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Internal Assessment Test 2 – Dec. 2022

Sub:	Satellite communication					Sub Code:	18EC732	Branch:	ECE
Date:	02-12-2022	Duration:	90 Minutes	Max Marks:	50	Sem / Sec:	7th/A,B,C,D		OBE

	Answer any FIVE FULL Questions	MARKS	CO	RBT
1	Describe Telemetry, Tele-command & Tracking control monitoring system of a communication system.	[10]	CO3	L2
2	Illuminate the terms SCPC systems and MCPC systems in detail.	[10]	CO3	L2
3	Explain Faraday Rotation and Scintillation effect with respect to propagation consideration for satellite link design.	[10]	CO3	L2
4	Describe about the following sub-systems briefly: (i) Attitude and Orbit Control (ii) Payload	[10]	CO3	L2
5	With a neat block diagram, briefly describe each of the following Earth station hardware components: (i) Antenna (ii) Up/Down Converters	[10]	CO3	L2
6 (a) 6(b)	A geostationary satellite has a round-trip propagation delay variation of 20 ns/s due to station-keeping errors. If the time synchronization of DS-CDMA signals from different Earth stations is not to exceed 20 % of the chip duration, determine the maximum allowable chip rate so that a station can make a correction once per satellite round - trip delay. Assume the satellite round-trip delay to be equal to 220 ms. A geostationary satellite at a distance of 36 000 km from the surface of the Earth radiates a power of 20 watts in the desired direction through an antenna having a gain of 20 dB. What would be the power density at a receiving site on the surface of the Earth and also the power received by an antenna having an effective aperture of 10 m^2?	[5+5]	CO2	L3
7	Explain the typical TDMA Frame Structures.	[10]	CO2	L2
8	Write short notes on followings: (i) Satellite Link Parameters (ii) Satellite Link Transmission Equation	[5+5]	CO3	L3

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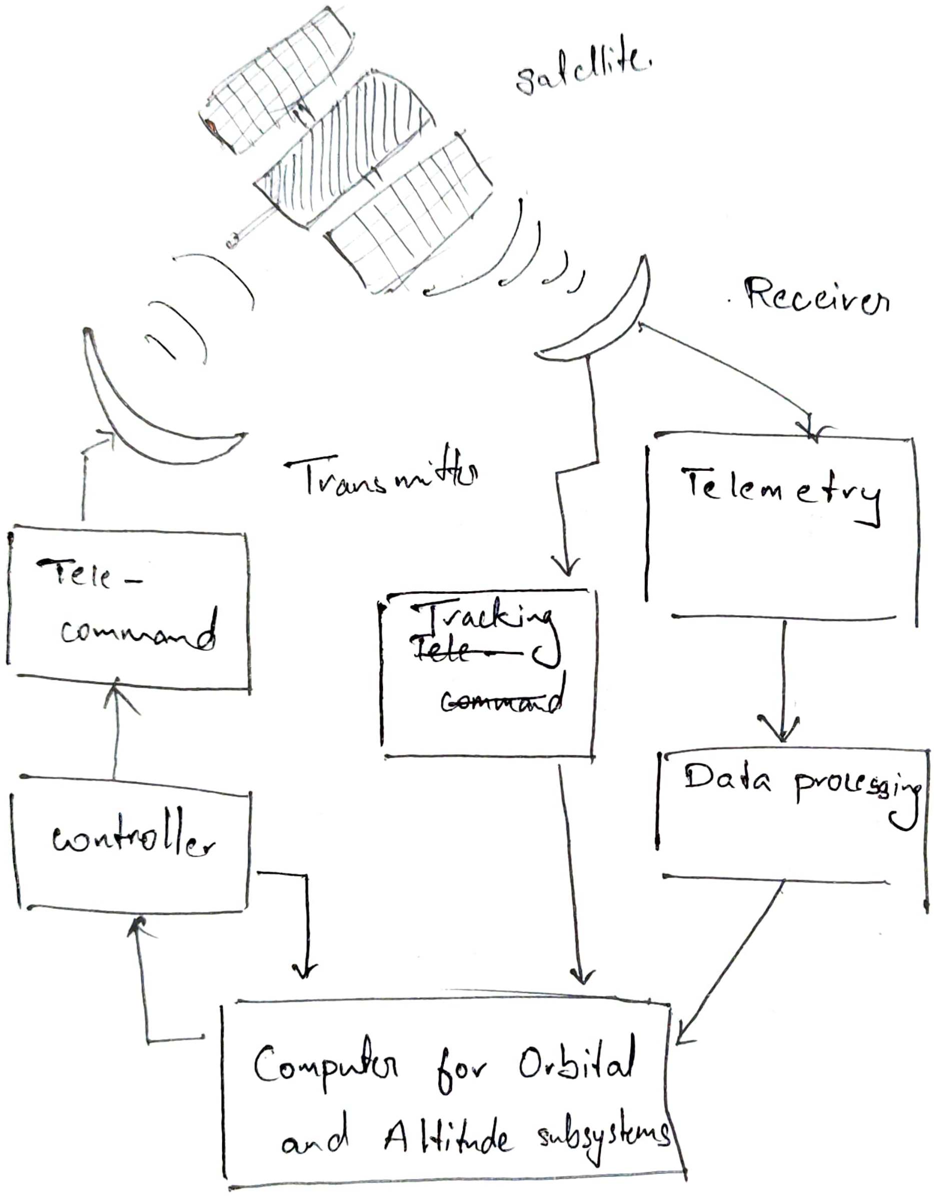
1.



- The telemetry, telecommand & Tracking control monitoring system of the communication system is used to keep track of the system from the initial launch of the satellite to the very end of its life after its purpose in space.

- It monitors the health of the satellite's subsystem, sending data of the status of the satellite's subsystem to the earth's stationary centers that receive and process the data.
- It monitors the path of the satellite and sees to it by making sure its on the pre planned orbit. If not, it collects the data from the satellite's position, angular velocity, power etc, processes them and then sends the corrections from the earth stations to the satellites.

Telemetry: It basically monitors the health of the sub systems, and sends the data accordingly to the data processing unit.

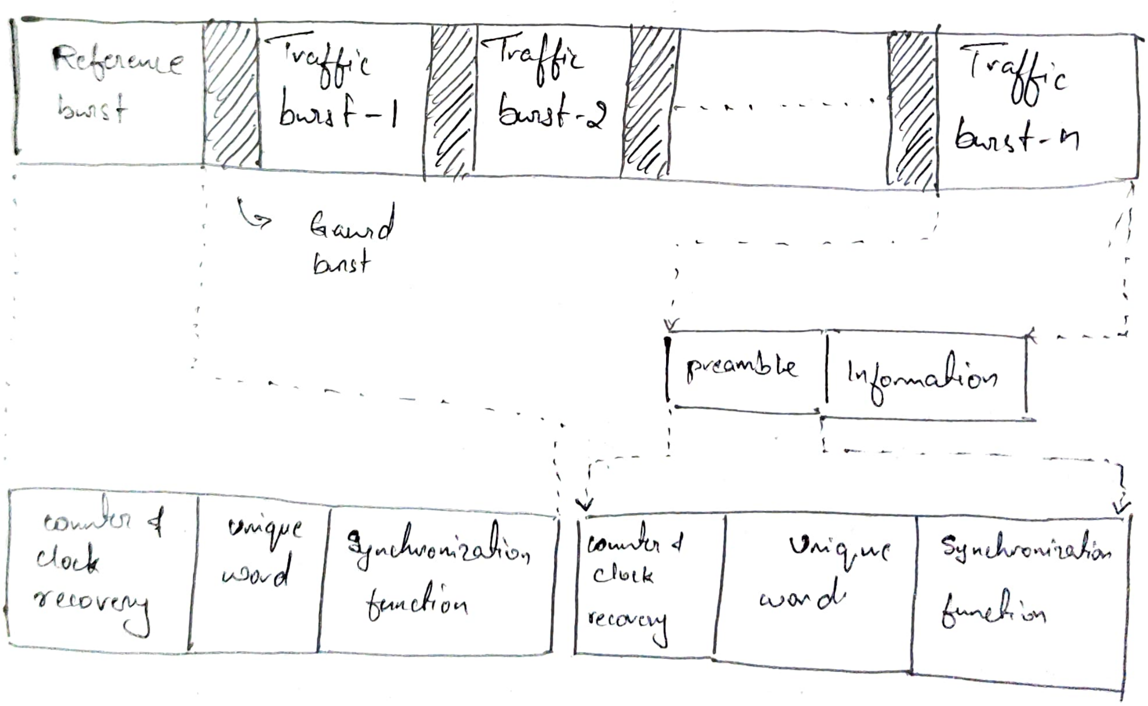
Tracking: In tracking unit, it monitors the position, speed, direction, propulsion, battery power etc, and sends the data accordingly to the computer for the orbital & altitude calculations.

The computer then calculates and sends the necessary corrections accordingly from the tele-command to the transmitter.

These steps are necessary to make sure that the satellite stays on its path, performs its required functions and works without any issue. If it does face any difficulties, these above mentioned components decide, process and sends the necessary corrections.

(7.)

TDMA Frame structures.



The time division multiple access frame structure is a structure that consists of the following components from the structure. It is a series of signals sent from the stations around the earth to the satellite in different time slots.

CMR

(1) <u>Reference burst</u>: The reference burst consists of two bursts, one is RB1 and RB2. The reference burst is sent to the satellite to help it synchronize and start the counter for the oncoming traffic of signals from the earth stations. If RB1 is sent, but fails, the RB2 is sent as a backup for the smooth execution of receiving the incoming traffic.

(2) <u>Gaurd burst</u>: The guard burst is the burst time allotted after a traffic burst or a reference burst ~~to so that~~ to help the satellite synchronize up for the next traffic. It is present between and before every traffic burst., similar to a waiting period.

(3) The traffic burst consists of the following

→ Preamble & Information.

<u>Preamble</u>: It is the setup bits for synchronization, clock and counter recovery, unique word etc.

~~→ Clock recovery.~~

<u>Information</u>: It is the main data that is sent from the earth stations to the ~~stat~~ satellite.

* Counter & clock recovery: Sets up & recovers the clock for receiving the next traffic burst.
* Unique word: Marks the satellite for the next synchronization.
* Synchronization function: Sets up the synchronization & does the clock management.

(4) (ii) Altitude & Orbit Control:

The altitude & orbit control is one of the important sub-systems of the satellite. It is used to track the distance of the satellite from the earth and also monitor the orbit of the satellite or the path in which it is orbiting around the earth. If there is any error or deviation of the intended altitude or orbit path it should maintain, ~~it sends the~~ the continuous data received from the satellites system is then collected, processed and the required error corrections are transmitted from the earth stations to correct its orbital path, trajectory, altitude etc. The altitude and the orbital path, trajectory can be altered depending upon the application it is required for and can be corrected accordingly.

(iii) Payload:

The payload is basically the instrumentation, items, etc that is required for the sole purpose of sending the satellite to ~~the~~ space. The payload is a very important factor as it determines the initial cost of launching the satellite to space. As the payload weight increases, the cost proportionally increases as well. Some of the instruments can be to monitor the weather patterns, map ~~the~~ a particular region or to collect and process data from the multiple transmitters around the world.

~~The~~

(6) (b) The distance = 36 000 km (d)

power radiated = 20 watts. (P_T)

antenna gain = 20dB (G)

∴ so first we have to calculate the radiated power density.

$$\therefore P_{rd} = \frac{P_T G_T}{4\pi d^2}$$

∴ ~~first~~ converting the gain from dB

$$20\,dB = 10^{\frac{20}{10}} \Rightarrow 10^2 = 100$$

$$\therefore \quad P_{rd} = \frac{20 \times 10^{2}}{4 \times 3.16 \times (36 \times 1000 \times 1000)^{2}}$$

$$= 1.228 \times 10^{-13} \; W/m^{2}$$

now, the power received by the antenna of effective aperture of $10\,m^2$ is

$$= P_{rd} \times A_T$$

$$= 1.228 \times 10^{-13} \times 10$$

$$= 1.228 \times 10^{-12} \text{ watts.}$$

4.

Attitude and Orbit Control

- The attitude and orbit control subsystem performs twin functions of controlling the orbital path and to provide attitude control.

- It also ensures that the antennae remain pointed at a fixed point on the Earth's surface.

The requirements on the attitude and orbit control subsystem differ during the launch phase and the operational phase of the satellite.

Attitude Control

- The attitude control system maintains the correct attitude of the satellite so that it is able to maintain link with the ground Earth station and controls its orientation such that the satellite is in the correct direction for an orbital manoeuvre.

- Attitude control systems can be either passive or active.

- Passive systems maintain the satellite attitude by obtaining equilibrium at the desired orientation. There is no feedback mechanism to check the orientation of the satellite.

Active control maintains the satellite attitude by sensing its orientation along the three axes and making corrections based on these measurements.

Orbit Control

- Orbit control is required in order to correct for the effects of perturbation forces. These perturbation forces may alter one or more of the orbital parameters.

- The orbit control subsystem provides correction of these undesired changes. This is usually done by firing thrusters.

- In the case of geostationary satellites, the inclination of the orbit increases at an average rate of about 0.85◦ per year.

In the case of non-circular orbits, the velocity of the satellite needs to be increased or decreased on a continuous basis. This is done by imparting corrections in the direction tangential to the axis lying in the orbital plane.

2. SCPC and MCPC

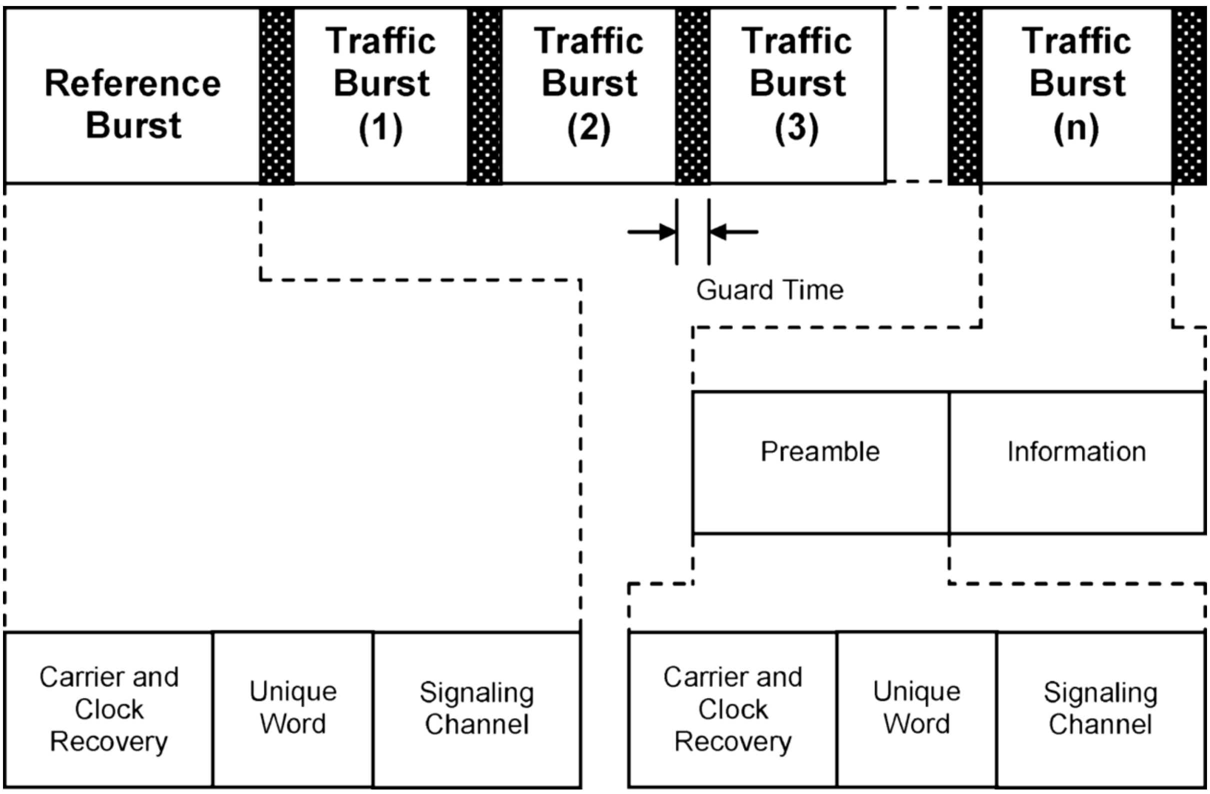
Specifications	SCPC	MCPC
Full form	Single Channel Per Carrier-single voice or data channel is modulated and transmitted over one RF carrier	Multiple Channels Per Carrier-Mlutiple voice and/or data channels are multiplexed(using TDM),modulated and transmitted over one RF carrier
Transmission format	Analog (voice channel) or Digital data (email,image/ text file)	Analog (voice channel) or Digital data (email,image/ text file
Multiplexing	Not provided	FDM or TDM
Modulation technique	FM or PSK(continuous/voice activated), voice activation is provided to save power when there is no voice activity	FM or PSK
Carrier Bandwidth(BW) usage	It can provide one connection and can use full bandwidth of transponder.	It can have multiplexed many connections over single carrier which uses full bandwidth of transponder. It efficiently uses bandwidth of transponder.
Capacity(Per MHz of transponder bandwidth)	more channels	less to medium channels depends on data rate of a system(VSAT)
Application	low data rate VSATs	High data rate VSATs
Burst transmission	Inefficient for such transmission.	Ideal for burst transmission e.g. packet based data transmission.
Dedicated connection	User pays for dedicated connection even if connection is not used. SCPC DAMA implementation avoids this situation.	It does not need dedicated channel for each of the connection.

Sr. No.	FDMA	TDMA	DS-SS CDMA
1	Overall bandwidth is shared among many stations.	Time sharing of satellite transponder takes place	Sharing of bandwidth,and time both takes place.
2	Due to non-linearity of transponders amplifiers, inter modulation products are generated causing interference between adjacent channels.	Due to incorrect synchronization there can be interference between the adjacent time slots.	Both types of interference will not be present.
3	Synchronisation is not necessary.	Synchronisation is essential.	Synchronisation is not necessary.
4	Code word is not required.	Code word is not required.	Code word is required.
5	Guard bands between adjacent channels are necessary.	Guard time between adjacent times slots are necessary.	Guard times and guard bands are not necessary.

Advantages of TDMA:

- TDMA can easily adapt to transmission of data as well as voice communication.
- TDMA has an ability to carry 64 kbps to 120 Mbps of data rates.
- TDMA allows the operator to do services like fax, voice band data, and SMS as well as bandwidth-intensive application such as multimedia and video conferencing.
- Since TDMA technology separates users according to time, it ensures that there will be no interference from simultaneous transmissions.
- TDMA provides users with an extended battery life, since it transmits only portion of the time during conversations.
- TDMA is the most cost effective technology to convert an analog system to digital.

7. TDMA frame



- Different stations accessing the satellite transponder may transmit one or more traffic bursts per TDMA frame and position them anywhere in the frame according to a burst time plan that coordinates traffic between various stations.
- The timing reference for the location of the traffic burst is taken from the time of occurrence of the primary reference burst.
- With this reference, a station can locate and then extract the traffic burst or portions of traffic bursts intended for it.
- The reference burst also provides timing references to the stations for transmitting their traffic bursts so as to ensure that they arrive at the satellite transponder within their designated positions in the TDMA frame.

8. Satellite Link Parameters

Important parameters that influence the design of a satellite communication link include the following:

1. Choice of operating frequency
2. Propagation considerations
3. Noise considerations
4. Interference-related problems

Choice of Operating Frequency

- Factors such as propagation considerations, coexistence with other services, interference-related issues, technology status, economic considerations and so on.
- There would be interference-related problems as a large number of terrestrial microwave links use frequencies within these bands. Hence it is economic to use lower frequency bands.
- Higher frequency bands offer higher bandwidths but suffer from the disadvantage of severe rain-induced attenuation, particularly above 10 GHz.
- It may be mentioned here that for frequencies less than 10 GHz and elevation angles greater than 5°, atmospheric attenuation is more or less insignificant.

Propagation considerations

- The nature of propagation of electromagnetic waves or signals through the atmospheric portion of an Earth station–satellite link has a significant bearing on the link design.
- It is mainly the operating frequency and to a lesser extent the polarization that would decide how severe the effect of atmosphere is going to be.
- It is the first few tens of kilometres constituting the troposphere and then the ionosphere extending from about 80 km to 1000 km that do the damage.
- The effect of atmosphere on the signal is mainly in the form of attenuation caused by atmospheric scattering and scintillation and depolarization caused by rain in the troposphere and Faraday rotation in the ionosphere.

Noise considerations

- The quality of signal received at the Earth station is strongly dependent on the carrier-to-noise ratio of the satellite link.
- The quality of the signal received on the uplink therefore depends upon how strong the signal is, as it leaves the originating Earth station and how the satellite receives it.
- On the downlink, it depends upon how strongly the satellite can retransmit the signal and then how the destination Earth station receives it.
- If the received signal is sufficiently weak as compared to the noise level, it may become impossible to detect the signal.
- Even if the signal is detectable, steps should be taken within the system to reduce the noise to an acceptable level lest it impairs the quality of the signal received.

Interference-related problems

- Major sources of interference include interference between satellite links and terrestrial microwave links sharing the same operational frequency band, interference between two satellites sharing the same frequency band, interference between two Earth stations accessing different satellites operating in the same frequency band. Interference between satellite links and terrestrial links could further be of two types: first where terrestrial link transmission interferes with reception at an Earth station and the second where transmission from an Earth station interferes with terrestrial link reception.

The power flux density at the receiving antenna is given as

$$\Psi_M = \frac{\text{EIRP}}{4\pi r^2}$$

The power delivered to a matched receiver is this power flux density multiplied by the effective aperture of the receiving antenna, given by Eq. The received power is therefore

$$P_R = \Psi_M A_{\text{eff}}$$

$$= \frac{\text{EIRP}}{4\pi r^2} \frac{\lambda^2 G_R}{}$$

$$= (\text{EIRP})\,(G_R)\left(\frac{\lambda}{4\pi r}\right)^2$$

$$[P_R] = [\text{EIRP}] + [G_R] - 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

$$[\text{FSL}] = 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

$$[P_R] = [\text{EIRP}] + [G_R] - [\text{FSL}]$$