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Radar and Satellite communication

Q1

a) Find and explain Track and Search Radar Range equation.

Ans

Radar Range Equation

- For a directional radar, the power density per unit area is given by

$$P_{direction} = \frac{P_1 G_1}{4\pi R^2}$$

where $P_{directional}$ = radiation power density of the isotropic radiation [w/m^2]

G_t = directional gain of the antenna measured in the target direction

- A target at distance R intecepts the transmitted energy, Part of the energy will be reflected by the target
- The re-radiated power due to the reflection

$$P_{Target} = P_{direction}$$

$$\Phi = \frac{P_T G_T}{4\pi R^2} \sigma$$

where σ = target radar cross section, the target EM size viewed by the radar.

- The reflected power from the target received by the radar,

$$P_{reflected} = \frac{P_{T.target}}{4\pi R^2}$$

$$= \frac{P_T G_T \sigma}{(4\pi R^2)^2}$$

- $P_r = P_{reflected} A_e = \frac{P_T G_T A_e}{(4\pi R^2)^2} \sigma$

$$A_e = \frac{G_r \lambda^2}{4\pi}$$

$$P_r = \frac{P_T G_T G_r \lambda^2}{(4\pi)^3 R^4} \sigma$$

$$P_r = \frac{P_T G^2 \lambda^2}{(4\pi)^3 R^4} \sigma$$

- The signal to noise ratio at output,

$$SNR_o = \frac{S_o}{N_o} = \frac{AP_r/L}{AF_n KTB} = \frac{P_r}{F_n KTBL}$$

$$P_r = \frac{P_T G^2 \lambda^2}{(4\pi)^3 R^4} \sigma$$

the complete radar equation

$$SNR_o = \frac{P_T G^2 \lambda^2 \sigma}{(4\pi)^3 R^4 F_n KTBL}$$

Maximum Detection Range

- The maximum detection rang of a target with a specified radar cross section, σ, is

$$R = \left[\frac{P_T G^2 \lambda^2 \sigma}{(4\pi)^3 F_n KTBL (SNR_o)}\right]$$

- The maximum range is obtained when the signal-to-noise ratio of a target is minimum,

$$R_{max} = \left[\frac{P_T G^2 \lambda^2 \sigma}{(4\pi)^3 F_n KTBL (SNR_{o,min})}\right]$$

Development of Search Radar Equation:-

Track Radar Equation

$$\frac{S}{N} = \frac{P_T G^2 \lambda^2 \sigma}{(4\pi)^3 R^4 K T_s B_n L}$$

Search Radar Equation

$$\frac{S}{N} = \frac{P_{av} A_e t_s \sigma}{4\pi \Omega R^4 T_s L}$$

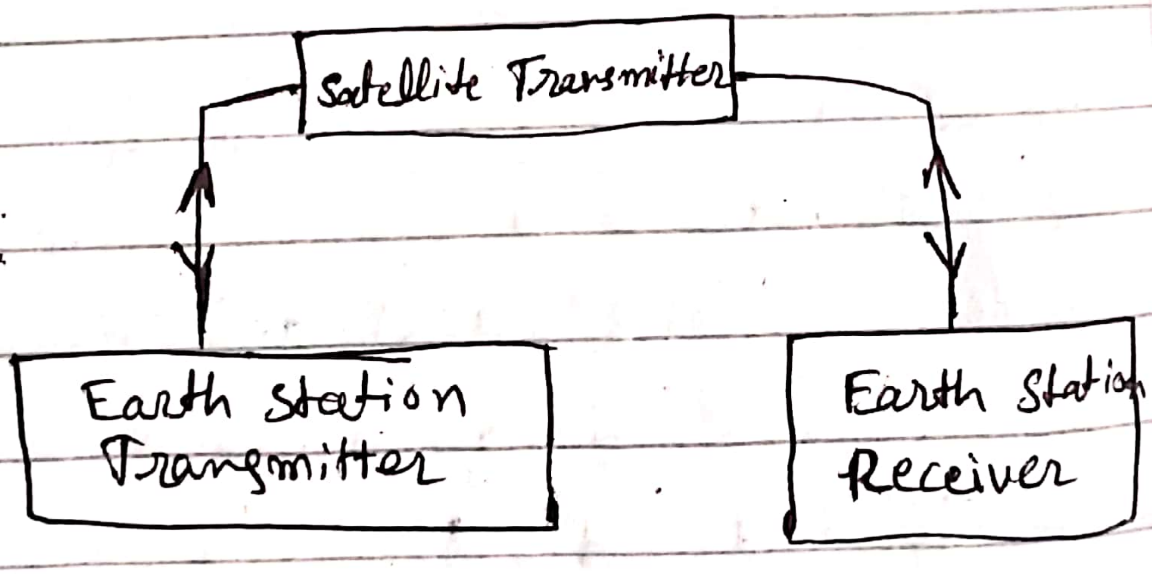
Q.1

Part B Explain working principle of satellite communications system (GPS), and difference between triangulation and Trilateration?

Ans Principle of Communication

→ In satellite communication, signal transferring between the sender and receiver is done with the help of satellite.

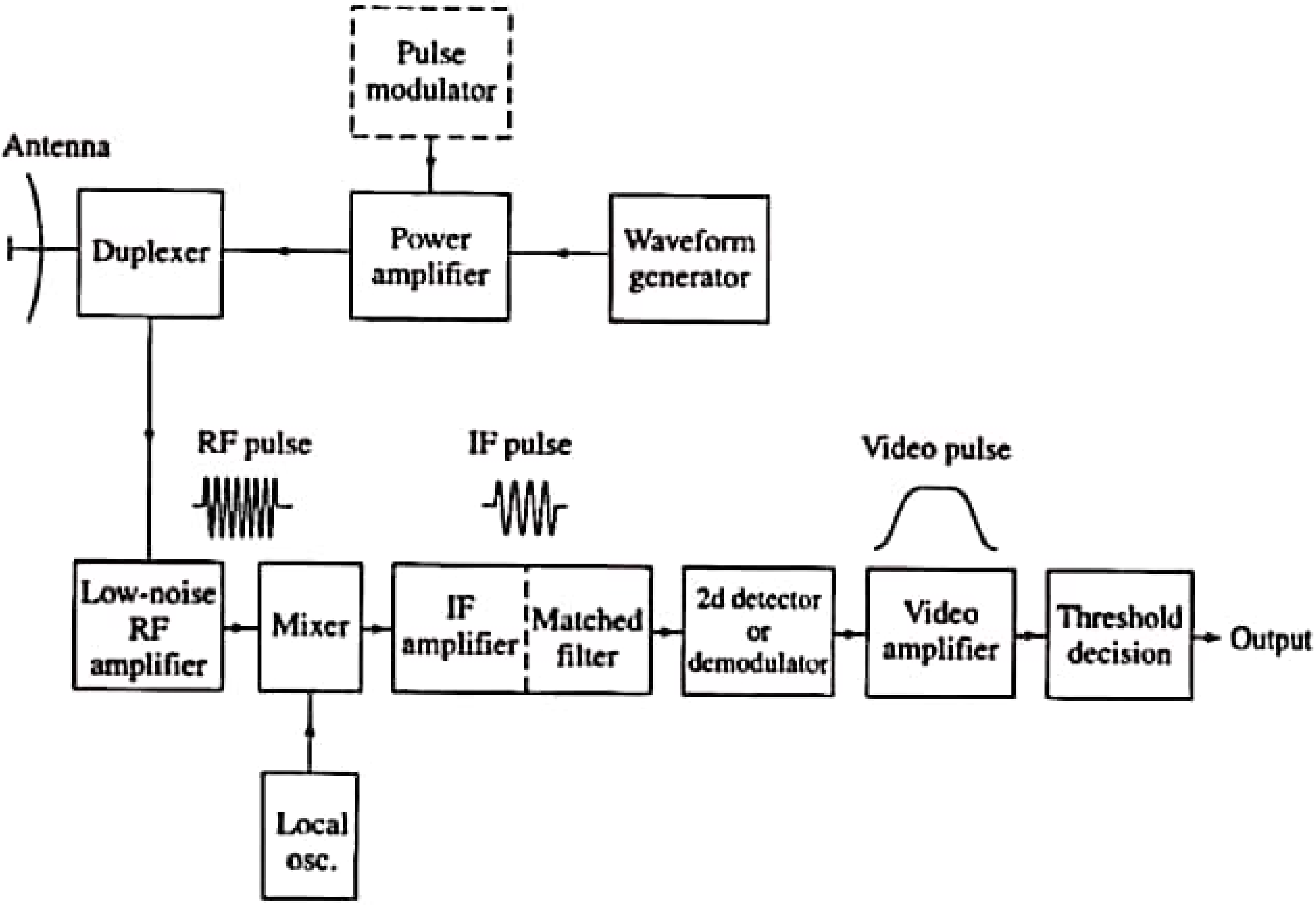
→ In this ~~pross~~ process, the signal which is basically a beam of modulated microwaves is sent towards the satellite. then the satellite amplifies the signal and sent it back to the receiver's antenna present on the earth's surface.



GPS Basics:

- Triangulation
  - Multiple bearings on an unknown target
  - Readings taken from known Locations
  - Tends to be planar
- Trilateration
  - Multiple distance determinations to an unknown target
  - Readings taken from known Locations
  - 3D positioning

Q.2 Draw and Explain
a) Radar Block Diagram.
Ans Explanation:
The block diagram of a simple radar system is shown in figure. This block diagram indicates that the radar


Pulse modulator
Antenna
Duplexer
Power amplifier
Waveform generator
RF pulse
IF pulse
Video pulse
Low-noise RF amplifier
Mixer
IF amplifier
Matched filter
2d detector or demodulator
Video amplifier
Threshold decision
Output
Local osc.

system consists of both the transmitting and the receiving system - this connects the antenna to the transmitter during transmission and to the receiver during reception.

b) Find the escape velocity of satellite?

Ans Escape velocity

- The minimum velocity needed for a celestial body to escape the gravitational pull of another, larger body and not fall back to that body's surface. In our case, satellites escape earth's gravity

Expression for orbital velocity

$1/2\, m v_R^2 = G M_E m / R$ or $V_e = \sqrt{(2 G M_E (R)} = \sqrt{Rg}$

Relation between orbital velocity and Escape Velocity

orbital velocity $v_0 = \sqrt{Rg}$

Escape velocity $v_e = \sqrt{2Rg}$

$v_e = \sqrt{2} v_0$

Q.3 a) Find out the orbital speed and Time period of Satellite?

Ans Time Period of a satellite.

Distance covered by the Satellite in 1 revolution

= circumference of the circle

Time taken to cover this distance is the time Period

Critical speed $V_c = \frac{\text{circumference}}{\text{Period/c time}}$

$$V_c = \frac{2\pi r}{T}$$

But $V_c = \sqrt{\frac{GM}{r}}$

$$\sqrt{\frac{GM}{r}} = \frac{2\pi r}{T}$$

$$\frac{GM}{r} = 4\frac{\pi^2 r^2}{T^2}$$

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

As $\frac{4\pi^2}{GM}$ is a constant,

so we get

$T^2 \propto r^3$

$$T = 2\pi\sqrt{\frac{r^3}{GM}}$$

Orbital speed

- Orbital speed of a satellite is the minimum speed required to put the satellite into a given orbit around earth.
- Expression - V_o = sqrt (R_e g)
  Where, g = 9.8 m/s and R_e = radius of earth. The value for orbital velocity was found to 7.9 km/s.

$$u = \sqrt{\frac{GM}{r}} = \sqrt{\frac{gR^2}{r}}$$

- It is independent of mass of the satellite.
- Decrease with an increase in the radius in the radius in the height of satellite.

Q.3 Part B — Explain different types of radar system.

Radar
- Primary radar
  - CW radar
  - Pulse radar
- Secondary radar

Types of Radar

There are basically two different types of radar, primary and secondary

Primary Radar:
relies solely on the energy that it has generated and radiated, being reflected back from the target.

Secondary Radar:
has some co-operation from the target the target generates its own (em) radiation.

- Frequency Modulated CW Radar
  - Use for radar altimeters and missile guidance.
- Pulse Doppler
  - Carrier wave frequency within pulse is compared with a reference signal to detect moving targets.