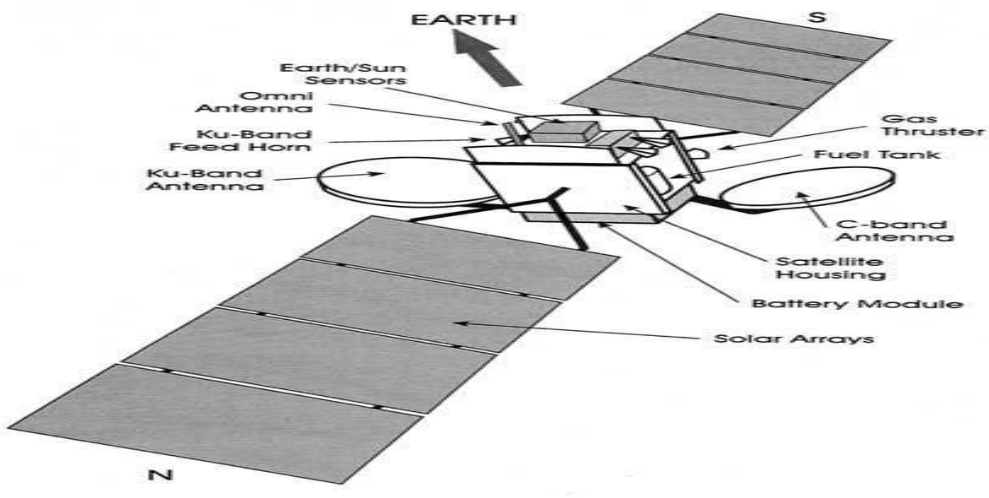
UNIT-1

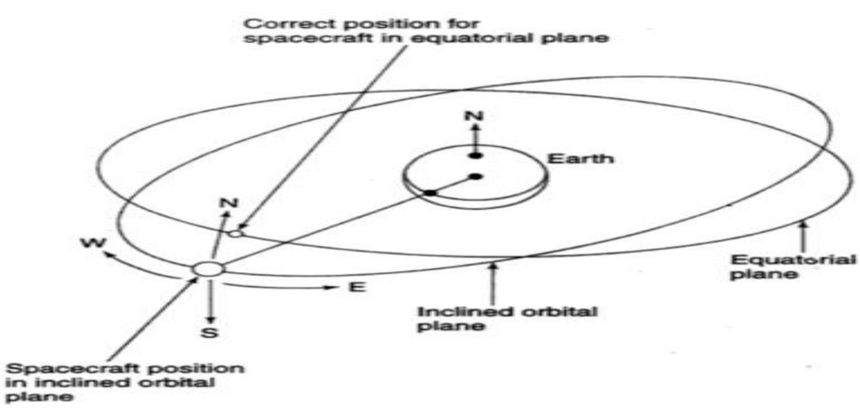
Q1a) What are the orbital elements? Explain them briefly.

- **Attitude and Orbit Control System (AOCS)**
- This subsystem consists of rocket motors that are used to move the satellite back to the correct orbit when external forces causes it to drift off and gas jets that control the attitude of the satellite.
- The attitude and orbit of a satellite must be controlled so that the satellite's antennas point toward the earth and so that the user knows where in the sky to look for the satellite.
- Solar pressure acting on a satellite's solar sails and antennas, and the earth's magnetic field generating eddy current in the satellite's metallic structure as it travels through the magnetic field.
- This will cause rotation of the satellite body.
- There are two ways to make a satellite stable in orbit, when it is weightless.
- The body of the satellite can be rotated at a rate between 30 and 100 rpm, to create a gyroscopic force that provides stability of the spin axis and keeps it pointing in the same direction. Such satellites are known as spinners.
- Example: Hughes 376 satellite.
- The satellite can be stabilized by one or more momentum wheels.
- The momentum wheel is usually a solid metal disk driven by an electric motor.
- Increasing the speed of the momentum wheel causes the satellite to precess in the opposite direction.
- Example: Hughes 701 series.



Orbit Control System

- A geostationary satellite is subjected to several forces that tend to accelerate it away from its required orbit.The gravitation forces of the moon and the sun cause inclination of the orbital plane and the nonspherical shape of the earth around the equator, which causes drift of the subsatellite point.



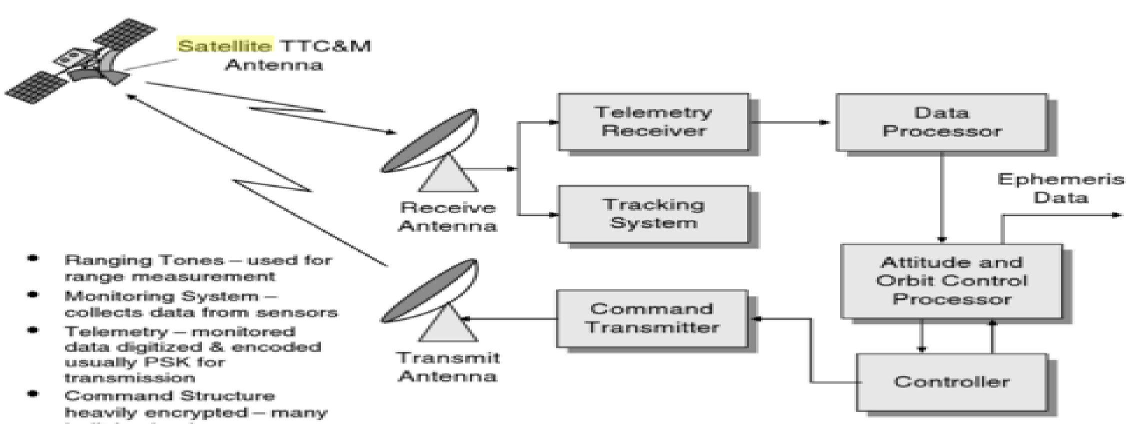
- Fig. shows a diagram of an inclined orbital plane close to the geostationary orbit.
- For the orbit to be truly geostationary, it must lie in the equatorial plane, be circular, and have the correct altitude.
- The function of the orbit control system to return it to the correct orbit.
- If the orbit is not circular, a velocity increase or decrease will have to be made along the orbit.

- On a spinning satellite, this is achieved by pulsing the radial jets when they point along the X axis.
- On a three-axis stabilized satellite, there will usually be two pairs of X-axis jets acting in opposite directions
- The orbit of a geostationary satellite remains approximately circular for long periods of time and does not need frequent velocity corrections to maintain circularity.
- Altitude corrections are made by operating the Z-axis gas jets.

Q2b) Expalin Telemetry,Tracking and Command power system with neat sketch.

Telemetry, Tracking, Command, and Monitoring (TTC&M)

- The TTC&M system is essential to the successful operation of a communications satellite.
- The main functions of satellite management are to control the orbit and attitude of the satellite, monitor the status of all sensors and subsystems on the satellite, and switch on or off sections of the communication system.
- The monitoring system collects data from many sensors within the satellite and sends these data to the controlling earth station.
- There may be several hundred sensors located on the satellite to monitor pressure in the fuel tanks, voltage and current in the power conditioning unit, current drawn by each sybsystem.



Tracking

- A number of techniques can be used to determine the current orbit of a satellite.
- Velocity and acceleration sensors on the satellite can be used to find the change in orbit from the last known position.
- The earth station controlling the satellite can observe the Doppler shift of the telemetry carrier or beacon transmitter carrier to determine the rate at which range is changing.
- Active determination of range can be achieved by transmitting a pulse, or sequence of pulses, to the satellite and observing the time delay before the pulse is received again.

Command

- A secure and effective command structure is vital to the successful launch and operation of any communications satellite.
- The command system is used to make changes in attitude and corrections to the orbit and to control the communication system.
- During the launch, it is used to control the firing of the apogee kick motor and to spin up a spinner or extend the solar sails and antennas of a three-axis stabilized satellite.

UNIT-2

Q3a)Explain system noise temperature and G/T ratio.

System Noise Temperature & G/T Ratio

- Noise temperature is a useful concept in communications receivers.
- It provides a way of determining how much thermal noise is generated by active and passive devices in the receiving system.
- At microwave frequencies, a black body with physical temperature Tp degrees kelvin, generates electrical noise over a wide bandwidth. The noise power is given by

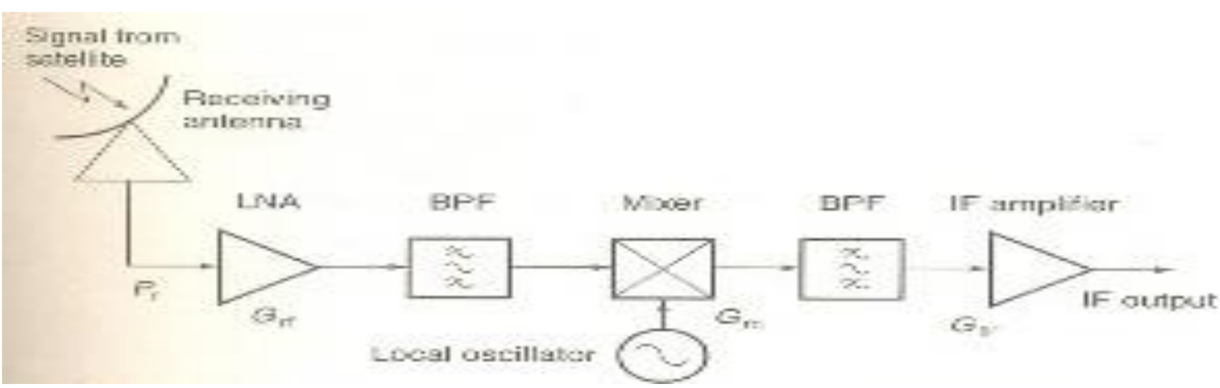
- $$P_n = kT_pB_n$$

Where

k = Boltzmann's constant $(1.39 \times 10^{-23} J/K)$

T_p= physical temperature of source in kelvin degrees

B_n=noise bandwidth in which the noise power is measured, in hertz



Calculation of System Noise Temperature

- Figure shows a simplified communications receiver with an RF amplifier and single frequency conversion.
- This is the form used for all radio receivers. It is known as the superhet (superheterodyne).

- The superhet receiver has three main sybsystems: a front end (RF amplifier, mixer and local oscillator), an IF amplifier (IF amplifiers and filters), and a demodulator and baseband section.

- The RF amplifier in a satellite communications receiver must generate as little noise as possible, so it is called a low noise amplifier of LNA.
- The mixer and local oscillator form a frequency conversion stage that down converts the RF signal to a fixed intermediate frequency (IF), where the signal can be amplified and filtered accurately.
- Many earth station receivers use the double superhet configuration shown in fig, which has two stages of frequency conversion.
- The front end of receiver converts the incoming RF signals to a first IF in the range 900 to 1400 MHz. This allows the receiver to accept all the signals transmitted from a satellite in a 500 MHz bandwidth.
- The next section of the receiver is called low noise block converter (LNB).
- The 900-1400 MHz signal is sent over a coaxial cable to a set-top receiver that contains another down-converter and a tunable local oscillator.
- The local oscillator is tuned to convert the incoming signal from a selected transponder to a second IF frequency.
- The second IF amplifier has a bandwidth equal to the spectrum of the transponder signal.

Q3b) Explain Downlink Design in detail.

Design of Downlinks

- The design of any satellite communication is based on two objectives:
- Meeting a minimum C/N ratio for a specified percentage of time, and carrying the maximum revenue earning traffic at minimum cost.
- Any satellite link can be designed with very large antennas to achieve high C/N ratios under all conditions, but the cost will be high.
- The art of good system design is to reach the best compromise of system parameters that meets the specification at the lowest cost.
- All satellite communications links are affected by rain attenuation.
- Satellite links are designed to achieve reliabilities of 99.5 to 99.99%, over one year. That means the C/N ratio in the receiver will fall below the minimum permissible value for proper operation of the link for between 0.5 and 0.01 % of the specified time. This specified time is called *outage*.

Satellite link design

- The cost to build and launch a GEO satellite is about $25,000 per kg.
- Weight is the most critical factor in the design of any satellite, since the heavier the satellite the higher the cost.
- The overall dimensions of the satellite are critical because the spacecraft must fit within the confines of the launch vehicle.
- Typically the diameter of the spacecraft must be less than 3.5m.
- The weight of the satellite depends on two factors: the number and output power of the transponders and the weight of station-keeping fuel.
- This link design calculation takes into account several factors such as absorption of signal by the space through which it propagates, various noise sources present in the satellite system, gain of transmitting and receiving antennas, and also the uplink and downlink frequencies because the absorption of signal by the atmosphere varies with frequencies.
- The design of uplink is simpler than the design of downlink, because any amount of required power can be generated in an earth station by using large number of vacuum devices.
- However this is not possible inside a satellite due to its limited size.

Q4a) Explain Domestic satellite system with suitable example.

- The design of a satellite communication system is a complex process, involved compromises between many factors in order to obtain the maximum performance at an acceptable cost. Several factors dominate the design. These are
  - • The weight of the satellite
  - • The DC power that can be generated on board.
  - • The frequency bands allocated for satellite communication
  - • The maximum dimensions of satellite and ground station antennas,
  - • The multiple access technique used to share communications capacity between many earth stations
- The 6/4 Ghz bands have been the most popular and heavily used for the first 15 years of satellite communication systems, because they offer the fewest propagation problems, lower sky noise, lower noise temperature and historically, RF components for these bands have been readily available.
  - The weight of the satellite is limited by the high cost of launching a spacecraft into geostationary orbit.
  - In the design of satellite link two main designs are considered. They are

- • Uplink design
- • Downlink design

- A **direct-broadcast satellite** (DBS) is an example of domestic satellite is a type of artificial satellite which usually broadcasts satellite television signals for home reception.
- The type of satellite television which uses direct-broadcast satellites is known as direct-broadcast satellite television (DBSTV) or direct-to-home television (DTHTV).
- The term "direct broadcast" is used to distinguish satellites which transmit radio or television signals directly to receivers in consumers' homes from other communications satellites which transmit signals to satellite ground stations, for example those which distribute cable television signals to cable head end facilities.

Q4b) Explain one-way satellite communication link.

- The uplink design is rather easier than the downlink in most cases, since an accurately specified carrier power density must be presented at the satellite transponder and it is feasible to use much higher power transmitters at earth stations than can be used on a satellite in most cases.

  - The cost of transmitters tends to be high compared to the cost of receiving equipment in satellite communication system.
  - Generation of high stability, high power microwave carriers is invariably expensive, and considerable care is needed throughout the transmitter to control spurious emissions and group-delay effect.
  - As a result, the major growth in satellite communications has been in point-to-multipoint transmission, as in cable TV distribution. One high cost transmit earth station provides service to many low-cost receive-only stations.
  - The situation worsens as antenna diameter is reduced. Smaller antenna gain requires greater transmitter power for a given EIRP, and use of TDMA requires still more power if the satellite transponder is to be driven into saturation. For example, a TV receive only earth station for the 4 GHz band costs as a little as $1500 with a 10-ft dish (1984 prices). To add a 6 GHz transmitter to this station would increase the cost by factor of 10 or 15, given for a low output power.

  - At L-band (1000-2000 MHz) where the maritime system operate, transistor amplifiers can be used to generate 50 W of output power, costs are not so high as 14 or 30 GHz, where the traveling wave tube is the main HPA in use.
  - The development of a low-cost, high-power, high-stability microwave source that could operate a millimeter wavelength would open up a vast range of new satellite communication services from nation wide mobile communication to wristwatch personal two-way radios.

- The satellite transponder is quasilinear amplifier and the received carrier levels determine the output level.
- Where a traveling wave tube is used as the output high-power amplifier (HPA) in the transponder, as is often the case, and FDMA is employed, the HPA must be run with a predetermined back off to avoid inter modulation products appearing at he output. The output back off is typically 3 to 7 dB and is determined by the uplink carrier power level received at the spacecraft. Accurate control of the power transmitted by the earth station is therefore essential, and Intelsat specifies +/- 0.5 dB for standard A stations when operated in the FDMA mode.

UNIT-3

Q5b) Explain the importance of Multiple access techniques in FDMA.

MULTIPLE ACCESS TECHNIQUES

- Multiple access techniques are used to allow a large number of mobile users to share the allocated spectrum in the most efficient manner.
- As the spectrum is limited, so the sharing is required to increase the capacity of cell or over a geographical area by allowing the available bandwidth to be used at the same time by different users.
- And this must be done in a way such that the quality of service doesn't degrade within the existing users.

MULTIPLE ACCESS TECHNIQUES FOR WIRELESS COMMUNICATION

- In wireless communication systems it is often desirable to allow the subscriber to send simultaneously information to the base station while receiving information from the base station.
- A cellular system divides any given area into cells where a mobile unit in each cell communicates with a base station.
- The main aim in the cellular system design is to be able to increase the capacity of the channel i.e. to handle as many calls as possible in a given bandwidth with a sufficient level of quality of service.

- There are several different ways to allow access to the channel. These includes mainly the following:
- Frequency division multiple-access (FDMA)
- Time division multiple-access (TDMA)
- Code division multiple-access (CDMA)

1) FREQUENCY DIVISION MULTIPLE ACCESS

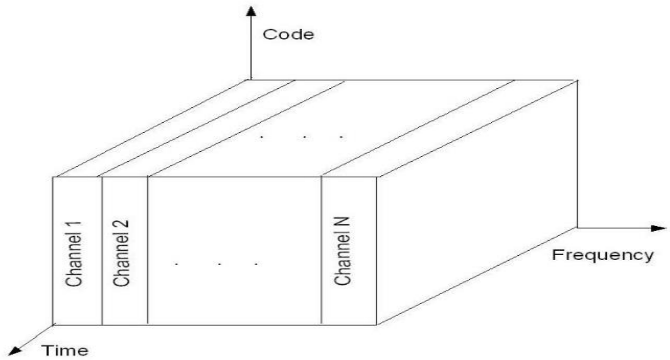


Figure : The basic concept of FDMA.

- This was the initial multiple-access technique for cellular systems in which each individual user is assigned a pair of frequencies while making or receiving a call as shown in Figure.
- One frequency is used for downlink and one pair for uplink. This is called frequency division duplexing (FDD).

- That allocated frequency pair is not used in the same cell or adjacent cells during the call so as to reduce the co channel interference.
- Even though the user may not be talking, the spectrum cannot be reassigned as long as a call is in place.
- Different users can use the same frequency in the same cell except that they must transmit at different times. The features of FDMA are as follows:
- The FDMA channel carries only one phone circuit at a time. If an FDMA channel is not in use, then it sits idle and it cannot be used by other users to increase share capacity.
- After the assignment of the voice channel the BS and the MS transmit simultaneously and continuously.
- The bandwidths of FDMA systems are generally narrow i.e. FDMA is usually implemented in a narrow band system The symbol time is large compared to the average delay spread.

- The complexity of the FDMA mobile systems is lower than that of TDMA mobile systems. FDMA requires tight filtering to minimize the adjacent channel interference.

FDMA/FDD in AMPS

- The first U.S. analog cellular system, AMPS (Advanced Mobile Phone System) is based on FDMA/FDD.
- A single user occupies a single channel while the call is in progress, and the single channel is actually two simplex channels which are frequency duplexed with a 45 MHz split.
- When a call is completed or when a handoff occurs the channel is vacated so that another mobile subscriber may use it.
- Multiple or simultaneous users are accommodated in AMPS by giving each user a unique signal.
- Voice signals are sent on the forward channel from the base station to the mobile unit, and on the reverse channel from the mobile unit to the base station.
- In AMPS, analog narrowband frequency modulation (NBFM) is used to modulate the carrier.

FDMA/TDD in CT2

- Using FDMA, CT2 system splits the available bandwidth into radio channels in the assigned frequency domain.
- In the initial call setup, the handset scans the available channels and locks on to an unoccupied channel for the duration of the call.
- Using TDD(Time Division Duplexing), the call is split into time blocks that alternate between transmitting and receiving.

FDMA and Near-Far Problem

- The near-far problem is one of detecting or filtering out a weaker signal amongst stronger signals.
- The near-far problem is particularly difficult in CDMA systems where transmitters share transmission frequencies and transmission time.
- In con- trast, FDMA and TDMA systems are less vulnerable. FDMA systems offer different kinds of solutions to near-far challenge.

- Here, the worst case to consider is recovery of a weak signal in a frequency slot next to strong signal.
- Since both signals are present simultaneously as a composite at the input of a gain stage, the gain is set according to the level of the stronger signal; the weak signal could be lost in the noise floor. Even if subsequent stages have a low enough noise floor to provide

2) TIME DIVISION MULTIPLE ACCESS

- In digital systems, continuous transmission is not required because users do not use the allotted bandwidth all the time.
- In such cases, TDMA is a complimentary access technique to FDMA. Global Systems for Mobile communications (GSM) uses the TDMA technique.
- In TDMA, the entire bandwidth is available to the user but only for a finite period of time. In most cases the available bandwidth is divided into fewer channels compared to FDMA.
- The users are allotted time slots during which they have the entire channel bandwidth at their disposal, as shown in Figure

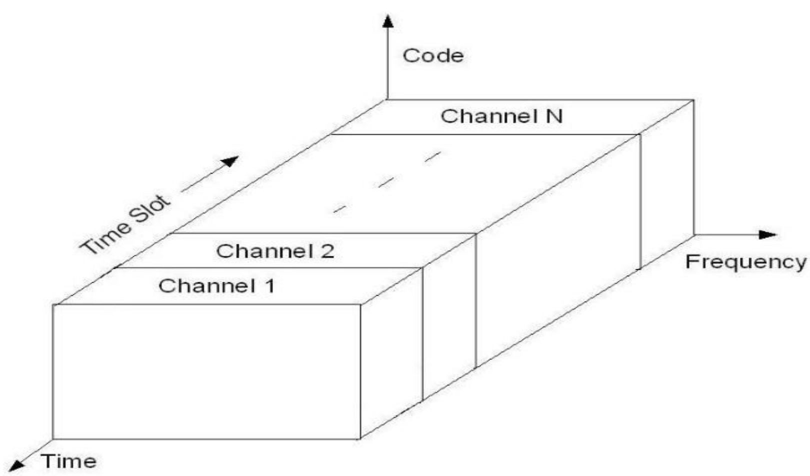


Figure : The basic concept of TDMA.

- TDMA requires careful time synchronization since users share the bandwidth in the frequency domain. The number of channels are less, inter channel interference is almost negligible.

- TDMA uses different time slots for transmission and reception. This type of duplexing is referred to as Time division duplexing (TDD).

- The features of TDMA includes the following:

a) TDMA shares a single carrier frequency with several users where each users makes use of non overlapping time slots.

b) The number of time slots per frame depends on several factors such as modulation technique, available bandwidth etc.

c) Data transmission in TDMA is not continuous but occurs in bursts. This results in low battery consumption since the subscriber transmitter can be turned OFF when not in use. Because of a discontinuous trans- mission in TDMA the handoff process is much simpler for a subscriber unit, since it is able to listen to other base stations during idle time slots.

d) TDMA uses different time slots for transmission and reception thus duplexers are not required.

- TDMA has an advantage that is possible to allocate different numbers of time slots per frame to different users.
- Thus bandwidth can be supplied on demand to different users by concatenating or reassigning time slot based on priority.

TDMA/FDD in GSM

- GSM is widely used in Europe and other parts of the world. GSM uses a variation of TDMA along with FDD.
- GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its

3) CODE DIVISION MULTIPLE ACCESS

- In CDMA, the same bandwidth is occupied by all the users, however they are all assigned separate codes, which differentiates them from each other shown in Figure.
- CDMA utilize a spread spectrum technique in which a spreading signal (which is uncorrelated to the signal and has a large bandwidth) is used to spread the narrow band message signal.

Direct Sequence Spread Spectrum (DS-SS)

- This is the most commonly used technology for CDMA. In DS-SS, the message signal is multiplied by a Pseudo Random Noise Code.
- Each user is given his own codeword which is orthogonal to the codes of other users and in order to detect the user, the receiver must know the codeword used by the transmitter.
- There are, however, two problems in such systems which are discussed in the sequel.

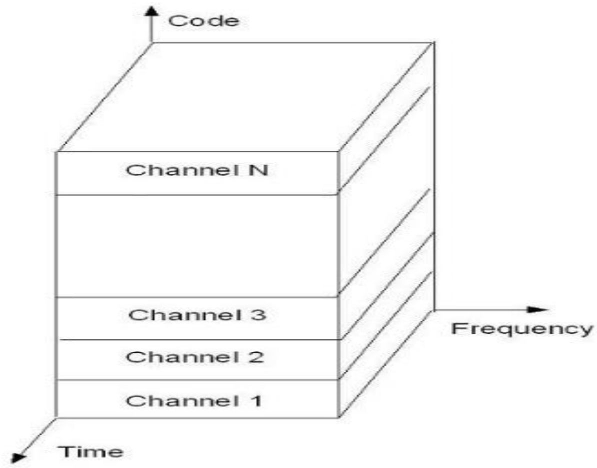


Figure : The basic concept of CDMA.

CDMA/FDD in IS-95

- In this standard, the frequency range is: 869-894 MHz (for Rx) and 824-849 MHz (for Tx).
- In such a system, there are a total of 20 channels and 798 users per channel.
- For each channel, the bit rate is 1.2288 Mbps.
- For orthogonality, it usually combines 64 Walsh-Hadamard codes and a m-sequence.

CDMA and Self-interference Problem

- In CDMA, self-interference arises from the presence of delayed replicas of signal due to multipath.
- The delays cause the spreading sequences of the different users to lose their orthogonality, as by design they are orthogonal only at zero phase offset.
- Hence in despreading a given user's waveform, nonzero contributions to that user's signal arise from the transmissions of the other users in the network.

- This is distinct from both TDMA and FDMA, wherein for reasonable time or frequency guardbands, respectively, orthogonality of the received signals can be preserved.

CDMA and Near-Far Problem

- The near-far problem is a serious one in CDMA. This problem arises from the fact that signals closer to the receiver of interest are received with smaller attenuation than are signals located further away.
- Therefore the strong signal from the nearby transmitter will mask the weak signal from the remote transmitter.
- In TDMA and FDMA, this is not a problem since mutual interference can be filtered. In CDMA, however, the near-far effect combined with imperfect orthogonality between codes (e.g. due to different time sifts), leads to substantial interference.
- Accurate and fast power control appears essential to ensure reliable operation of multiuser DS-CDMA systems.

Q5b) Explain the effect of Intermodulation with necessary equation.

- **Intermodulation** is the amplitude modulation of signals containing two or more different frequencies, caused by nonlinearities in a system.
- The intermodulation between each frequency component will form additional signals at frequencies that are not just at harmonic frequencies (integer multiples) of either, like harmonic distortion, but also at the sum and difference frequencies of the original frequencies and at multiples of those sum and difference frequencies.
- Intermodulation is caused by non-linear behaviour of the signal processing (physical equipment or even algorithms) being used.
- The theoretical outcome of these non-linearities can be calculated by generating a Volterra series of the characteristic, while the usual approximation of those non-linearities is obtained by generating a Taylor series.
- Practically all audio equipment has some non-linearity, so it will exhibit some amount of IMD, which however may be low enough to be imperceptible by humans.
- Due to the characteristics of the human auditory system, the same percentage of IMD is perceived as more bothersome when compared to the same amount of harmonic distortion.
- Intermodulation is also rarely desirable in radio, as it creates unwanted spurious emissions, often in the form of sidebands. For radio transmissions this increases the occupied bandwidth, leading to adjacent channel interference, which can reduce audio clarity or increase spectrum usage.
- IMD is only distinct from harmonic distortion in that the stimulus signal is different. The same nonlinear system will produce both THD (with a solitary sine wave input) and IMD (with more complex tones).
- In music, for instance, IMD is intentionally applied to electric guitars using overdriven amplifiers or effects pedals to produce new tones at *sub*harmonics of the tones being played on the instrument.

- IMD is also distinct from intentional modulation (such as a frequency mixer in superheterodyne receivers) where signals to be modulated are presented to an intentional nonlinear element (multiplied).
- See non-linear mixers such as mixer diodes and even single-transistor oscillator-mixer circuits. However, while the intermodulation products of the received signal with the local oscillator signal are intended,.
- superheterodyne mixers can, at the same time, also produce unwanted intermodulation effects from strong signals near in frequency to the desired signal that fall within the passband of the receiver.
- Intermodulation occurs when the input to a non-linear system is composed of two or more frequencies. Consider an input signal that contains three frequency components at fa,fb and fc are expressed as,

$$x(t) = M_a \sin(2\pi f_a t + \phi_a) + M_b \sin(2\pi f_b t + \phi_b) + M_c \sin(2\pi f_c t + \phi_c)$$

where the M and ϕ are the amplitudes and phases of the three components, respectively.

We obtain our output signal, $y(t)$, by passing our input through a non-linear function G:

$$y(t) = G\left(x(t)\right)$$

$y(t)$ will contain the three frequencies of the input signal, f_a, f_b, and f_c (which are known as the *fundamental* frequencies), as well as a number of linear combinations of the fundamental frequencies, each of the form

$$k_a f_a + k_b f_b + k_c f_c$$

where k_a, k_b, and k_c are arbitrary integers which can assume positive or negative values. These are the **intermodulation products** (or **IMPs**).

In general, each of these frequency components will have a different amplitude and phase, which depends on the specific non-linear function being used, and also on the amplitudes and phases of the original input components.

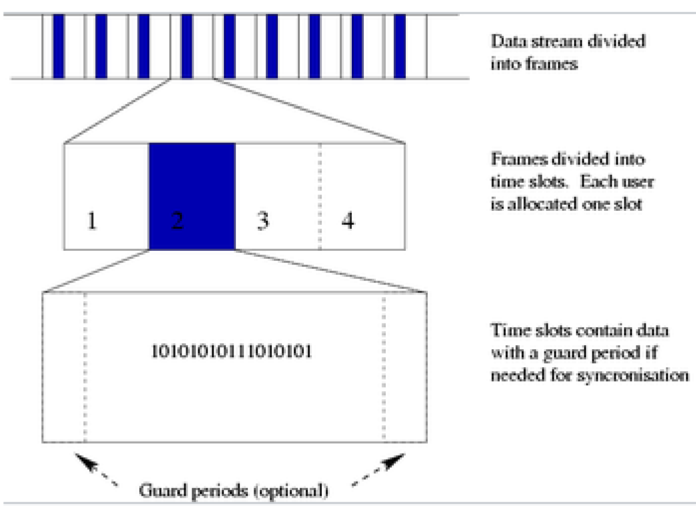
More generally, given an input signal containing an arbitrary number N of frequency components $f_a, f_b, \ldots, f_N$, the output signal will contain a number of frequency components, each of which may be described by

$$k_a f_a + k_b f_b + \cdots + k_N f_N,$$

where the coefficients $k_a, k_b, \ldots, k_N$ are arbitrary integer values.

Q6b) Explain TDMA Synchronization.

- **Time division multiple access** (TDMA) is a channel access method for shared medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots.
- The users transmit in rapid succession, one after the other, each using its own time slot.
- This allows multiple stations to share the same transmission medium (e.g. radio frequency channel) while using only a part of its channel capacity.
- TDMA is used in the digital 2G cellular systems such as Global System for Mobile Communications (GSM), IS-136, Personal Digital Cellular (PDC) and iDEN, and in the Digital Enhanced Cordless Telecommunications (DECT) standard for portable phones.
- It is also used extensively in satellite systems, combat-net radio systems, and PON networks for upstream traffic from premises to the operator.



TDMA frame structure showing a data stream divided into frames and those frames divided into time slots.

- Notice that a ``clock" is required for TDMA.
- All transmitters and receivers must be aware of this ``clock" to schedule their transmissions and receptions.

- We say that transmissions are *synchronized*.
- In cellular telephone systems a clock signal that indicates the beginning of time-slots is transmitted by the base stations. From this signals, mobile stations can determine when their turn comes up.

- In the digital telephone system, the transmitting exchange sends synchronization information together with the conversations.

Q6b) SS Transmission & Reception.

- In telecommunication and radio communication, **spread-spectrum** techniques are methods by which a signal (e.g., an electrical, electromagnetic, or acoustic signal) generated with a particular bandwidth is deliberately spread in the frequency domain, resulting in a signal with a wider bandwidth.
- These techniques are used for a variety of reasons, including the establishment of secure communications, increasing resistance to natural interference, noise and jamming, to prevent detection, and to limit power flux density (e.g., in satellite downlinks).
- This is a technique in which a telecommunication signal is transmitted on a bandwidth considerably larger than the frequency content of the original information.
- Frequency hopping is a basic modulation technique used in spread spectrum signal transmission.
- Spread-spectrum telecommunications is a signal structuring technique that employs direct sequence, frequency hopping, or a hybrid of these, which can be used for multiple access and/or multiple functions.
- This technique decreases the potential interference to other receivers while achieving privacy. Spread spectrum generally makes use of a sequential noise-like signal structure to spread the normally narrowband information signal over a relatively wideband (radio) band of frequencies. The receiver correlates the received signals to retrieve the original information signal.
- Originally there were two motivations: either to resist enemy efforts to jam the communications (anti-jam, or AJ), or to hide the fact that communication was even taking place, sometimes called low probability of intercept (LPI).
- Frequency-hopping spread spectrum (FHSS), direct-sequence spread spectrum (DSSS), time-hopping spread spectrum (THSS), chirp spread spectrum (CSS), and combinations of these techniques are forms of spread spectrum.

- Each of these techniques employs pseudorandom number sequences — created using pseudorandom number generators — to determine *and* control the spreading pattern of the signal across the allocated bandwidth.
- Ultra-wideband (UWB) is another modulation technique that accomplishes the same purpose, based on transmitting short duration pulses. Wireless standard IEEE 802.11 uses either FHSS or DSSS in its radio interface.

UNIT-4

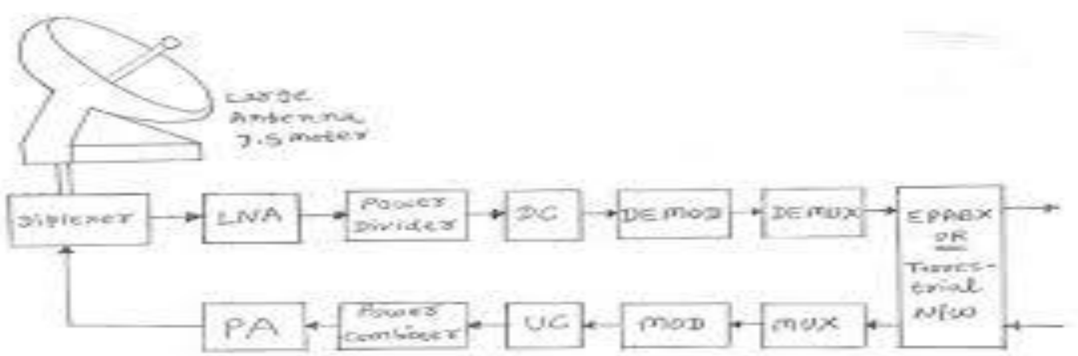
Q11a) Expalin the earth station design requirement in detail.

- Earth station is a vital element in any satellite communication network.
- The function of an earth station is to receive information from or transmit information to, the satellite network in the most cost-effective and reliable manner while retaining the desired signal quality.
- The design of earth station configuration depends upon many factors and its location. But it is fundamentally governed by its location which are listed below,

  - In land
  - On a ship at sea
  - Onboard aircraft

The factors are

- Type of services
- Frequency bands used
- Function of the transmitter
- Function of the receiver
- Antenna characteristics



Satellite Ground Station Block Diagram

EARTH STATION CONFIGURATION

Any earth station consists of four major subsystems

- Transmitter
- Receiver
- Antenna
- Tracking equipment

Two other important subsystems are

- Terrestrial interface equipment
- Power supply.

The earth station depends on the following parameters

- Transmitter power
- Choice of frequency
- Gain of antenna
- Antenna efficiency
- Antenna pointing accuracy
- Noise temperature
- Local conditions such as wind, weather etc,
- Polarization
- Propagation losses

➢ The functional elements of a basic digital earth station are shown in the below figure

- Digital information in the form of binary digits from terrestrial networks enters earth station and is then processed (filtered, multiplexed, formatted etc.) by the base band equipment.

- The encoder performs error correction coding to reduce the error rate, by introducing extra digits into digital stream generated by the base band equipment. The extra digits carry information. The presence of noise and non-ideal nature of any communication channel produces error rate is established above which the received information is not stable.

- The function of the modulator is to accept the symbol stream from the encoder and use it to modulate an intermediate frequency (I.F) carrier. In satellite communication, I.F carrier frequency is chosen at 70

MHz for communication using a 36 MHz transponder bandwidth and at 140 MHz for a transponder bandwidth of 54 or 72 MHz. The I.F is needed because it is difficult to design a modulator that works at the uplink frequency of 6 GHz (or 14GHz) directly.

- The modulated I.F carrier is fed to the up-converter and frequency-translated to the uplink r-f frequency.

- This modulated R.F carrier is then amplified by the high power amplifier (HPA) to a suitable level for transmission and radiation by the antenna to the satellite.

- On the receive side, the earth station antenna receives the low-level modulated R.F carrier in the downlink frequency spectrum.

- The low noise amplifier (LNA) is used to amplify the weak received signals and improve the signal to Noise ratio (SNR). The error rate requirements can be met more easily.

- R.F is to be reconverted to I.F at 70 or 140 MHz because it is easier design a demodulation to work at these frequencies than 4 or 12 GHz.

- The demodulator estimate which of the possible symbols was transmitted based on observation of the received if carrier.

- The decoder performs a function opposite that of the encoder. Because the sequence of symbols recovered by the demodulator may contain errors, the decoder must use the uniqueness of the redundant digits introduced by the encoder to correct the errors and recover information-bearing digits.

- The information stream is fed to the base-band equipment for processing for delivery to the terrestrial network.

- The tracking equipments track the satellite and align the beam towards it to facilitate communication.

ANTENNA SUBSYSTEM

The antenna system options are

1. Large antenna: say, for INTELSAT earth station typical diameter: 30M(cassegrain geometry used)

2. Small antenna: say, for option o0f direct broad television (DBS – TV). For deep space communication, the diameter of antenna may be very large, say over 35m.

FEED SYSTEM

- The primary feed system used in existing earth stations performs a number of functions. Depending on the type of earth station, these functions may be:
- • To illuminate the main reflector.
  • To separate the transmit and receive bands
  • To separate and combine polarizations in a dual polarized system.
  • To provide error signals for some types of satellite tracking system.

A horn antenna is commonly used as the primary feed at microwave frequencies.

- A horn antenna consists of an open waveguide which is flared at the transmitting end so that the impedance of the free space matches the impedance of the waveguide.
- This ensures an efficient transfer of power.

- A higher mode coupler (mode extractor) provides the error signal to the monopulse tracking system, if such a method is used.
- The orthogonal mode junction (OMJ) assembly is used to separate the dually polarized transmit and receive signal.
- The orthogonal mode transducer (OMT) separates the two linear orthogonally polarized signals into a composite linear orthogonally polarized signal on the transmit side.

- Because OMT operates on linearly polarized signals, polarizer’s are used to convert a circular polarization to a linear.
- Polarizer’s are therefore not required for linearly polarized system.
- Some earth stations have the capability to compensate polarization variations introduced by atmospheric effects by means of a feedback control system.
- The polarization properties of an antenna are mainly affected by the characteristics of the primary radiator and the polarizer

Q11b) Expalin importance of LNA,HPA in earth station design.

LNA

- A low-noise amplifier (LNA) is an electronic amplifier that amplifies a very low-power signal without significantly degrading its signal-to-noise ratio.
- An amplifier increases the power of both the signal and the noise present at its input. LNAs are designed to minimize additional noise.
- Designers minimize noise by considering trade-offs that include impedance matching, choosing the amplifier technology (such as low-noise components) and selecting low-noise biasing conditions.
- LNAs are found in radio communications systems, medical instruments and electronic equipment.
- A typical LNA may supply a power gain of 100 (20 decibels (dB)) while decreasing the signal-to-noise ratio by less than a factor of two (a 3 dB noise figure (NF)).
- \Although LNAs are primarily concerned with weak signals that are just above the noise floor, they must also consider the presence of larger signals that cause intermodulation distortion.

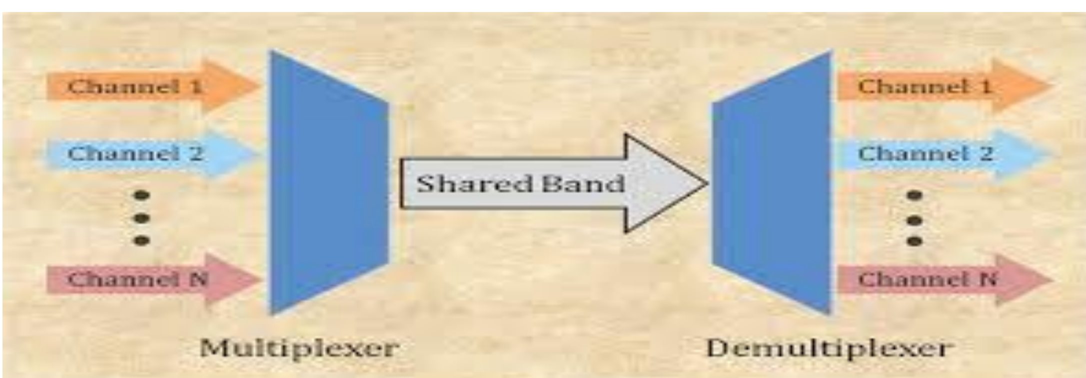
HPA

- The high-power amplifier (HPA) provides the RF power for a payload downlink. Before the signal goes to the HPA, the preamplifier boosts the signal to a level proper for input to the HPA.
- We may call these two together the HPA subsystem. There are two types of HPA subsystem: the traveling-wave tube amplifier(TWTA) subsystem and the solid-state power amplifier(SSPA). A subsystem named for the TWTA is not normally identified, but for the purposes of this book it must be so.
- The TWTA subsystem is more common than the SSPA. The HPA subsystem has the following functions:
- Channel preamplification for the HPA, with the flexibility to make the downlink power independent of the uplink power over a wide range of uplink power
- Predistortion (optional) to counteract the HPA's nonlinear amplification characteristics
- High-power amplification

Q12 Explain:

a) RF Multiplexing

- In telecommunications and computer networks, multiplexing (sometimes contracted to muxing) is a method by which multiple analog or digital signals are combined into one signal over a shared medium. The aim is to share an expensive resource.
- For example, in telecommunications, several telephone calls may be carried using one wire.
- Multiplexing originated in telegraphy in the 1870s, and is now widely applied in communications..
- The multiplexed signal is transmitted over a communication channel such as a cable.
- The multiplexing divides the capacity of the communication channel into several logical channels, one for each message signal or data stream to be transferred. A reverse process, known as demultiplexing, extracts the original channels on the receiver end.
- A device that performs the multiplexing is called a multiplexer (MUX), and a device that performs the reverse process is called a demultiplexer (DEMUX or DMX).
- Inverse multiplexing (IMUX) has the opposite aim as multiplexing, namely to break one data stream into several streams, transfer them simultaneously over several communication channels, and recreate the original data stream.



b) Factor Affecting Orbit Utilization

- There are major categories of factor which affect orbit utilization,
- Technical Factor, causes frequency to shift.
- These forces of inertia and gravity have to be perfectly balanced for an orbit to happen. If the forward movement (inertia) of one object is too strong, the object will speed past the other one and not enter orbit. If inertia or momentum is much weaker than the pull of gravity, the object will be pulled into the other one completely and crash.
- There are various solar/celestial effects that exist which have an effect on Earth's climate. These effects usually occur in cycles, and primarily include how Earth's obliquity, the eccentricity of Earth's orbit, and the precession of the equinoxes and solstices affect Earth's climate.
- In addition to these effects, there are also other factors that have an effect on Earth's climate. These other factors include how sun activity affects climate and how celestial phenomena, such as meteors, affect Earth's climate.
- Some of these factors aren't yet well understood, for instance the ice ages occur on 100,000 year cycles, and it's not completely understood why the various effects with this periodicity have such a strong effect on glaciation - see the 100,000-year problem.

c) Tracking

- A number of techniques can be used to determine the current orbit of a satellite.
- Velocity and acceleration sensors on the satellite can be used to find the change in orbit from the last known position.
- The earth station controlling the satellite can observe the Doppler shift of the telemetry carrier or beacon transmitter carrier to determine the rate at which range is changing.
- Active determination of range can be achieved by transmitting a pulse, or sequence of pulses, to the satellite and observing the time delay before the pulse is received again.

d) HPA: Refer above question