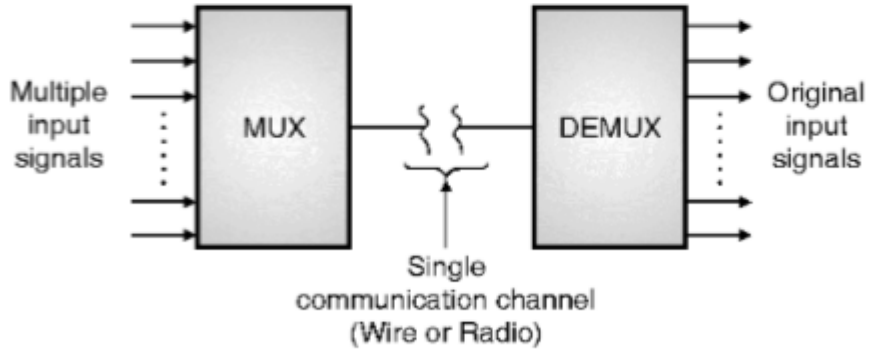
Definition of multiplexing :

- Multiplexing is the process of simultaneously transmitting two or more individual signals over a single communication channel.
- Due to multiplexing it is possible to increase the number of communication channels so that more information can be transmitted.

Multiplexer :

- An electronic circuit which carries out multiplexing is known as a multiplexer.
- The concept of a simple multiplexer is illustrated in Fig. 8.2.1.
- The multiplexer receives a large number of different input signals.
- Multiplexer has only one output which is connected to the single communication channel.
- The multiplexer combines all input signals into a single composite signal and transmits it over the communication medium.



(D-499) Fig. 8.2.1 : Concept of multiplexing

- Sometimes the composite signal is used for modulating a carrier before transmission.

Demultiplexing :

- Demultiplexing is the process of separating the signals from a multiplexed signal. It is exactly the opposite process of multiplexing.

Demultiplexer :

- An electronic circuit which carries out demultiplexing is known as a demultiplexer.
- At the receiving end, of communication link, a demultiplexer is used to separate out the signals into their original form.
- The operation of demultiplexer is exactly opposite to that of a multiplexer.

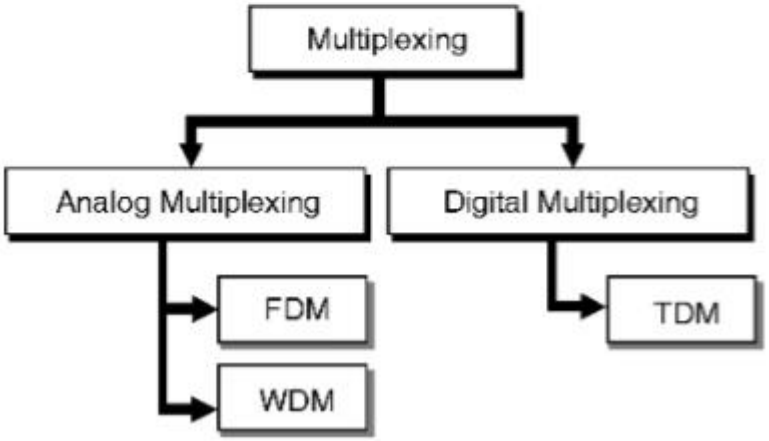
Need of Multiplexing :

- In the applications like telephony, there are large number of users involved.
- It is not possible to use a separate pair of wires from each subscriber to all the other subscribers. This is very expensive and practically impossible.
- Instead if we use the principle of multiplexing, then we can use a common communication medium such as a coaxial cable or an optical fiber cable to carry telephone signals originated from a number of subscribers.

The same principle is applicable to every application in which many signals originating from different sources are to be sent over a single communication medium.

8.2.1 Types of Multiplexing :

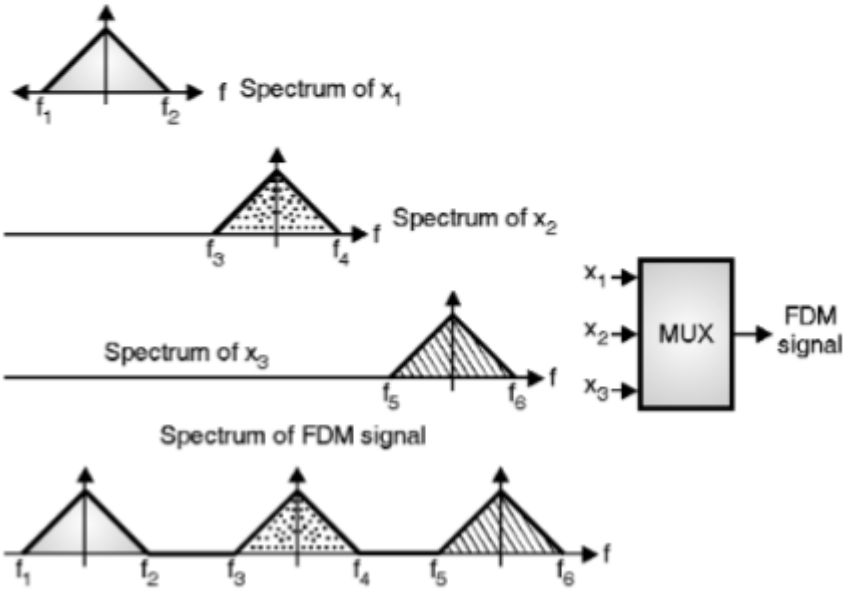
- Different types of multiplexing are :
  1. Frequency Division Multiplexing (FDM).
  2. Time Division Multiplexing (TDM).
  3. Wavelength Division Multiplexing (WDM).
  4. Orthogonal FDM (OFDM)
- Fig. 8.2.2 shows the classification of multiplexing techniques.



8.3 Frequency Division Multiplexing (FDM) :

Definition :

- FDM is the multiplexing technique in which many signals are sent simultaneously (at the same time) in time domain but are separated from each other in the frequency domain (i.e. they occupy different slots in the frequency spectrum).
- Fig. 8.3.1 explains the concept of FDM.
- The FDM is based on the concept of sharing bandwidth of a common communication channel. The signals which are to be transmitted simultaneously will each modulate a separate carrier.

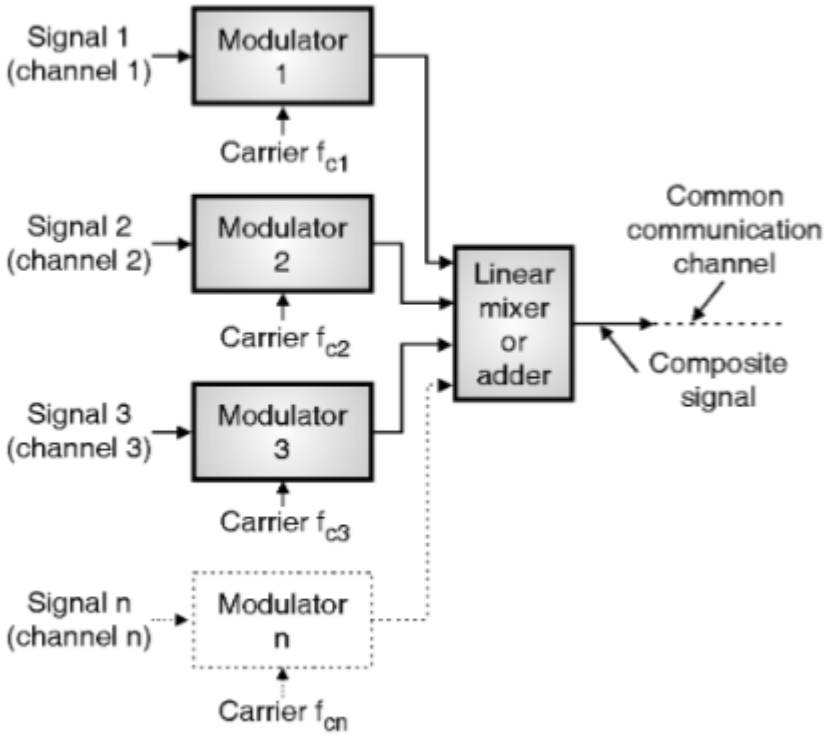


(E-1136) Fig. 8.3.1 : Concept of FDM

8.3.1 FDM Transmitter :

Block diagram :

– Fig. 8.3.2 shows the block diagram of an FDM transmitter. The signals which are to be multiplexed will each modulate a separate carrier.



(D-501) Fig. 8.3.2 : The FDM transmitter

Operation :

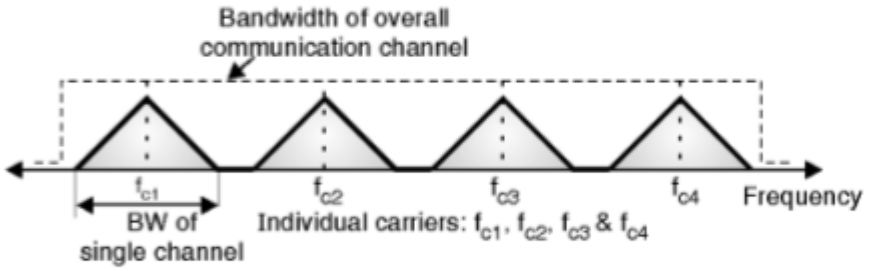
- Each signal modulates a separate carrier. The modulator outputs will contain the sidebands of the corresponding signals.
- The modulator outputs are added together in a linear mixer or adder. The linear mixer is different from the normal mixers. Here the sum and difference frequency components are not produced. But only the algebraic addition of the modulated outputs will take place.
- Different signals are thus added together in the time domain but they have their own separate identity in the frequency domain. This is as shown in the Fig. 8.3.2.
- The composite signal at the output of mixer is transmitted over the single communication channel as shown in Fig. 8.3.2.

– This signal can be used to modulate a radio transmitter if the FDM signal is to be transmitted through air.

Spectrum of FDM :

– Fig. 8.3.3 shows the spectrum of the FDM signal. It shows that the bandwidth of the FDM signal is larger than that of the individual signal bandwidths.

– In fact the bandwidth of FDM signal is equal to the sum of individual signal bandwidths and the guard bands.



(E-753) Fig. 8.3.3 : Spectrum of FDM signal

Guard Bands :

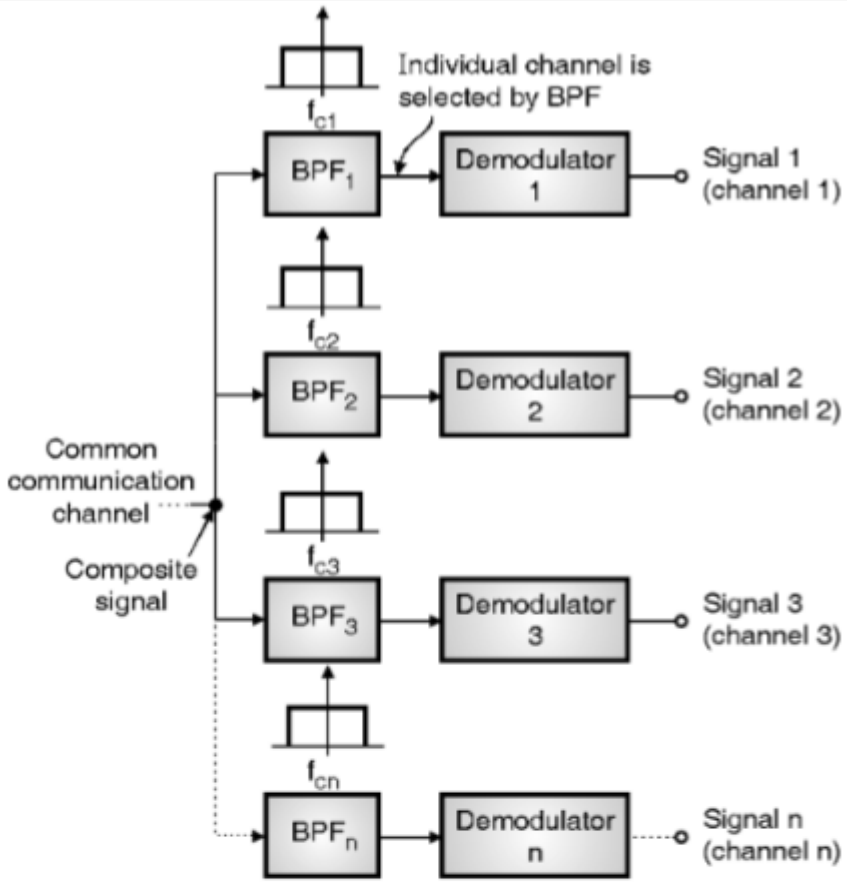
– The guard bands are introduced in order to avoid any interference between the adjacent channels as shown in Fig. 8.3.3.

8.3.2 FDM Receiver :

Block diagram :

– The block diagram of an FDM receiver is as shown in Fig. 8.3.4.

– The composite signal is applied to a group of Band Pass Filters (BPF).



(D-502) Fig. 8.3.4 : FDM receiver

Operation :

- Each BPF has a center frequency corresponding to one of the carriers used in the transmitter
  i.e. f_{c1}, f_{c2}, ...f_{cn} etc.
- The BPFs have an adequate bandwidth to pass all the channel information without any distortion.
- Each filter will pass through only its channel and reject all the other channels. Thus all the multiplexed channels are separated out.
- The channel demodulator then removes the carrier

– The channel demodulator then removes the carrier and recovers the original signal back.

8.3.3 Advantages of FDM :

1. A large number of signals (channels) can be transmitted simultaneously.
2. FDM does not need synchronization between its transmitter and receiver for proper operation.
3. Demodulation of FDM is easy.
4. Due to slow narrow band fading only a single channel gets affected.

8.3.4 Disadvantages of FDM :

1. The communication channel must have a very large bandwidth.
2. Intermodulation distortion takes place.
3. Large number of modulators and filters are required.
4. FDM suffers from the problem of crosstalk.
5. All the FDM channels get affected due to wideband fading.

8.3.5 Applications of FDM :

– Some of the important applications of FDM are :

1. Telephone systems.
2. AM (amplitude modulation) and FM (frequency modulation) radio broadcasting.
3. TV broadcasting.
4. First generation of cellular phones used FDM.

8.4.8 Comparison of FDM and TDM Systems : MU : May 12, Dec. 13, Dec. 16

University Questions

Q. 1 Compare TDM and FDM.

(May 12, Dec. 13, Dec. 16, 5 Marks)

Sr. No.	FDM	TDM
1.	The signals which are to be multiplexed are added in the time domain. But they occupy different slots in the frequency domain.	The signals which are to be multiplexed can occupy the entire bandwidth but they are isolated in the time domain.

Sr. No.	FDM	TDM
2.	FDM is usually preferred for the analog signals.	TDM is preferred for the digital signals.
3.	Synchronization is not required.	Synchronization is required.
4.	The FDM requires a complex circuitry at the transmitter and receiver.	TDM circuitry is not very complex.
5.	FDM suffers from the problem of crosstalk due to imperfect band pass filters.	In TDM the problem of crosstalk is not severe.
6.	Due to wideband fading in the transmission medium, all the FDM channels are affected.	Due to fading only a few TDM channels will be affected.
7.	Due to slow narrowband fading taking place in the transmission channel only a single channel may be affected in FDM.	Due to slow narrowband fading all the TDM channels may get wiped out.