Chapter - 6

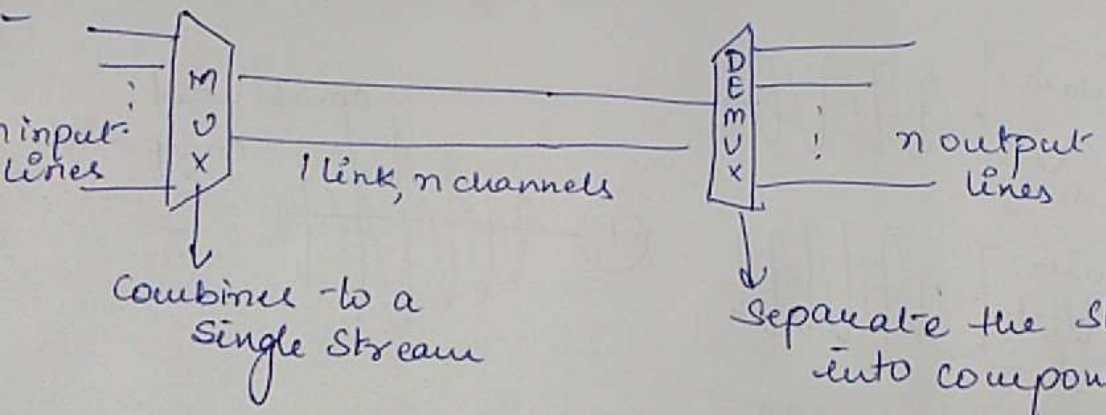
Bandwidth utilization: Multiplexing & Spreading

- 2 categories of Bandwidth utilization

Multiplexing	Spreading
- Combine multiple channels into 1.	- done to achieve privacy & antijamming

Multiplexing

- whenever the bandwidth of the medium is greater than the bandwidth needs of the devices, the link can be shared.
- Multiplexing is a technique that allows the simultaneous transmission of multiple signals across a single data link.
- Higher bandwidth mediums :- optical fiber, satellite microwaves.

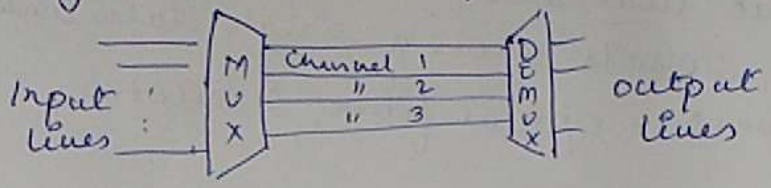


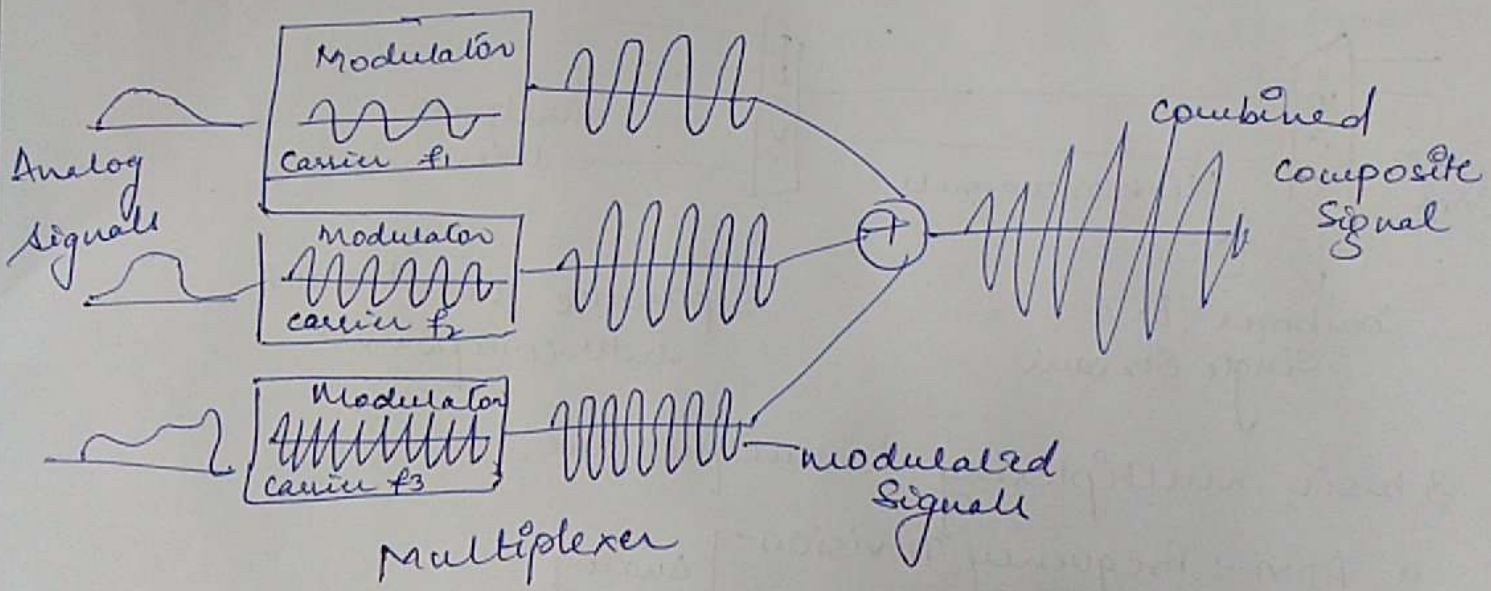
- 3 basic multiplexing techniques are :-

a. FDM : Frequency Division] Analog
b. WDM : Wavelength "]
c. TDM : Time "] Digital
d. CDM

Frequency Division Multiplexing

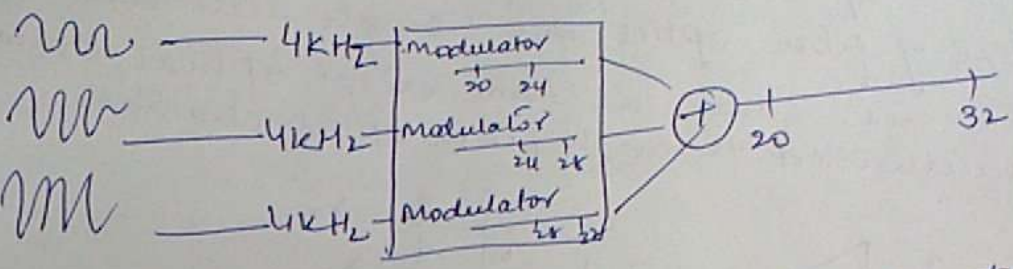
- It is an analog technique
- Applied when bandwidth of a link is greater than the combined bandwidths of the signals to be transmitted.
- Sending devices use different carrier frequencies.
- Different modulated signals are combined into a composite signal.
- Carrier frequencies are separated by bandwidths (Channels) to accomodate the modulated signal.
- Channels are separated by strips of unused bandwidth guard bands to prevent overlapping.



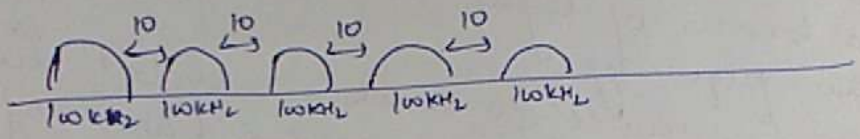


- Series of filters are used to decompose the multiplexed signal.

Ans Assume that a voice channel occupies a bandwidth of 4 kHz. We need to combine 3 voice channels with a bandwidth of 12 kHz from 20 to 32 kHz. Show the configuration using FDM. There are no guard bands.



Ans 5 channels, each with a 100 kHz bandwidth, are to be multiplexed together. What is the minimum bandwidth of the link if there is a need for a guard band of 10 kHz between the channels to prevent interference?

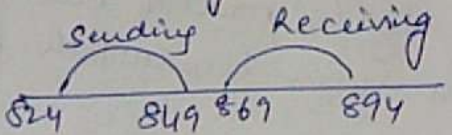


$100 \times 5 + 10 \times 4$

$500\ kHz + 40\ kHz = 540\ kHz$

- FDM is commonly used in AM and FM radio broadcasting.
- " " " " Television broadcasting.
- " " " " First generation of cell phones.

Ans A system uses 2 bands. First band of 824 to 849 MHz used for sending and 869 to 894 MHz used for receiving. Each user has a bandwidth of 30 kHz in each direction. The 3 kHz voice is modulated using FM, creating 30 kHz of modulated signal. How many people can use phones simultaneously?



$849 - 824 = 25$

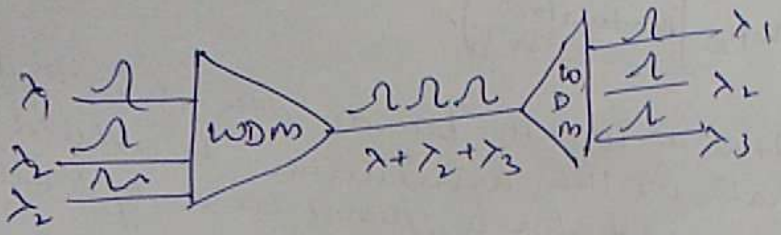
$894 - 869 = 25$

$$\frac{25\ MHz}{30\ kHz} = \frac{25 \times 10^6}{6300} = \frac{5 \times 10^6}{6}$$

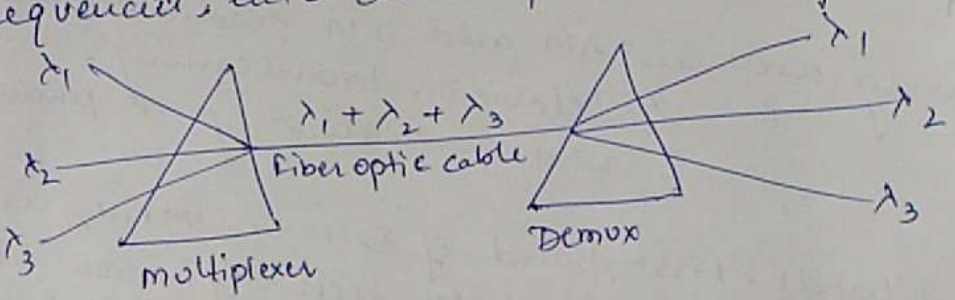
$= 8333$ channels

Wavelength Division Multiplexing

- It is designed to use the high data rate capability of fiber optic cable.
- Use of fiber optics for 1 single line wastes the bandwidth.
- It is same as FDM except optical signals are transmitted through fiber optics channels.



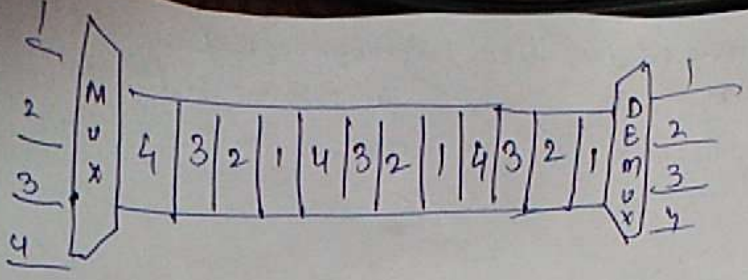
- It is a complex technology.
- The combining & splitting of light sources are easily handled by a prism.
- A prism bends a beam of light based on the angle of incidence & the frequency.
- A multiplexer can be made to combine several input beams of light, each containing a narrow band of frequencies, into one output beam of wider band of frequencies.



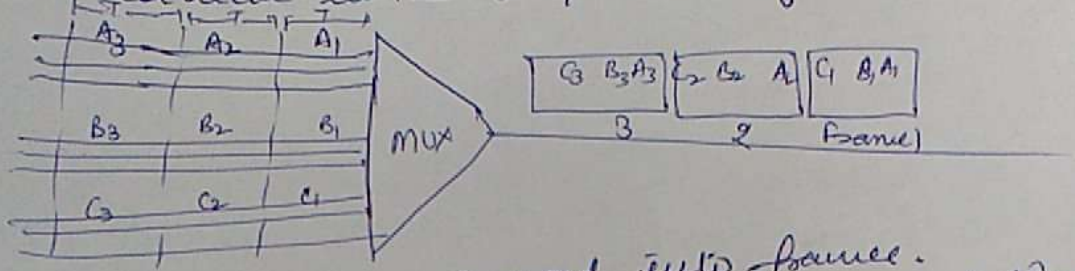
Dense WDM can multiplex a very large no. of channels by spacing channels very close to one another.

Synchronous Time-Division Multiplexing

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



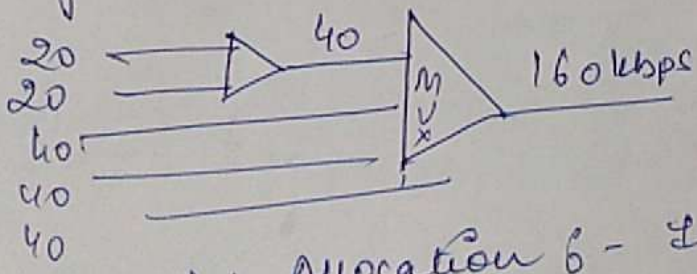
- TDM has 2 streams:-
  Synchronous and Statistical
- In synchronous TDM, each input connection has an allotment in the output even if it is not sending data.



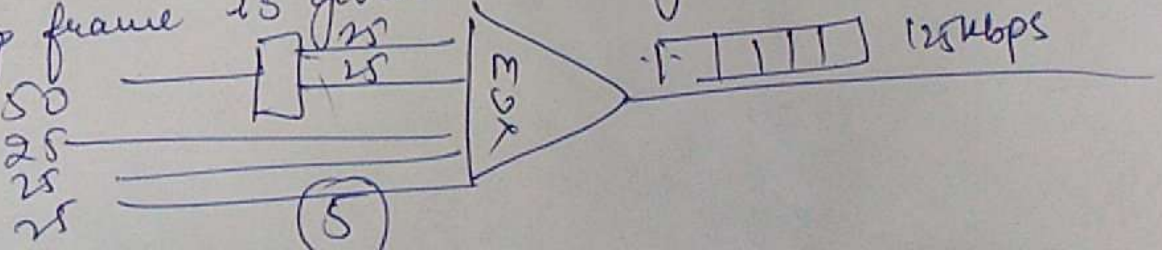
- Time slots are grouped into frames.
- A frame consists of one complete cycle of time slots; with one slot dedicated to each sending device.
- In a system with n input lines, each frame has n slots, with each slot allocated to carrying data from a specific input line.
- TDM can be viewed as 2 fast rotating switches.

If input data rates are not same then 3 strategies are used:- Multilevel multiplexing, multiple slot allocation pulse stuffing.

a Multilevel Multiplexing :- It is used when the data rate of an input line is a multiple of others.



b Multiple slot Allocation :- In this more than 1 slot in a frame is given to a single input line.



Pulse Stuffing :- Sometimes the highest input data rate is the dominant data rate & then add dummy bits to the input lines with the lower rates. This will increase their rates.