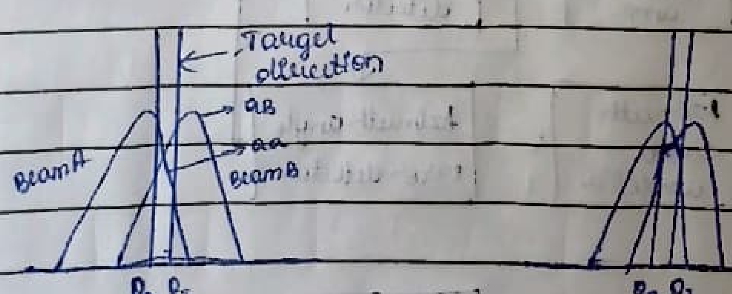
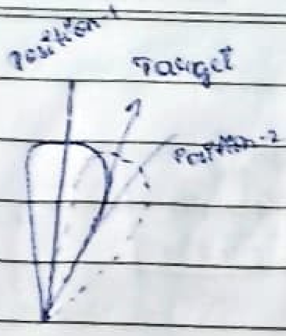
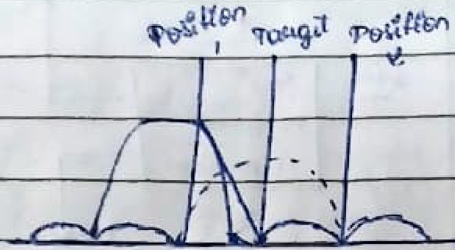
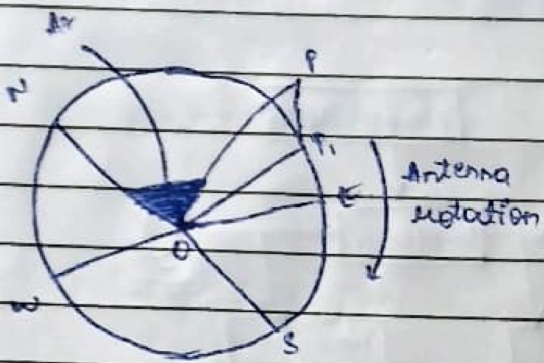


Methods to extract error signal

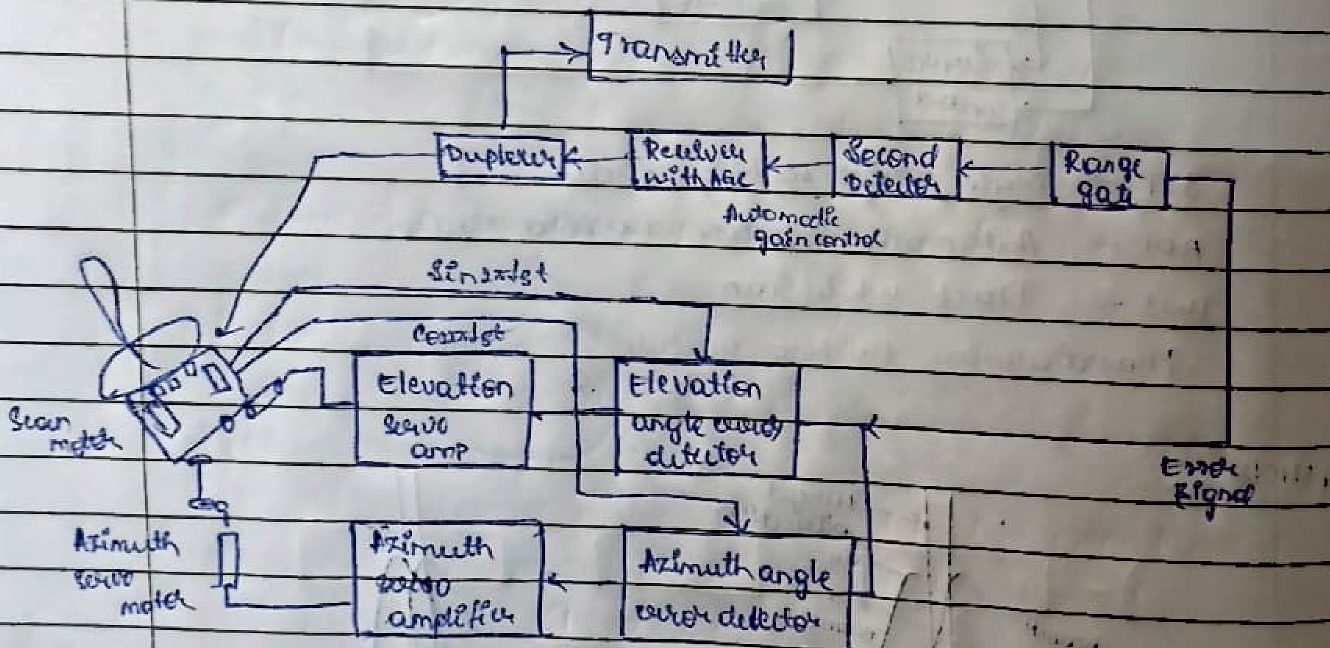
- Sequential Lobing
  - Conical scan
- Monopulse

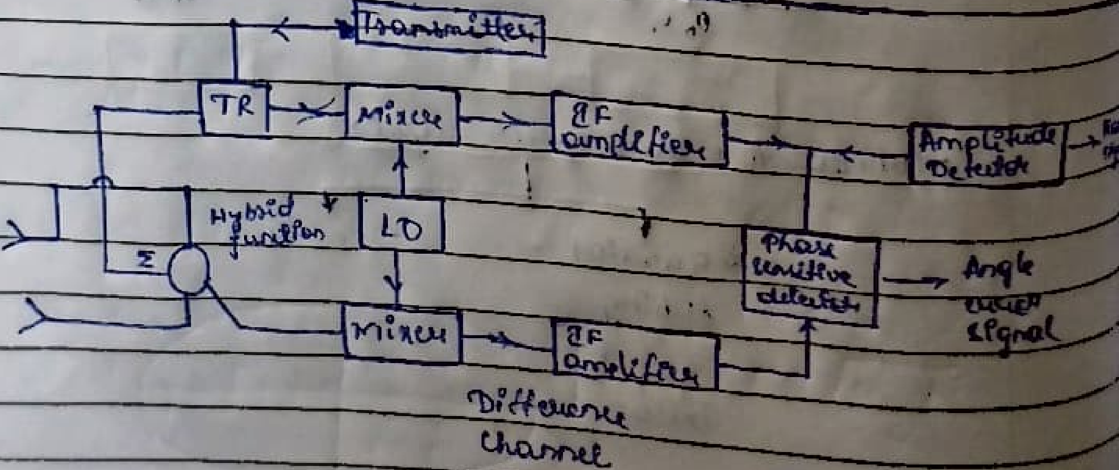

Position 1
Target
Position 2


Position 1
Target
Position 2


N
P
P1
E
O
W
S
Antenna rotation

Ar = ∠NOP1

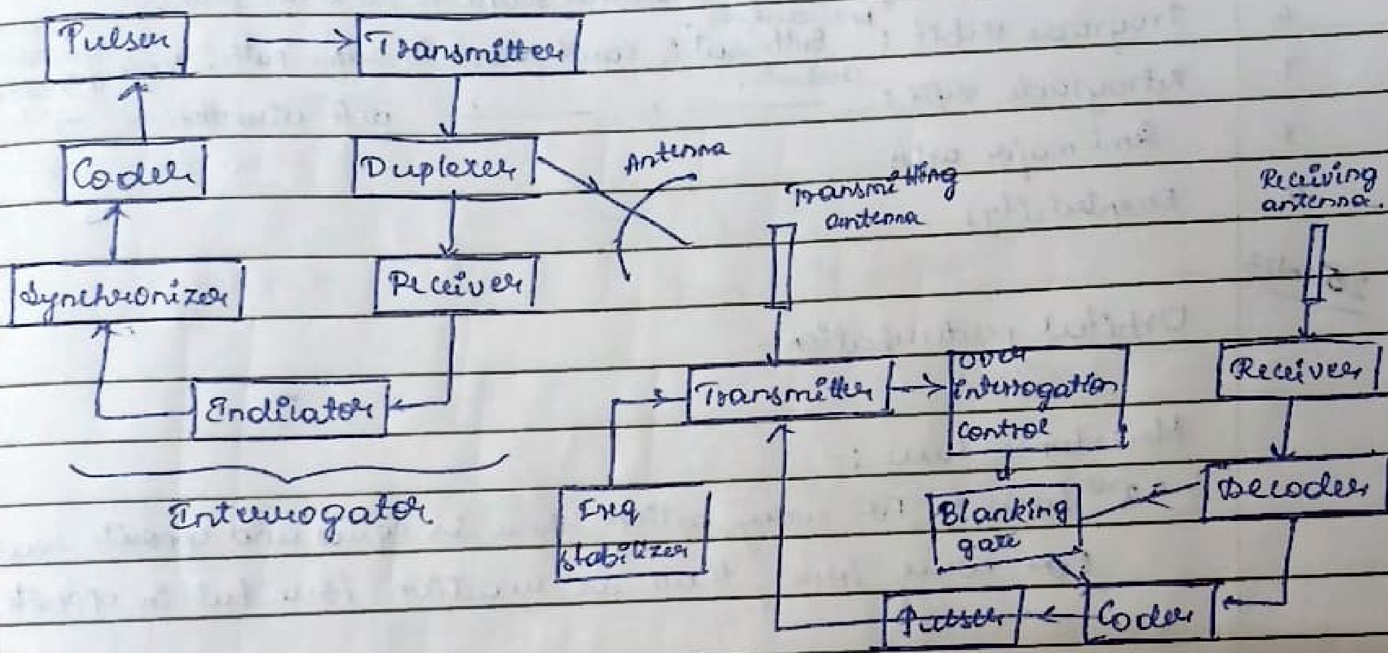

Transmitter
Duplexer
Receiver with AGC
Second Detector
Range gate
Automatic gain control
Scan motor
Elevation servo amp
Elevation angle error detector
Azimuth servo motor
Azimuth servo amplifier
Azimuth angle error detector
Error signal


Transmitter
TR
Mixer
IF amplifier
Amplitude Detector
Hybrid junction
LO
Σ
Phase sensitive detector
Angle error signal
Mixer
IF amplifier
Difference Channel

Unit-2

Satellite Communication

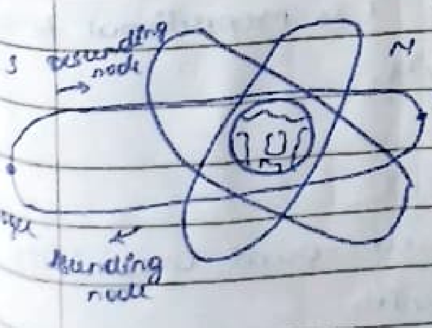
RACONS: Radar beacons.



Unit-2 → start.

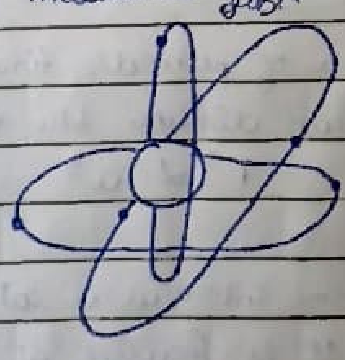
LEO

Low earth orbit



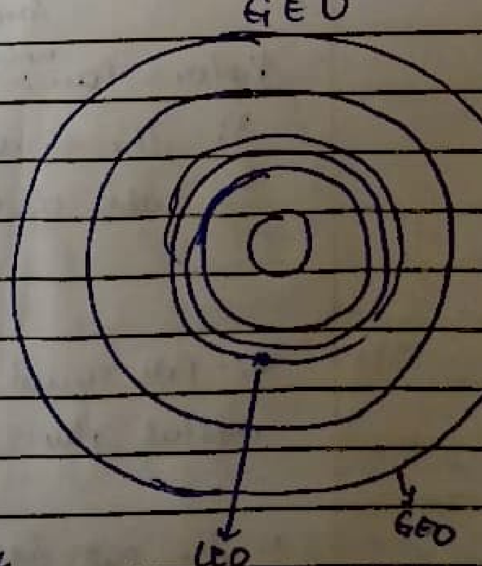
MEO

Medium earth orbit



Geostationary earth orbit

GEO



Geostationary :- 36000km

* appears to be stationary

• Less than 1000km

• 23 hrs 56 mins sec.

• 3 km / sec.

• 35 780 km above Earth

DATE

Line joining Perigee & Apogee

1. Line of apsides: Distance b/w satellite & surface Perigee & Apogee
2. Ascending node: North to South to North. Point where orbit crosses eq plane
3. Descending node: South to North to South
4. Line of node: Line joining Ascending & Descending node through the centre of the earth
5. Inclination: Angle b/w equatorial plane to orbital plane. Measured from ascending node only
6. Prograde orbit: Anti-clockwise. Both sat & earth move in same path. Angle of inclination 0-90°
7. Retrograde orbit: Clockwise. ——— " ——— diff direction → 90° to 180°
8. Semi major axis:-
9. Eccentricity:

25/10/23

Orbital perturbation:-

Newton's law :-

3rd law :- For every action there is equal and opposite reaction.
For every force, there is reaction force but in opposite direction

2nd law :- Acceleration is produced when force acts on a mass.

1st law :- An obj at rest will remain at rest unless acted on by an unbalanced force or an obj in motion continues to be in motion, in same speed & dir unless acted upon by an unbalanced force.

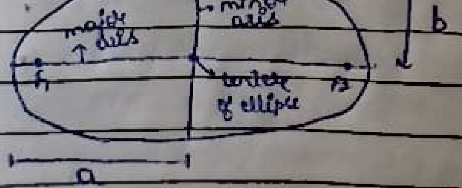
Kepler's law:-

3: The square of periodic time of orbit T is proportional to the cube of mean distance b/w two bodies.

$$T^2 \propto a^3$$

2:- For equal time interval a sat will sweep equal area in it's orbital plane. It is focused at barycenter.

1: The path followed by the sat around the primary will be an ellipse



$$e = \frac{\sqrt{a^2 - b^2}}{a}$$

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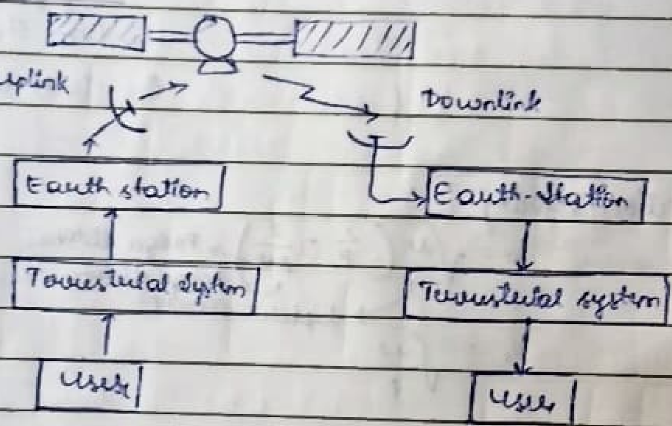
1. Geostationary & Non-Geostationary orbits
2. Eclipse   March 21st & Sept 23rd → equi changover of day & night time.
   122 days, there will be eclipse
   Equinox → Sun is directly above the equator.

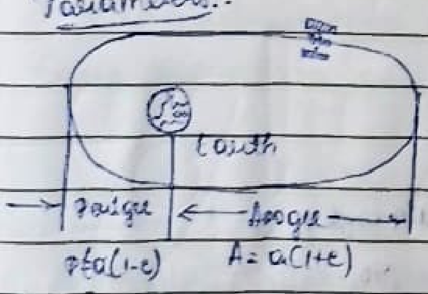
3. Sub satellite point:-
4. Space & Earth Segment ?

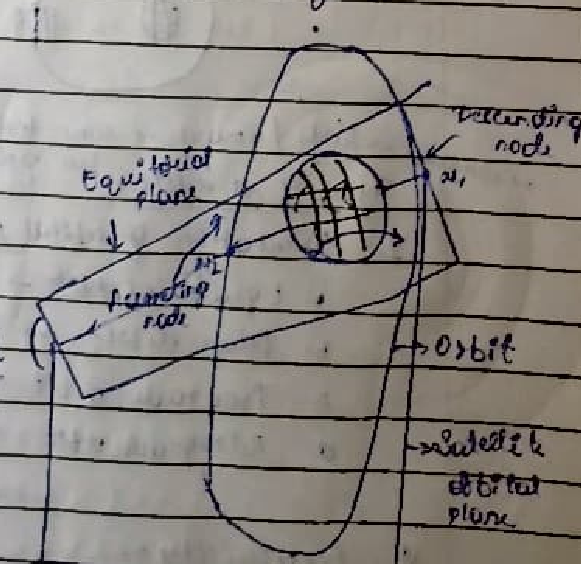
General architecture



TT&C → Track telemetry and command
TT&MC   Tracking telemetry control and monitoring.

Parameters:-





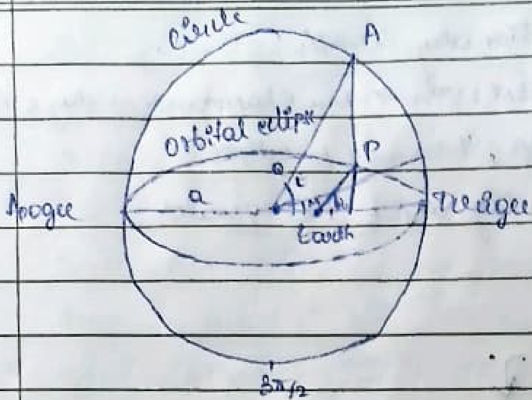
w → Argument of perigee → Angle b/w perigee & centre of the earth.

classmate

PAGE

$\phi_0 \rightarrow$ True anamoly
$M \rightarrow$ Mean anamoly
$E \rightarrow$ eccentric anamoly

DATE



$\phi_0 \rightarrow$ Angle from perigee to the sat ra is true anamoly

$M \rightarrow$ Arc length. The sat would traverse since the perigee passage if it is moving on a circle with a mean angular velocity

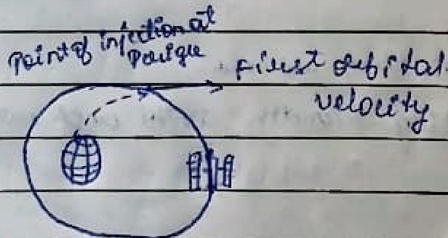
$E \rightarrow$ It is angle. drawing a vertical line from the sat intersecting the circle at A.

1. Injection velocity

$$V_P = \sqrt{\mu\left(\frac{1}{P} - \frac{2}{A+P}\right)}$$

$P \rightarrow$ Perigee distance, $A \rightarrow$ Apogee distance, $\mu \rightarrow$ Kepler's constant

$$V_1 = \sqrt{\frac{\mu}{P}}$$



10 marks $\rightarrow$ full | 5 marks $\rightarrow$ same topics less explanation

Types of sat orbits

1. Orientation of orbital plane
   a. Equitorial orbit $\rightarrow$ inclination angle $i \sim 0$
   b. Polar orbit $\rightarrow$ $i \rightarrow 90°$
   c. Prograde orbit $\rightarrow$ $0 \leq i \leq 90°$
   d. Retrograde orbit $\rightarrow$ $90° < i < 180$.

2. Eccentricity :-
   $e = 0 \rightarrow$ Circle
   $e < 1 \rightarrow$ Ellipse
   $e = 1 \rightarrow$ Parabola
   $e > 1 \rightarrow$ Hyperbola.

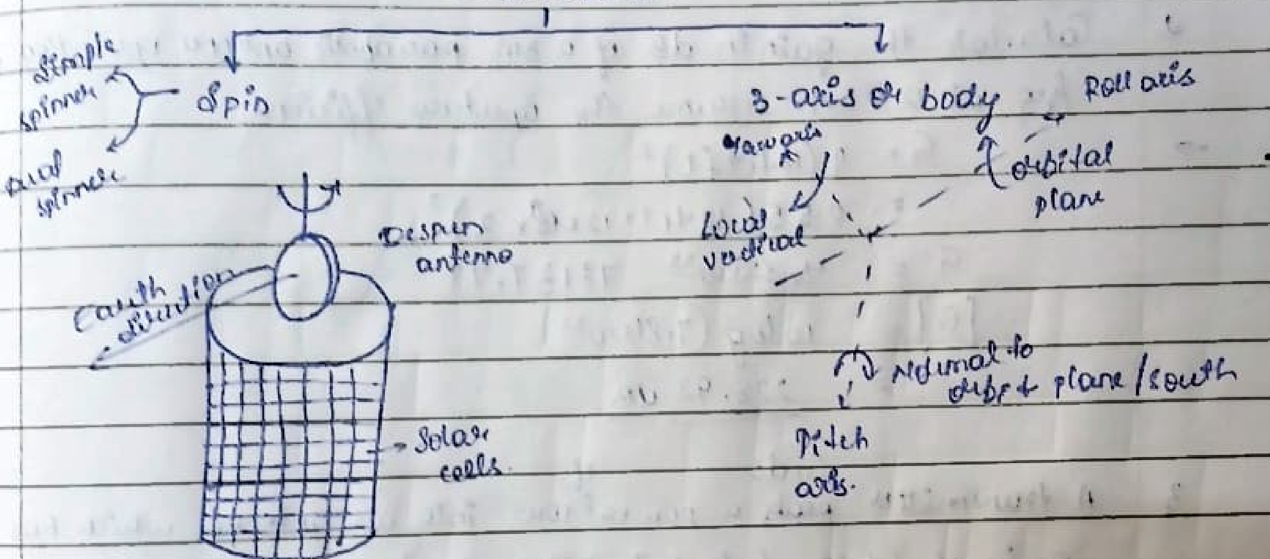
3. Distance from Earth:

a. LEO → Lowest lifespan & low distance.

b. MEO → Mid — " ——

c. GEO → Highest lifespan & height.

Stabilization



Link power budget calculation
↳ Uplink,
Downlink

Isotrope → Remains same

EIRP → Equivalent Isotropic Radiated Power.

The maximum power flux density at some distance from a transmitting antenna gain

$$\psi_m = \frac{G P_s}{4\pi r^2} \rightarrow ①$$

An isotropic radiator with an i/p power equal to gain of the transmitting antenna will try to produce same flux density

$$EIRP = G P_s$$

$$[EIRP] = [G][P_s] \ dBW$$

Problems:

A sat downlink at 6 GHz operates with a tr. power of 6W and a antenna gain of 48.2 dB. Calculate EIRP in dBW.

$$[EIRP] = [G] + [P_t] \ dBW \rightarrow 10 \log_{10}\left(\frac{6W}{1W}\right)$$

$$= 48.2 + 7.78 = 56 \ dBW$$

In case of parabolic antenna

$$G = \eta (10.47 f D)^2$$

where f = carrier frequency

$D \rightarrow$ diameter.

η = efficiency (0.55).

2 Calculate the gain in dB of a 3m parabolic antenna operating at a freq at 12 GHz assume the aperture efficiency

$\rightarrow$ $G = \eta (10.47 f D)^2$

$= 0.55 (10.47 \times 12 \times 10^9 \times 3)^2$

$G = 78137.77$

$[G] = 10 \log (7.81 \times 10^{22})$

$= 228.92\ dB$

3. A transmitter feeds a power of 10W into an antenna which has a gain of 46dB. Calculate EIRP in terms of W & dBW.

$\rightarrow$ $EIRP = G P_s$ $\qquad [46] = 10 \log G$

$\Rightarrow 39810 \times 10$

$EIRP = 398100\ W$

$[EIRP] = [G] + [P_s]\ dBW.$

$= 46 + 10$

$= 56\ dBW$

4 Calculate the gain of a 3m parabolic antenna at 6 GHz, 14 GHz, 20 GHz

$\rightarrow$ (i) $G = \eta (10.47 f D)^2$

$= 0.55 (10.47 \times 6 \times 3)^2$

$G = 19541.9$

$= 42.9\ dBW$

(ii) $G = 0.55 (10.47 \times 14 \times 3)^2$

$= 50.26\ dBW$

(i) $G = 0.55 (10.47 \times 20 \times 3)^2 = 53.36\ dBW$

DATE

Free space transmission:

$$\Psi_m = \frac{EIRP}{4\pi r^2} \rightarrow ①$$

$r \rightarrow$ range b/w transmitter & receiver.

$G_R \rightarrow$ Isotropic power gain

Standard:

$D \rightarrow km$

$C \rightarrow \times 10^8 m/s$

$f \rightarrow MHz$

$$P_R = \Psi_m A_{eff}$$

$$= \frac{EIRP}{4\pi r^2} \cdot \frac{\lambda^2 G_R}{4\pi}$$

$$P_R = (EIRP)(G_R)\left(\frac{\lambda}{4\pi r}\right)^2$$

$$[P_R] = [EIRP] + [G_R] - 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

$$\Rightarrow [FSL] = 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

$$[FSL] = 32.4 + 20\log r + 20\log f$$

1. Calculate the range b/w ground station & sat is 42000km. Calculate FSL at a freq of 6GHz.

$\rightarrow$

$$[FSL] = 32.4 + 20\log 42000 + 20\log 6000$$

$$= 200.428 \text{ dB}$$

2. Calculate the FSL as a power ratio & in decibels. for a transmission at freq of 4GHz, 6GHz, 12GHz, 14GHz. & range being 42000 km.

$\rightarrow$ $[FSL] = 32.4 + 20\log(42000) + 20\log(4000)$

$= 196.9 \text{dB}$

$[FSL] = 32.4 + 20\log(42000) + 20\log(6000)$

$= 200.428 \text{dB}$

$[FSL] = 32.4 + 20\log(42000) + 20\log(12000)$

$= 206.44 \text{dB}$

$[FSL] = 32.4 + 20\log(42000) + 20\log(14000)$

$= 207.78 \text{dB}$

Free space transmission

$$\Psi_m = \frac{EIRP}{4\pi r^2} \longrightarrow ①$$

r → range b/w transmitter & receiver

EIRP → Isotropic power gain

Standard:

D → km

C → 3×10^8 m/s

f → MHz

$$P_R = \Psi_m A_{eff}$$

$$= \frac{EIRP}{4\pi r^2} \cdot \frac{\lambda^2 G_R}{4\pi}$$

$$P_R = (EIRP)(G_R)\left(\frac{\lambda}{4\pi r}\right)^2$$

$$[P_R] = [EIRP] + [G_R] - 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

$$\rightarrow [FSL] = 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

$$[FSL] = 32.4 + 20\log r + 20\log f$$

1. Calculate the range b/w ground station & sat is 42000km. Calculate FSL at a freq of 6GHz

→

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$$= 200.428 \text{ dB}$$

2. Calculate the FSL as a power ratio & in decibels for a transmission at freq of 4GHz, 6GHz, 12GHz, 14GHz & range being 42000 km.

→

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$$= 196.9 \text{ dB}$$

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$$= 200.428 \text{ dB}$$

$$[FSL] = 32.4 + 20\log(42000) + 20\log(12000)$$
$$= 206.44 \text{ dB}$$

$$[FSL] = 32.4 + 20\log(42000) + 20\log(14000)$$
$$= 207.78 \text{ dB}$$

11/4/23 $[EIRP] - [losses] + [G_R]$ DATE

Types of losses.

1. FSL → Free space loss
2. RFL → Receiver feeder loss
3. AML → Antenna misalignment loss.
4. AA → ~~Alt~~ Atmospheric absorption loss
5. PL → Polarization mismatch loss

$$[Losses] = [FSL] + [RFL] + [AML] + [AA] + [PL]$$

Problem

1. A sat link which is operating at 14 GHz has receiver feeder losses of 1.5dB, FSL → 207dB, AA → 0.5dB, PL → 0.5dB, depolarization losses maybe neglected. Calculate total link loss for clear sky condition

→

Total link loss = 207 + 1.5 + 0.5 + 0.5
= 209.5 dB

Carrier to Noise ratio

$$\left[\frac{C}{N}\right] = [P_r] - [P_N]$$

$$\left[\frac{C}{N}\right] = [EIRP] + [G_R] - [Losses] - [k] - [T_s] - [B_N]$$

→ system noise temp

$$[G/T] = [G_R] - [T_S] \text{ dB/K}$$

$$\left[\frac{C}{N}\right] = [EIRP] + [G/T] - [Losses] - [K] - [B_N]$$

$$[C/N] = [C/N_0 B_N]$$

$$= \left[\frac{C}{N_0}\right] - [B_N]$$

P_R/N_0

$P_N = KT_N B_N$

$= N_0 B_N$

$$\left[\frac{C}{N_0}\right] = \left[\frac{C}{N}\right] + [B_N]$$

$$[C/N_0] = [EIRP] + [G/T] - [losses] - [k]$$

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