IV/IV B.Tech Regular/Supplementary Degree Examination

Scheme of satellite Communications (14EC 705D)

November-2019

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I answer all questions 12×1M = 12M

a) Freq allocations for satellite services

L-band (1–2 GHz) Global Positioning System (GPS) carriers and also **satellite** mobile phones, Such as Iridium, Inmarsat providing **communications** at sea, land and air.

C-band (4–8 GHz) , X-band (8–12 GHz) ,Ku-band (12–18 GHz) , Ka-band (26–40 GHz)

The C band is used for fixed satellite services, and no direct broadcast services are allowed in this Band. The VHF band is used for certain mobile and navigational services and for data transfer from Weather satellites. The L band is used for mobile satellite services and navigation systems. The 6/4 GHz frequencies (means. the 6-8 GHz slot and the 4-6 GHz frequency slot) are used for C band Transmissions. The higher frequency 6-8 GHz slot is for uplink signals to the satellite, and the lower Frequency 4-6 GHz slot is used for downlink signals to earth receivers. For the direct broadcast service in the Ku band, the frequency used is 14/12 GHz. Many communications satellites use C-band and Ku-band.

b) satellite to continue in its orbit is due to(does not fall back to Earth) i.e gravitational force acting on satellite must be equal to inertial force

c) Apogee is the farthest point of satellite in its orbit
Perigee is the shortest point of satellite in its orbit

d) ASLV ,PSLV ,GSLV , ARIANE, etc

e) Transponder function is to Receive and Transmit signals from different earth stations.

f) It is the geosynchrous transfer orbit , elliptical in nature to transfer a GEO satellite from LEO to GEO orbit

g) The size of VSAT earth station antenna is less than 2.4m

h) Guard time is the time interval between different time slots of the earth station to avoid overlapping the transmissions of different earth stations.

i) No inter symbol interference and do not require synchronization between different earth stations to transmit

j) Trilateration is the method of drawing 3 arcs with 3 satellite's pseudo ranges to measure the exact position of GPS receiver.

k) Advantages L band frequencies in GPS satellites are

1. The low **frequency** range makes it easier to design and source components. The Components for this **band** are less expensive than those for higher **frequency Bands**.
2. **L band** waves are used for **GPS** units because they are able to penetrate clouds, Fog, rain, storms, and vegetation

l) Navigation file consists of large amount of information which optimizes acquisition of satellite signals and to calculate position. It consists of 1500 bits sent as 30 s frame with 5 sub frames like Header with subframes1,2,3,4,5

UNIT-I

2.a) Kepler's laws of planetary motion **(6M)**

Firstlaw:

- The path followed by a satellite around the primary will be an ellipse.
- An ellipse has two focal points shown as *F*1 and *F*2.
- The center of mass of the two-body system, termed the *barycenter,* is always centered on one of the foci.
- In our specific case, because of the enormous difference between the masses of the earth and the satellite, the center of mass coincides with the center of the earth, which is therefore always at one of the foci.
- The semimajor axis of the ellipse is denoted by *a,* and the semiminor axis, by *b.* The eccentricity *e* is given by

$b^2 = a^2 (1-e^2)$ where a= semi major axis of ellipse

b= semi minor axis of ellipse

e= eccentricity of ellipse

Second law: The line joining the centre of the earth and the satellite sweeps out equal areas in equal Time intervals.

Third law: The Square of the periodic time of satellite in orbit is proportional to the cube of of the Mean radial distance between two bodies

$T^2 \ \alpha \ R^3$

Where T =time period, R= Mean radial distance

2.b) Find orbit eccentricity e

a=16000km

Difference b/n Apogee and Perigee = 25000km =2a

Earth radius, R= 6360km

$a^2 = b^2 (1-e^2)$

$e^2 = 1- (a/b)^2$

$e = sqrt (1- (a/b)^2)$

$2a= 2r_e + h_p + h_a$

h_p = Height of Perigee

h_a = Height of Apogee

Data insufficient to find eccentricity (e)

OR

3.a) Orbital perturbations:

The Satellite in orbit is affected by

1. Asymmetry of the Earth's Gravitational field,
2. Gravitational fields of the Sun and Moon
3. Solar radiation pressure
4. Atmospheric drag (not important in GEO Satellite) of the Earth

The above forces cause the true orbit of satellite to be different from designed one.

If these perturbations are unchecked then the sub satellite point changes and moves with time. They must be checked continuously. Effects of earth's oblateness on orbital inclination of geosynchronous satellite:

Since Earth is not a perfect sphere or perfect ellipse, it will have asymmetric mass distribution.Hence its gravitational potential does not have simple 1/r , (r=radial distance) dependence as assumed for Gravitational potential. Earth's gravitational potential is expressed more accurately by Legendre polynomial J_n in ascending power's of Earth's radius to orbital radius as $J_2\ (r_e/r)^2$. .This term causes the geosynchronous satellite to drift toward and circulate around the nearer of two stable points.

They correspond to two sub satellite points of longitudes of 252^0E or105^0 W and 75^0E, locations called graveyards in space. These two points are used to collect old satellites at the end of their life time or whose station keeping fuel exhausted.Due to the regions where the average density of earth appears to be higher and also due to equatorial bulges there are 4 equilibrium points in geostationary orbit.

3 b) Semi major axis (a) = 42164.8km (6M)

Eccentricity (e) = 0.0011

find Average angular velocity , **n = 2πa/ T**

$$T^2 = (4\pi^2 a^3 / \mu)$$

UNIT-II

4.a) Description of TTC facilities of a satellite communication system (6M)

- **MAJOR FUNCTIONS**
  - **Reporting spacecraft health**
  - **Monitoring command actions**
  - **Determining orbital elements**
  - **Launch sequence deployment**
  - **Control of thrusters**

Control of payload (communications, etc

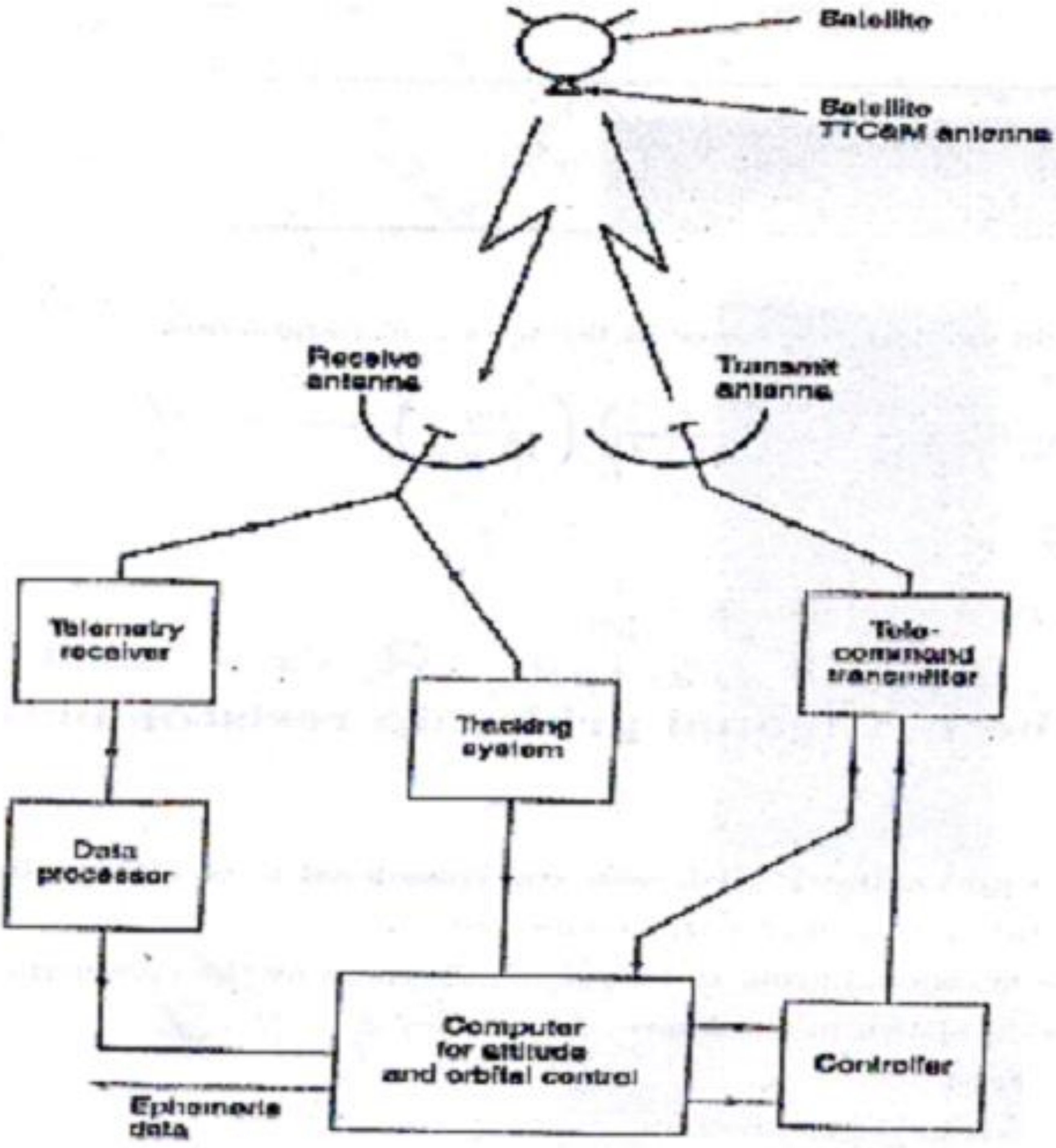
1. **TELEMETRY**
   MONITOR ALL IMPORTANT
   - **TEMPERATURE**
   - **VOLTAGES**
   - **CURRENTS**
   - **SENSORS**

- **TRANSMIT DATA TO EARTH**
- **RECORD DATA AT TTC&M STATIONS**
- **TWO TELEMETRY PHASES OR *MODES***
  - **Non-earth pointing**
    - **During the launch phase**
  - **Earth-pointing**
    - **During parts of the launch phase**
    - **During routine operations**
    TRACKING
- **MEASURE RANGE REPEATEDLY**
- **CAN MEASURE BEACON DOPPLER OR THE COMMUNICATION CHANNEL**
- **COMPUTE ORBITAL ELEMENTS**
- **PLAN STATION-KEEPING MANEUVERS**
- **COMMUNICATE WITH MAIN CONTROL STATION AND USERS**

2.TRACKING : To determine the satellite coordinates like Range, Azimuth and Elevation angles continuously. Then the satellite may be assumed in correct orbit and may be controlled from earth.

3.COMMAND :

- **DURING LAUNCH SEQUENCE**
  - **SWITCH ON POWER**
  - **DEPLOY ANTENNAS AND SOLAR PANELS**
  - **POINT ANTENNAS TO DESIRED LOCATION**
- **IN ORBIT**
  - **MAINTAIN SPACECRAFT THERMAL BALANCE**
  - **CONTROL PAYLOAD, THRUSTERS, ETC.**

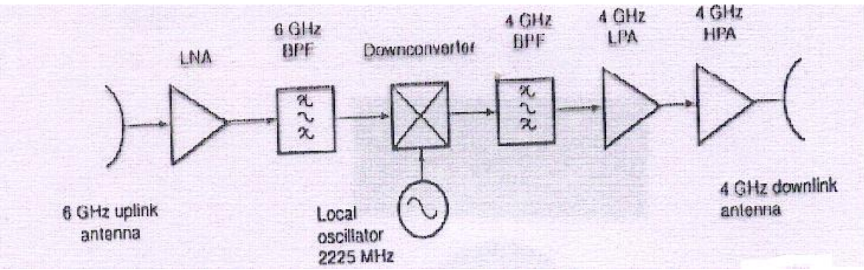

Satellite
Satellite
TTC&M antenna
Receive
antenna
Transmit
antenna
Telemetry
receiver
Tracking
system
Tele-
command
transmitter
Data
processor
Computer
for attitude
and orbital control
Controller
Ephemeris
data

4 b) Block diagram and explanation satellite communication subsystem (6M)

It is part of the space segment.it is the revenue generating system for the satellite owner. It may single conversion (6/4 GHz) or double conversion (14/11GHz) systems

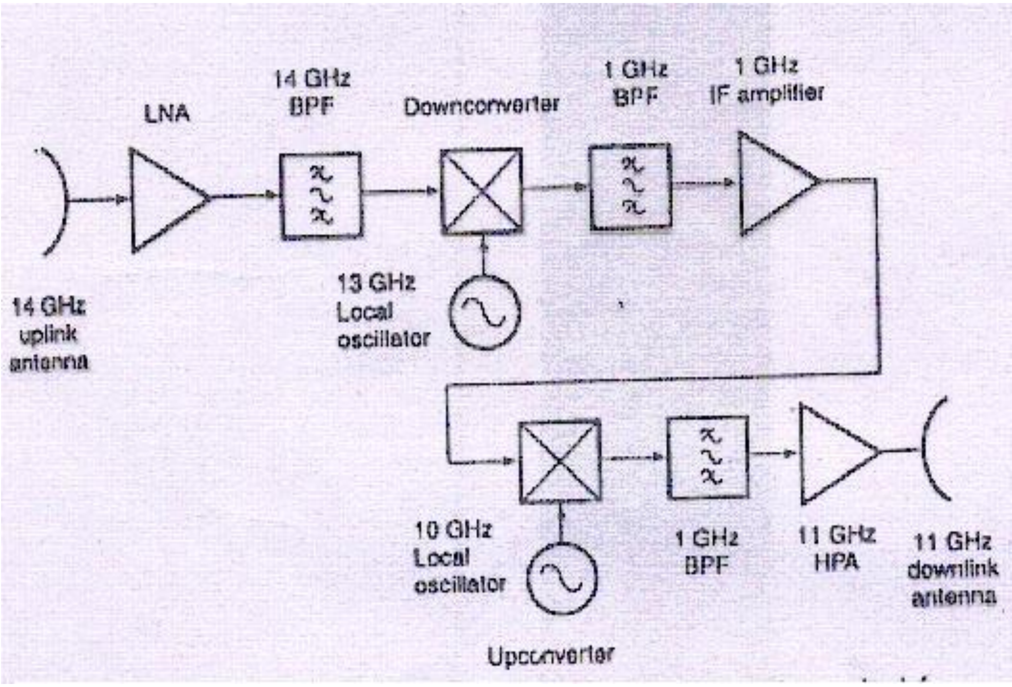
1. Single conversion process

Space segment



2..Double conversion process

Space segment



OR

5 a) Derive link equation and find the expression for C/N and G/T ratios

The output power of a transmitter HPA is:

P_{out} **watts**

Some power is lost before the antenna:

$P_t = P_{out}/L_t$ **watts reaches the antenna**

P_t **= Power into antenna**

The antenna has a gain of:

G_t **relative to an isotropic radiator**

- **This gives an effective isotropic radiated power of:**

$EIRP = P_t G_t$ **watts relative to a 1 watt isotropic radiator**

Power Flux Density, $F = \frac{EIRP}{4\pi R^2} = \frac{P_t G_t}{4\pi R^2}$ W/m^2

The power available to a receive antenna of area A_r m^2 we get:

$$P_r = F \text{ x } A_r = \frac{P_t G_t A_r}{4\pi R^2}$$

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

$$\boxed{P_r = \frac{P_t G_t G_r}{L_p L_a L_{ta} L_{ra} L_{pol} L_{other} L_r}}$$

- L_a = Losses due to attenuation in atmosphere
- L_{ta} = Losses associated with transmitting antenna
- L_{ra} = Losses associates with receiving antenna
- L_{pol} = Losses due to polarization mismatch
- L_{other} = (any other known loss - as much detail as available)

  Lr = additional Losses at receiver (after receiving antenna

5.b)The types of antennas used in satellites are (6M)

1. Wire type antennas: these are mono poles and dipoles type.

They are primarily used at VHF and UHF bands to provide communication for the TT&C systems.They must be positioned with great care on the body of satellite to provide omnidirectional coverage.

2. Horn antennas: these are used at microwave frequencies.

They generate wide beams for global coverage.They provide good impedance match between Waveguide and free space. Horns may be used as feeds for Reflectors. The gains obtained from Horns is not more than 23 dB and beam widths not less than 10^0.

3 Reflector antennas: They are usually illuminated by one or more Horn antennas to have more Effective aperture area. For maximum gain it is required to generate a plane wave in the Aperture of the reflector like Paraboloid.

Aperture gain = $\eta(4\pi A_e/\lambda^2)$
Where η is 50% to 65% for reflectors with single feedsand η will be 65% to 80% for Horn Antennas.
A_e is effective aperture area
λ is operating wavelength
Beam width of antenna is given by $\Theta_{3dB} = (75\ \lambda/ D)$ in degrees
For antennas with η=55% the gain will be $G= 30{,}000/(\Theta_{3dB})^2$
Practically one beam per all earth stations is used by using Zone coverage beams and Orthogonal polarizations within the same beam to provide more channels per satellite. Each Reflector i s illuminated by a complex feed that provides the required beam shape to permit Communication between earth stations within a given coverage zone.

4. Frequency reuse antennas:

These are also used with spatial beam separation and orthogonal polarization. They allow a Single design of antenna to be fitted to satellite which will operate at different longitudes and Serve different geographical areas. With switched beam antenna technology we can have more EIRP at receiving earth stations.

UNIT-III

6.a) Explain about TDMA (6M)

1. It is the most efficient method today for Transmitting digitally modulated carriers (PSK signals).
2. Each earth station transmits a short burst of a digitally modulated carrier during a precise time slot with in a TDMA frame.
3. Each station's burst is synchronized so that it arrives at the satellite transponder at a different time.
4. Only one earth station's carrier is present in the transponder at any given time , which avoids a collision with another station's carrier.
5. The transponder is an RF to RF repeater , simply receives the earth station transmissions , amplifies them and then retransmits them in a downlink beam that is received by all the participating earth stations.

Each earth station receives the bursts from all other earth stations and must select from them the traffic destined

The TDMA Frame consists of following segments.

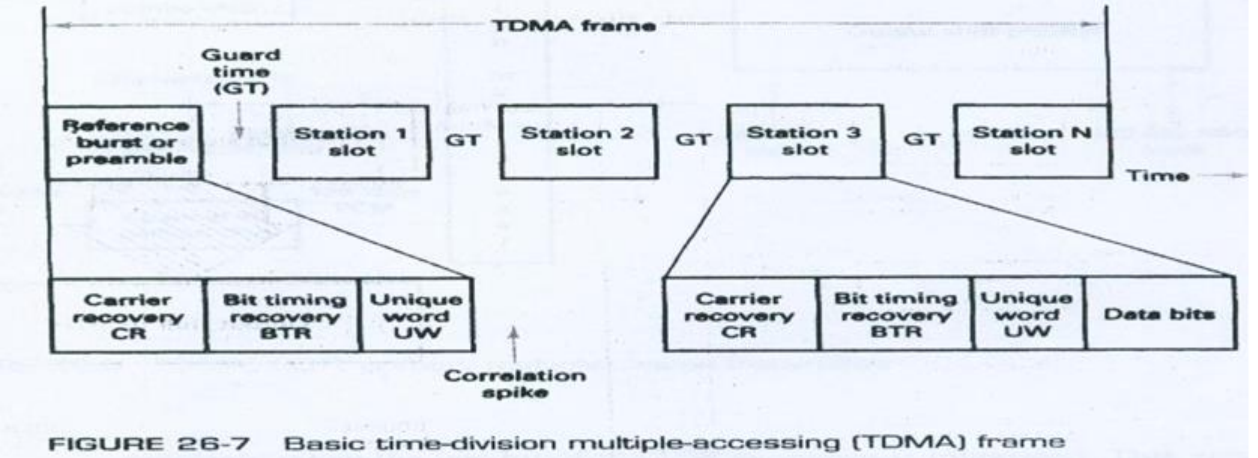


FIGURE 26-7 Basic time-division multiple-accessing (TDMA) frame

Reference Burst or Preamble

This is used for synchronization. There can be more than one reference bursts. It contains three different sequences.

(i) **Carrier recovery sequence (CR) :** It contains information of frequency and phase of carrier. The earth stations generate local carrier from this sequence.

(ii) **Bit timing recovery (BTR) :** From this sequence earth stations recover the clock.

(iii) **Unique word :** This sequence is used for timing reference for synchronization of transmission of the reference burst. Unique word is the string of twenty successive 1's and it is terminated by zero.

Unique word contd.

- Each earth station Rx demodulates and integrates the UW sequence.
- After the last bit of unique word is integrated, it reaches a threshold level and the Threshold Detector generates a correlation spike at its output which is at the exact time where uw sequence ends.
- Each earth station synchronizes the transmission of its carrier to the occurrence of the UW correlation spike.
- Each station waits a different length of time before it begins transmitting. Hence no two stations will transmit at the same time.
- Each station precedes the transmission of data with a preamble which is equivalent to ref burst. It is for each earth station's transmissions must be received by all other earth stations and all stations must recover carrier and clocking information prior to demodulating the data
- If demand assignment is used , a CSC also must be included in the preamble

6 b) Operation of typical VSAT system: (6M)

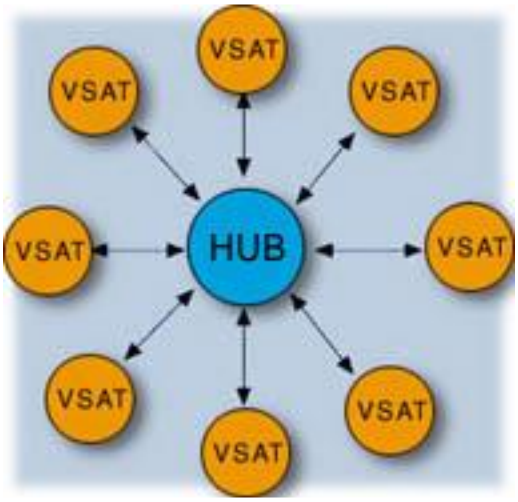
Early Earth Stations in commercial systems were very large and expensive (30 m).

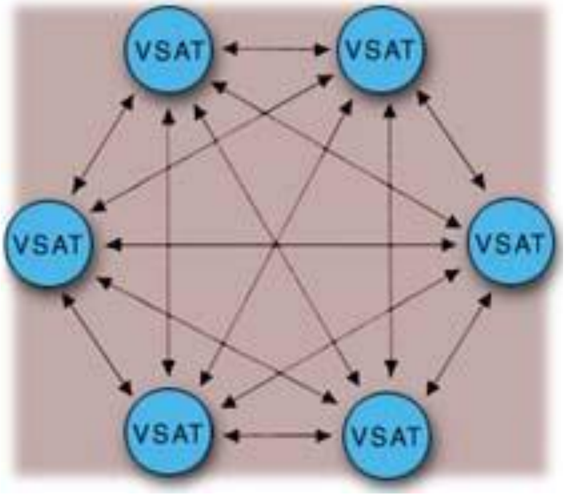
- Need to make system more affordable to end user:
    - Increased transmit power from satellite.
    - Higher frequencies

  The Result: Smaller ES antenna size required.
- TheUnderlying objective of VSAT Systems: **To bring the service directly to the end-user** Major reasons for doing this is to
- Reduce hierarchical distribution network (make more efficient and faster - e.g. POS credit)
- Reduce distribution costs
- "Leapfrog" technology in developing countries (e.g. VSAT/WLL)
- **SOLUTION**
- Distribute links to communities by satellite/VSAT
- Use Wireless Local Loop from the VSAT
- An economic advantage of VSAT/WLL solution depends primarily on user density.
- Physical distances, major transportation routes, and geographic barriers, as well as the The
- Individual country's demographics and political influences, can alter the breakpoints.
- Hard to reach areas
- Reliability
- Time to deploy (4-6 months vs. 4-6 weeks)
- Flexibility
- Cost

There are several ways VSAT services might be implemented

- ***One-Way*** (e.g. TV Broadcasting satellites)
- ***Split-Two-Way (Split IP) Implementation*** (return link from user is not via the satellite; e.g. DirecTV)
- ***Two-Way Implementation*** (up- and down-link)





<u>STAR network:</u>

- Higher Propagation delay
- Used by TDMA VSATs
- High central hub investment
- Smaller VSAT antenna sizes (1.8 m typically)
- Lower VSAT costs
- Ideally suited for interactive data applications
- Large organizations, like banks, with centralized data processing requirements

Disadvantages:

1. In STAR VSAT network terminals cannot communicate directly with each other; they have to go through the central hub
2. VSAT-to-VSAT communications are necessarily double-hop
3. GEO STAR networks requiring double-hops may not meet user requirements from a delay Perspective

<u>Mesh network:</u>

Lower Propagation delay (250 ms)
- Used by PAMA/DAMA VSATs
- Lower central hub investment
- larger VSAT antenna sizes (3.8 m typically)
- Higher VSAT costs
- Suited for high data traffic
- Telephony applications and point-to-point high-speed links

Disadvantages:

1. Low EIRP and G/T of user terminals causes relatively low transponder occupancy
2. with many potential user-to-user connections required, the switching requirements in the Transponder will almost certainly require On-Board Processing (OBP) to be employed
3. OBP is expensive in terms of payload mass and power requirements

VSAT networks are composed of low-cost Earth stations for use in a wide variety of telecommunications applications. Unlike the point-to-multipoint systems VSATs are two-way communications installations designed to achieve interactivity over the satellite. Interconnection with various terrestrial networks is also a feature.Internet has taken over the role of the common structure for integrating data communications for the majority of applications in information technology (IT).

This has rationalized the field to the point that a single protocol and interface standard provide almost all of what an organization needs. The overriding principle of the VSAT is that it is a small bidirectional Earth station that delivers integrated data, voice, and video serviceswithin a package that is often cost justified when compared to terrestrial alternatives. Today, terrestrial copper, fiber lines, data routing and switching in conjunction with VSATs provide a fast and effective mix to advance the competitive strategy of many medium to large businesses.VSAT networks also address the needs of small businesses and individualsThey use computer network architecture like 7 layer model as shown below to have connectivity with domestic network and to Master or Satellite.

These are small and low cost earth stations which may use different modulation/multiple access schemes.They may be suited for low speed networks and Remote places.The antenna diameter is less than 2.4 m and G/T ratio is less than $15dBk^{-1}$.The LNA in the Receiver system is uncooled GaAsFETwith 100^0k noise temperature. Even on the Transmitter side a GaAsFET may be used as HPA with an output power of 1 to 5w.

Applications: Banking, Financial institutions, Airline and Hotel booking agencies,
Large retail stores with geographical separation.

.

OR

7 a) distinguish between TDMA and FDMA (6M)

- RF B.W. is divided into smaller freq bands called (subdivisions).
- Each sub division has it’s own IF carrier freq.
- A control mechanism is used to ensure that two or more Earth stations do not transmit in the same subdivision at the same time.
- The control mechanism designates a receive station for each of the subdivisions.
- In Demand Assignment systems the control mechanism is also used to establish or terminate the links b/n the source and destination stations. Due to this any of subdivisions may be used by any of the participating earth stations at any given time.
- SCPC (single channel per carrier): if each subdivision carries only one 4 KHz voice band channel it is known as SCPC.
- MCPC (multiple channels per carrier): when several voice band channels are FDM together to form a composite baseband signal comprised of groups, super groups or even master groups, a wider sub division is assigned. This is MCPC.
- Carrier frequencies and bandwidths for FDM/FM satellite systems using MCPC formats are generally assigned and remain fixed for a long period of time known as Fixed Assignment Multiple Access or FDM/FM/FAMA
- An alternate channel allocation scheme Demand Assigned Multiple Access (DAMA) where all users have continuous and equal access of the entire Transponder Bandwidth by assigning carrier frequencies on a temporary basis.
- The number of sub-channels is limited by three factors:
- **Thermal noise** (too weak a signal will be affected by background noise).
- **Intermodulation noise** (too strong a signal will cause noise).
- **Crosstalk** (cause by excessive frequency reusing).
- **Fixed-assignment multiple accesses** (FAMA): The sub-channel assignments are of a fixed allotment. Ideal for broadcast satellite communication.
- **Demand-assignment multiple access** (DAMA): The sub-channel allotment changes based on demand. Ideal for point to point communication.(**centralized control and distributed control)**

In FDMA a single channel is allocated to one user at a time.
If the transmission path deteriorates, the controller switches the system to another Channel. FDMA is wasteful of bandwidth. It cannot handle alternate forms of data and Can handle only voice transmissions. When FDMA is used to allow multiple users to Share a physical communication channel it is called FDMA.FDMA analog transmissions are the least efficient networks since each analog channel Can only be used by one user at a time. Analog channels don't take full advantage of Band Width.

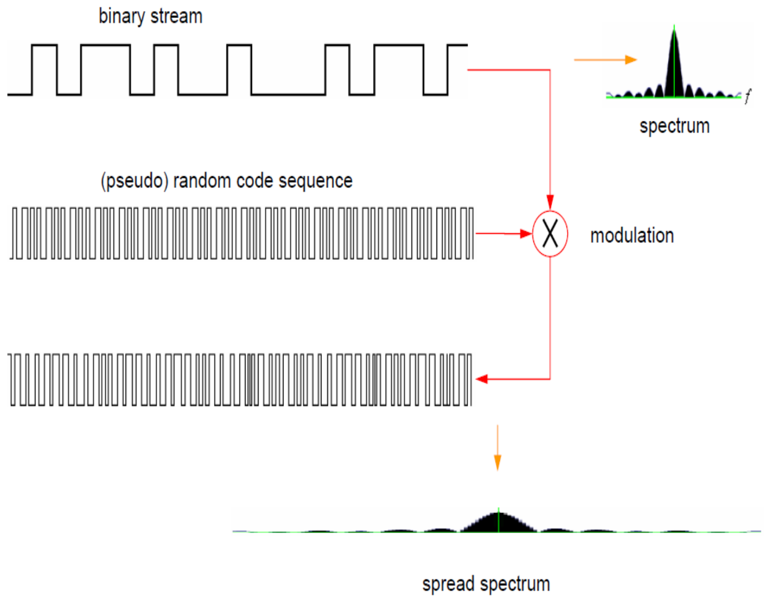
TDMA

1. It is the most efficient method today for Transmitting digitally modulated carriers (PSK signals).
2. Each earth station transmits a short burst of a digitally modulated carrier during a precise time slot with in a TDMA frame.
3. Each station's burst is synchronized so that it arrives at the satellite transponder at a different time.
4. Only one earth station's carrier is present in the transponder at any given time , which avoids a collision with another station's carrier.
5. The transponder is an RF to RF repeater , simply receives the earth station transmissions , amplifies them and then retransmits them in a downlink beam that is received by all the participating earth stations.
6. Each earth station receives the bursts from all other earth stations and must select from them the traffic destined only for itself.

7 b) Explanation of Spreading and dispreading process in DS-CDMA with a diagram (6M)

CDMA– code division multiple access. In this a no. of users can occupy all of the transponder bandwidth all of the time. Information from an individual Transmitter can be recovered by a receiving station that knows the code being used among all CDMA signals in the same network. Each receiving earth station is allocated a CDMA code.

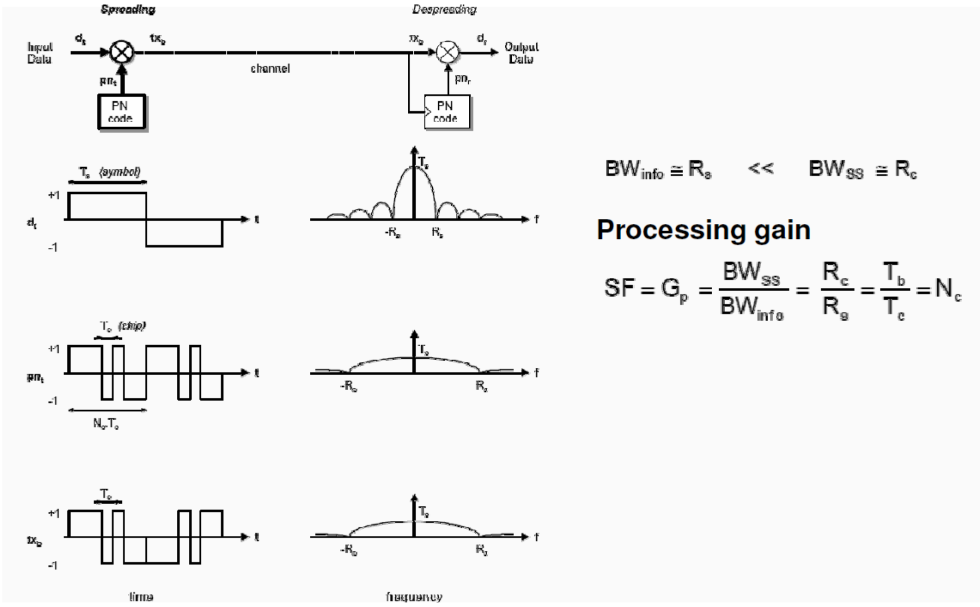
Any transmitting station wants to send data to that station it must use correct code .CDMA codes are 16 bits to many thousands of bits in Length. Bits of a CDMA code are called chips to distinguish it from message Bits. The CDMA chip sequence modulates the Data bits of original message. Chip rate is always greater than data rate.



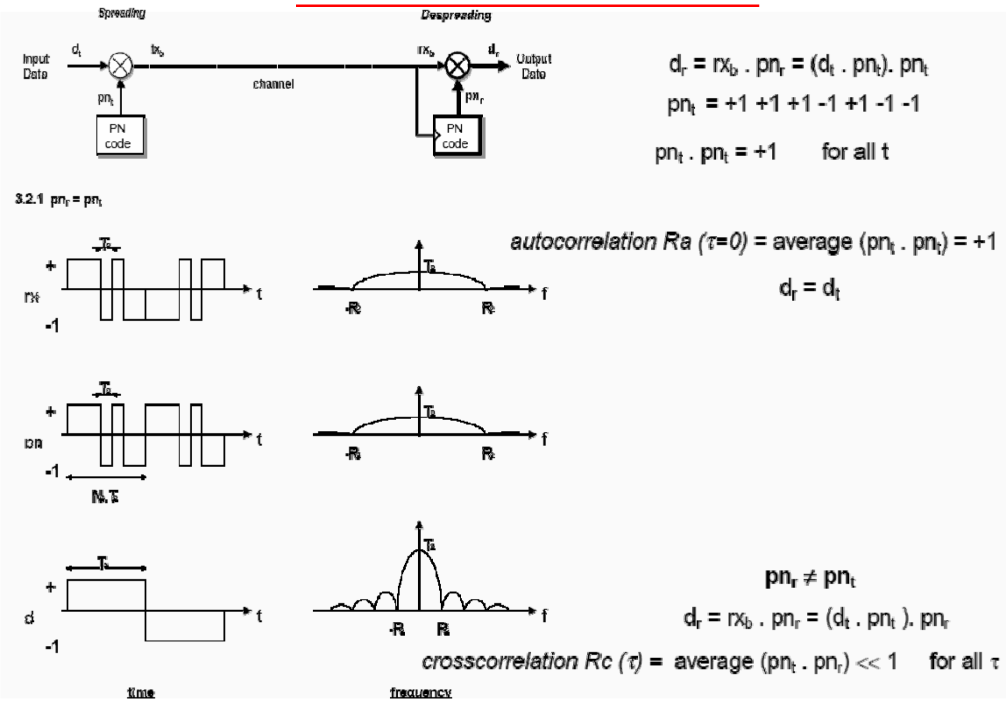
Hence CDMA is known as Spread Spectrum modulated signal. This is of two types

1. DIRECT SEQUENCE SPREAD SPECTRUM (DSSS)
   1. First, incoming data sequence is used to modulate a wideband code.
      This code transforms the narrow band data sequence to a noise like wideband signal.
   2. The resulting wideband signal undergoes a second modulation using PSK technique

SPREADING



DESPREADING



Unit-IV

8.a) Explanation about GPS codes : (6M)

GPS satellites transmit C/A code and P codes.

1. C/A code: These are 1023 bit Gold codes.

These are generated from two 1023 bit m-sequences called G_1 and G_2.

Then these two are multiplied with different time offsets.

M-sequence is a maximum length pseudorandom (PN) sequence and easy to generate with shift register and feedback taps.

A shift register with n stages can generate a PN sequence of $2^n -1$ bits in length.

The bit pattern is set by the feedback taps and combining logic of the shift register.

G_1 and G_2 are generated by 10 bit shift registers.

The clock rate for C/A code is 1.023 MHz; hence each sequence lasts for 1ms

The satellite with ID number i have C/A code sequence given by

$C_i(t) = G_{1(t)} \times G_2 (t+10iT_c)$ where T_c is the clock period for the C/A code

2. P code: It is generated using the algorithm

$P_i(t) = X_1(t) + X_2(t+ iT_c)$ where

T_c is period of X_1 sequence which contains 15,345,000 Bits and repeats for every 1.5 s

And X_2 sequence is 37 bits longer.

The P code repeats after 266.4 days, but it is changed for every 7 days for security reasons.

The long length of P code sequence makes the distance measurements unambiguous.

The P codes cannot be acquired easily because they do not repeat , to prevent unauthorized user to receive. The C/A code provides information to authorized users on the starting time of P code , which is contained in the Navigation message as an encrypted handover word. The P code is transmitted using BPSK modulation at the L2 carrier frequency of 1227.6MHz (120x10.23MHz) Even it is transmitted with BPSK modulation on the L1 carrier frequency in phase quadrature with C/A code BPSK modulation. The p and C/A codes are transmitted from all GPS satellites are overlaid in L1 and L2 frequency bands. This makes GPS a direct sequence spread spectrum System (DS-SS).

GPS Satellite Signals:

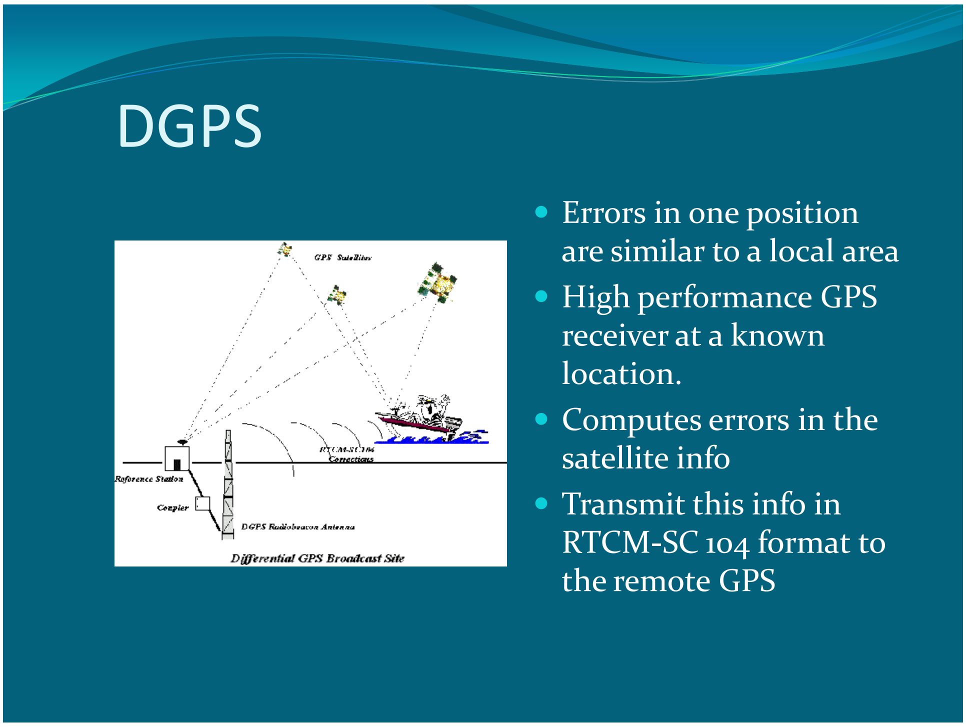
L1 freq. (1575.42 MHz) carries the SPS code and the navigation message.

L2 freq. (1227.60 MHz) used to measure ionosphere delays by PPS receivers.

3 binary code shift L1 and/or L2 carrier phase

- The C/A code
- The P code
- The Navigation message which is a 50 Hz signal consisting of GPs satellite orbits. Clock correction and other system parameters.

8.b) Explanation about DGPS (6M)



More precise and accurate compared to GPS .It also requires 4 satellite signals at any time for position calculation besides signals from a fixed GPS transmitter . Here the errors are reduced drastically by continuous comparison w.r.t. fixed GPS transmitter signals.The difficulty with DGPS is Phase comparison measurements. Here it will create range ambiguities which must be resolved

Disadvantages:

1. Cost of Rx is high due to complex Rx system.
2. Operating costs of DGPS system is more when compared with GPS

Requirements for a DGPS :

- Reference station:
- Transmitter

Operates in the 300 kHz range

- DGPS correction receiver

GPS receiver

- Data Links
- Land Links
- MF,LF,UHF/VHF freq used
- Satellite links
- DGPS corrections on the L band of geostationary satellites
- DGPS gives accuracy of 3-5 meters, while GPS gives accuracy of around 15-20 mts
- Removes the problem associated with SA.

The accuracy of GPS measurements can be increased considerably by using Differential GPS. Even it is used to remove the effects of selective availability. In DGPS a fixed GPS receiver in a known position to calculate errors in GPS position measurement or errors in the pseudo ranges to all visible satellites. Then these are sent over a radio link to other GPS receivers.

For even greater accuracy, a user can implement a differential GPS (DGPS) solution. The principle behind DGPS is to use the reference location of the base receiver to correct for the error position of the unknown rover position. Since the base station is fixed, we can use the difference between the measurement of the base and the rover receivers to create an error correction vector. The precise location of the rover can then be calculated if we apply the error correction over all the satellite data. DGPS can be achieved through real-time telemetry links between a base and a rover or through post-processing the data. Real-time methods include a) medium frequency beacon differential service, b) L-Band satellite differential service, c) frequency modulation subcarrier differential service, or d) on-site, radio frequency telemetry link. All the real-time services have a coverage area and a range limitation and require a local radio/receiver to obtain the transmitted service.

. Generally, centimeter resolution is possible with this technique, whereas the non-DGPS can only achieve a resolution of a few meters. They feature 12 parallel channels that receive coarse acquisition (C/A) code phase and full wavelength carrier phase measurement on L1 frequency (1575 MHz), precise (P) code phase and full wavelength carrier phase on L1 and L2 frequency (1227 MHz).

9 a) Signal levels in GPS Satellite Systems

GPS Receiver Antennas have very low gains and omnidirectional.

Even it picks up noise from environment, so antenna temperature may be close to 273 K

The LNA temp can be up to 25 K.

Hence overall system noise temperature of GPS Receivers, T_s = 273 K

GPS antennas are circularly polarized patches or quadrafilar Helics , which are carefully designed shaped patterns, such that when El < 10^0 , then they are cutoff to minimize noise pick up from ground. Generally LNA's are mounted directly below to reduce noise temp due to lossy antenna cables. GPS satellites have array of Helical antennas and P_t = 10 W leading to EIRP of 19 to 27dBW

The C/A code transmitted by satellite is DSSS, so the CNR in C/A code's RF Bandwidth is less than 0 dB. This low value of CNR is converted to usable SNR by correlation of the code sequences, which adds a dispreading (processing) gain to CNR.

Theoretical Processing gain (PG) = (T_c / T_b)

= (Chip Rate/ Bit Rate) within the spreading sequence.

The losses in correlation process makes PG little lower.

1.For a C/A code transmitted at 1.023 Mbps and 1 ms correlation time ,

PG = 1023 or 30.1 dB

2. The PG for a Code will be 40.1 dB.

GPS Receiver can pick up signals from 10 satellites at same time. The Rf energy in the satellite transmitted Spread Spectrum adds to noise in the Receiver as Interference (I). The SNR at the O/P of Correlator is 10.7dB for C/A code and 8.2 dB for P code in the same L_1 band. The NAV message has 50 bps bit rate and each bit extends over 20 C/A code correlation periods. The C/A code correlator O/P is passed through a 50Hz Bandwidth filter, which integrates the 20 pulses to give a single message bit in the form of a 50 bps BPSK signal. The SNR of BPSK message signal is 13dB higher than the SNR at correlator O/P .The correlation and filtering processes are not perfect, hence implementation margins of several dB must be allowed. Generally the SNR of BPSK signal will be above 20 dB in most of the cases, guaranteed error free detection of the navigation message.

GPS Satellite Signals:

L1 freq. (1575.42 MHz) carries the SPS code and the navigation message.

L2 freq. (1227.60 MHz) used to measure ionosphere delays by PPS receivers.

3 binary code shift L1 and/or L2 carrier phase

- The C/A code
- The P code
- The Navigation message which is a 50 Hz signal consisting of GPs satellite orbits. Clock correction and other system parameters.

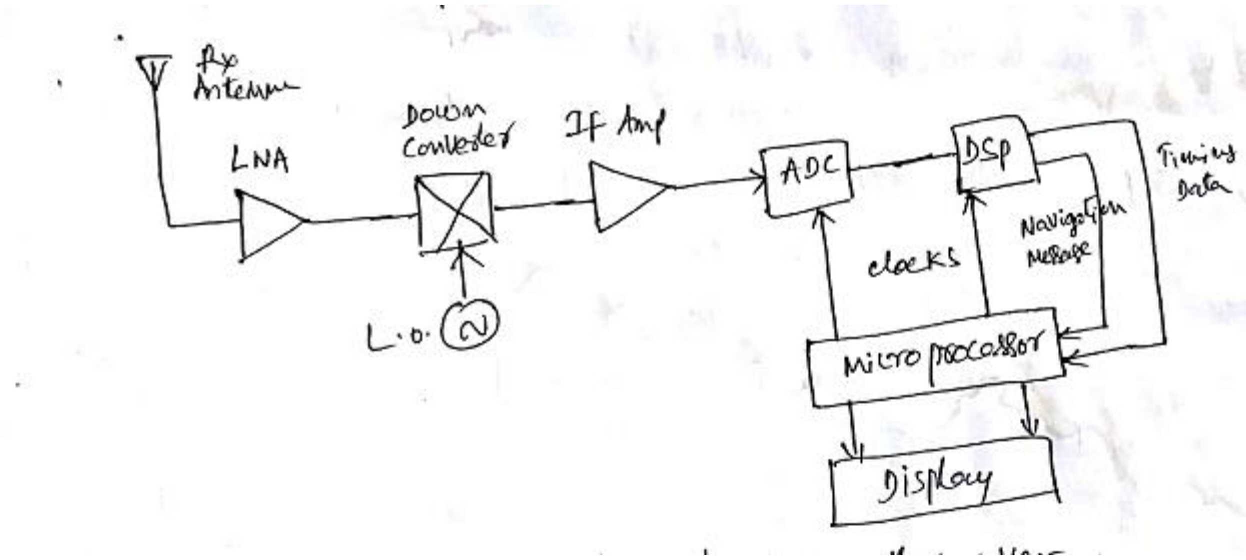
In low cost GPS receivers sequential correlation process is done. In sophisticated GPS receivers parallel correlation process which can acquire 12 satellites and guarantees all visible GPS satellites are acquired. This will have more accuracy and start up time is shorter.GPS receivers used for Navigation process like aircrafts in bad weather conditions, they must have integrity monitoring to guard against Receiver or satellite failures and also to interference with or jamming of GPS signals.

9.b) GPS Receiver operation

It has revolutionalized navigation and position location.It is the primary means of navigation for most of the ships, aircrafts and also employed in surveying.Earlier it was used by USA for military navigation for guiding missiles, war ships, and jet fighters to their Targets.GPS satellite transmits in L-band frequencies, which are modulated by several codes. The C/A code made available to public in mid 1980's.

The secure and high accuracy P code allows authorized users to achieve positioning accuracy up to 3m.Such accuracies are needed for targeting smart bombs, cruise missiles and even auto landing of aircrafts, ships to dock in fog, night time and also during bad weather conditions.In a GPS receiver we have adirect readout of the current positionof it with a typical accuracy of 30m.Unlimited no of GPS receivers can operate simultaneously without any restriction.

GPS system consists of 1.Space segment 2.Controlsegment, 3. User segment.



The GPS receiver must find the starting time of the unique C/A code for each of 4 satellites. It is done by correlating the received signal with the stored C/A codes. The Rx automatically selects the 4 strongest signals and correlates them. When the satellites are close together and pseudo ranges are nearly equal, The Rx may also use several weaker signals. When there is no information about current position of GPS satellites or its own location, it must search all 37 possible C/A codes until it can correlate with one.

Once correlation is obtained, the Navigation message from the satellite can be read by the Receiver. The NAV message (Data stream) contains information about adjacent satellites. A DSSS receiver locks to a given code by matching the locally generated code to the code received from the wanted satellite bit by bit. Through all 1023 bits of the sequence. If lock is not found or then the code is not correct. If the starting time for locally generated code was not selected correctly, correlation takes some time. Once one C/A code is found the remaining satellites can acquire the remaining satellite's C/A codes because their ID's are known from the data transmitted in the navigation message of each satellite.

The Rx bandwidth is to be matched with the C/A code of 1.023 MHz. The Rx may need to search in Doppler shift because the position of the relative satellites is not known. The GPS receiver retains the information from the NAV message when it is switched off, even it runs its internal clock. For the next switched on of Rx, it will assume that its position is close to its last known position, when it was switched off. This speeds up acquisition process. If the Rx moved to a large distance while turned off, cold start may be needed.