MAWLANA BHASHANI SCIENCE AND TECHNOLOGY UNIVERSITY

DEPARTMENT OF ICT

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Assignment - 03

Questions:

1| (a) What are the applications of Wireless Mesh Network ?

(b) Determine the limits of visibility for an earth station situated at mean sea level, at latitude 48.42° north, and longitude 89.26 degrees west. Assume a minimum angle of elevation of 5°.

(c) What is Nyquist Theorem ? Write down few applications of Nyquist Theorem.

2| (a) Explain briefly the operation of a basic time division space switching.

(b) A satellite is orbiting in the equatorial plane with a period from perigee to perigee of 12 h. Given that the eccentricity is 0.002, calculate the semi-major axis. Consider the earth's equatorial radius is 6378.1414 km.

(c) Define Apogee and Perigee Heights.

3] (a) Determine the cutoff frequency of 26 gauge cable loaded with 22 mH inductors at 3000 spacings.

(b) Draw the block diagram of a PCM system and describe the operation of different blocks.

(c) How many telecommunication network topologies are there?

4] (a) Mention the advantages and limitations of different topologies along with associated figures.

(b) For satellite no. 14452 the NASA prediction bulletin for a certain epoch gives the eccentricity as 9.5981×10^{-3} and the mean anomaly as 204.9779°. The mean motion is 14.2171404 rev/day, calculate the true anomaly and the magnitude of the radius vector 5 s after epoch. The semi-major axis is known to be 7194.9 km.

5| (a) Define and explain Kepler's law ?

(b) In a group of 10 servers, each one is occupied for 30 minutes in an observation interval of two hours. Calculate the traffic carried by the group.

(c) Write an algorithm to implement a leaky bucket algorithm.

6| (a) What are the advantages of the token bucket algorithm.

(b) Derive the maximum radar range equation and describe the effects of each parameter.

(c) Why are capture area and effective area selected as optimal in radar range equation ?

7] (a) How are colors created in the TV ? Explain color TV screen with figure.

(b) Why is it necessary to modulate the picture and sound signals before transmission ? Why is TV transmission carried out in the UHF and VHF bands ?

(c) What is the composite video signal ? Enumerate the basic requirements that must be satisfied by the pulse train added after each field.

8| (a) Explain the operation of a Time multiplexed Time Division Space Switch with N incoming trunks and N outgoing trunks.

(b) Draw Subscriber Line Signalling diagram ?

(c) For a transmitter antenna with a power gain $G_T = 100$ and input power $P_t = 10$ W. Determine –

(i) EIRP in watt, dBm, dBW

(ii) P_D at 100 km

(iii) P_D for Isotropic antenna

Answere to the Ques. No - 1 (a)

Wireless mesh networcks are communication networcks which comprise radio nodes in which nodes are arcranged in a mesh topology. Mesh topology is an interconnection of all nodes connected with all other nodes in the networck. Some of the applications of mesh networcks which, deserve communication are :

- ↳ Battlefield surveillance
- ↳ Tunnels
- ↳ Mobile video applications
- ↳ Emergency situations
- ↳ Real time car racing etc.

Voice overc Internet Acotocol (VoIP) is the main application of wirceless mesh networcks. In orcderc to provide quality of servcice (QoS)

wireless mesh network is used in telecommunication for voice communication. Military forces in the USA are using wireless mesh networks to connect their devices for field operations.

Answer to the Ques. No – 1(b)

Given data:

$\lambda_E = 48.42^\circ$; $\phi_E = -89.26^\circ$; $El = 5^\circ$

$a_{GSO} = 42164$ km ; $R = 6371$ km

$\sigma_{min} = 90^\circ + El_{min}$

We know,

$$S = \arcsin\left(\frac{R}{a_{GSO}} \sin \sigma_{min}\right)$$

$$= \arcsin\left(\frac{6371}{42164} \sin(90^\circ + 5^\circ)\right)$$

$$= 8.66^\circ$$

$$b = 180^\circ - \sigma_{min} - 5$$

$$= 180^\circ - (90^\circ + 5^\circ) - 8.66^\circ$$

$$= 76.34^\circ$$

$$B = \arccos\left(\frac{\cos b}{\cos \lambda_E}\right)$$

$$= \arccos\left(\frac{\cos 76.34^\circ}{\cos 48.42^\circ}\right)$$

$$= 69.15^\circ$$

The satellite limit east of the earth station is at

$$\phi_E + B = -20^\circ \text{ approx} \quad (-89.26^\circ + 69.15^\circ)$$

and west of the earth station at

$$\phi_E - B = -158^\circ \text{ approx} \quad (-89.26^\circ - 69.15^\circ)$$

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Answer to the Ques. No - 1(c)

The Nyquist theorem states that an analog signal waveform may be uniquely and precisely reconstructed from samples taken of the waveform at equal time intervals, provided the sampling rate is equal to, or greater than, twice the highest significant frequency in the analog signal.

$$f_s \geq 2 f_{max}$$

* **Applications:**

The Nyquist Theorem, also known as the sampling theorem. There are few applications of Nyquist Theorem are listed below:

i. To maintain sound quality in music recordings.

ii. Sampling process applicable in the conversion of analog to discrete form.

iii. Speech recognition systems and pattern recognition systems.

iv. Modulation and demodulation systems

v. In sensor data evaluation systems

vi. Radar and radio navigation system sampling is applicable.

Answer to the Ques. No – 2 (a)

Time Division Space Switching : The incoming and outgoing signals when received and re-transmitted in a different time slot, is called Time Division Switching. Time division switches may also employ space division switching techniques, whereas an appropriate

mixeture of both time and space division switching is advantageous in various circumstances.

A time division space switch takes outputs of several time-division switches which are then given as inputs to space division switches. This means that one of the two similar outputs produced by a TDM switch, can be selected by space switch to deliver to another output path which reduces the number of crosspoints. The model of time division space switch is as shown in the following figure :

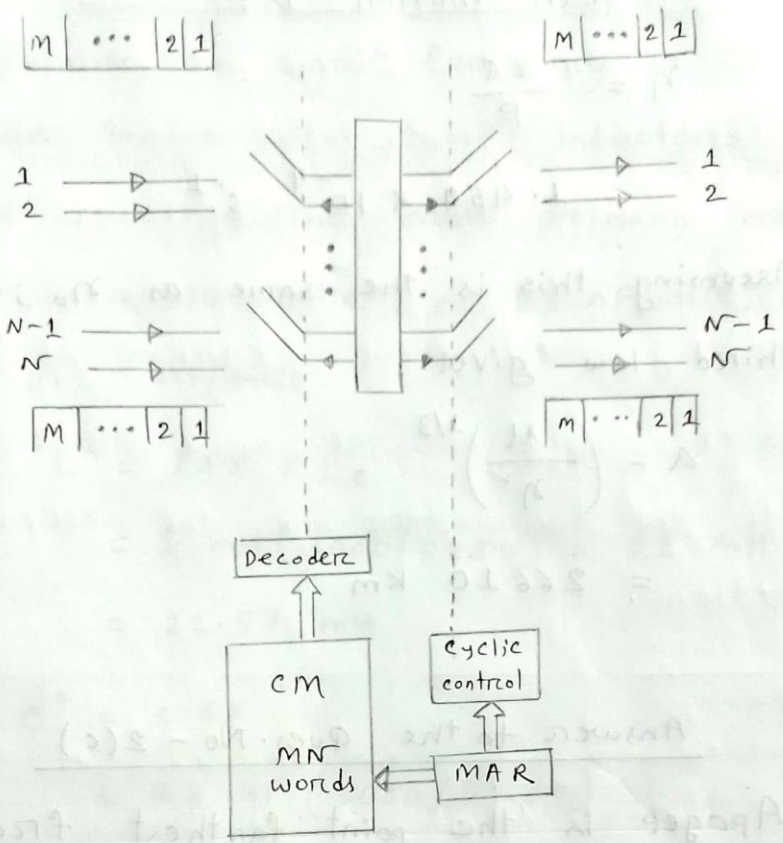


Fig: Time Division Space Switching

Answer to the Ques. No-2(b)

Given data:

$e = 0.002$; $i = 0^{\circ}$; $P = 12\,h$;

$K_1 = 66063.1704\ km^2$; $a_E = 6378.1414\ km$;

$\mu = 3.986005 \times 1014\ m^3/s^2$

The mean motion is:

$$n = \frac{2\pi}{P}$$

$$= 1.454 \times 10^{-4} \ s^{-1}$$

Assuming this is the same as n_0, Kepler's third law gives

$$a = \left(\frac{\mu}{n^2}\right)^{1/3}$$

$$= 26610 \ km$$

Answer to the Ques. No - 2(c)

Apogee is the point farthest from earth.

Perigee is the point of closest approach to earth.

Answer to the Ques. No – 3(a)

Determine the cutoff frequency of 26 gauge cable loaded with 22 mH inductors at 3000' spacings. The cable primary constants are: $r = 440\ \Omega/\text{mile}$, $c = 83\ nF/\text{mile}$, $l = 1\ mH/\text{mile}$, $g = 0.2\ \mu s/\text{mile}$.

Ans: $L' = l\Delta x + L_c$

$= 1\ mH\,(3000/5280) + 22\ mH$

$= 22.57\ mH$

$c'' = c\,\Delta x$

$= 83\ nF\,(3000/5280)$

$= 42.2\ nF$

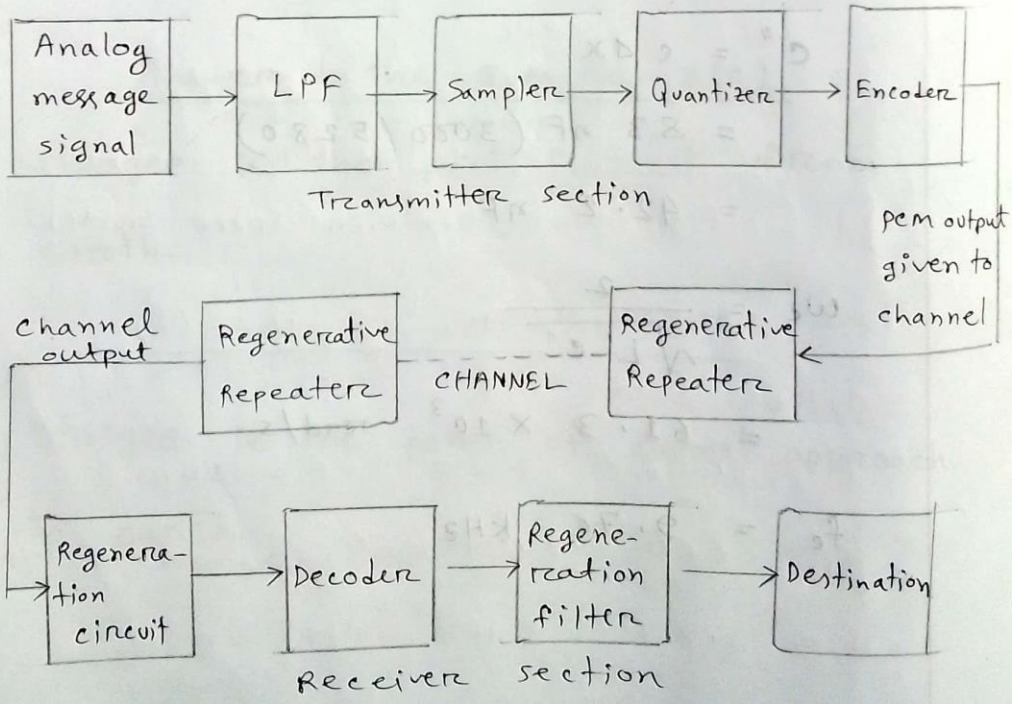
$$\omega_c = \frac{2}{\sqrt{L'c''}}$$

$= 61.3 \times 10^3$ rad/s

$f_c = 9.76\ kHz$

Answer to the Ques. No - 3(b)

A technique by which analog signal gets converted into digital form in order to have signal transmission through a digital network is known as PCM. Following is the block diagram of PCM which represents the basic elements of both the transmitter and the receiver sections.



Answere to the Ques. No - 3 (c)

There are eight basic network topologies:

(I) point-to-point

(II) Bus

(III) star

(IV) ring or circular

(V) mesh

(VI) tree

(VII) hybrid or

(VIII) daisy chain

Answer to the Ques. No - 4 (a)

Advantages and limitations of different network topologies:

* **Bus Topology:**

Advantages:

↳ It is easy to handle and implement.

↳ It is best suited for small networks.

Disadvantages:

↳ The cable length is limited. This limits the number of stations that can be connected. This network topology can perform well only for a limited number of nodes.

* Ring topology:

Advantages:

↳ The data being transmitted betⁿ two nodes passes through all the intermediate nodes. A central server is not required for the management of this topology.

Disadvantages:

↳ The failure of a single node of the network can cause the entire network to fail.

↳ The changes made to network nodes affects the performance of the entire network.

* Mesh topology:

Advantage:

↳ The arrangement of the network nodes is such that it is possible to transmit data from one node to many others nodes at the same time.

Disadvantages:

↳ The arrangement wherein every network node is connected to every other node of the network, many of the connections serve no major purpose. This leads to the redundancy of many of the network connections.

* Star topology:

Advantage:

↳ Due to its centralized nature, the topology offers simplicity of operation.

↳ It also achieve an isolation of each device in the network.

Disadvantage:

↳ The network operation depends on the functioning of the central hub. Hence, the failure of the central hub leads to the failure of the entire network.

Answer to the Ques. No-4(b)

The rotation in radia per second is

$$n = \frac{14.2171404 \times 2\pi}{86400}$$

$$\cong 0.001034 \text{ rad/s}$$

The mean anomaly of 204.9779°, in radius is 3.57754, and 5s after epoch the mean anomaly becomes

$$M = 3.57754 + 0.001034 \times 5$$

$$= 3.5827 \text{ rad or } 205.27°$$

Since the orbit is near-circular. Hence, to calculate the true anomaly ν as

$$\nu \cong 3.5827 + 2 \times 9.5981 \times 10^{-3} \times \sin 3.5827 + \frac{5}{4} \times (9.5981 \times 10^{-3})^2 \times \sin(2 \times 3.5827)$$

$$= 3.5746 \text{ rad} \quad (\text{or } 204.81^\circ)$$

The magnitude r is

$$r = \frac{7194.9 \times (1 - 9.5981^2) \times 10^{-6}}{1 + 9.5981 \times 10^{-3} \times \cos 204.81}$$

$$= 7257.5 \text{ km}$$

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Answer to the Ques. No - 5(a)

Kepler's three laws of planetary motion can be described as follows:

(i) The path of the planets about the sun is elliptical in shape, with the center of the sun being located at one focus. (The Law of Ellipses)

(ii) An imaginary line drawn from the center of the sun to the center of the planet will sweep out equal areas in equal intervals of time. (The Law of Equal Areas)

(iii) The ratio of the squares of the periods of any two planets is equal to the ratio of the cubes of their average distances from the sun. (The Law of Harmonies)

Answer to the Ques. No. - 5(b)

Given,

Number of servers = 10

Calculate traffic carried, A = ?

Traffic carried per sources = $\frac{30}{120}$

= 0.25 erlang

Traffic carried by the group = 10 × 0.25

= 2.5 £

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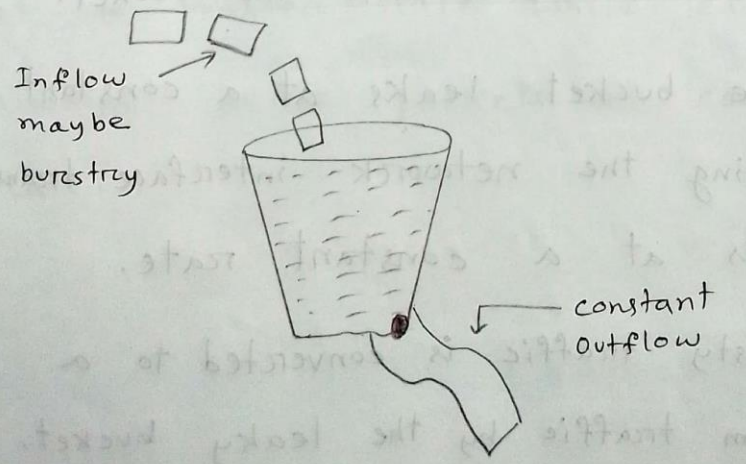
Answer to the Ques. No - 5(c)

The leaky bucket algorithm is a method of temporarily storing a variable number of requests and organizing them into a set-rate output of packets in an asynchronous transfer mode (ATM) network.

Leaky Bucket Algorithm:



Let us consider an example to understand- Imagine a bucket with a small hole in the bottom. No matter at what rate water enters the bucket, the outflow is at constant rate. When the bucket is full with water additional water entering spills over the sides and is lost.

Similarly, each network interface contains a leaky bucket and the following steps are involved in leaky bucket algorithm:

1. When host wants to send packet, packet is thrown into the bucket.

2. The bucket leaks at a constant rate, meaning the network interface transmits packets at a constant rate.

3. Bursty traffic is converted to a uniform traffic by the leaky bucket.

9. In practice the bucket is a finite queue that outputs at a finite rate.

Answer to the Ques. No - 6 (a)

Some advantage of token Bucket over leaky bucket –

↳ If bucket is full in token Bucket, tokens are discard not packets. While in leaky bucket, packets are discarded.

↳ Token Bucket can send Large Bursts at a faster rate while leaky bucket always sends packets at constant rate.

Answer to the Ques. No - 6(b)

The radar range equation relates the range of the radar to the characteristics of the transmitter, receiver, antenna, target and the environment. It is used as a tool to help in specifying radar subsystem specifications in the design phase of a program.

Let us derive the standard form of Radar range equation.

The Power density at a distance R from isotropic antenna

$$R = \frac{P_t}{4\pi R^2} \quad \text{watts/m}^2$$

Power density at a distance R from directive antenna of gain G

$$R = \frac{P_t G}{4\pi R^2} \quad \text{watts/m}^2$$

The total power intercepted by a target having area 'A' is :

$$R = \frac{P_t G}{4\pi R^2} \cdot A \quad \text{watts} \quad \text{where } A \text{ is area seen by radar.}$$

Power density of echo signal at radar station is

$$\rho = \frac{P_t G A}{4\pi R^2} \cdot \frac{1}{4\pi R^2} \quad \text{watts}$$

The radar antenna captures a portion of echo power. Let effective area of receiving antenna is A_R, the power P_r received by radar is :

$$P_r = \frac{P_t \cdot G \cdot A \cdot A_R}{(4\pi R^2)^2} \quad \text{watts}$$

$$R_{max} = \left(\frac{P_t G^2 (\lambda)^2 A}{(4\pi)^3 \cdot S_{min}} \right)^{1/4}$$

* Factors of affecting radar range equation:

i. Transmitter Power: In case the radar range

is to be doubled, we have to increase the transmitter power 16 times since $R_{max} \propto (P_t)^{1/4}$

ii. Minimum Detectable Signal : $R_{max} \propto \left(\frac{1}{S_{min}}\right)^{1/4}$; thus reducing S_{min}, the receiver has to be very sensitive and gain of the Rx should be high.

iii. Target cross sectional area : The radar cross section of a target is the area of the target as seen by a radar. The radar cross sectional area of the target is not a controller factor.

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Answer to the Ques. No - 6(c)

One of the important uses of the radar range equation is in the determination of detection range, or the maximum range at which a target has a given probability of being detected by the radar. The criterion for detecting a target is that the SNR be above some threshold value. If we consider the above radar range equations, we note that SNR varies inversely with the fourth power of range. This means that if the SNR is a certain value at a given range, it will be greater than that value at shorter ranges. We define the detection range as the range at which we achieve a certain SNR. In order to find detection range, we

need to solve the readare range equation for R.

Answer to the Ques. No - 7 (a)

TV's create color by mixing the red, blue and green beam and sheets. A color broadcast can be created by broadcasting three monochrome images, one each in the three colors of red, green and blue (RGB). When displayed together, these images will blend together to produce a full color image as seen by the viewer. Mixing all three colors create white, however black is created by turning off all three beams.

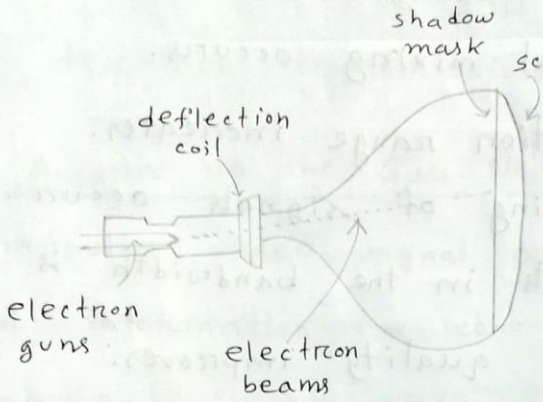


fig: The TV set

Answer to the Ques. No -7 (b)

Modulation allows us to send a signal over a bandpass frequency range. If every signal gets its own frequency range, then we can transmit multiple signals simultaneously over a single channel, all using different frequency ranges. Another reason to modulate a signal is to allow the use of a smaller antenna.

So advantages of modulation is:

i. Antenna size gets reduced.

ii. No signal mixing occurs.

iii. Communication range increases.

iv. Multiplexing of signals occur.

v. Adjustments in the bandwidth is allowed.

vi. Reception quality improves.

* Why TV transmission is carried out in the UHF and VHF bands:

A television transmission requires a wide bandwidth — very much wider than that of an audio transmission.

The bands reserved for audio broadcasting, both m.f. and h.f, are much narrower than the bands allocated for television; too narrow to accommodate even a single station to operate satisfactorily.

The V.h.f. and U.h.f bands allocated to television are wide enough to accommodate several television transmissions.

Answere to the Ques. No- 7(c)

A composite video signal contains video picture information for color, brightness and synchronization (horizontal and vertical). A composite video signal is a type of analog video transmission. It carries a standard definition video of 480i or 576i resolution. There are three main variants of composite videos: NTSC, PAL and SECAM.

A horizontal synchronizing (sync) pulse is needed at the end of each active line period whereas a vertical sync pulse is required after each field is scanned.

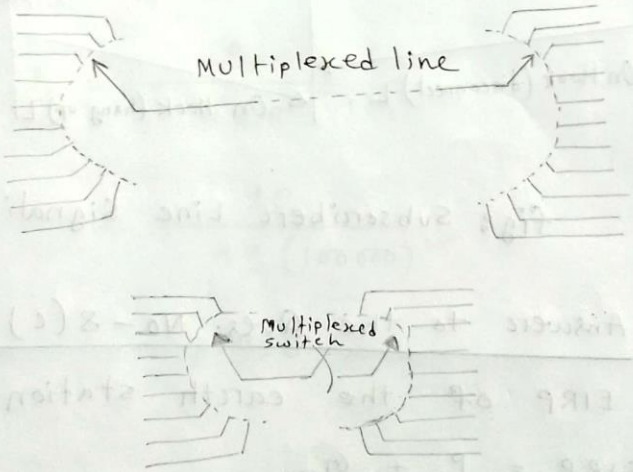
The amplitude of both horizontal and vertical sync pulses is kept the same to obtain higher efficiency of picture signal transmission but their duration (width) is chosen to be different for separating them at the receiver.

Since sync pulses are needed consecutively and not simultaneously with the picture signal, these are sent on a time division basis and thus form a part of the composite video signal.

Answer to the Ques. No - 8(a)

A time multiplexed space switch is shown in the following figure. There are N incoming trunks and N outgoing trunks, each carrying a time

division multiplexed stream of M samples per frame. For normal telephony, each frame is of 125 us. In one frame duration, a total of MN speech samples have to be switched. One sample duration, usually, 125/M us. is referred to as a time slot. In one time slot N samples are switched.



Answer to the Ques. No – 8 (b)

Subscriber Line signalling:

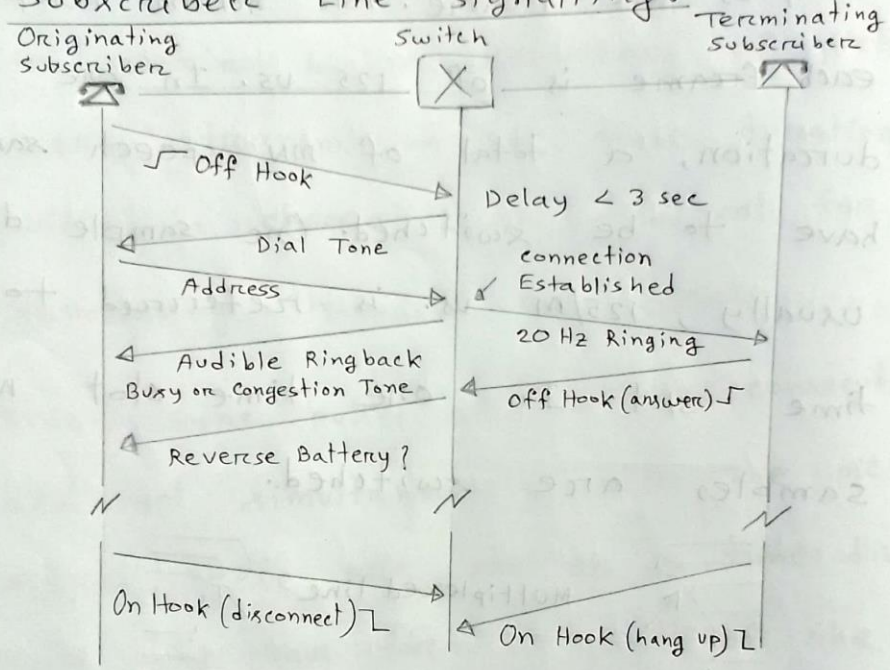


fig: Subscriber Line Signaling

Answer to the Ques. No – 8 (c)

(1) The EIRP of the earth station

$$EIRP = P_t + G_T$$
$$= 10 + 100$$
$$= 110 \quad dBW$$

(ii) The power density of a directional antenna is –

$$P_D = \frac{P_t G_t}{4\pi R^2}$$

$$= \frac{10 \times 100}{4\pi \times (100000)^2}$$

$$= 7.9577 \times 10^{-9}$$

(iii) The power density of an isotropic antenna is –

$$P_D = \frac{P_t}{4\pi R^2}$$

$$= \frac{10}{4\pi (100000)^2}$$

$$= 7.958 \times 10^{-11}$$

END