The operation of FDM is based on sharing the available bandwidth of a communication channel among the signals to be transmitted.

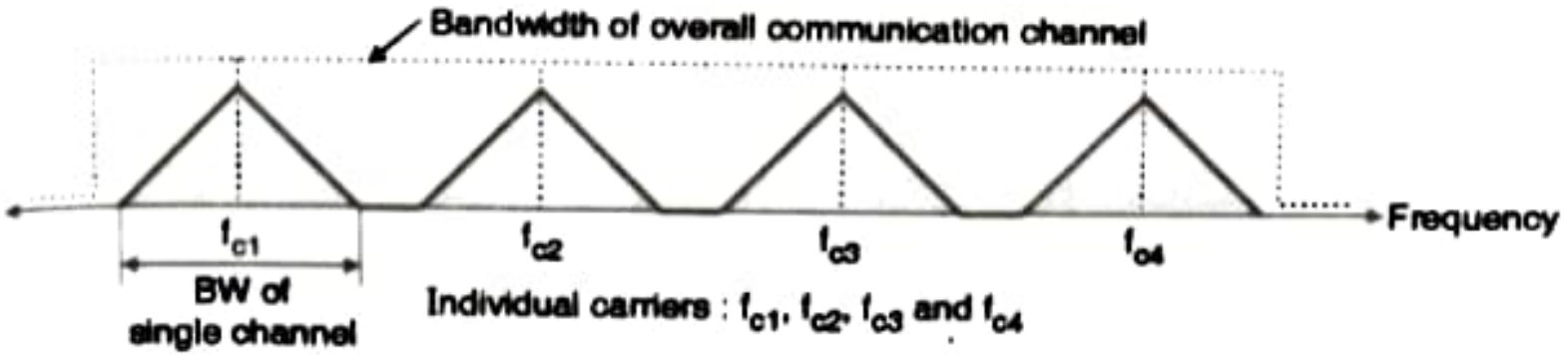
That means many signals are transmitted simultaneously with each signal occupying a different frequency slot within the total available bandwidth.

Each signal to be transmitted modulates a different carrier. The modulation can be AM, SSB, FM or PM.

The modulated signals are then added together to form a composite signal which is transmitted over a single channel.

The spectrum of composite FDM signal is shown in Fig. 11.3.1(a).

Generally the FDM systems are used for multiplexing the analog signals.



(L-167) **Fig. 11.3.1(a) : Spectrum of FDM signal**

dbands and their importance :

The adjacent spectrums in the spectrum of an FDM signal (Fig. 11.3.1(a)) do not touch each other. They are separated from each other by the guard bands.

The guard bands are introduced in order to avoid any interference between the adjacent channels.

Wider the guard band, smaller the interference.

3.1 FDM Transmitter (Multiplexing Process) :

Fig. 11.3.1(b) shows the block diagram of an FDM transmitter. The signals which are to be multiplexed will each modulate a separate carrier.

The type of modulation can be AM, SSB, FM or PM.

The modulated signals are then added together to form a complex signal which is transmitted over a single channel.

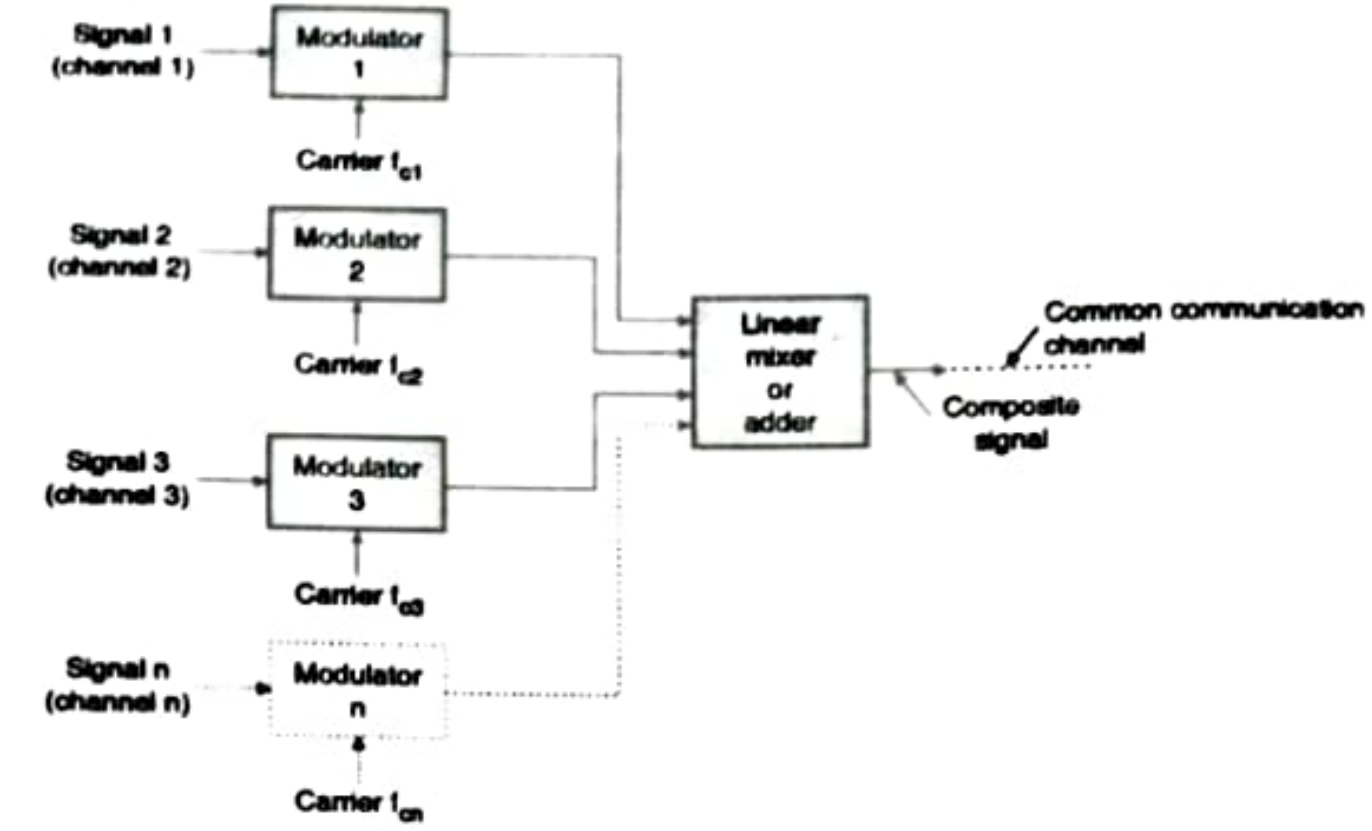
peration :

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.

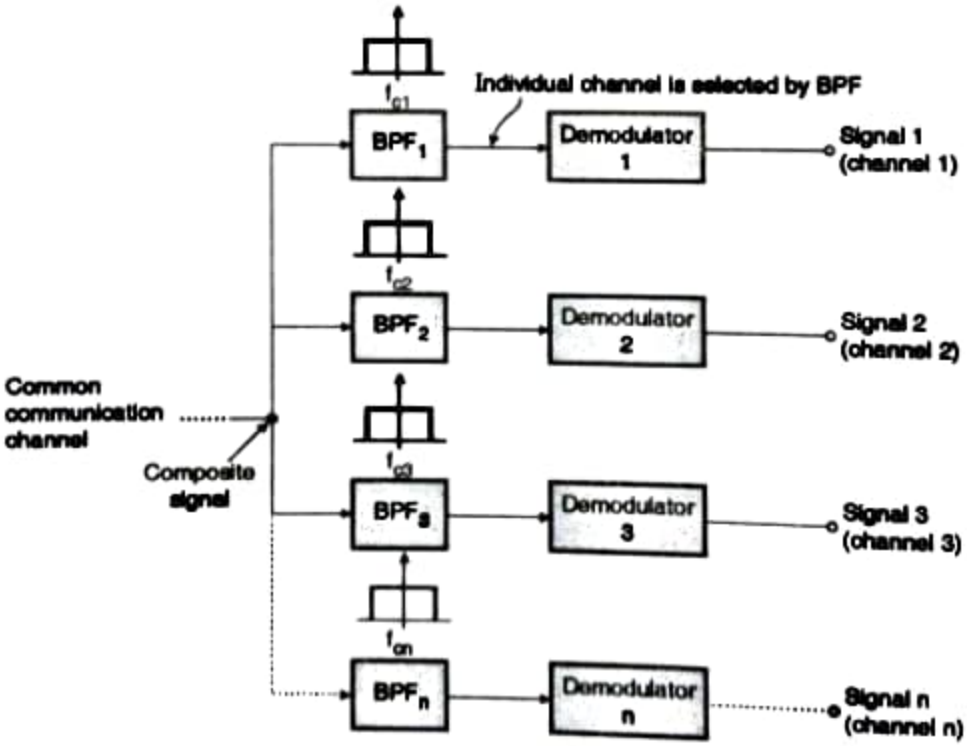
Different signals are thus added together in the time domain but they have their own separate identity in the frequency domain. This is as shown in the Fig. 11.3.1(a).

The composite signal at the output of mixer is transmitted over the single communication channel as shown in Fig. 11.3.1(b). This signal can be used to modulate a radio transmitter if the FDM signal is to be transmitted through air.



3.2 FDM Receiver :

The block diagram of an FDM receiver is as shown in Fig. 11.3.1(c). The composite signal is applied to a group of band pass filters (BPF).



(L-109) **Fig. 11.3.1(c) : FDM receiver**

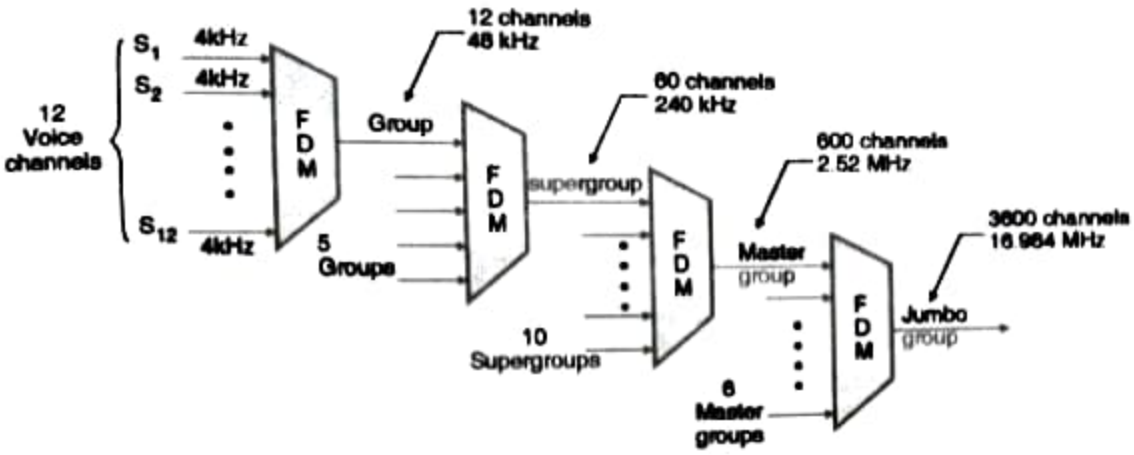
Each BPF has a center frequency corresponding to one of the carriers used in the transmitter i.e f_{c1}, f_{c2}, ... f_{cn} etc.

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 and recovers the original signal back.

3.4 Multiplexing Hierarchy in FDM :



(L-110) **Fig. 11.4.1 : FDM hierarchy**

The levels of multiplexing is also called as multiplexing hierarchy.

The different levels of multiplexing which is also called multiplexing hierarchy is as follows :

Level (1) : Basic Group. [12 voice channels multiplexed together].

↓

Level (2) : Super Group. [Upto 5 basic groups multiplexed together

↓ i.e. upto 60 voice channels].

Level (3) : Master Group. [Upto 10 super groups multiplexed together

↓ i.e. upto 600 voice channels].

Level (4) : Jumbo Group. [Upto 6 master groups multiplexed together

i.e upto 3600 voice channels].

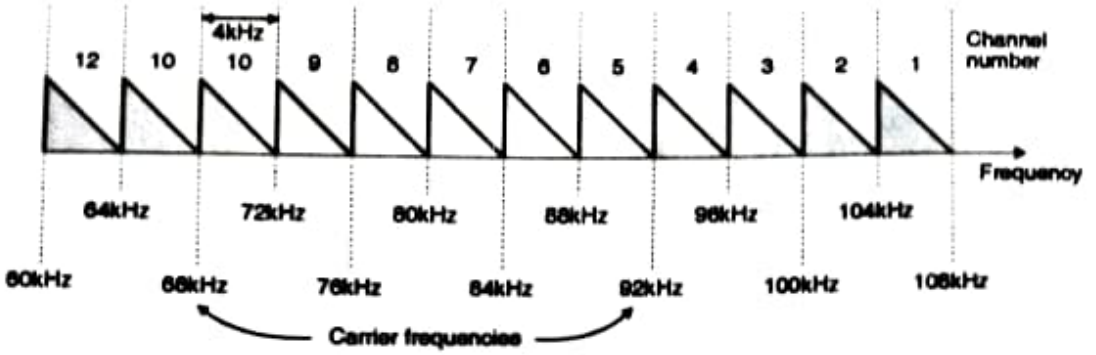
This hierarchy is used by AT and T and shown in Fig. 11.4.1.

asic Group [12 voice channels] :

The frequency plan for the typical basic group is as shown in Fig. 11.4.2. Here the 12 voice channels such as telephone channels modulate the carrier frequencies in the range of 60 to 108 kHz range. The carrier frequencies are spaced at 4 kHz from each other.

SSB modulation technique is used to save the bandwidth. Each voice channel is applied to a balanced modulator along with a carrier. The output of a balanced modulator consists of the upper and lower sidebands.

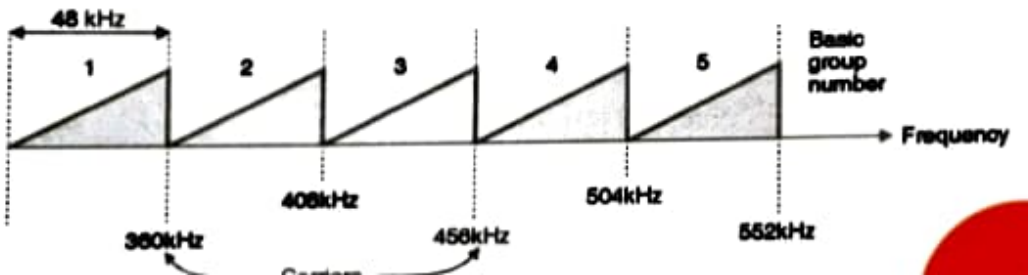
- Frequency plans of groups of FDM are nothing but the frequency spectrums.
- The frequency plan for the basic group of FDM is shown in Fig. 11.4.2.



(L-111) **Fig. 11.4.2 : Frequency plan for the basic group of FDM**

Super group :

The frequency plan for a super group is as shown in Fig. 11.4.2. A super group consists of at the most 60 voice channels.



Advantages, Disadvantages and Applications of FDM :

.1 Advantages of FDM :

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

.2 Disadvantages of FDM :

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

.3 Applications of FDM :

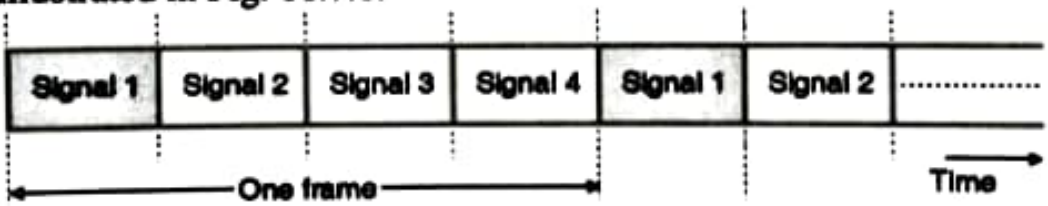
e of the important applications of FDM are :
Telephone systems.
AM (amplitude modulation) and FM (frequency modulation) radio broadcasting.
TV broadcasting
First generation of cellular phones used FDM.

The process called multiplexing is used in order to utilize common transmission channel or medium to transmit more than one signals simultaneously.

TDM is a digital multiplexing process.

In TDM all the signals to be transmitted are not transmitted simultaneously. Instead, they are transmitted one-by-one.

Thus each signal will be transmitted for a very short time. One cycle or frame is said to be complete when all the signals are transmitted once on the transmission channel. The TDM principle is illustrated in Fig. 11.7.1.



(L-122) **Fig. 11.7.1 : Principle of TDM**

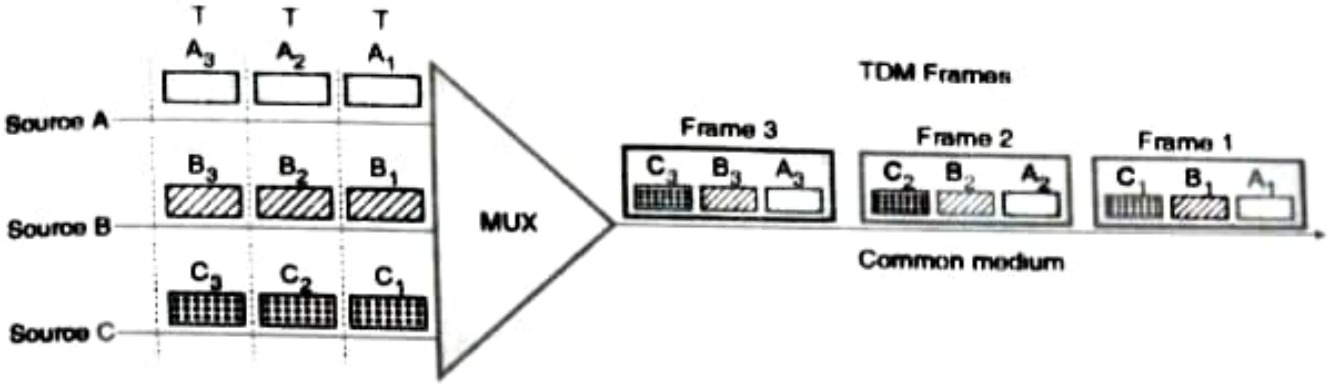
As shown in the Fig. 11.7.1 one transmission of each channel completes one cycle of operation called as a "Frame".

The TDM system can be used to multiplex analog or digital signals, however it is more suitable for the digital signal multiplexing.

The concept of TDM will be more clear if you refer to Fig. 11.7.2.

The data flow of each source (A, B or C) is divided into units (say A_1, A_2 or B_1, C_1 etc.)

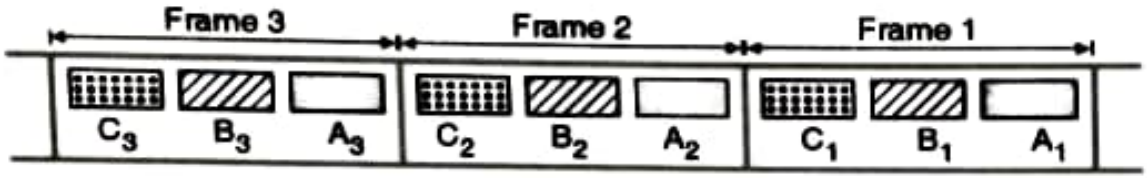
Then one unit from each source is taken and combined to form one frame. The size of each unit such as A_1, B_1 etc. can be 1 bit or several bits.



(L-123) **Fig. 11.7.2 : TDM system**

Fig. 11.7.3 shows the frames of TDM signal. For 3 inputs being multiplexed, a frame of TDM will consist of 3 units i.e. one unit from each source.

Similarly for n number of inputs, each TDM frame will consist of n units.



(L-124) **Fig. 11.7.3 : TDM frames**

The TDM signal in the form of frames is transmitted on the common communication medium.

ta rate :

For a TDM, the data rate of the multiplexed signal is always n times the data rate of individual sources, where n is the number of sources.

So if three sources are being multiplexed, then the data rate of the TDM signal is three times higher than the individual data rate.

Naturally the duration of every unit (A_1 or B_1 etc.) in TDM signal is n times shorter than the unit duration before multiplexing.

7.5 Advantages of TDM :

Full available channel bandwidth can be utilized for each channel.

Intermodulation distortion is absent.

TDM circuitry is not very complex. 4. The problem of crosstalk is not severe.

7.6 Disadvantages of TDM :

Synchronization is essential for proper operation.

Due to slow narrowband fading, all the TDM channels may get wiped out.

FDM	TDM
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.
FDM is usually preferred for the analog signals.	TDM is preferred for the digital signals.
Synchronization is not required.	Synchronization is required.
The FDM requires a complex circuitry at the transmitter and receiver.	TDM circuitry is not very complex.
FDM suffers from the problem of crosstalk due to imperfect band pass filters.	In TDM the problem of crosstalk is not severe.
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.
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.