Wireless transmission

Radio wave | Microwave | Infrared

Radio wave (fregnencies between 3kHz and 1 GHz)

Radio waves are omnidirectional. When an antenna transmits radio waves, they are propagated in all directions. A sending antenna sends waves that can be received by any receiving antenna. The omnidirectional property has a disadvantage, too. The radio waves transmitted by one antenna are susceptible to interference by anothere antenna that may send signals using the same fregnency or band.

Radio waves, particularly those of low and medium fregnencies, can penetrate walls. propagate in the sky mode, can travel long distances.

Applications

The omnidirectional characteristics of radio waves make them useful for multicasting, in which there is one sender but many receivers. AM and FM radio, television, Cordless phones are example of multicasting

Microwaves (fregnencies between 1 and 300 GHz)

Microwaves are unidirectional. When an antenna transmits microwaves, they can be narrowly focused. This means that the sending and receiving antennas need to be aligned.

Microwave propagation is line-of-sight. Since the towers with the mounted antennas need to be in direct sight of each other, towers that are far apart need to be very tall.

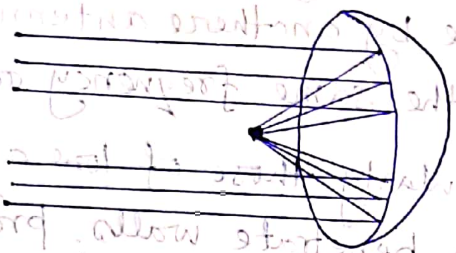
Very high-freqnency microwaves cannot penetrate walls.

Unidirectional antenna:

Two types of antennas are used for microwave communications: the parabolic dish and the horn.

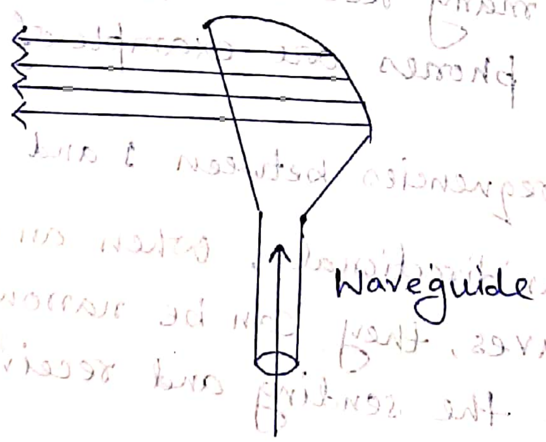
parabolic dish antenna:

Every line parallel to the line of symmetry reflects off the curve at angles such that all the lines intersects in a common point called the focus.



horn antenna

looks like a gigantic scoop. Outgoing transmission are broadcast up a stem and deflected outward in a series of narrow parallel beams by the curved head.



Applications

very useful when unicast (one to one) communication is needed between sender and the receiver. They are used in cellular phones, satellite networks and wireless LANs.

Infrared (frequencies from 300 GHz to 400 THz)

Having high frequencies, cannot penetrate walls. can be used for short-range communication. In addition, we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with the communication.

Applications

has an excellent potential for data transmission. can be used for short-range communication in a closed area using line-of-sight propagation.

TRANSMISSION IMPAIRMENT

Signals travel through transmission media, which are not perfect. The imperfection causes signal impairment. This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium. Three causes of impairment.

Impairment causes

- Attenuation
- Distortion
- Noise.

Attenuation

means a loss of energy. When a signal, simple or composite, travels through a medium, it loses some of its energy in overcoming the resistance of the medium. Some of the electrical energy in the signal is converted to heat. To compensate for this loss, amplifiers are used to amplify the signal.

Decibel: To show that a signal has lost or gained strength engineers use the unit of the decibel. decibel (dB) measures the relative strengths of two signals

$$dB = 10 \log_{10} \frac{P_2}{P_1} \quad \text{or} \quad dB = 20 \log_{10} \frac{V_2}{V_1}$$

[∵ power is proportional to the square of the voltage]

<u>Example:</u> Suppose a signal travels through a transmission medium and its power is reduced to one-half. This means that $P_2 = \frac{1}{2} P_1$. In this case, the attenuation can be calculated as

$$10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{0.5 P_1}{P_1} = 10 \log_{10} 0.5 = 10(-0.3) = -3$$

A loss of 3 dB (−3 dB) is equivalent to losing one-half the power.

<u>Noise</u>

Noise is another cause of impairment. Several types of noise, such as thermal noise, induced noise, crosstalk and impulse noise, may corrupt the signal.

<u>thermal noise:</u> is the random motion of electrons in a wire which creates an extra signal not originally sent by the transmitter.

<u>induced noise:</u> comes from sources such as motors and appliances. These devices act as a sending antenna and transmission medium acts as the receiving antenna.

<u>Crosstalk:</u> is the effect of one wire on the other. One wire acts as a sending antenna and the other as the receiving antenna.

<u>Impulse:</u> it is a spike (a signal with high energy in a very short time) that comes from

power lines, lightning and so on.

Signal-to-Noise Ratio (SNR)

signal-to-noise ratio is defined as.

$$SNR = \frac{\text{average signal power}}{\text{average noise power}}.$$

SNR is actually the ratio of what is wanted (signal) to what is not wanted (noise). A high SNR means the signal is less corrupted by noise; a low SNR means the signal is more corrupted by noise.

LINE CODING

Line coding is the process of converting digital data to digital signals. We assume that data, in the form of text, numbers, graphical images, audio or video, are stored in computer memory as sequences of bits. Line coding converts a sequence of bits to a digital signal.

We can divide line coding schemes into five broad categories.

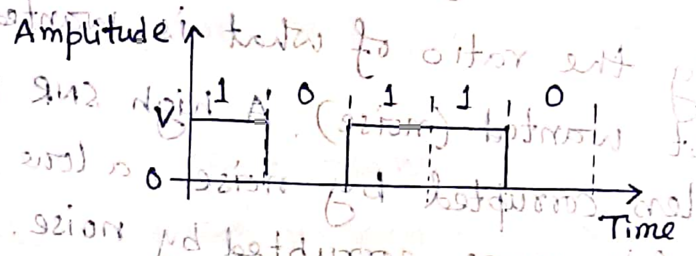
Line coding
- Unipolar
- Polar
- Bipolar
- Multi level
- Multitransition

Unipolar scheme :

In a unipolar scheme, all the signal levels are on one side of the time axis, either above or below.

NRZ (Non-Return-to-Zero)

a unipolar scheme was designed as a non-return-to-zero (NRZ) scheme in which the positive voltage defines bit 1 and the zero voltage define bit 0. It is called NRZ because the signal does not return to zero at the middle of the bit.

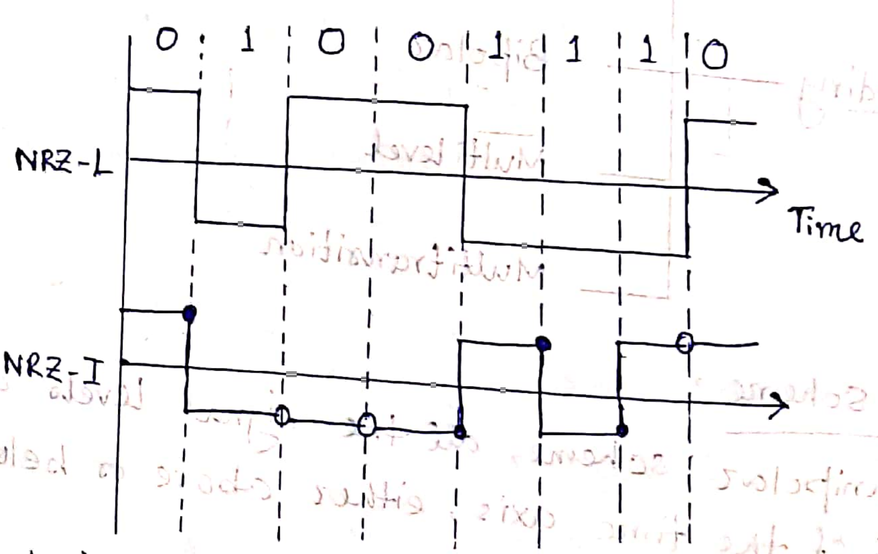


Polar Schemes

In polar schemes, the voltages are on the both sides of the time axis. For example, the voltage level for 0 can be positive and the voltage level for 1 can be negative.

Non-Return-to-Zero (NRZ) In polar NRZ encoding, we use two levels of voltage amplitude. We can have two versions of polar NRZ: NRZ-L and NRZ-I.

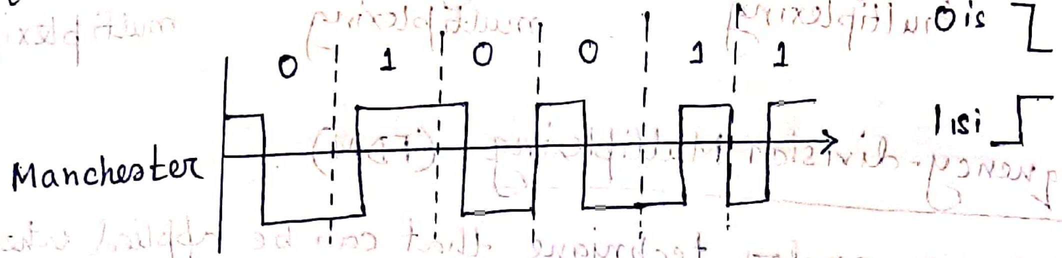
In the first variation NRZ-L, the level of the voltage determines the value of the bit. In the second variation, NRZ-I, the change or lack of change in the level of the voltage determines the value of the bit.



O No inversion: ...

Bipolar : Manchester and Differential Manchester.

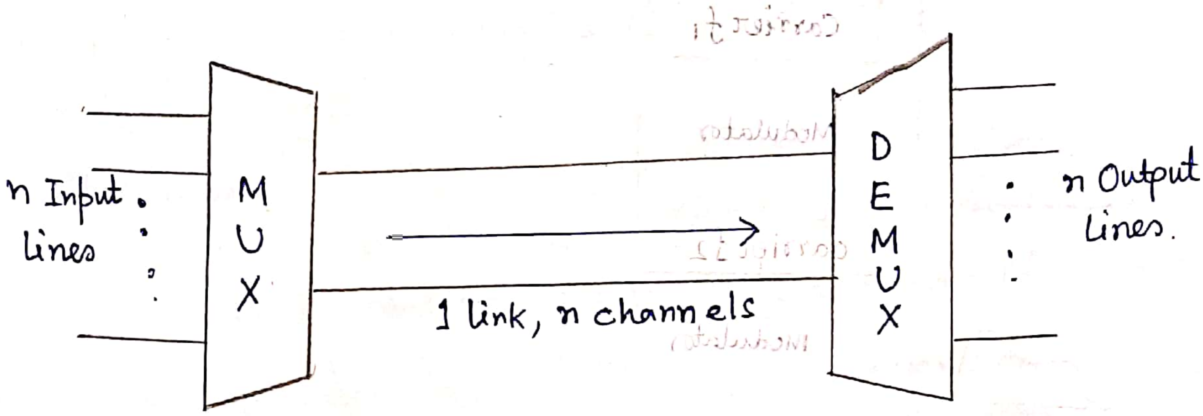
In Manchester encoding, the duration of the bit is divided into two halves. The voltage remains at one level during the first half and moves to the other level in the second half.



Bandwidth Utilization : Multiplexing

Multiplexing is the set of techniques that allows the simultaneous transmission of multiple signals across a single data lik.

In multiplexed system, n lines share the bandwidth of one link. The lines on the left direct their transmission streams to a multiplexer (MUX), which combines them into a single stream. At the receiving end, that stream is fed into a demultiplexer (DEMUX), which separates the stream back into its component transmissions and directs them to their corresponding lines.



Categories of multiplexing

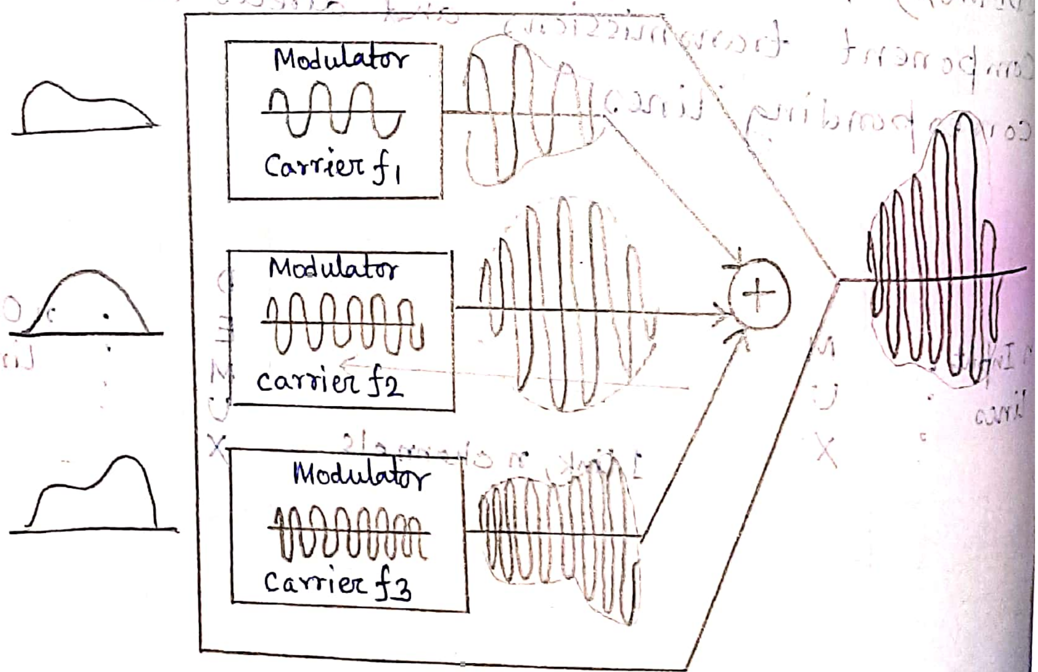
Multiplexing

- Frequency-division multiplexing
- Wavelength-division multiplexing
- Time-division multiplexing

Frequency-division Multiplexing (FDM)

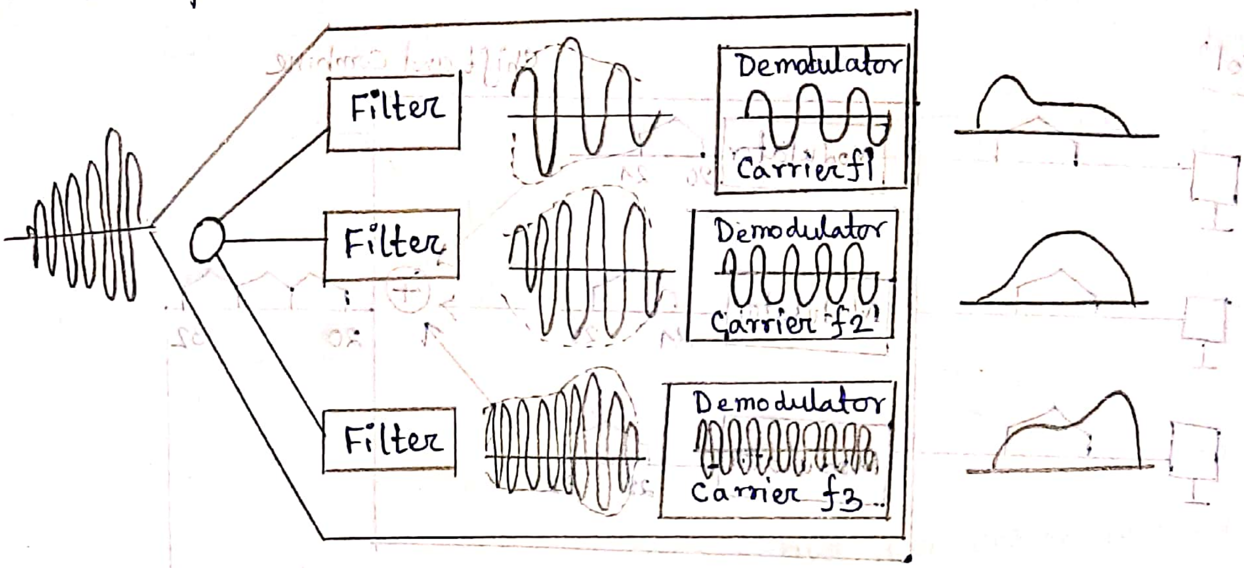
FDM is an analog technique that can be applied when the bandwidth of a link (in hertz) is greater than the combined bandwidths of the signals to be transmitted. In FDM, signals generated by each sending device modulate different carrier frequencies. These modulated signals are then combined into a single composite signal that can be transported by the link. Channels can be separate by strips of unused bandwidth — guard bands — to prevent signals from overlapping.

Multiplexing Process:



Demultiplexing Process

The demultiplexer uses a series of filters to decompose the multiplexed signal into its constituent component signals. The individual signals are then passed to a demodulator that separates them from their carriers and passes them to the output lines.



Application:

1) A very common application of FDM is AM and FM radio broadcasting. Radio uses the air as the transmission medium. A special band from 530 to 1700 KHz is assigned to AM radio. Each AM station needs 10 KHz of bandwidth. Each station uses a different carrier frequency, which means it is shifting its signal and multiplexing. The signal that goes to the air is a combination of signals. A receiver receives all these signals, but filter (by tuning) only the one which is desired.

2) The situation is similar in FM broadcasting. However, FM has a wider band of 88 to 108 MHz. because each station needs a bandwidth of 200 KHz.

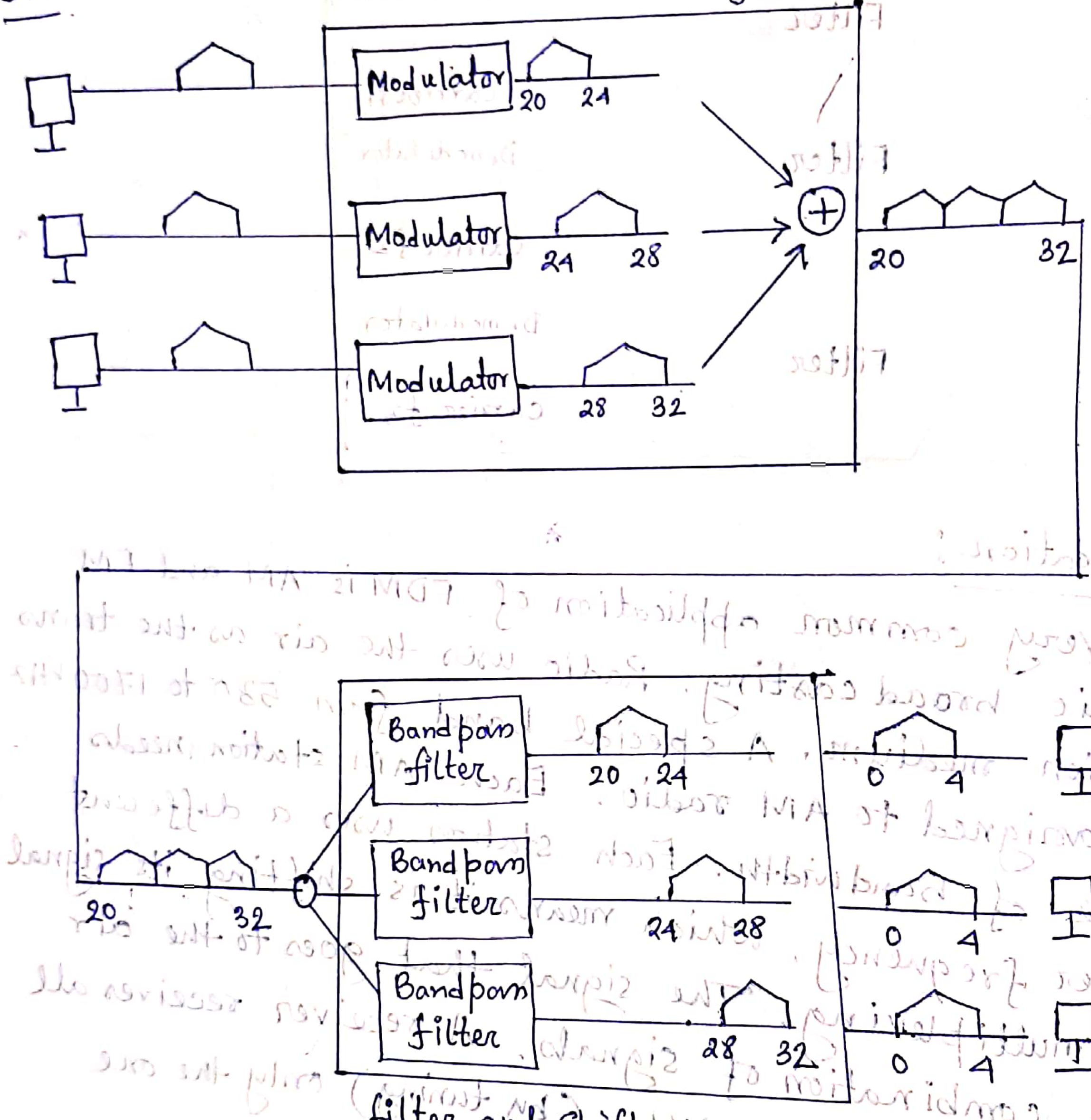
3) Another common use of FDM is in television broadcasting. Each TV channel has its own bandwidth of 6 MHz.

Example

Assume that a voice channel occupies a bandwidth of 4 KHz. We need to combine three voice channels into a link with a bandwidth of 12 KHz. from 20 to 32 KHz. Show the configuration using the frequency domain.

Sol'n

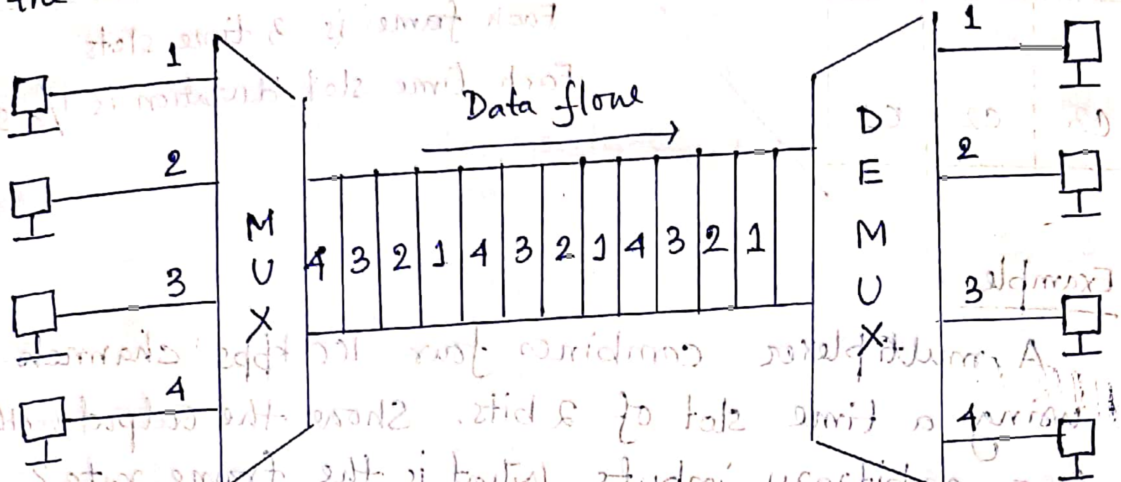
Shift and combine



Filter and shift

Synchronous Time-Division Multiplexing

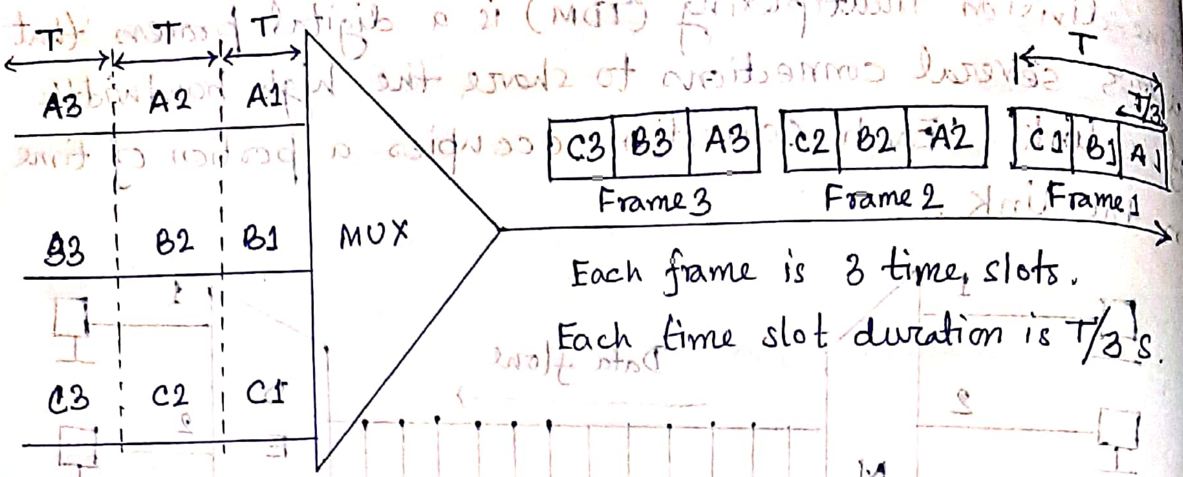
Time-division multiplexing (TDM) is a digital process that allows several connections to share the high bandwidth of a link. Each connection occupies a portion of time in the link.



In synchronous TDM, each input connection has an allotment in the output even if it is not sending data.

Time Slots and Frames

In synchronous TDM, the data flow of each input connection is divided into units, where each input occupies one input time slot. Each input unit becomes one output unit and occupies one output time slot. However, the duration of an output time slot is n times shorter than the duration of an input time slot. If an input time slot is T s, the output time slot is T/n s, where n is the number of connections.

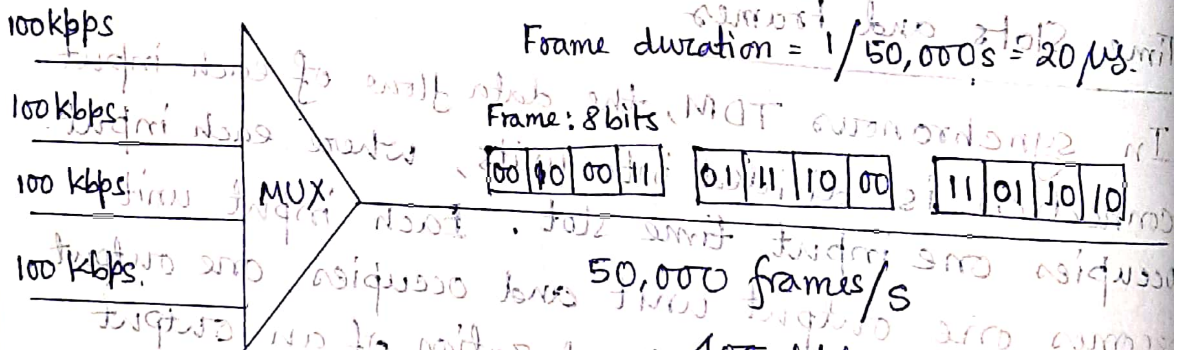


Each frame is 3 time slots.
Each time slot duration is T/3 s.

Example:

A multiplexer combines four 100 kbps channels using a time slot of 2 bits. Show the output with four arbitrary inputs. What is the frame rate? What is the frame duration? What is the bit rate? What is the bit duration?

Sol:



Each channel is sending 100 kbps/s = 100,000 b/s

Since each frame contain 2 bits per channel.

$\therefore$ 100,000 ÷ 2 = 50,000 frames per second

The frame rate is 50,000 frame per second and each frame carries 8 bits

$\therefore$ bit rate is 50 000 × 8 = 400,000 bits or 400 kbps.