V. Shruthi
15B81A04H6
ECE-C

Satellite Communication

4 b) Draw the block diag. of an earth station

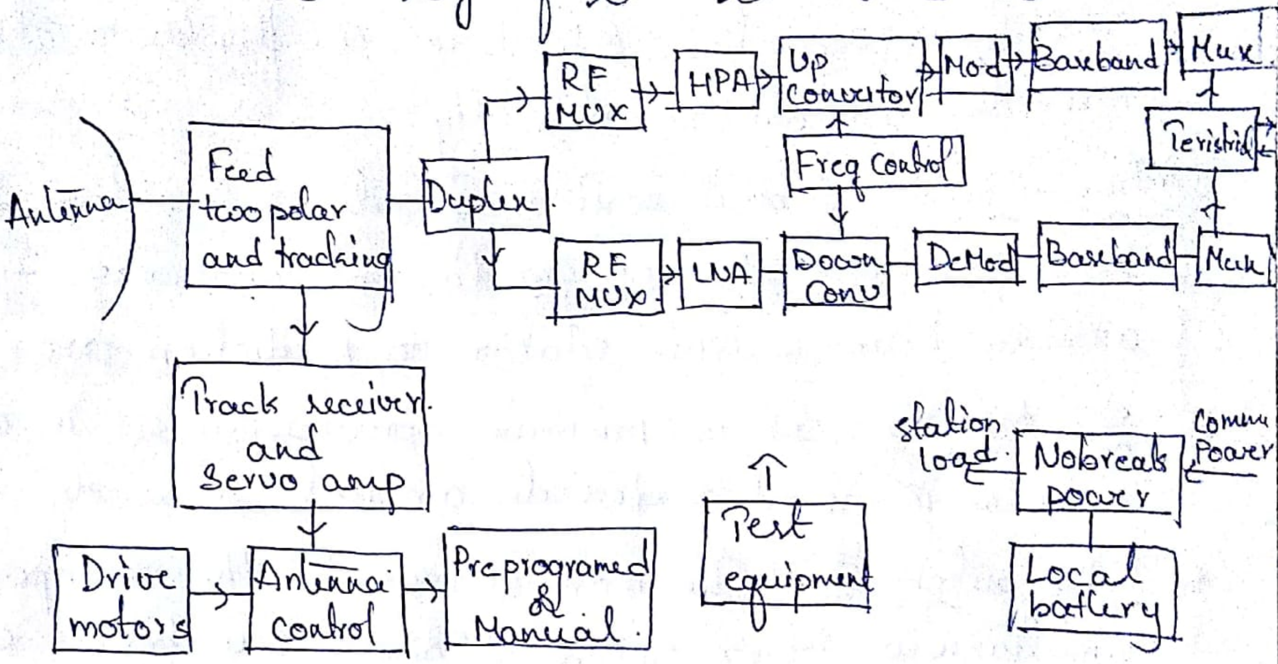


fig. Earth station Transmitter

Transmitters vary from very simple single transmitters of just few watts for data gathering purpose to multichannel transmitters using 10kw amplifiers.

When multiple transmitting chains are required, common wide band PWPA are used each channel can use a seperate high power amplifier

c) Explain various tracking systems used in Earth station

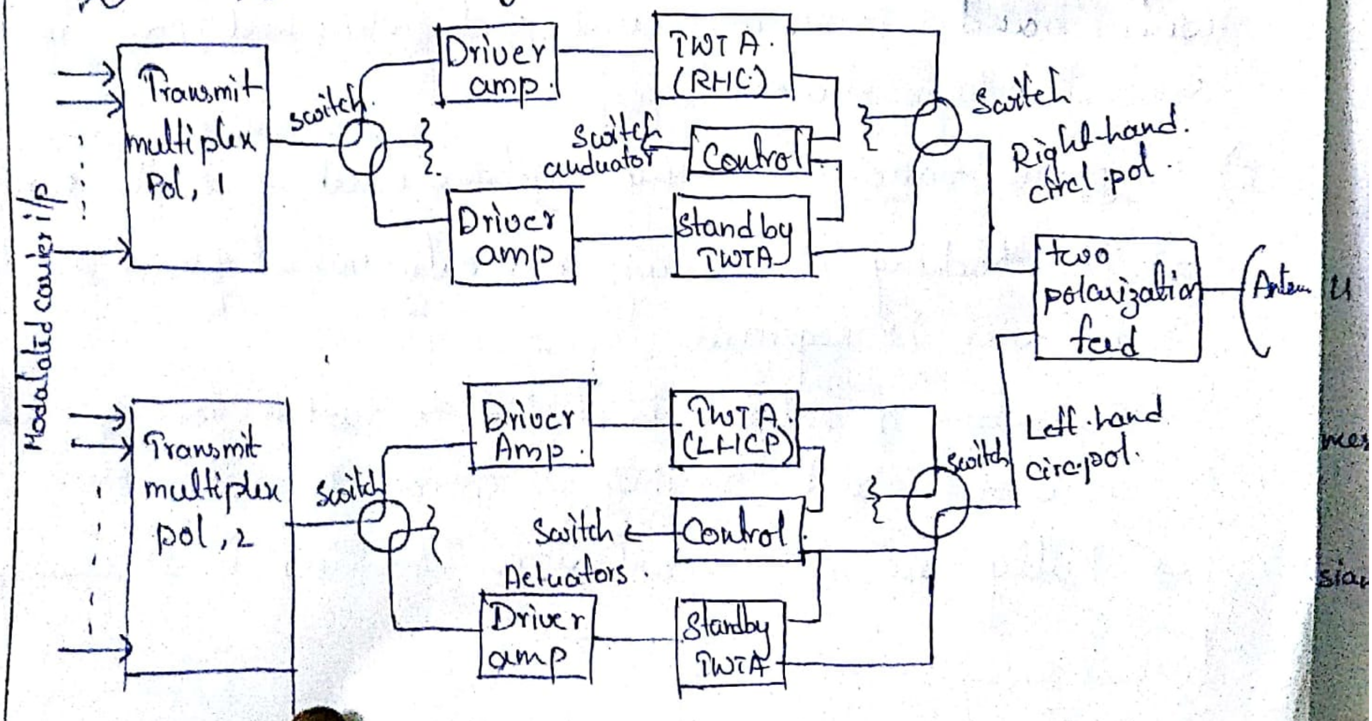
→ No tracking is necessary and only initial fixed pointing adjustment is required.

→ Repointing of antenna is needed to switch from one sat. to another and possibly to correct for sat motion.

→ Fully automatic continuous tracking is necessary.

1. Fixed pointing only: these systems use wide beam antennas
2. Occasional repointing: Adjustments are flexible to change manually without any difficulty
3. Preprogrammed: Orbital position of satellite is calculated with high precision allowing gravitational anomalies. If the antenna beam is wide relative to prediction error.
4. Step tracking: It is primitive servomechanism in which antenna is moved a discrete amount in a step.
5. Fully automatic: The most common is the monopulse or simultaneous lobing system, in which four beams are generated and combinations of those signals are used to generate left-right, up-down error signals. These error signals are detected, amplified and used to generate control signals to drive antenna.

b) Draw the block diag. of earth station transmitter.



Transmitter subsystem vary from very simple single transmitters of just a few watts for data gathering purpose to multichannel transmitter using 10kw amplifier, such as those found in Intelsat standard a stations. When multiple transmitter chains are required, common wideband travelling wave tube amp can be used, such as the arrangement, & each channel can use a seperate high power amp.

Two-for-one redundancy switching is shown, by way of example, with the TWTA. Numerous method and levels of redundancy exists. Similarly, multiplexer and filter arrangement are also multitudinous. and only one scheme is shown. Note that a tramitter carrier to intermodulation ratio that is not very high must be considered in calculating the overall $(C/N)_T$.

(5a) Describe features of moulnia orbit?

→ The former soviet union had a difficult comm design problem. Much of landmass is in far norther latitudes.

→ immense tracts of siberia lie inside the Arctic circle. To compound the problem futher, the country was spread across 11 time zones.

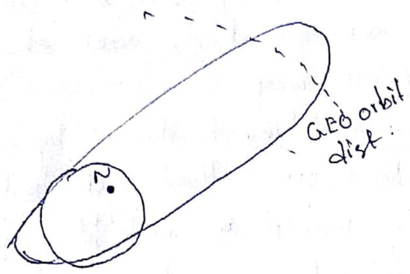
→ A GEO satellite cannot reach that far north over 11 time zones simultaneously. A type of orbit was required to provide good Comm. coverage over the former USSR. What transpired the Molniya orbit.

→ The word molniya means flash of lightning in Russian

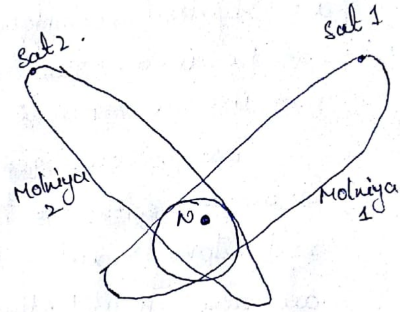
→ The apogee of molniya orbit is at an altitude of 39,152 km and perigee at 500km.

→ The orbital period is 11 hr and 38 Min. and inclination is 62.9°.

→ Two molniya orbits, with the planes of orbits seperated by 180°.



schematic of a Molniya orbit



Schematic of an operation Molniya System.

⑥ a) What are segments used in GPS describe in detail?

GPS architecture consists of three segments.

- Space segments.
- Control segment.
- User segment.

Space segment:

- GPS satellite constellation consists of a minimum of 24 Sat.
- Altitude of about 20,183km and takes 11 hr 58 min to orbit one time.
- There are 6 orbital planes, each consisting of a minimum of 4 Sat.
- The orbits are at an inclination of 55° with respect to the equator.

Control Segment :

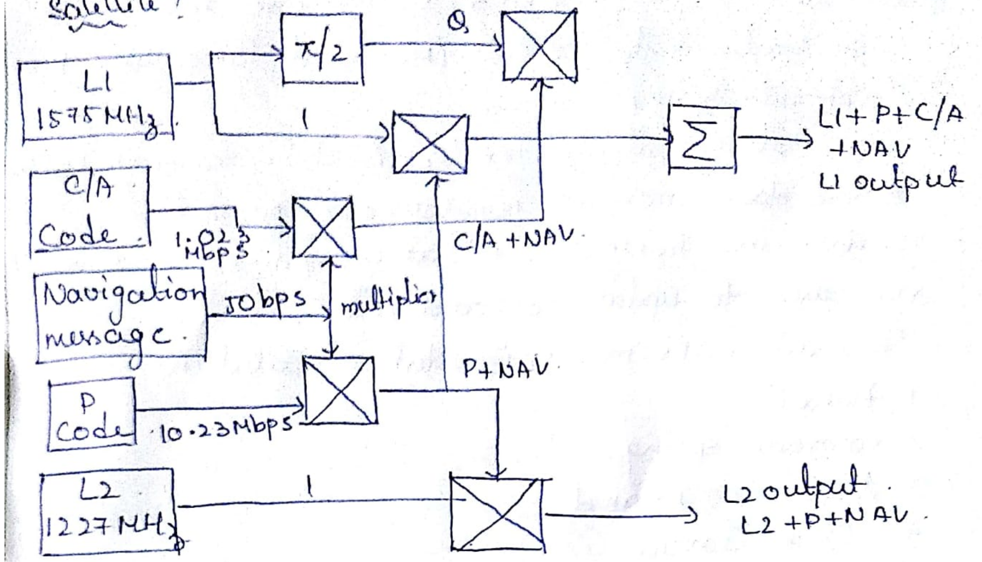
- The GPS is controlled by the US Air force from
  - The master control station (MCS), at falcon air base in Colorado springs, colorado.
- These stations calculate ephemeris data for each satellite, atomic clock error, and numerous other parameters.
- The data are transmitted to sat using a secure S-band link and used to update onboard data.
- There are 5 GPS monitoring station located in.

1. Hawaii
2. Colorado spring.
3. Ascension Island
4. Diego Garcia.
5. Kwajalein.

User Segment :

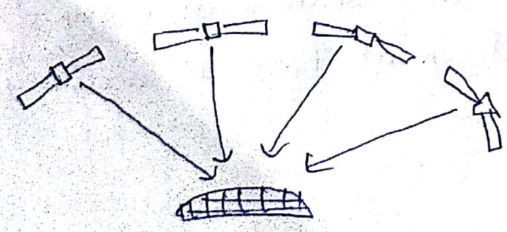
- The position of a GPS Rx is found by Trilateration
- The distance between a transmitter and receiver can be found by measuring the time it takes for a pulse of RF energy to travel. between the two.
  - The distance between a transmitter and receiver can be found by measuring the time it taken for a pulse of RF energy to travel between the two.
- To achieve. GPS location accuracy of 1m, timing measurements must have an accuracy of better than 3ns.

) Draw the block diag of GPS signal generation in a ... satellite?



) Describe GPS location principle with necessary diag & eq.

— Basic requirement of satellite navigation system →
4 satellite transmitting suitable coded signals from known position.
— 3 satellite → provide 3 dist. measurement.
1 satellite → to remove receiver clock error.
— R1 — range measurement from receiver to 3 known points
— Receiver lies at the intersection of 3 spheres, with satellite at the centre.



→ Range is calculated from the time delay incurred by the satellite signal in traveling from the sat to the GPS receiver, using known velocity of EM waves in free space.

→ To measure the time delay we should known the precise instant at which the signal was transmitted.

→ GPS satellite carry four atomic clocks → time standard → GPS time.

→ Accuracy of atomic clock – 1 part in 10^11.

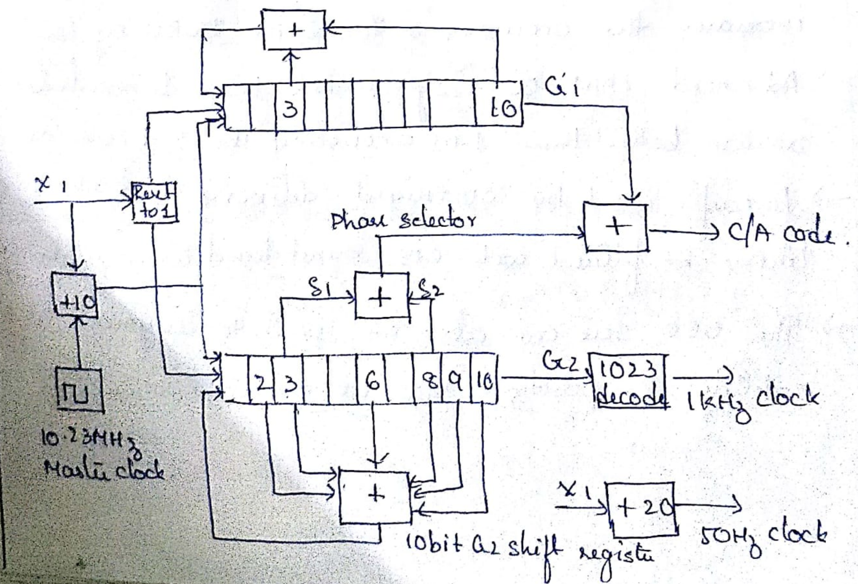
→ clock offset.

→ It is easy to remove the clock error.

→ 3 times measurement to define location (x, y, z)

→ 4th time measurement to remove receiver clock offset error T (x, y, z, T).

d) How C/A code is generated in GPS. describe it with a block diag.



Satellite ID number	GPS PRN Signal no.	Codephase Selection.	Codedelay chips	First 10 chips C/A octal.
1	1	2 ⊕ 6	5	1440
2	2	3 ⊕ 7	6	1620
3	3	4 ⊕ 8	7	1710
4	4	5 ⊕ 9	8.	1744
5	5	1 ⊕ 9.	17	1133
6	6	2 ⊕ 10	18.	1455
7	7	2 ⊕ 3.	139.	1131
8	8	3 ⊕ 4.	140.	1454
9	9	5 ⊕ 6.	141.	1626.
10	10.	6 ⊕ 7.	251.	1504.
⋮	⋮	⋮	⋮	⋮

c) What are advantages of differential GPS. describe its priciple

→ The WAAS GEO satellite transmits. signals which are in a. similar format to the L1 signal transmitted by a GPS sat.

→ Conventional GPS receiver with suitable software can extract the pseudorange error values from the WAAS sat.

→ Position data error from the C/A code, significantly increases the accuracy of the WAAS DGPS system.

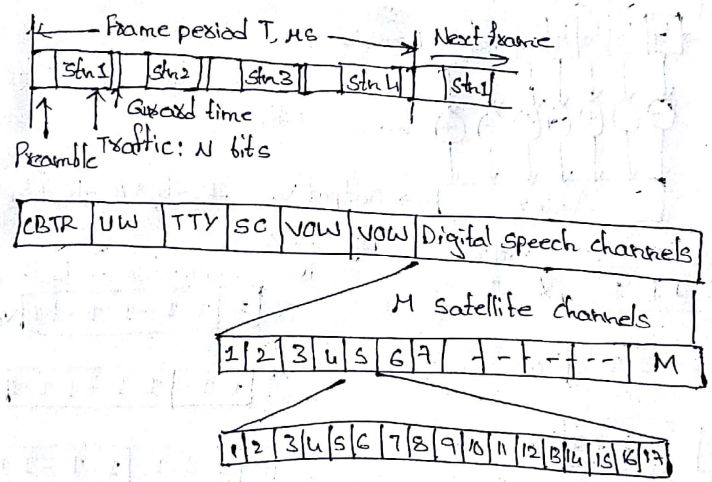
→ Advanced LAAS DGPS system has been demonstrated to achieve better than 1-m accuracy in 3 dimensions.

→ Aircrafts used by overnight. delivery companies will likely be fitted with GPS blind landing system first.

→ The GEO sat can also be used to augment GPS satellite for position measurements.

3a) Explain Principle of TDMA with its Frame structure?

A TDMA frame contains the signals transmitted by all of the earth station in a TDMA network. It has a fixed length, & is built up from the burst transmissions of each earth station, with guard times b/w each burst. The frame exists only in the satellite transponder & on the downlinks from the satellite to the receiving earth stations. Each station transmits a preamble that contains synchronization & other data essential to the operation of network before sending data.



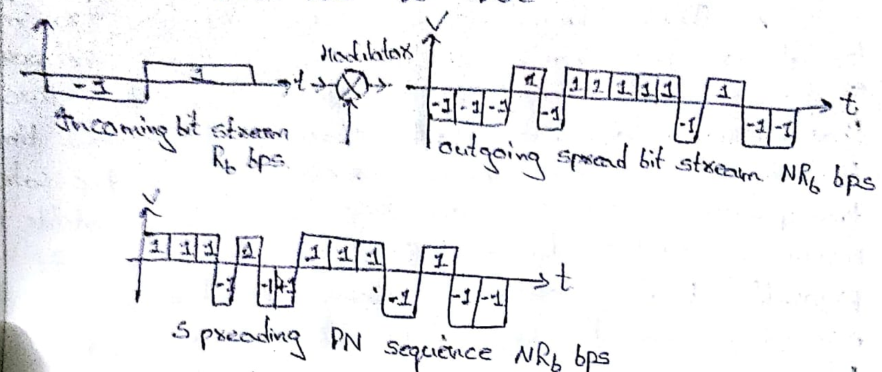
$$T_d = [T_{frame} - N(t_g + t_{pre})] / N \text{ seconds}$$

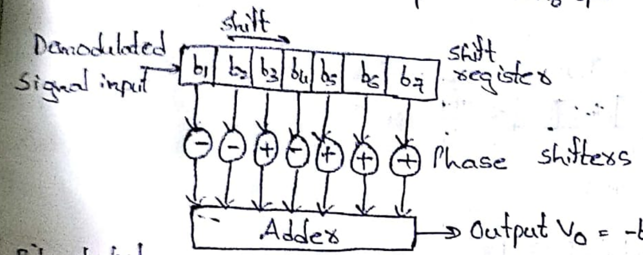
$$C_b = [T_{frame} - N(t_g + t_{pre})] \times R_b / T_{frame}$$

$$\eta = [T_{frame} - N(t_g + t_{pre})] \times \frac{R_b}{T_{frame} \times r_{sp}}$$

tasks easier.

Q8) What is the Principle of CDMA?

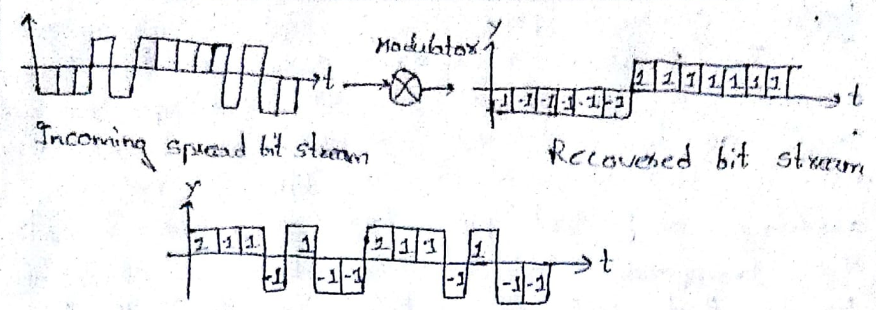




Output $V_0 = -b_1 - b_2 + b_3 - b_4 + b_5 + b_6 + b_7$

Bits clocked in	Register contents	output
0	1 1 1 1 1 1 1	$V_0 = 1$
1	-1 1 1 1 1 1 1	$V_0 = 3$
2	-1 -1 1 1 1 1 1	$V_0 = 5$
3	-1 -1 -1 1 1 1 1	$V_0 = 3$
4	1 -1 -1 -1 1 1 1	$V_0 = 3$
5	-1 1 -1 -1 -1 1 1	$V_0 = 1$
6	1 -1 1 -1 -1 -1 1	$V_0 = -1$
7	1 1 -1 1 -1 -1 1	$V_0 = -7$

Bits clocked in	Register contents	output
8	1 1 1 -1 1 -1 1	$V_0 = 1$
9	1 1 1 1 -1 1 -1	$V_0 = 3$
10	1 1 1 1 1 -1 1	$V_0 = 1$
11	-1 1 1 1 1 1 -1	$V_0 = 1$
12	1 -1 1 1 1 1 1	$V_0 = 3$
13	-1 1 -1 1 1 1 1	$V_0 = 1$
14	-1 -1 1 -1 1 1 1	$V_0 = 7$



Despreading PN sequence.

30) Explain : Syncrohization. in TDMA Network?

Earth stations operating in a TDMA network must transmit their RF bursts at precisely controlled times such that bursts from each of the earth stations arrive at the satellite in the correct sequence. This poses two problems: how to start up a new earth station that is joining the TDMA network, & how to maintain the correct burst timing. If the satellite is in low earth orbit, or if it is a GEO satellite with a rapidly changing range, each earth station will perceive a different carrier frequency & frame rate, & even a different frame length.

Maintaining synchronization with the TDMA frame is easier than initial synchronization when an earth station joins a TDMA network.

This is usually done by monitoring the TDMA frame at the transmitting station and adjusting the burst timing to keep the transmitted burst in the correct time slot in the frame.

In satellite switched & multiple beam satellite systems the cooperating control station must provide information to a new earth station that wishes to join the network.

The availability of a global GPS time standard with better than 1-μs accuracy has made some of these tasks easier.

3) Explain - On-board processing in Satellite communication?

The discussion of multiple access so far has assumed the use of a bent pipe transponder, which simply amplifies a signal received from earth & retransmits it back to earth at a different frequency. The advantage of a bent pipe transponder is flexibility. The transponder can be used for any combination of signals that will fit within its bandwidth. The disadvantage of the bent pipe transponder is that it is not well suited to uplinks from small transmitting earth station & a large hub station via a bent pipe GEO satellite transponder. These will usually be a small rain fade margin on the uplink from the transmiting station because of its low EIRP.

Baseband Processing Transponders.

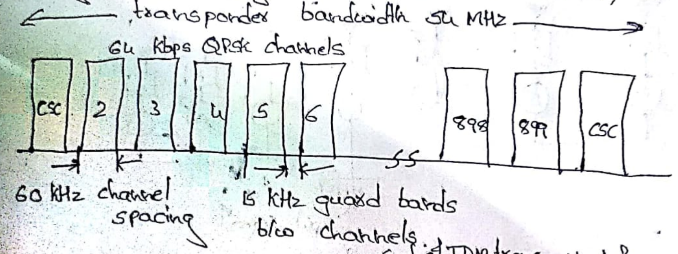
A baseband processing transponder has a receiver & transmitter similar to those found in an earth station. The received signal from the uplink is converted to an intermediate frequency & demodulated to recover the baseband signal, which is then processed & reassembled. The baseband signal is modulated onto a carrier at a downlink frequency & transmitted back to earth.

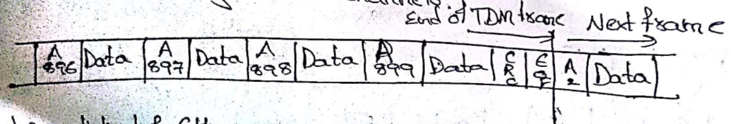
Satellite Switched TDMA with Onboard Processing

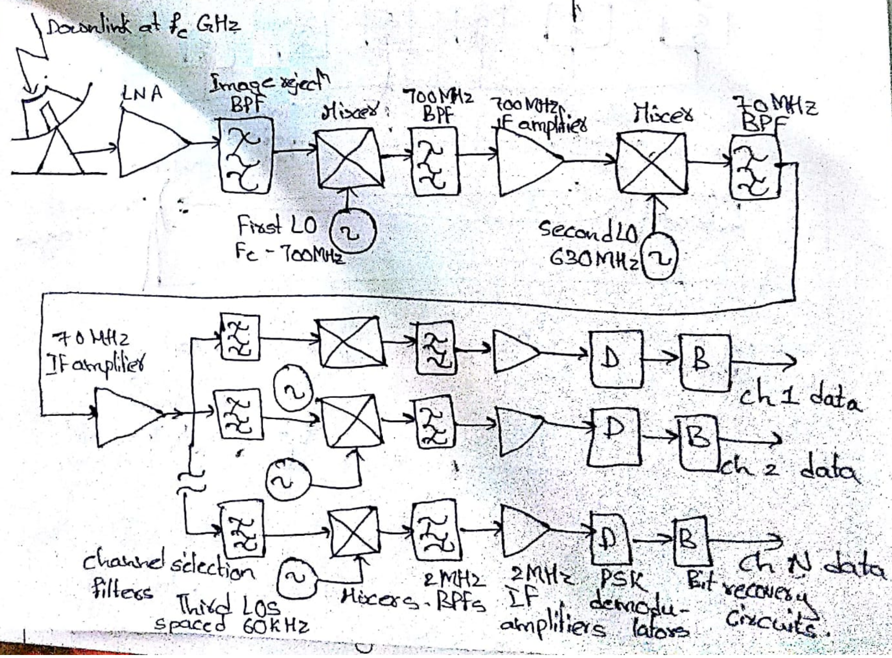
Baseband processing is essential in satellites using satellite switched TDMA, because data packets must be routed to different antenna beams based on the address of the destination earth station. The data in such systems is always sent in packets which contain a header & a traffic section. The header contains the address of the originating station & the address of the destination earth station.

3f) Describe the features of DAMA?

Demand access can be used in any satellite communication link where traffic from an earth station is intermittent. An example is an LEO satellite system providing links to mobile telephones. The two-way telephone channel may be a pair of frequency slots in a DA-SCPC system, a pair of time slots in a TDM or TDMA system, or any combination or FDMA, TDM & TDMA.

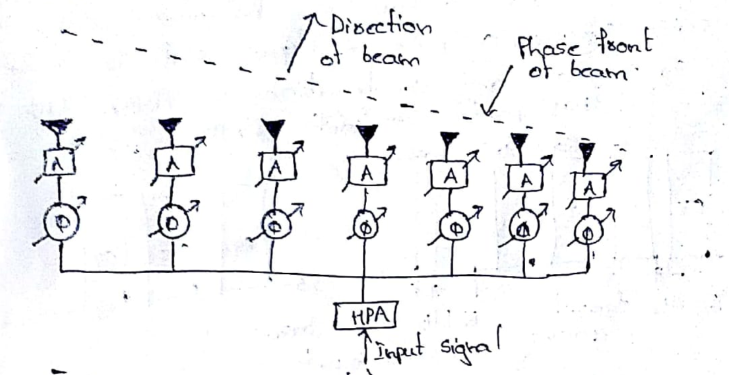




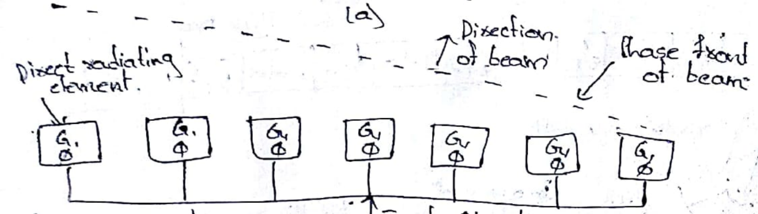


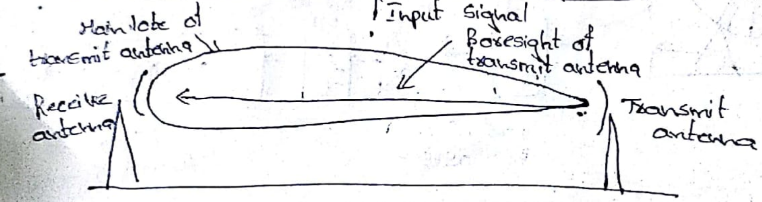
2a Explain off-Axis, Scanning?

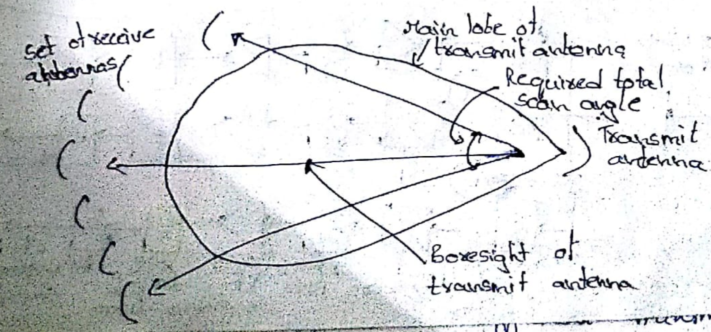
The design of a point-to-point wireless communications system requires that the antenas at either end be directed towards each other for maximum gain advantage. This was the approach adopted for the fixed service (FS), the terrestrial microwave communications service.



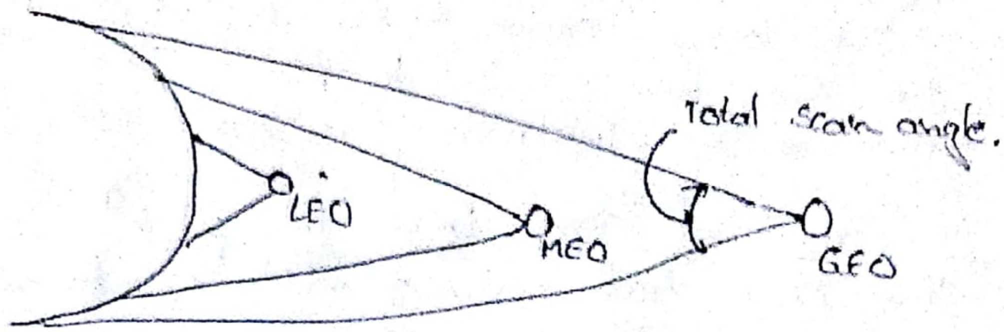
(a)



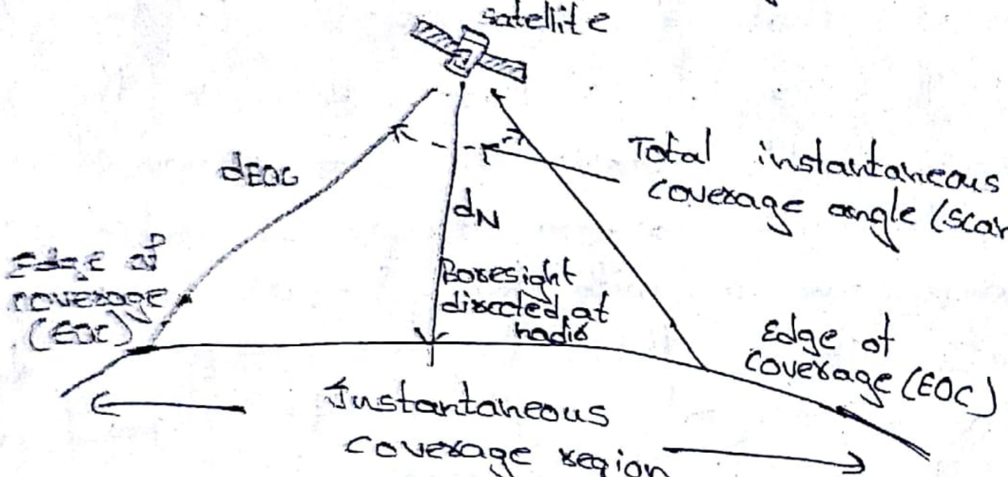


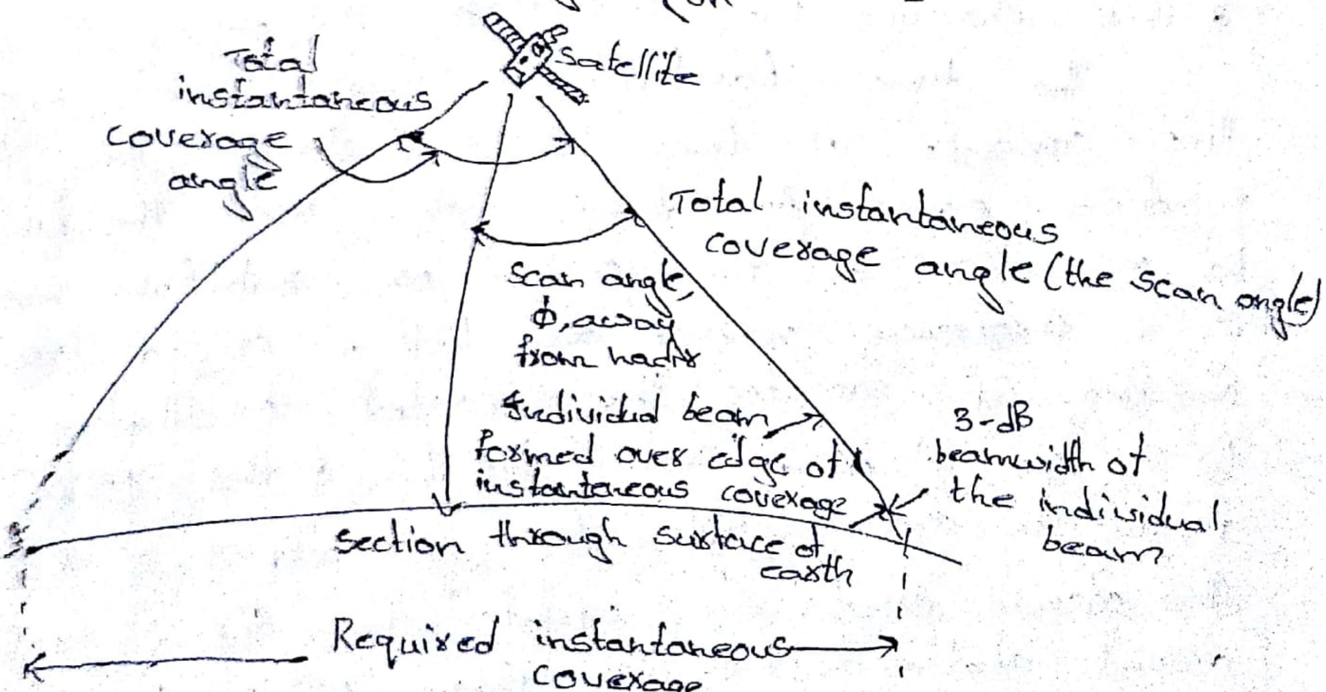


A satellite is a prime example of a point-to-multipoint system.



A number of factors influence the coverage of a phased array antenna from a given satellite.





→ Scan loss for a phased array antenna normally follow the relationship

$$\text{- Scan loss} = (\text{cosine } \phi)^k$$

where ϕ is the scan angle off boresight & K is an empirical number b/w 1.2 & 1.5.

$$-\text{Scan loss} = (\text{cosine } 57.2)^{1.3} = 0.4507 \Rightarrow -3.5 \text{ dB}$$

Thus the scan loss is 3.5 dB for a beam transmitted to the edge of an instaneous coverage of $\pm 57.2°$.

2b what is effect of clock bias in GPS?

The clock bias value τ which is found as part of the position location calculation process can be added to the GPS receiver clock time to yield a time measurement that is synchronized to the GPS time standard. The crystal oscillator used in the GPS receiver is highly stable over a period of a few seconds, but will have a frequency which changes with temperature & with time. Temperature changes cause the quartz crystal that is the frequency determining element of a crystal oscillator to expand or contract & this changes the oscillator frequency.

The time standard on board each GPS satellite consists of two cesium clocks plus two rubidium clocks. An atomic clock uses the fundamental resonance of the cesium or rubidium molecule as a frequency refence to lock a crystal oscillator. In the GPS satellites, the master oscillator is at 10.23 MHz; all code rates, the L1, & the L2 RF frequencies are multiples or submultiples of 10.23 MHz. The atomic clocks are updated by the controlling ground stations to keep them within 1µs of Universal Time Coordinated, & the navigation message broadcast by each satellite contains information about its current clock errors relative to GPS time.

2d what are types of DOP's in GPS Measurement?
→ Horizontal DOP (HDOP) → most important DOP factors. It provides error metric in x & y directions.
→ HDOP → 1.5 (typical value)
→ Horizontal measurement error for a C/A code RX → 14.3 m with SA off. 50 m with SA on (Both values are in 1DRMS)
→ 2DRMS accuracy of 28.6 m with SA off.
GDOP :- Geometrical Dilution of Precesion (measure of accuracy in 3-D position & time)
PDOP : Position Dilution of Precision (measure of accuracy in 3-D position), also called spherical DOP.
HDOP : Horizontal Dilution of Precision (measure of accuracy in 2D position, for example latitude & longitude)
VDOP : vertical Dilution of Precision (measure of accuracy in 1 D position Height)
TDOP : Time Dilution of Precision (measure of accuracy in Time)

2e what are differences among SPS & PPS in GPS?
The Precise Positioning Service (PPS)
PPS Receivers track both P-code & C/A code on L1 & L2 frequencies.
PPS is used mainly by military users
Since the P-code is encrypted as Y-code before transmission & requires decryption equipment in the receiver.
Standard Positioning Service (SPS)
SPS receivers track the C/A code on L1 only
SPS is used by general public.
→ The (P(Y)) & C/A codes tramitted by each satillite create direct sequence spread spectrum signals which occupy the same frequency bands.

→ Both C/A & P codes are publicly available, but P-code can't be recovered in a GPS Rx without a knowledge of the Y-code decryption algorithm.

(1d) How delay and throughput can be effected in satellite communication?

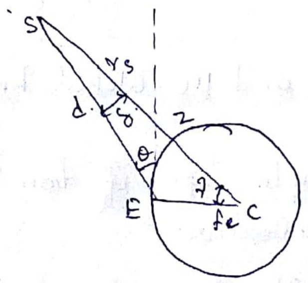
Delay in a comm. link is not normally a problem unless the interaction between the users are very rapid - a few milliseconds apart in response time. Long delays, such as those associated with manned missions to the moon, required the development of agreed procedures, much like tactical military or police communications require specific hand off code word such as "over" to signal the end of one user's input. For most commercial satellite links that are over long distances, particularly those with satellite in geostationary orbit, the main problem was not delay, but echo. A mismatched transmission line will always have a reflected signal. If the mismatch is large, a strong echo will return. Over a GEO satellite link, the echo arrives back in the telephone headset about half a second after the speaker has spoken, and usually while the speaker is still speaking. This will interrupt the speaker and the conversation becomes fragmented. The development of echo suppressors and, even better, echo canceller, solved the problem.

Scanned by CamScanner

8 h) Explain the factors involved while considering the coverage frequency of satellite.

General Aspects :- In some cases, the designer of a satellite system has few degree of freedom in designing a pay load to provide optimum coverage.

Frequency band :- low earth orbit sat systems providing data and voice services to mobile user tend to use the lowest available RF freq. The EIRP required by the sat transponder establish a given C/N ratio in mobile receiver is proportional to square of the freq of down link.

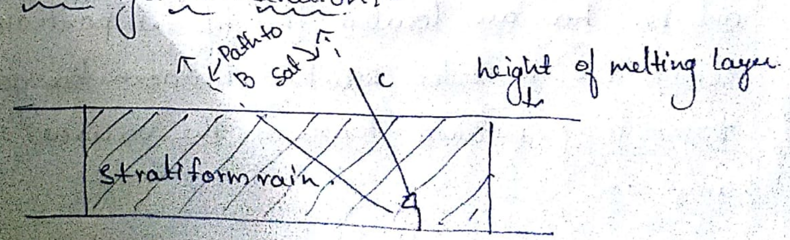


$F = P_t G_t / A$

$A_e = G_r \lambda^2 / 4\pi$

$$P_r = \frac{P_t G_t G_r \lambda^2}{4\pi A} \text{ watts}$$

Elevation angle consideration :-



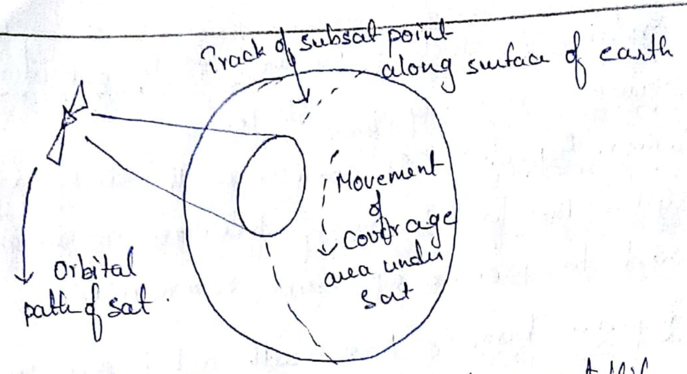


Illustration of coverage area under a satellite.

Number of beams per coverage :- The very small spectrum allocation available for MSS system (<50 MHz) and the many competing systems that aim to provide mobile sat service.

Iridium, Globalstar, and ICO-Global, known generarically as big LEO's.

New ICO is an MSS system spun off from the international maritime satellite orgnisation.

Off Axis Scanning :- The design of a point to point wireless communications system requires that the antenna at either end be directed towards each other for maximum gain advantage. The transmitting antenna has to communicate with more than one receiving antenna, and these antennas ~~has~~ are located in different positions, a compromise must be reached between the gain of transmitting antenna towards the various receiving antennas.

Determination of optimum orbital altitude :- The location at the edge of coverage within the instantaneous Coverage region normally present the greatest problem in the design of a satellite service. It is at the edge of coverage that the power flux density into the user terminal is at its lowest.

Radiation safety and satellite Telephone :- The FCC mandates strict limits on radiated power levels through out the spectrum. The office of engineering of the FCC has also posted an RF safety program on the website, which provides guidance on the specific absorption rate (SAR) for wireless phones and devices.

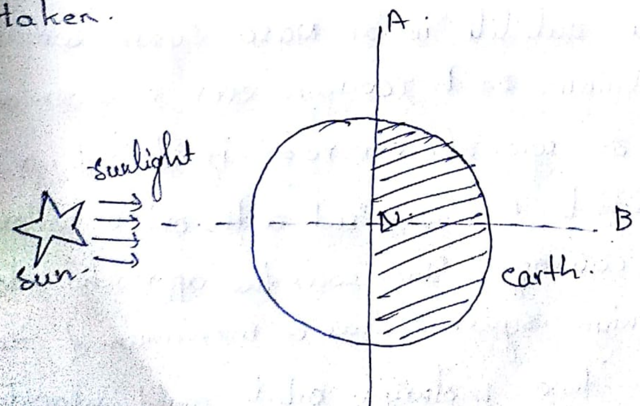
Projected NGSO system customer service base :-

A single satellite in an NGSO System will not provide continous 24-h coverage over a given area. If a national or regional coverage is desired, a Constellation of NGSO satellite is required with orbits tailored to match the coverage. This was the approach adopted for the Molniya system where a minimum of two satellites in two molniya orbits could provide continous 24h service. Most of the new NGSO System has been aimed at mobile user. For mobile user, the problem is to generate sufficient transmit

Power in terminal without exceeding the limits.

1 c) **What is Sun synchronous orbit?**

A Sun synchronous orbit is a special form of low earth orbit where the plane of the orbit minimum a constant speed angle with the direction to the sun. Some satellite missions require a specific orbit with such a constant relation to the direction of the sunlight. One example is an earth resource satellite that requires a large amount of direct sunlight to illuminate the region below the satellite so that photographs can be taken.



Examples of two Sun synchronous orbits

This particular sunset-sunrise orbit always has the satellite illuminated by the sun while the region below it has the scan at almost gazing incidence.

(1a) What are properties of DSSS Code?

In a DS-SS CDMA system where there are a number of CDMA signals present at the in-put to each receiver, it is usual to treat the unwanted CDMA signals as noise, If a receiver has an input containing Q signals, each at a power level C watts, and the receiver thermal noise power is N_t watts, the $(C/N)_{in}$ ratio for the wanted signal is approximately.

$$(C/N)_{in} = 10\log_{10}[C/(N_t + (Q-1)\times C)]\,dB$$

where $[N_t + (Q-1)\times C)$ watts is the total noise at the receiver input. The term $(Q-1)\times C = 1$ watts is the power of the $Q-1$ interfering CDMA signals. The correlator in the receiver adds a processing gain of $10\log_{10} M$ dB to the input C/N as seen in Eq. (6.14) and outputs a correlated a signal with a signal-to-noise ratio $(S/N)_{out}$. Hence, the output S/N ratio for the bit stream in the receive is given by

$$(S/N)_{out} = 10\log_{10}[C/(N_t + (Q-1)) \times C)] + 10\log_{10} M\,dB$$

If Q is a large number, it is portable that

$[N_t + (Q-1) \times C)] + 10\log_{10} M\,dB \approx (Q-1) \times C$ watts,

at then Eq. (6.16) reduces to

$$(S/N)_{out} = 10\log_{10}[1/(Q-1)] + 10\log_{10} M = 10\log[M/(Q-1)]\,dB$$

If Q is also large such that $M \gg 1$ then

$$(S/N)_{out} = 10\log_{10}(M/Q)\,dB$$

Examination of Eq. shows that M, the number of chip in the spreading code must be 10 times larger than Q if the output S/N ratio is to be greater than 10dB and that the system capacity is independent rate of each signal given by

$$R_b = R_c/N = B/[N \times (1+\alpha)].$$