Assignment

Q1:- Describe the main features of the technical structure of a GPS system.

→ The main features of the technical structure of a GPS system are :-

i) The GPS space segment consists of 24 satellites in medium Earth orbit (MEO) at a nominal altitude of 20, 200km with an orbital inclination of 550.

ii) The satellites are clustered in groups of four called constellations with each constellation separated by 600 in longitude.

iii) The orbital period is approximately one half a sidereal day (11 hours 58 minutes), so the same satellites appear in the same position in the sky twice each day.

iv) The satellites carry station keeping fuel and are maintained in the required orbits by occasional station keeping maneuvers just like GEO satellites.

v) The orbits of the 24 GPS satellites ensure that at any time, anywhere in the world a GPS receiver can pick up signals from at least four satellites.
Upto 10 satellites may be visible at some times and more than four satellites are visible nearly all the time.
They provide a direct readout the present position of a GPS receiver with a typical accuracy of 90m.

vi) A large number of GPS receiver can operate simultaneously because all that a GPS receiver has to do to locate itself is to receive signals from four GPS satellites.

Other position location such as LORAN (Long Range navigation) that can also provide direct read-out of position, but have far less accuracy and reliability.

Q2 Explain the Trilateration Method used in GPS system to locate a receiver.

→ One of the simplest and most accurate method of locating an unknown position is the Trilateration Method.

In this method the distance of the unknown point from three unknown point is measured. The intersection of the arcs corresponding to three distances defines the unknown point relative to the known points, since three measurements can be used to solve three equations to give the latitude, longitude and elevation for the receiver.

In the GPS system, the Trilateration Method is used to locate a GPS receiver. Here the distance between a transmitter and a receiver is estimated by measuring the time taken by a pulse of RF energy to travel between the two. This distance is calculated using the velocity of electromagnetic waves in free space (the velocity of light is

299, 972, 458 m/sec). Time is measured electronically more accurately by the use of atomic clocks so that the GPS position location system is able to achieve a measurement accuracy of 1 meter in a distance of 20, 000 km.

However, this position location accuracy can be obtained if timing measurement have an accuracy better than 3ns.

This is achieved as follows:

i) Each satellite carries several high accuracy atomic clocks and radiates a sequence of bits that starts at a precisely known time.

ii) A GPS receiver contains a clock that is synchronous in turn to the clock on each satellite that it is receiving.

iii) The receiver measures the time delay of the arrival of the bit sequence which is proportional to the distance between the satellite and the GPS receiver.

iv) After the distance of a GPS receiver from three satellites has been measured, it is now required to know the position of each satellite. This is calculated in the GPS receiver using the ephemperis for the satellite orbits that are broadcast by each satellites in its navigation message.

v) As the time at which the transmitted bit sequence is started is known at the receives the position of the satellite at that time can be calculated from its orbital data.

vi) Apart from the three satellites, a fourth satellites is also used because the clock in the receiver is not inherently accurate enough. The fourth distance measurement provides information from which clock errors in the receiver can be corrected and the receiver clock synchronised to GPS time with an accuracy better than 100 n sec.

Q3:- Explain the method of C/A code generation in GPS system.

→ The method C/A code generation in GPS system.

i) The C/A codes transmitted by GPS satellites are all 1023 bit Gold codes. The GPS C/A codes are created from two 1023 bit in sequences, called G1 and G2 by multiplying together G1 and G2 sequences with different time offsets.

ii) An m-sequence is a maximum length pseudo-random (PN) sequence which is easy to generate with a shift register and feedback taps.

iii) As a shift register with n stages can generate a PN sequence $2^n - 1$ bits in length, the bit pattern is set by its feedback taps and combining logic. The PN sequences G1 and G2 are both generated by 10 bit shift registers and are therefore both 1023 bits long.

iv) The clock rate for the C/A code is 1.023 MHz so each sequence lasts 1.0 ms.

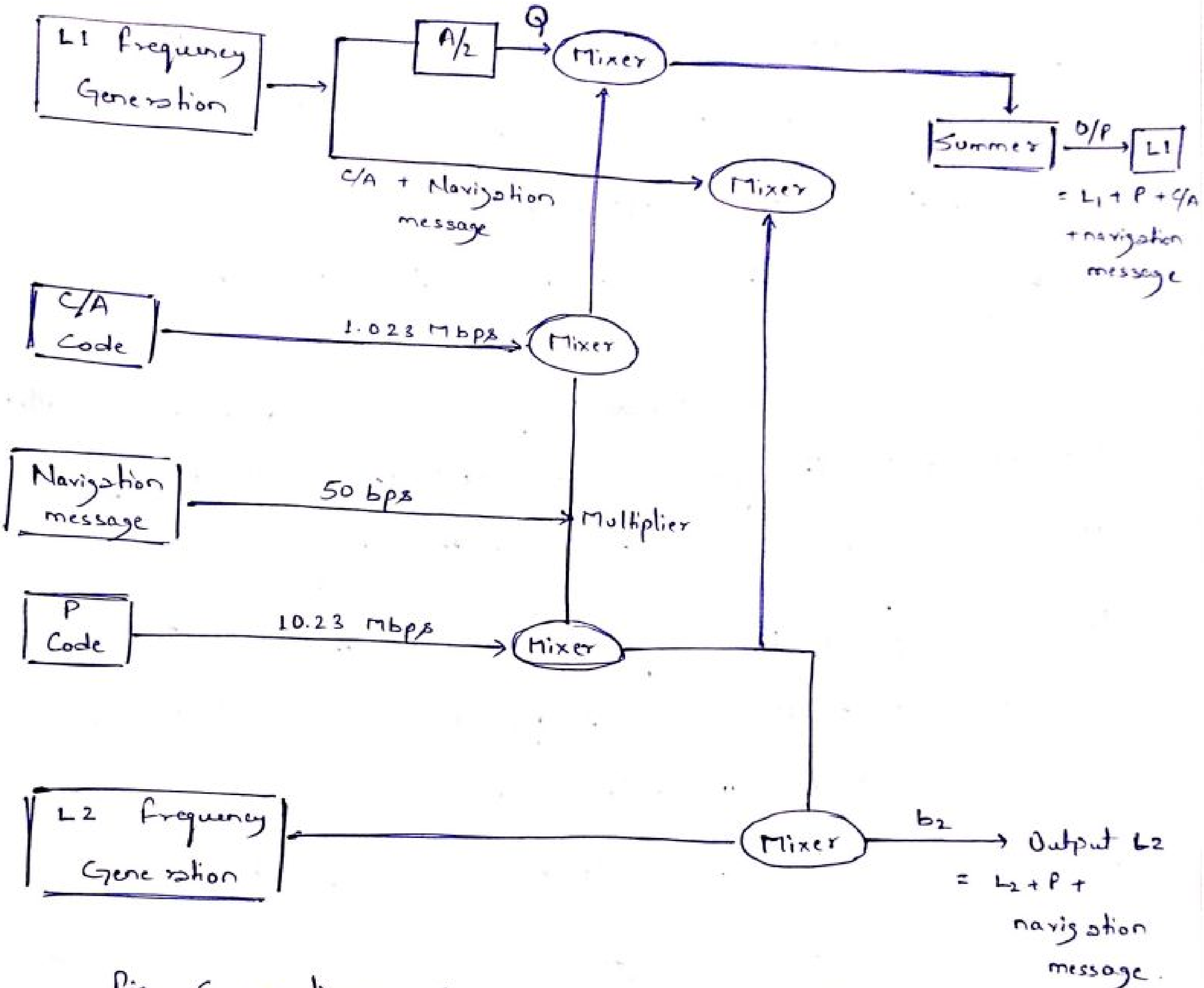

Fig. Generation of L1 and L2 signals in a GPS satellite.

This figure shows the schematic of a C/A code generator.

For a particular satellite in the GPS system. the C/A code is created with an algorithm that includes the identification number (ID) of the GPS satellite, thus creating a unique code for each satellite. For the satellite with ID number 'i' a C/A code sequence $C_i(t)$ given by:

$$C_i(t) = G_1(t) \times G(t) + 10 i T_c \quad \text{—(1)}$$

where T_c is the clock period for the C/A code.

Since there are 64 Gold sequences available for satellite numbered 1, through 64 a total of 100 Gold sequences can be created using the algorithm of Eq (1).

However, not all the sequences have sufficient low cross corelation properties and it has been seen that only 37 are actually used in the GPS system.

Low cross corelation that only of the sequences is necessary because the GPS receiver can pick up signals from 12 satellites at the same time.

The corelator in the receiver searches one of the sequences and must reject all other that are present.

Two C/A code sequences with zero cross corelation would achieve a rejection ratio of 1023, but the

G4 available codes sequences of C/A will not all have zero cross corelation. The selected group of 37 are the sequences with the lowest levels of cross corelation among the available at set of 100 Gold code sequences.

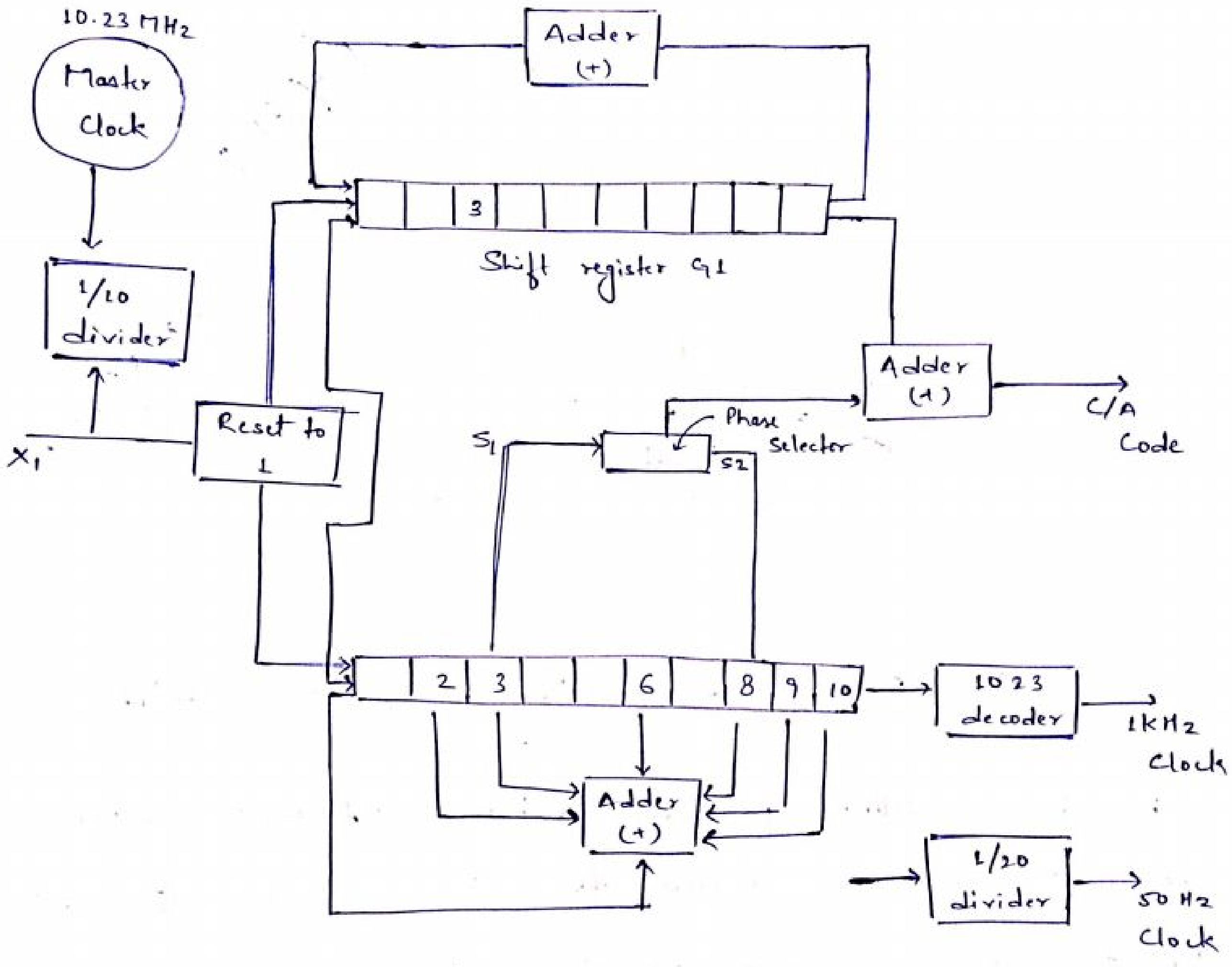

fig: Generation of C/A code in a GPS system.

Q4 :- Drive the four ranging equation used in locating the position of a receiver in GPS system.

→ The four ranging equations used in locating the position of a receiver in GPS system are :

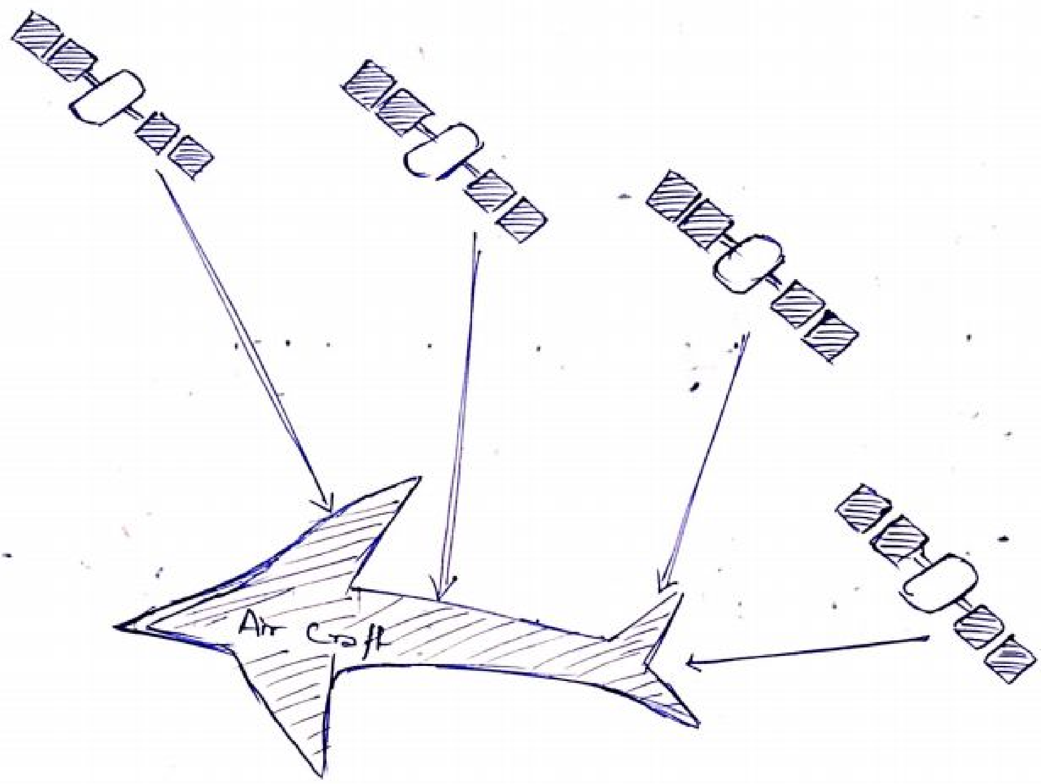

fig: GPS . Position location using four satellites.

i) The three satellites provide distance information when the GPS receiver makes three measurements of range R_i, from the receiver to three known points.

ii) Each distance R_i can be thought of as the radius of a sphere with a GPS satellite at the center.

The receiver lies at the intersection of three such spheres with a satellite at the center of each sphere. Locally at the receiver, the spheres will appear to be planes since the radii of the spheres are very large.

iii) Since the intersection of three planes completely defines a point, three satellites, through measurement of their distances to the receiver, defines the receiver location close to the Earth's Surface.

Calculation of position location in GPS system:

- In position location, first the coordinates of the GPS receiver and the GPS satellites are defined in a rectangular co-ordinate system with its origin at the center of the Earth. This is called the Earth centered Earth fixed (ECEF) coordinate system.

- The ECEF co-ordinate system is a part of the WGS-84 description of the Earth. WGS-84 is an Internationally agreed description of the Earth's shape and parameters derived from observations in many countries.

- GPS receivers use the WGS-84 parameters to calculate the orbits of the GPS satellites with the accuracy required for precise measurement of the range to the satellites.

i) The z-axis of the coordinate system is directed through the Earth's North Pole and the x and y-axis are in the equatorial plane.

ii) The x-axis passes through the Greenwich meridian - the line of zero ECEF co-ordinate system rotates with the Earth.

iii) The receiver coordinates are (U_x, U_y, U_z) and the four satellites have coordinates (x_i, y_i, z_i) where $i = 1, 2, 3, 4$

iv) The measured distance to satellite 'i' is called a pseudo-range R_i, because it uses the internal clock of the receiver to make a timing measurements that includes errors caused by receiver clock offset.

Pseudo range R_{pi} is measured from the propogation time delay T_i between the satellite 'i' and the GPS receiver. i.e.

$$R_{pi} = T_i \times c \quad \text{—— (1)}$$

We know from geometry that the distance 'R' between two points A and B in a rectangular coordinate system will be.

$$R^2 = (x_A - x_B)^2 + (y_A - y_B)^2 + (z_A - z_B)^2$$

Using this above equation, the ranging equations which relate pseudo range to time delay will be.

$$\left.\begin{aligned}
(X_1 - U_x)^2 + (Y_1 - U_y)^2 + (Z_1 - U_z)^2 &= (PR_1 - T_c^2) \\
(X_2 - U_x)^2 + (Y_2 - U_y)^2 + (Z_2 - U_z)^2 &= (PR_2 - T_c^2) \\
(X_3 - U_x)^2 + (Y_3 - U_y)^2 + (Z_3 - U_z)^2 &= (PR_3 - T_c^2) \\
(X_4 - U_x)^2 + (Y_4 - U_y)^2 + (Z_4 - U_z)^2 &= (PR_4 - T_c^2)
\end{aligned}\right\} \text{—— (2)}$$

where T_c is receiver clock error (offset or bias)

The process for position location is as follows:

i) The position of the satellite at the instant when sends the timing signal (that is, the start of a long sequence of bits) is obtained from ephemaris data transmitted along with the timing signals.

ii) Each satellite sends out a data stream that includes its own ephemers data and that of the adjacent satellites.

iii) The receiver now calculates the coordinates of the satellites relative to the center of the Earth (x_i, y_i, z_i) and then its circuitry solves the four ranging equations using the standard numerical techniques.

iv) Solving of above equations leads to the values of the four unknown the location of the GPS receiver (U_x, U_y, U_z) relative to the center of the Earth and the clock offset called clock bias in GPS technology.

v) The receiver position is now refrenced to the surface of the Earth, and is displayed in latitude, longitude and elevation.

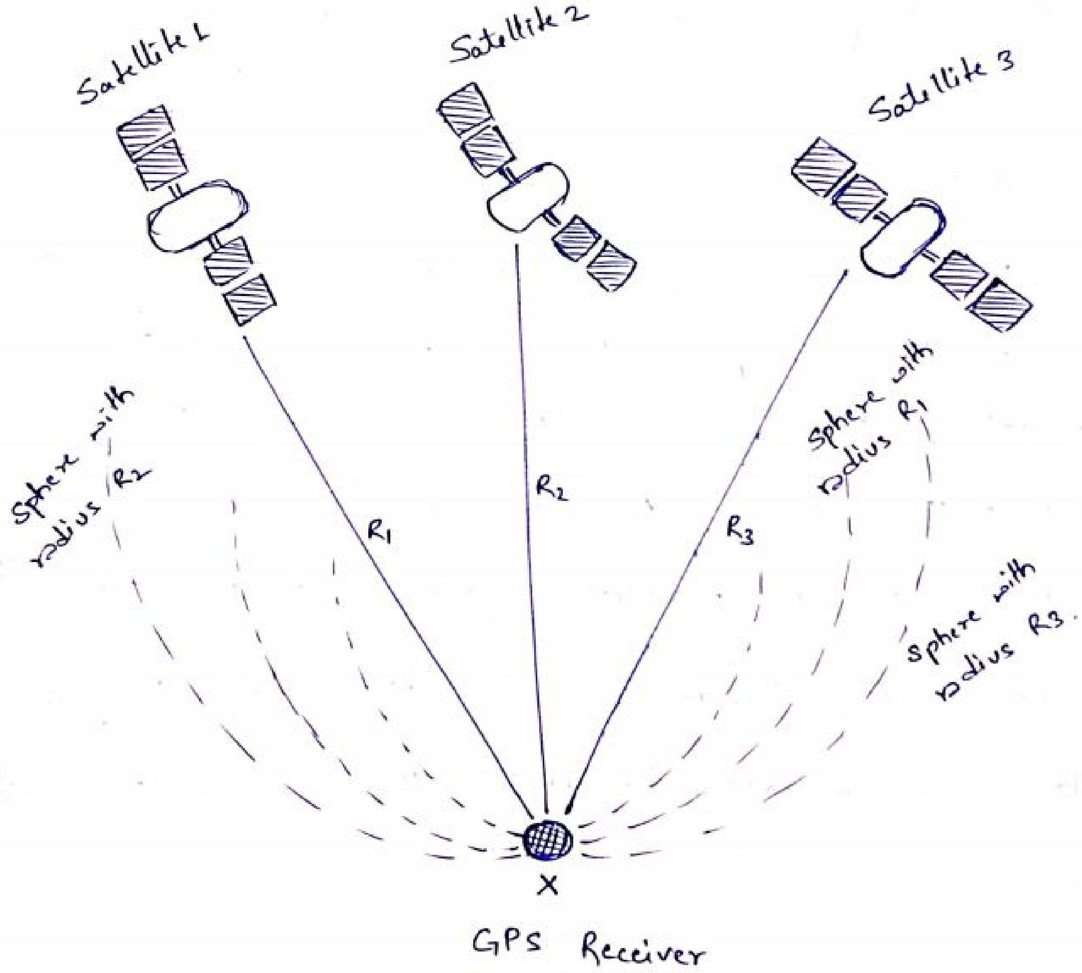

Fig:- GPS Position Location by measuring distance from three Satellites.

Q5:- Describe the method of Satellite Signal Acquisition by GPS receiver by code synchronisation.

→ This is carried out by the GPS receiver by two corelation process:

a) Code synchronisation with the satellites.

b) Doppler frequency offset measurements.

Code Synchronisation

Step 1 The GPS receiver first determines the starting time of the unique C/A code for each of four satellites. This is done by corelating the received signal with stored C/A codes, as in any direct sequence spread spectrum system. In practice, the receiver automatically selects the four strongest signals and corelates to these. However, it faces the problems.

i) In case, the strongest satellite are quite close to each other, and have nearly equal pseudoranges, the receiver also uses several weaker signals.

ii) If in situation called cold start, the receiver makes no information about the current position of GPS satellites, or its own location it takes up search of all 37 possible C/A codes until it can correlate with one of the satellites.

Step 2 :- Once correlation is obtained the data stream. called the navigation message from that satellite can be read by the receiver. This stream contains information about the adjacent satellites, so that one signal is correlated there is no need for the receiver to search through all the other 36 possible codes to find the next satellites and thus can go directly to the correct code.

Step 3 :- The receiver now locked to a given code by matching the locally generated code to the code received from the unknown satellite. Since the start time of the code transmitted by the satellite is not known when the receiver commences the locking process, it selects an arbitary start point. The locally generated code is compared to the received code, bit by bit through all 1023 bits of the sequence, until the lock is traced.

Otherwise the receiver realises that it is not receiving the correct code for the satellite in question.

Step 4 :- If the correct code for the satellite has not been found, the receiver moves the locally generated code forward one bit in time and attempts correlation again. The process is continued 1023 times until all possible starting times for the locally generated code have been evaluated. It takes a minimum of 1s to search all 1023 bit positions of a 1023 bit C/A code, so in a typical case, it will take atleast 15 seconds to acquire the first satellite.

Step 5 :- Once C/A code is found, the remaining satellite can be acquire in a few seconds because their IDs are known from the data transmitted in the navigation message of each satellite.

Q6 :- List and explain GPS applications.

→ GPS Applications

- GPS and Satellite Image :- GPS has been widely used to prepare map through satellite images especially topographic surveys and thematic mapping.

- Road Traffic Congestion :- A navigation device has a GPS receiver for receiving real time information about or slow average repeat speed on a stretch of motor way, indicating congestion. The device calculates a new itineary to avoid the congestion, based on historically record speeds on secondary roads weighed by the current average speed in the congestion area.

- GPS and Defense :- Cops use GPS as a modern defensive purpose like trending and rescuing.

- Accidental Purpose :- To find and rescue any crashed ship and airplanes, GPS plays very important role.

- GPS for Tectonics :- GPS enables direct fault motion measurement of earthquake between Equake GPS can be used to measure crystal motion and deformation to estimate seismic strain build up for creating seismic hazard maps.

- GPS and Terrorism :- GPS is very important to determine the location of terrorist attacks. for example the surgical strike, Indian intelligence agencies had using the GPS and Indian Army carried out surgical strike against terror launch pads on and along the line of Control (LOC) in 2016.

- GPS of Mining :- The use of R+K GPS has significantly improved several mining operations such as drilling, shoveling, vehicle tracking and surveying.

- GPS and Climatology :- GPS plays very important role to prepare weather map and computerized maps.

- GPS and Tours :- Location determines what content to display for instance, information about an approaching point of interest.

- <u>Navigation</u> :- Navigators value digitally precise velocity and orientation measurements. With the help of GPS roads or paths available, traffic congestion and alternative roads or paths that might be taken to get to the destination. If some roads are busy then the best route to take, The location of food, banks, hotels, fuel, airports. or other places of interests.

- <u>Disaster Relief</u> :- GPS gives us the facility to measure the capabilities of earthquakes, flood, wildfires.

- <u>Fleet Tracking</u> :- The use of GPS technology to identify, locate and maintain contact reports with one or more fleet vehicles in real time.

- <u>Robotics</u> :- Self navigation autonomous robots using GPS sensors which calculate latitude, longitude, time, speed and heating.

- <u>Sport</u> :- GPS also used in footballs and rugby and different sports for control and analysis of the training lead.

- **Distance and height measurements**:- GPS helps to calculate the distance and heights of different places on the Earth surface.

- **Automated Vehicle**:- With the help of GPS location and routes for cars and trucks to function without a human driver.

- **Agriculture**:- GPS based applications in precision farming are being used for farm planning, field mapping, soil sampling tractor guidance, crop scouting, variable rate applications, and yield mapping.

- **GPS and fishing**:- Synoptic maps of the main concentration of fisherman villages, fishing ports and beach landing points, markets, processing, freezing and transhipment points, coastal landforms can be studied with the help of GPS.

- **GPS and Oil Leak**:- GPS tracking technology is helping with the study by examining how currents are influencing by winds and waves and measuring wind speed to find out how oil would spread from the ocean onto the beach.

• GPS and Forestation :- GPS Technology makes tree planting more efficient. Deforestation and dissappearing wildlife habitats are a big problem in the modern world. Manufacturing industries use state of the art technologies to produce and sell more paper and wood products, but there is growing concern over the devastation wrought by their methods of obtaining materials. The rate with which large forests are being cut down. The trees are being removed much more quickly than we can hope to replant as trees take many years to grow. to their full potential.

• GPS and Urban Planning :- A special GPS technology has been used in Urban planning and engineering survey.